turtles may nest at other rookeries and it is important that these alternate nesting beaches are 'turtle friendly'. Thus protection of all three rookeries is extremely crucial for the survival of turtles in Orissa.

Acknowledgements

The data presented here were collected as part of Wildlife Institute of India's sea turtle research program in Orissa. We thank the Packard Foundation and the Barbara Delano Foundation, USA for providing travel grants to participate in the symposium.

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Possible Threats to and Conservation Measures for the Nesting Olive Ridley Populations, *Lepidochelys olivacea,* at Andhra Pradesh Coastline, India

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Abstract

Olive ridley sea turtles, *Lepidochelys olivacea,* found in the Indian Ocean and its bay islands are highly vulnerable from various threats. At Gahirmatha in Orissa state, India, the olive ridleys have their largest rookery (mass nesting). Every year around February, the breeding populations migrate from the Indian Ocean to the mass nesting sites after travelling from the coastal waters of Tamilnadu and Andhra Pradesh. Even though these migratory populations are protected under Schedule I of the Indian Wildlife (Protection) Act, 1972, their exploitation is continuing in the coastal villages of Andhra Pradesh. Live turtles are captured incidentally in courtship activity or subjected to strandings of nesting turtles for meat, shell and calipee. Other possible threats identified in the region are human interference to their nesting habitats, nests and hatchlings, due to major construction works and artificial illumination on the beaches.

In every breeding season (November to March) it was estimated that from 2000 to 3000 live turtles of breeding stock are subjected to indiscriminate exploitation and as many carcasses (dead turtles > 2 per km) on coastline due to trawl fishing and instant mortality. Besides live turtles, freshly laid nests are predated by jackals, foxes and domestic dogs and are also excavated by beachcombers, resulting in 90% losses. To prevent these possible threats, conservation programs were initiated to reduce the mortality of nesting turtles, and to protect the nests, eggs and hatchlings. Also a management plan was formulated for the development of important nesting habitats and feeding grounds of olive ridleys in this region.

Introduction

Of the world's seven species of sea turtles, five species: the green turtle (*Chelonia mydas*); loggerhead (*Caretta caretta*); hawksbill (*Eretmochelys imbricata*); leatherback (*Dermochelys coriacea*) and the olive ridley (*Lepidochelys olivacea*) are distributed in the Indian Ocean and placed in Schedule I of the Indian Wildlife (Protection) Act, 1972. These species are also listed in Appendix I of the Convention on International Trade in Endangered species of wild fauna and flora (CITES, 1975). All the five species nest on the coasts of the Indian Ocean and its Bay Islands, while the olive ridleys have their largest (mass) nesting site at Gahirmatha of Orissa state in Northern Indian Ocean (Kar, 1980).

In winter months (January to March) olive ridleys migrating from the Indian Ocean to the coasts of Orissa for mass nesting (arribada) pass through the coastal waters of Tamilnadu and Andhra Pradesh. During migration these breeding populations are utilizing the nearby suitable habitats to lay their nests sporadically, along the coastline of Andhra Pradesh (Raja Sekhar, 1987). These migratory turtles are exploited by the local people for meat, shell and calipee, also the nests, eggs, and hatchlings subject to over predation by canine predators. Apart from biotic interferences, the developmental activities and intensive shrimp fishing along the coastline cause threats to the survival of olive ridleys in the region.

Study Area

The coastline between Kalingapatnam (Vamsadhara River) in the north and Kakinada (Godavari River) in the south is an important area. As a migratory corridor for olive

ridleys, it has been selected for the present study. These coastal areas have different shore conditions ranging from rocky to shallow sandy shores with several rivers entering into the North Indian Ocean (Bay of Bengal). There are 53 villages on the coastline (population around 6,3,000) most of which belongs to fishing tribes. A total of 600 to 700 trawls operate along the coastline and 2000 to 3000 of traditional catamarans also operate from the coastal villages. Major industries, fishing harbours and shipping ports are located at the coasts of Visakhapatnam and Kakinada (**Fig. 1**).

Observations

Survey work has been conducted along this coastline during winter months (December - March) in 1996-97 and 1997-98. A major part of the survey was made on foot with the assistance of natives of the region when required. The status of these breeding turtles and possible threats to these nesting turtles were determined based on:

- Human interference (Exploitation of breeding turtles).
- Disturbances (Human and Predatory) to the nesting turtles, nests and hatchlings.
- Incidental catches of migratory turtles.
- Coastal developmental activities and marine pollution.

Human Interference (Exploitation of Live Turtles): The olive ridleys were captured during courtship or on shore during nesting activity and brought to villages for trade or personal consumption. These turtles were turned on their backs for up to 3 to 4 days in the hot sun before slaughter and sale in nearby weekly markets. During the period 1968 female olive ridleys (85.00%) were caught from courtship activity; 280 were captured (12.00%) on shore during their nesting activity and 45 turtles are subjected (2.00%) to stranding accidentally trapped in fishing nets spread on the shoreline. Some times canine predators (jackal and hyena) attacked the nesting turtles and killed them on shore and 22 of such evidences (1.00%) were recorded during the study period (**Table 1**).

Human and Predatory Disturbances: Domestic dogs and predators like foxes, *Vulphus bengalensis*, jackal, *Canis aureus*, hyena, *Hyaena striata* preyed upon the freshly laid nests accounting for 43.58% of the disturbances; these same animals preyed upon the nests at later stages for 3.42% of disturbances before hatchling (middle of incubation). Newly emerged hatchlings fall prey to crows, owls, white-bellied sea eagle, and ghost crabs. Freshly laid nests excavated by beachcombers accounted 954 nests for personal consumption or for sale (53.00%) in local markets (**Table 2**).

Incidental Catches and Accidental Mortality: The fishing activity was intensive all along the coast from River Godavari at Kakinada to Vamsadhara river of Kalingapatnam. For deep sea fishing 600 to 700 trawls were extensively used in the port areas of Visakhapatnam and Kakinada and Kalingapatnam, with gill and drag nets for shrimp catches. Many of the migratory turtles are accidentally trapped in gill or dragnets, then wash ashore as dead carcasses. The density of carcasses was 4 per km at Godavari river mouth and > 2 per km for the remaining coastline. There was a total of 926 carcasses in 1996-97 and 1158 during 1997-98. Kakinada coasts had the highest percentage (35.17%) of carcasses, Visakhapatnam had 30.90%, followed by Kalingapatnam with 18.00, and Pentakota with 15.93% respectively (**Table 3**).

Coastal Development and Pollution Threats: In recent times the coastline of Andhra Pradesh is subjected to major developmental activities for setting of Industries, Road formations, Brackish water Shrimp farming, Agriculture and Commercial plantations. At the major nesting beaches (Godavari river and at the Vamsadhara river mouths) placement of permanent nets for intensive seed collection (average density of 25-30/km) prevents the turtles from nesting.

The other potential threats to the nesting habitats include human settlements nearer to shore line with an average

Table 1. Exploitation of nesting olive ridleys for meat, shell and calipee during 1996-1998.

Type of exploitation	Study period		
	1996-97	1997-98	Total (%)
Turtles caught during courtship activity	948	1020	1968 (85.00)
Caught while nesting	170	110	280 (12.00)
Trapped in nets on shoreline (strandings)	25	20	45 (2.00)
Nesting turtles killed by dogs or predators	9	12	22 (1.00)

Table 2. Nest predation during 1996-1998.

Type of disturbance	1996-1997	1997-98	Total (%)
Human excavated nests	442	512	954 (53.00)
Nests disturbed by predators (freshly laid nests)	363	420	783 (43.58)
Nests disturbed at the time of hatching by domestic dogs/ predators	24	36	60 (3.42)

Table 3. Number of carcasses found near major port areas 1996-1998.

Coastline area	Dead Turtles on Shore		Total	%
	1996-97	1997-98		
Kakinada (Godavari River)	342	391	733	35.17
Pentakota	134	198	332	15.93
Visakhapatnam	326	318	644	30.90
Kalingapatnam (Vamsadhara River)	124	251	375	18.00
Total for the period	926	1158	2089	

density varied from 200 to 400 per km. Pollution from nearby industries causes severe threat to marine environment at Kakinada and Visakhapatnam coastline (**Table 4**).

Discussion

The Andhra Pradesh coastline is a migratory route or pathway for the olive ridleys to approach Gahirmatha beaches in Orissa state, where the largest 'arribada' was reported by Bustard (1976). It is most likely that a good number of turtles sporadically nest along the coastline of Northern Andhra between Godavari River mouth to Vamsadhara River. Frazier (1980) described various conditions of exploitation of sea turtles in the Indian Ocean and explained the reasons for subsistence economy of local inhabitants.

Subsistence pattern of hunting for the olive ridleys was reported along the coasts of Orissa and West Bengal (Das and Kar 1986). However such large scale commercial exploitation was not intensified in the Andhra Pradesh coastline. Incidental catches of turtles in the trawl nets, poaching of nesting turtles and destruction of nests were intensive all along the coastline, not only removing the turtles but severely limiting their reproduction.

In spite of several protection measures (Wildlife Protection Act, 1972) sea turtles are intensively subjected to over exploitation for their meat, shell, eggs, and calipee, all along the coastline by the subsistence economy. Apart from biotic interference the breeding habitats of these turtles are faced with severe threats from beach erosion, sand mining, formation of roads, encroachments and to a larger extent marine water pollution.

Pollution sources from nearby industries, mostly of untreated or semi-treated effluents from the Nagarjuna and Godavari fertilizer plants and the discharge of hot waters (30-40°C) from NTPC Gas Based Power Project (GBPP) at Kakinada Bay cause synergistic effects to the marine coastal environment and threaten the Godavari mangroves which are an important breeding and feeding habitat to olive ridleys. Oil drilling sites nearer to Hope Island and Sacramento shoals cause long-term detrimental effects to the nesting habitats. Other possible threats are from the increasing rate of human settlements, conversion of coastal habitats for aquaculture, and industrial pollution to coastal areas nearer to the nesting habitats.

To mitigate these possible threats the following programs were initiated for the conservation of olive ridley sea turtles along the coastline.

1. Subsistence hunting can be avoided through intensive education programs in all 53 fishing villages of the study area to bring awareness of the importance of sea turtles.
2. Use of TEDs (Turtle Excluder Devise): There are around 600-700 shrimp fishing trawls operating from Visakhapatnam and Kakinada Port. TEDs should be introduced progressively after teaching boat owners about the importance of sea turtles. Mandatory implementation may be necessary.
3. Protection of sea turtle nests '*In situ'* from the areas where the nests are likely to be poached or disturbed, or other threatening factors and survey of turtle nesting sites in the remaining coastline.
4. Strict implementation of the Wildlife Protection Act of 1972 and severe punishment for the commercial exploiters of sea turtles and their eggs. Declare Sacramento and Hope Islands near Kakinada, Andhra Pradesh as a sea turtle sanctuary and ban all fishing and other activities that are detrimental to the turtles and their nesting habitats.

Acknowledgements

I express my sincere gratitude to the Packard Foundation, USA for travel assistance. I take this opportunity to acknowledge Ms. Marydele Donnelly Regional Chair, Travel Committee Asia and Pacific and the

Table 4. Possible threats to the olive ridley sea turtle nesting habitats along the coastline of Andhra Pradesh

Name of the area (Coastal habitat)	Developmental activities on the coast line	Possible threats
Kakinada coast, Hope Island and Sacramento shoals of Godavari River adjacent to Coringa Wildlife Sanctuary	Brackish water shrimp culture, Port operations, Godavari & Nagarjuna fertilizer plant, NTPC Gas based Power Project, ONGC Oil drilling sites, Extensive Shrimp seed collection,	Pollution destruction of mangrove forests and erosion
Pentakota beach	Shrimp farming, agriculture sand mining,	Shrinkage of coastline Casuarina plantations
Visakhapatnam coast	Port operations, fishing harbour sand digging & quarry mining-shipping activities and salt manufacturing units, shrimp hatcheries, Visakha Steel Plant	Urbanization shrinkage of coastline and pollution & lighting
Kalingapatnam Vamsadhara river	Sand mining, shrimp farming Erosion and Coconut plantations	Coastal erosion

organizing committee of 19th Annual Sea Turtle Symposium. I am thankful to Prof. M.V Subba Rao, Department of Environmental Science, Andhra University for the help in conducting the survey and also thanks are due to A.P. Forest Department.

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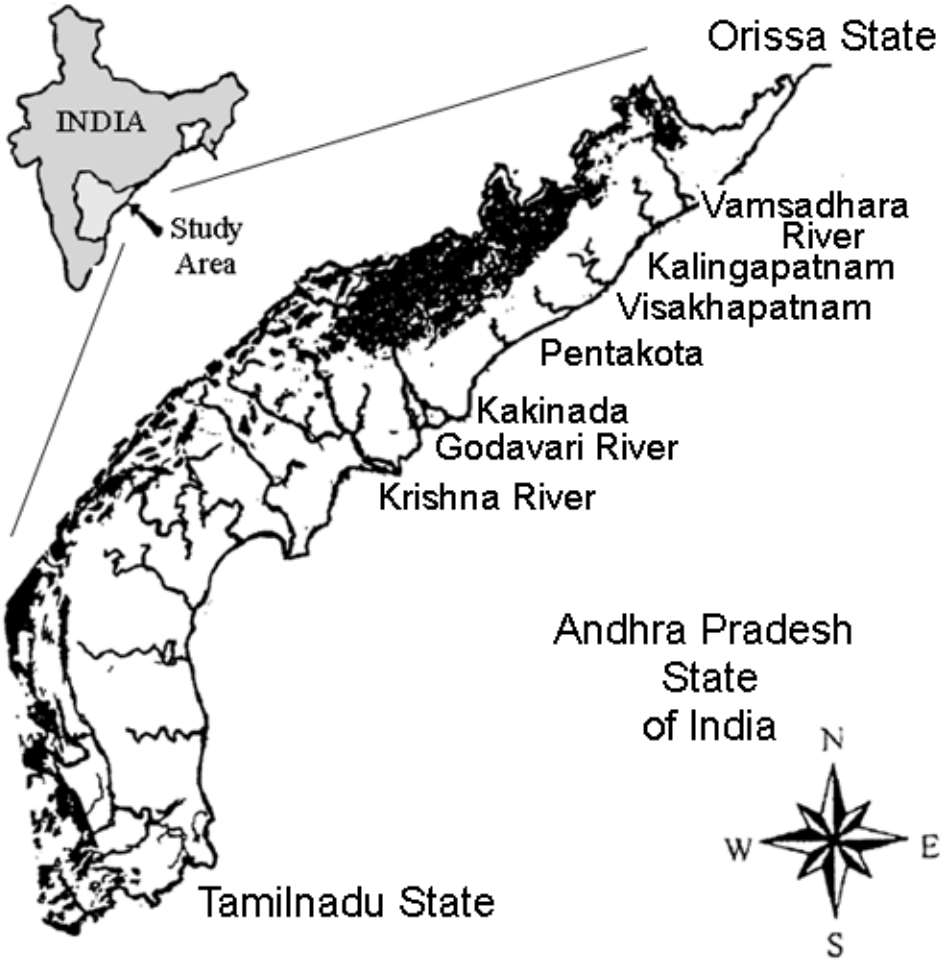

Figure 1. The shoreline of Andhra Pradesh state located to the south of the state of Orissa, India.

Analysis of Synchronized Mass Nesting Activity (Arribada) by Olive Ridley Sea Turtles (*Lepidochelys olivacea*) in the Ostional Wildlife Refuge, Guanacaste, Costa Rica

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The method used to estimate the size of arribada nesting assemblages in Ostional, developed by Cornelius and Robinson in the early 1980's, uses 3 fixed 10x15 m quadrants that are then extrapolated to the 880 m Main Nesting Beach (MNB). However, it is common for the main aggregation of nesting turtles to shift a bit north or south of the MNB (Ballestero *et. al*., 1997). Consequently, the static quadrant method could not follow nor describe the course of the arribada. The current status and recovery potential of these species can only be assessed using the long term monitoring of demographic variables, and by employing robust and reliable statistical methods for data analysis (Valverde and Gates, 1999).

In this paper, we estimate the size and distribution of 5 consecutive arribadas, from August to December of 1998, using the "Strip Transect in Time Instantaneous Count" method (IC) (Valverde and Gates 1999).

Methodology

Wooden stakes were placed at the vegetation line every 50 m for the entire 7 km length of the beach (**Fig. 1**). Transects the width of the technicians arm length, were walked perpendicular to the high water mark or berm every two hours, during which Egg Laying Females (ELF) and Total Turtles (TT) present (including ELF) were counted. Counts officially started the morning after the first night of the arribada, and continued throughout the arribada event. Since large numbers of turtles deposit their eggs below the berm and it is often difficult to define the berm, transects were extended to the water's edge after August. This modification also obliged us to adjust transect length with tides.

Results

The August arribada had a duration of 7 nights (Aug.15-21), with an estimate of 22,644 $\pm$ 4643 and 41,146 $\pm$ 8436 ELF and TT (**Table 1**). The majority of nesting activity occurred on the 880m stretch of the MNB, although the entire space used was 3 kms (**Fig. 2**). Greatest nesting activity occurred on August 18, after which nesting activity waned until August 21 (**Fig. 3**).

The September arribada had a duration of 6 nights (Sept 28-Oct 3), with an estimate of 80,542 $\pm$ 14,279 and 91,559 $\pm$ 11,982 ELF and TT (**Table 1**). The geographical distribution of the arribada nesting activity was limited to under 2 km of the beaches known as "El Rayo I" "El Rayo II" and "Pueblo" (**Fig. 2**). Greatest nesting activity occurred on September 30, after which nesting activity steadily waned until October 3 (**Fig. 4**).

The October arribada had a duration of 5 nights (Oct 27-31), with an estimate of 78,237 $\pm$ 10636, and 135,029 $\pm$ 16,008 ELF and TT (**Table 1**). The distribution of this arribada was 2.25 km, occurring in "El Rayo II" and "Pueblo" (**Fig. 2**). This arribada is noteworthy as the first published account of an arribada with a bimodal distribution. Greatest nesting activity was recorded on October 29 (**Fig. 5**).

The November arribada had a duration of 5 nights (Nov 25-29), with an estimate of 45,424 $\pm$ 3,823 and 50,515 $\pm$ 6859 ELF and TT (**Table 1**). Nesting activity covered roughly 3 kms of the beaches known as "El RayoI", "El Rayo II" and "Pueblo" nesting occurred almost to the Northern most end of the beach (**Fig. 2**). Nesting activity decreased roughly 40% on November 28, only to increase again on the 29 (**Fig. 6**).

The December arribada had a duration of 4 nights (Dec.16-19), with an estimate of 6,237 $\pm$ 2901 and 6,248 $\pm$ 3,372 ELF and TT (**Table 1**). The absolute direct count of visiting turtles was 7,790 $\pm$ 2,642. Nesting activity covered less than 2 km, in "El Rayo II" and "El Pueblo" **(Fig. 7)**.

Conclusion

Due to the size of the beach at Ostional and the unpredictability of the nesting behavior of the turtles, it is paramount that any studies on the arribadas be flexible enough to cope with their spatial and temporary distribution. The IC method allows a relatively small number of people to monitor the arribadas with little advanced training, and relatively simple preparatory posting of the beach. During the dry season, when arribadas are much smaller, direct counts should offer a more reliable estimate. It appears that the nesting population, as compared to the limited data from years past, seems to be relatively stable (Ballestero *et al*. 1997). In order to coordinate research and conservation efforts more effectively, it would be extremely beneficial if all researchers at arribada beaches around the world would use the IC method in addition to any other methods already in use, allowing easy comparisons of nesting activity.

Acknowledgements

The authors would like to thank the David and Lucile Packard Foundation for it's kind support, which permitted the participation of intern students Aaron Russell and Shyamoli Mehta to this event. A special thanks to Todd Steiner of the Sea Turtle Restoration Project, the Asociación PRETOMA of Costa Rica, and to the Ostional Development Association, for providing the economic and logistic support to make this project possible.

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