BREEDING BIOLOGY OF OLIVE RIDLEY SEA TURTLE, *LEPIDOCHELYS OLIVACEA* (ESCHCHOLTZ, 1829) ALONG THE POOMPUHAR COAST, TAMILNADU, SOUTHERN INDIA

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in

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by

J. GOKULAKRISHNAN, M. Sc., M. Phil.

SACON

Division of Conservation Ecology

Sálim Ali Centre for Ornithology and Natural History

Coimbatore 641 108

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CERTIFICATE

This is to certify that the thesis, entitled **"BREEDING BIOLOGY OF OLIVE RIDLEY SEA TURTLE, *LEPIDOCHELYS OLIVACEA* (ESCHCHOLTZ, 1829) ALONG THE POOMPUHAR COAST, TAMILNADU, SOUTHERN INDIA"** is a record of original work done by Mr. J. GOKULAKRISHNAN in the Division of Conservation Ecology, Sálim Ali Centre for Ornithology and Natural History, as a fulltime Research Scholar during November 2004 – March 2011 under my guidance and supervision for the award of the Degree of Doctor of Philosophy in ZOOLOGY. I further certify that this research work has not previously formed the basis for the award of any other Degree or Diploma or Associateship or Fellowship or other similar title to this or any other candidate in any University.

Signature of the Guide 31/3/11

Dr S Bhupathy
Principal Scientist & Head
Department of Zoology
Sálim Ali Centre for Ornithology and Natural History
Anaikatty (Post), Coimbatore 641 108

Countersigned 31/3/11

Head of the Department

Dr S Bhupathy
Principal Scientist & Head
Department of Zoology
Sálim Ali Centre for Ornithology and Natural History
Anaikatty (Post), Coimbatore 641 108

Countersigned

Director

डॉ. पी. ए. अज़ीज़ / Dr. P. A. Azeez
निदेशक / Director
सालिम अली प्रकृति विज्ञान केन्द्र
Sálim Ali Centre for Ornithology and Natural History
आनैकट्टी / Anaikatty (Post)
कोयम्बटूर / Coimbatore 641 108

DECLARATION

I, do hereby declare that the thesis entitled, "BREEDING BIOLOGY OF OLIVE RIDLEY SEA TURTLE, *LEPIDOCHELYS OLIVACEA* (ESCHCHOLTZ, 1829) ALONG THE POOMPUHAR COAST, TAMIL NADU, SOUTHERN INDIA" submitted to the Bharathiar University, Coimbatore, for the award of the Degree of Doctor of Philosophy in ZOOLOGY, is a record of original and independent research work done by me during November 2004 – March 2011 under the guidance and supervision of Dr. S. Bhupathy, Principal Scientist, Division of Conservation Ecology, Sálim Ali Centre for Ornithology and Natural History, Coimbatore and it has not previously formed the basis for the award of any other Degree or Diploma or Associateship or Fellowship or other similar title to any of this or any other candidate in any University.

Signature of the Candidate

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J.GOKULAKRISHNAN

DETICATED TO MY
BELOVED PARENTS

CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

SUMMARY

Sea turtles are of ancient origin and are in existence for millions of years and their first fossil records date back to 110 million years. They have worldwide distribution and are migratory in nature. Globally seven species of marine turtles have been recognized and five of them, the Olive Ridley, *Lepidochelys olivacea* (Eschcholtz, 1829), the Green Turtle, *Chelonia mydas* (Linnaeus, 1758), the Hawksbill *Eretmochelys imbricata* (Linnaeus, 1758), the Leatherback, *Dermochelys coriacea* (Linnaeus, 1766), and the Loggerhead *Caretta caretta* (Linnaeus, 1758) are reported from Indian region. It is reported that the populations of sea turtles have declined during the last century due to direct harvest, egg collection, by-catch in fisheries/ incidental capture in fishing gear, habitat loss and pollution.

The Olive Ridleys is the most common marine turtle found in Indian waters, and is distributed on both east and west coasts including the offshore islands. Most of the ecological works on the Olive Ridleys in India have been carried out in mass nesting beaches of Orissa. This species nests sporadically all over India, but barring a anecdotal notes, information on the ecology of this species is scanty in sporadic nesting areas. Hence, the present study was carried out to, (1) Understand the nesting habitats of Olive Ridleys along the (Poompuhar) Tranquebar- Pazhaiyar coast (2) Study the breeding biology of Olive Ridleys including offshore activities along the southeast coast, Bay of Bengal (3) Study the mortality and other anthropogenic pressure on marine turtles along the Tranquebar- Pazhaiyar coast, and (4) Conservation of Olive Ridleys along the southeast coast, Bay of Bengal.

The present study was conducted along the Poompuhar coast (51 km), Bay of Bengal, Tamil Nadu from November 2004 to May 2010. Fishing and agriculture are major occupations of the local inhabitants. The coastal area of this district is criss-crossed by many rivers, streams and canals due to the distributaries of the river Cauvery (delta). May is the hottest (36.95□ C) and December is the coolest (29.05□ C) month. Total annual rainfall of the area is about 1200 mm. Maximum rainfall was noted in November and minimum in January. This area is

one of the cyclone prone coastal belts in the country. Ground vegetations include the grass *Spinifex littoreus* and Ground glory *Ipomoea pescaprae*. No long-term research is available in the area with respect to the ecology of Olive Ridleys.

Physico- chemical analysis such as grain size of the sand, colour, pH, conductivity, alkali and alkaline metals and, hardness of were analysed using standard laboratory procedures.

The offshore surveys were conducted using mechanised fishing boats with jet engine. Sorties were made at three points; Tranquebar, Poompuhar and Pazhaiyar. From any of above mentioned point (station), about 10 nautical miles (1 nautical mile= 1.825 km) were travelled perpendicular to the shore at about 5 km/ hour (speed), a turn was taken at right angle (left or right) and traversed for about 5 km, and returned back to the shore recording the presence of Olive Ridleys.

The shoreline was surveyed for the presence of nesting signs once in a fortnight from November 2004 to May 2010. The study area was divided into 5 km sector using a Global Positioning System (GPS), and surveys were done on foot between 0600 and 0830 hrs and each sector was covered on five consecutive days for locating turtle tracks and nests. Nesting was confirmed following tracks, nesting site, body pit and egg chamber, and status of the same was assessed based on signs of predation including nest exploitation by humans. Crawls or nests counted during each surveys were considered new, as interval between surveys was 10-15 days. First nest sighted in a season (December to April) was considered as arrival date of turtles for nesting, and last nest as departure date.

Vegetation sampling was done at every 500 m along the entire beach using point sample method during March 2005. At each point, vegetation found along the perpendicular line from the high tide up to 25 m inland was noted. Proportion of major beach vegetation was calculated and the same was considered as their availability in the area. Vegetation found nearest to each

nest was considered as its use. The availability and utilization was considered to know the preference, if any.

Nests with signs of disturbance and eggs robbed by villagers during surveys were considered as an index of exploitation. Dead and stranded sea turtles found along the shore during fortnight surveys were accounted for mortality of turtles. Details on the number of dead turtles found on the beach, probable cause for the same and other relevant information were noted. Turtle carcasses were marked with enamel paint to avoid repeat count. On locating the stranded sea turtles, morphometry measurements such as Curve Carapace Length (CCL) and Width (CCW) were taken following standard protocol.

Data compilation and analysis were done using Microsoft Excel and statistical programme SPSS. Various descriptive and non-parametric tests were used for analyses.

Majority of the coastline (82.35%) was sandy and assumed to be suitable for turtle nesting. Subsequent to the Tsunami of 26th December 2004, several development programmes were executed by the government and non governmental agencies in the area, which severely altered the general area. Also, several industrial activities and habitat changes were observed between 2004 and 2010. It is suggested comprehensive assessment on the carrying capacity of the area should be done at the earliest.

Three species of marine turtles, the Olive Ridleys *Lepidochelys olivacea*, the Green Turtle *Chelonia mydas* and the Leatherback *Dermochelys coriacea* were observed during this study. The Olive Ridleys was common contributing about to about 97.8%.

In all, 107 turtles were observed on 73 occasions during 360 sorties from August 2005 to July 2010. Depth profile in these areas showed that turtles were found in the depth range from 22.5 m. to 45 m. Turtles were observed in almost all months in the offshore areas. The highest proportion (22.4%) of turtles was observed in about 14-16 km from the shore followed by 12-14 km category.

Based on tracks, 248 nests could be located in 51 km during fortnight sampling in six seasons (2004-2010). December to March may be considered as the nesting season of marine turtles along this area. Peak nesting was observed either during January 2nd fortnight or February 1st fortnight. The area had an average of 41.3 nests/ year which worked out to be 12.88 nests/ km. An estimated range of 221 to 945 nests is found (in 51 km) area. This works out to be 4.34 nests/ km/ season to 18.53 nests/ km/ season. Hatching of Olive Ridleys was recorded from February 1st fortnight to April 1st fortnight.

The sex ratio (based on dead) of Olive Ridleys in the area was 1male: 1.55 female. Higher number of turtles observed along the offshore of the study area coincided with the intensity of turtles emerged out for nesting (January-March). Majority of the nests (72.98%) was stolen by villagers on the same night of egg laid. Removal of nests by people may depend up on location socio-economic and cultural aspect of the community of an area. Higher number of females has been reported by previous studies from various countries. Only 18.15% nests survived from predation by human and animals.

Ivlov's Selectivity Index (I) showed that turtles selected vegetated areas for nesting and avoided open sandy areas (I= -0.414). I*pomoea pescapre* patches were highly selected (I= 0.69) for nesting compared to other vegetation, and *Casuarina* was least selected (I= 0.22). Selection of nest site would potentially alter the thermal profile of a nest, which may have implication on the sex ratio of the population.

Higher proportion of nests was found in areas with very pale brown sand. Various chemical parameters were correlated with turtle nesting and random sites, but significant variations was not obtained in many cases barring Potassium and Magnesium concentrations between random sample and from nest sites ($N = 30$, $p < 0.01$). The relationship between nest location and distance from river mouth, but was not statistically significant. Nest location and distance from High Tide Line (HTL) and village had significant negative correlation ($r= -0.681$, $P<0.05$, $df= 11$; $r= -0.676$, $P<0.01$, $df= 16$ respectively).

The selection of a nest site by the female is influenced by several physical and chemical factors, such as sand grain size, dune configuration, compressibility of beach sand and smell; thermal variation in beach sand may also be an important environmental cue for nest site selection. Nest success is believed to be influenced by a number of interacting ecological factors such as sand temperature, sand grain size, water content and salinity.

A total of 317 carcasses were observed in 51 km of the coastline which accounted for 1.04 carcasses/ km/year). The lowest of 20 (0.39/km) carcasses and highest of 69 (1.35/ km) were observed during 2004-05 and 2006-07 respectively. The relationship between turtle mortality and nesting was linear i.e. as mortality and nesting incidences were high at the same time indicating the movement of mating pairs and nesting females getting entangled in the gill nets used by the fishermen. In the present study, no relation was found between number of fishing vessels in a sector and corresponding mortality there i.e. the highest number of fishing vessels (138/ km) was observed Pazhaiyar (Northern location), but the lowest number of dead turtles was observed in that sector. Stranding of carcasses could be due to direction of ocean current and offshore movement of larger vessels such as ships.

The results of the present study (sporadic nesting area) with respect breeding season, arrival and departure of turtles to nesting area, peak nesting season, mortality, size of dead turtles and their size structure are similar to that of mass nesting area in Orissa. However, variations were observed with respect to offshore activity (congregation, distance from shore, water depth), offshore activity of turtles in various months, depredation of eggs and hatching pattern compared to this study and mass nesting area.

Detailed study on the breeding biology of Olive Ridleys in other sporadic nesting areas in the country is scanty; hence comparison on many aspects is difficult. Variation in nesting season was observed between areas located in west and east coasts. Data on factors with respect to nest site selection (geo-morphological and physico-chemical) are partly augmenting and partly

contradictory with that of studies elsewhere. In-depth studies in this regard may provide further insights on this aspect. Hence, marine turtle conservation plans/ strategies should be area specific.

The present study showed that Tranquebar to Pazhaiyar, Bay of Bengal, Tamil Nadu is an important Olive Ridley nesting area. Awareness programme on the importance of the area with respect to marine life including turtles should be undertaken focusing on various stakeholders. Methods of handling entangled turtles in the net must be demonstrated periodically or rescue teams should be formed and made operational in the area. The effectiveness of coastal plantations as barrier for cyclone/ storms and their impact on marine organisms should be studied. An integrated Coastal Conservation and Management Plan including various stakeholders such as Government and Non-Government Organisations, experts and people is required to ensure the long-term survival of Olive Ridleys along the Tranquebar- Pazhaiyar coast.

INTRODUCTION

CHAPTER 1

INTRODUCTION

One of the fundamental goals of ecology is to understand organisms' relationship with the environment. The life history of animals is reflected through foraging, habitat selection, and reproductive strategies. In the marine environment, these activities or strategies are often obscured by variations at spatial and temporal levels (Lima and Zollner, 1996; Fritz *et al.*, 2003; Pinaud and Weimerskirch, 2007, Wilson *et al.*, 2007). Many long-lived marine vertebrates exhibit life histories that allow them to exploit widely separated habitats during their development, often over the course of decades (Musick, 1999).

Sea turtles are of ancient origin and are in existence for millions of years and their first fossil records date back to 110 million years (Hiryama, 1998). Sea turtles have worldwide distribution and are migratory in nature. They are the deepest diving vertebrates, oldest hybrids with longest breeding migration and underwater hibernation (Walker and Parmenter, 1990; Meylan and Meylan, 1999). As on date, seven species of marine turtles have been reported, representing two families, Cheloniidae and Dermochelyidae; Olive Ridley (*Lepidochelys olivacea)*, Kemp's Ridley (*L. Kempii)*, Loggerhead (*Caretta caretta)*, Green Turtle (*Chelonia mydas)*, Flat back **(***Natator depressus)* Hawksbill (*Eretmochelys imbricata)* and Leatherback (*Dermochelys coriacea)*. An eighth species, the Black turtle or East Pacific Green Turtle *Chelonia agassizii* , is documented by some biologists, but morphological, biochemical, and genetic data published till date are conflicting, and the Black Turtle is currently treated as a species belonging to *Chelonia mydas* (Meylan and Meylan 1999). Different species of sea turtles occupy different ecological niches and the breeding areas are widely separated from the feeding areas (Kannan, 2004).

Marine turtles are being consumed by native people world-wide and for over 4,000 years are useful to humans in many ways (Peterson, 1997; Versteeg *et al.,* 1990; Frazier, 2003). It is reported that the populations of sea turtles have

declined during the last century due to direct harvest, egg collection, by-catch in fisheries by incidental capture in fishing gear, habitat loss and pollution (UNEP/GPA, 2006; Bräutigam and Eckert, 2006; Mortimer and Donnelly, 2007; Eckert, 2010). Mc Clenachan *et al.,* (2006) reported that about 20% of historic nesting sites of sea turtles have vanished entirely and nearly 50% of the remaining sites have reduced. Various levels of threat categories have been assigned to them by the IUCN Red List of Threatened Species at a global scale (http://www.iucnredlist.org/; Eckert, 2010).

Globally, many studies focusing on the ecology of marine turtles are available, but there have been a surge of interest on the subject globally during the past three decades.Few important studies on nesting period (Ehrenfeld,1979; Hendrickson,1982), ecology (Carr, 1980), biology (Hirth,1980; Wood and Wood, 1980; Wood *et al.*, 1982), thermal biology (Mrosovsky and Yntema,1982; Diamond,1983), egg development (Ewert,1979), migration (Meylan,1982), and nutrition (Bjorndal,1982). The nature of the offshore approach to nesting beaches, slope of the beach, vegetation, texture of the sand and illumination from inland are important factors influencing the selection of nesting sites by sea turtles (Mortimer, 1995).

The decline of the sea turtles population is attributed to increase in the fishery related mortalities, commercial exploitation, pouching of eggs, disturbance to the nesting habitats, environmental contamination and loss of habitats (Hutchinson and Simmonds, 1991; Bjorndal *et al.*, 1994). Following the conservation measures, undertaken by the governments of different nations, exploitation of eggs and nesting females has declained substantially,and also by incidental catch of sea turtles in fishing gears such as trawls and gill nets (Pritchard *et al.*,1983 Oravetz, 1999). An extensive national review on the sea turtles threats, shrimp trawling was singled out as the most important human-associated source of sea turtle mortality to 'juveniles, sub-adults, and breeders in U.S. coastal waters' by the National Research Council (1990). The report estimated that the annual mortality of Loggerhead (*Caretta caretta*) and Kemp's Ridley (*Lepidochelys kempii*) turtles associated with shrimping Other trawling traps, gill nets, long lines and entanglement in discarded fishing gear were

major sources of mortality. Available literatures on sea turtle mortality largely report by fishing gear (1) trawling; (2) pelagic and bottom long lines; (3) gill/ entanglement nets or entrapment gear (e.g., seines, pound nets); (4) entanglements in buoy or trap lines; and (5)hooks and lines from recreational and commercial fishing (Oravetz, 1999). Consolidated data on the ecology of Green Turtles is available in Lutz (1997) and Ozdilek (2007). Other species have received scientific attention only recently (Bijorndal *et al.*, 1994; Broderic *et al.*, 2010).

1.1 STUDIES FROM INDIA

Seven species of marine turtles have been recognized (Meylan and Meylan 1999), and among them the Olive Ridley, *Lepidochelys olivacea* (Eschcholtz, 1829), the Green Turtle, *Chelonia mydas* (Linnaeus, 1758), the Hawksbill *Eretmochelys imbricate* (Linnaeus, 1758), the Leatherback, *Dermochelys coriacea* (Linnaeus, 1766), and the Loggerhead *caretta caretta* (Linnaeus, 1758), occur in the Indian waters (Dash and Kar, 1990). There are a few other reports of Loggerhead turtles in Indian waters (Bhupathy and Saravanan, 2003, 2005, 2006), but no nesting of any species has been observed, while a few number nest in Sri Lanka (Tripathy, 2005). All other species nest along the beaches of mainland and bay islands of India (Kar and Bhaskar, 1982; Shanker and Choudhury, 2006), and they are protected under Schedule one of the Indian Wildlife Protection Act (1972).

The Olive Ridley sea turtles nest on both east and west coasts of the Indian mainland including the offshore islands, and on the coasts of Sri Lanka, Bangladesh, Pakistan and the Andaman and Nicobar Islands (Biswas, 1982, Kar and Bhaskar, 1982; Andrews 2000; Andrews *et al.*, 2001; ANET, 2003; Shanker and Andrews 2006). The Olive Ridley rookeries in Orissa are of global significance and they constitute one of the major mass nesting sites in the world (Pritchard, 1997). Large nesting Leatherback population in India is restricted to Great and Little Nicobar Islands, but a few turtles nest in the Andamans (Andrews *et al.*, 2002).

The Olive Ridley is known to nest along the Nagapattinam coast (Bhupathy and Karunakaran, 2003; Bhupathy and Saravanan 2006; Bhupathy *et al.*, 2007). Large numbers have been reported to migrate between the offshore waters of the states of Tamil Nadu and Andhra Pradesh and the nesting beaches of Orissa (Kar, 1983; Raja Sekhar and Subba Rao, 1993; Tripathy *et al.*, 2003, 2006). Fisheries related mortality of marine turtles has been reported along the Tamil Nadu coast (Bhupathy and Saravanan, 2006).

Recent studies show the uniqueness of the Indian Olive Ridley population in comparison to other populations globally (Shanker *et al.*, 2004a). These turtles might have served as an evolutionary source for the re-colonisation of Ridleys in the Pacific and Atlantic oceans, after the extirpation of populations in those basins over the decades over millions of years (Shanker *et al.*, 2004a). Hence, the subcontinent is clearly an important region for marine turtle conservation.

Monitoring of turtle nesting has started only three decades along the Chennai coast, on yearly basis with relocation of eggs to beach hatcheries and then release of hatchlings back into the sea (Valliapan and Whitaker, 1974; Silas and Rajagopalan, 1984; Abraham, 1990; Shanker, 2003). Information on turtle nesting sites in respect to the location of villages, river mouths and plantations are pertinent for both sea turtle conservation and coastal area development. Studies on the offshore activities of Olive Ridleys during the breeding season are rare and the same is in progress along the mass nesting areas in Orissa (Pandav, 2000). However, such kinds of studies are not available in sporadic nesting areas.

The Tamil Nadu coast has both breeding and foraging grounds suitable for Olive Ridleys,and also forms as the migratory corridor. The mortality of thousands of olive ridleys has been reported during nesting season both in mass nesting areas in Orissa and sporadic nesting areas due to incidental catch by fishing gear (Pandav 2000; Pandav *et al.*, 1994; 1998; Pandav and Choudhury, 1999, Pandav, 2000; Bhupathy and Karunakaran, 2003; Bhupathy *et al.*, 2007).

Owing to lack of uniform standards, the sporadic research even over decades in India is difficult to interrupt. Despite of research done at different sites for decades, the data available on turtle is scanty and hence, difficult to interpret (Shanker *et al.,* 2004b). Most of these early works were carried out by Satish Bhaskar for the Madras Crocodile Bank Trust (Valliappan and Whitaker, 1974; Whitaker, 1977; Kar and Bhaskar, 1982; Bhaskar, 1984). The country-wide GOI-UNDP surveys done during 2000-2002 bridge the gap information and provide an update on the status and threats to marine turtles in the Indian subcontinent (Shanker and Choudhury, 2006). Subsequent to this, MCBT-CMS funded project monitored the marine turtle populations during 2000-2001, 2003-2004 and 2004-05 along the entire coastline of India, involving several organizations (Shanker and Andrews, 2006).

Most of ecological works on the marine turtles in India have been carried out beaches of Orissa (Kar, 1982; Dash and Kar, 1990; Pandav *et al.*, 1998; Shanker and Choudhury 2006). Aspects such as breeding population, seasonality, mortality and off-shore movements of Olive Ridley sea turtles have been covered (Dash and Kar, 1990; Shanker and Choudhury, 2006). Some information are available on the breeding ecology of marine turtles in various coasts of Andhra Pradesh (Tripathy *et al.*, 2006), Gujarat (Sunderraj *et al.*, 2006), Maharashtra (Giri and Chaturvedi, 2006), Tamil Nadu (Bhupathy and Saravanan, 2006) and West Bengal (Chodhury *et al.*, 2006) (Plate 1).

Habitat characteristics of turtle nesting beaches are poorly understood and available information is sketchy. A remarkable anecdote of the marine turtle nesting is available from 4th century *Tamil Sangam* literature, described the nesting of turtles in beach with ground glory, *Ipomoea pescaprae* (Sanjeevaraj, 1958; Bhupathy *et al.,* 2007). Based on the locations of mass nesting areas in Orissa, it is only speculated that ridleys nesting in other parts of India would select beaches near river mouths (Tripathy *et al.*, 2003a). A brief study on nest site substratum and habitats of Olive ridleys along the Chennai Coast is available (Bhupathy *et al.*, 2007).

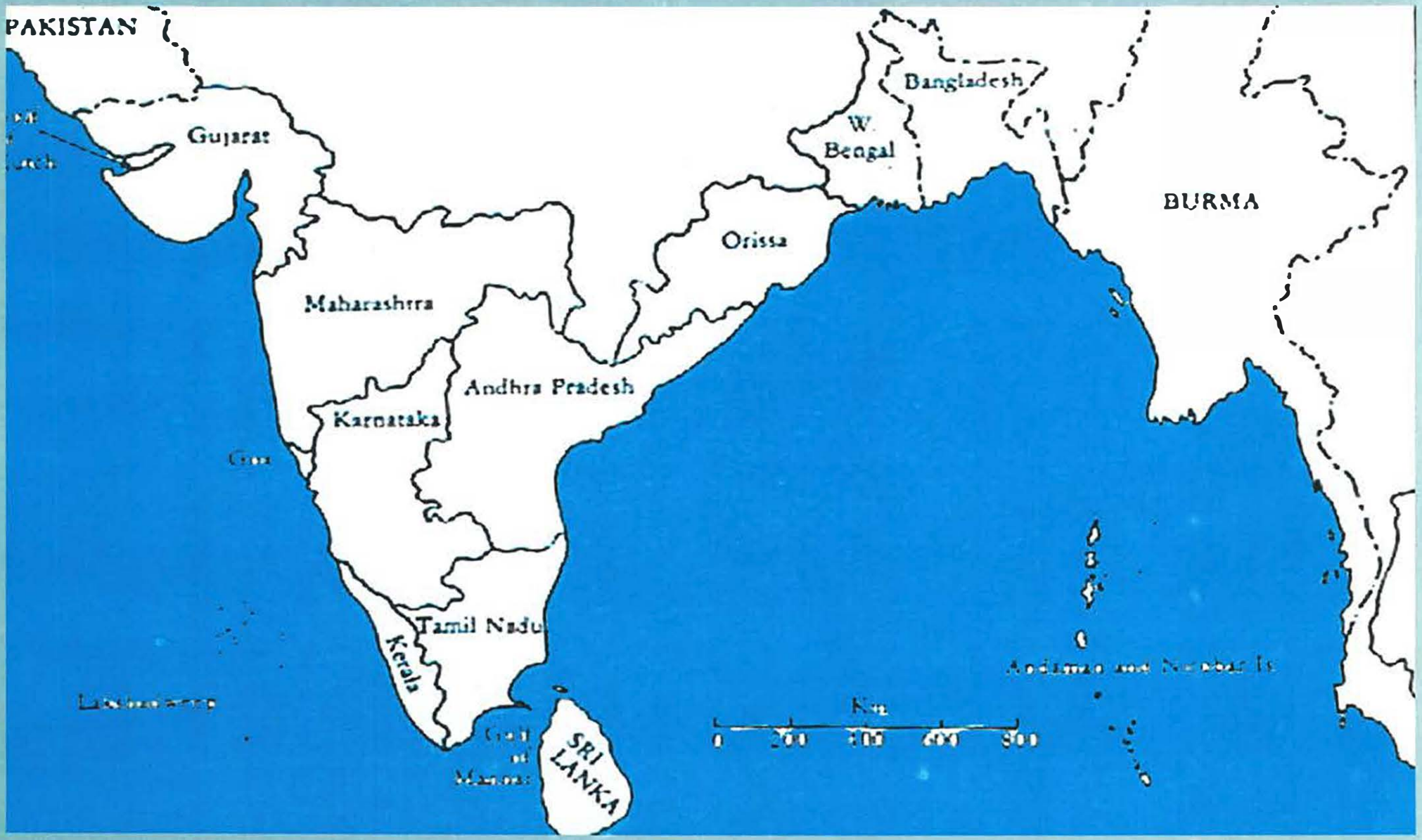


Plate 1. Map showing maritime states of India.

Declining of populations of all species of marine turtles is well known due to over exploitation (collection of eggs and adults), incidental catch in the fishing gears, alteration of beaches and other development activities (Limpus, 1994; 1995; Limpus and Reimer 1994). This is true for India as well. Exploitation of marine turtles has been reported from Gulf of mannar (Agastheesapillai and Thiagarajan, 1979; Bhupathy and Saravanan, 2006). Eggs of the turtles have been exploited in many states for several years (Shanker and Choudhury, 2006).

The information on the nesting of ridleys in India is Significant (Kar and Bhaskar, 1982; Dash and Kar, 1990; Pandav *et al.*, 1997; 1998; Pandav, 2000; Tripathy *et al.*, 2003). However, data from other (sporadic) nesting areas is limited. A compendium prepared by Shanker and Choudhury (2006) provided on this aspect; Andhra Pradesh (Tripathy *et al.*, 2006), Gujarat (Sunderraj *et al.*, 2006), Maharashtra (Giri and Chaturvedi, 2006), Tamil Nadu (Bhupathy and Saravanan, 2006) and West Bengal (Chodhury *et al.*, 2006) are available. Data of all these studies were based on one or two nesting seasons.

On the nesting beaches, sea turtles were measured by their relative body size to breeding productivity and, to measure minimum size at sexual maturity and to monitor nesting female size for a particular rockery. The size frequency of a population is important and is an essential parameter of that population's demographic structure (Bolten, 1999; Kannan and Rajagopalan, 2007). By analyzing the size composition of Olive Ridleys, habitat quality and physiological status can be understood (Bolten, 1999). Morphometeric data on the incidentally caught sea turtles can be used as a tool to estimate from the measurement of carapace length and carapace width. Morphometric characteristics of a species population can help to identify the population status and to find size group that get entangled in the fishing gears. It is also required to propose effective measures to reduce the mortality by altering the mesh size or by any other effective conservation measures.

Available information on sea turtle morphometry is restricted to nesting Olive Ridleys (Silas *et al.*, 1983; James *et al.*, 1989; Dash and Kar 1990; Bhupathy

and Karunakaran, 2003). However, considerable amount of work is available on the morphometric measurements of sea turtles from Sri Lanka (Deraniyagala, 1953), and is very fragmentary in India (Kannan and Rajagopalan, 2007) and there is no detailed work on the morphometry of incidentally caught sea turtles along the Nagapattinam coast.

Along the Tamil Nadu coast, reports on the marine turtles are available since early seventies. Most of the studies in the area are of short-term in nature, and the same have been undertaken by various institutions. They include, the Madras Snake Park Trust (MSPT), Madras Crocodile Bank Trust (MCBT), Students Sea Turtle Conservation Network (SSTCN), Central Marine and Fisheries Research Institute (CMFRI) and Sálim Ali Centre for Ornithology and Natural History (SACON). In addition, several educational institutions such as universities and colleges also contributed considerably.

The MSPT (now known as CSPT, Chennai) initiated surveys along the Chennai coast during mid 1970s and collected eggs for captive breeding (Valliappan and Whitaker, 1974; Whitaker, 1977; Bhaskar, 1981). The initiatives by MSPT and MCBT created awareness among public with respect to conservation of marine turtles. Apart from mainland, MCBT extended its work to Andaman and Nicobar Islands and Lakshadweep Islands (Whitaker, 2006),initiated a countrywide monitoring programme of marine turtles networking several organizations during 2004 (Shanker and Andrews, 2006, Bhupathy *et al.*, 2007).

The CMFRI worked on the exploitation, mortality and captive breeding of marine turtles in late 1970s. Important publications such as biology of Green turtles (Agastheesapillai and Thiagarajan, 1979), recovery programme for Olive Ridleys (Silas and Rajagopalan, 1984) and monitoring of incidental catches of sea turtles in a coordinated manner (Rajagopalan *et al.*, 2006) resulted from studies by CMFRI. Volunteer group such as Students Sea Turtle Conservation Network (SSTCN) organised annual sea turtle nest monitoring programme along the Chennai coast, which is being continued every year since 1982 (Shanker, 2003).

Started 2000, at least two larger programmes on sea turtles were organised national level, which covered the Tamil Nadu coast as well. The GOI-UNDP-Wildlife Institute of India Olive (WII) Ridley project (2000-2001) assessed the marine turtles involving several research organizations and NGOs. Subsequently, the MCBT initiated a marine turtle monitoring programme with support from Convention of Migratory Species (CMS). Several organizations were involved in this work (Shanker and Andrews, 2006). The Sálim Ali Centre for Ornithology and Natural History (SACON), Coimbatore was partnering in the above programmes and conducted surveys along the Tamil Nadu and Kerala coasts (Bhupathy and Saravanan, 2001; Bhupathy *et al.*, 2006). Several publications on the status of Tamil Nadu coast (Bhupathy and Saravanan, 2001), exploitation (Bhupathy and Saravanan, 2003; , 2006; Bhupathy *et al.*, 2007).

Apart from above studies, several educational institutions such as Sálim Ali School of Ecology, Puducherry, A V C College, Mayiladuthurai, Veterinary College, Tuticorin, Annamalai University and University of Madras have conducted studies on marine turtles from time to time.

The available literature on Olive Ridleys is restricted or only very little is known on their ecology. Hence, the present study was carried.

1.2 OBJECTIVES

Major objectives of the present study were to,

- Understand the nesting habitats of Olive Ridleys along the Tranquebar-Pazhaiyar coast.
- Study the breeding biology of Olive Ridleys including offshore activities along the southeast coast, Bay of Bengal.
- Study the mortality and other anthropogenic pressure on marine turtles along the Tranquebar- Pazhaiyar coast, and
- Conservation of Olive Ridleys along the southeast coast, Bay of Bengal.

STUDY AREA

CHAPTER 2

STUDY AREA

2. 1 LOCATION

Tamil Nadu, with a coastline of 980km (including Pondicherry), has both east (900km) and west (80km) coasts (Bhupathy and Saravanan, 2006). The present study was conducted along the Tranquebar (11^0 01' N- $79^0$85' E) to Pazhaiyar: ($11^0$35'N - $79^0$8'E) of the Cauvery Delta in Nagapattinam District Tamil Nadu. Nagapattinam, one of the 13 coastal districts of Tamil Nadu lies in the centre of the coastal districts and is bound on the north by Cuddalore district, south by Palk Bay, east by the Bay of Bengal and west by Thiruvarur and Thanjavur districts. Poompuhar is the mid point of the study stretch (Tranquebar-Pazhaiyar, Plate 2), and has greater historical importance, as it was reported to be Capital of Chola Kingdom during *Sangam* period.

2.2 HISTORY

The south-eastern coast of the Indian Peninsula is known as the Coromandel Coast. The name 'Coromandel' is derived from Cholamandal, the region of the ancient *Chola Dynasty*. Among the dynastic rulers, the *Cheras, Cholas, Pandias* and *Athriyas* ruled over the ancient Tamil Nadu. Cholas held *Puhar* (now called as Poompuhar) their Port capita. It is revealed from temple inscriptions, ancient literatures and travelogues, and this place was variously known as *Kaverypoompattinam, Kaganthi, Sampapathi, Paalarpukaz Moothur, Mannagathu vanpathi, Cholapattinam, Kaberis emporium* and *Kolappattinam*. The town structure of Poompuhar can be traced from *Sangam* literature, *Silappathigaram*. Sea shore was inhabited by the fisher-folk, later by various groups of people such as weavers, silk merchants, fish and meat sellers, potters, grain merchants and diamond makers. Nagapattinam and Pazhaiyar have small harbor and port. About 22 villages are present along the 51 km shoreline of the present study. The Karaikkal, a nearby town part of the Puducherry state, was under French Colonization, and the Tranquebar was under Spanish governance prior to the independence of India.

2.3 PEOPLE

Several communities of the people reside in the area. This region is a centre for fish landing and also exports of marine products such as crab, prawn, lobster and clam shells for generations. There is open 22 fish landing jetties to be found within the intensive study area (Plate 2). Among the 22 villagers, Tranquebar has the highest population and Kizhakarai the lowest (160 persons, Table 1).

Table 1. Villages found along the shoreline of Poompuhar region, India.

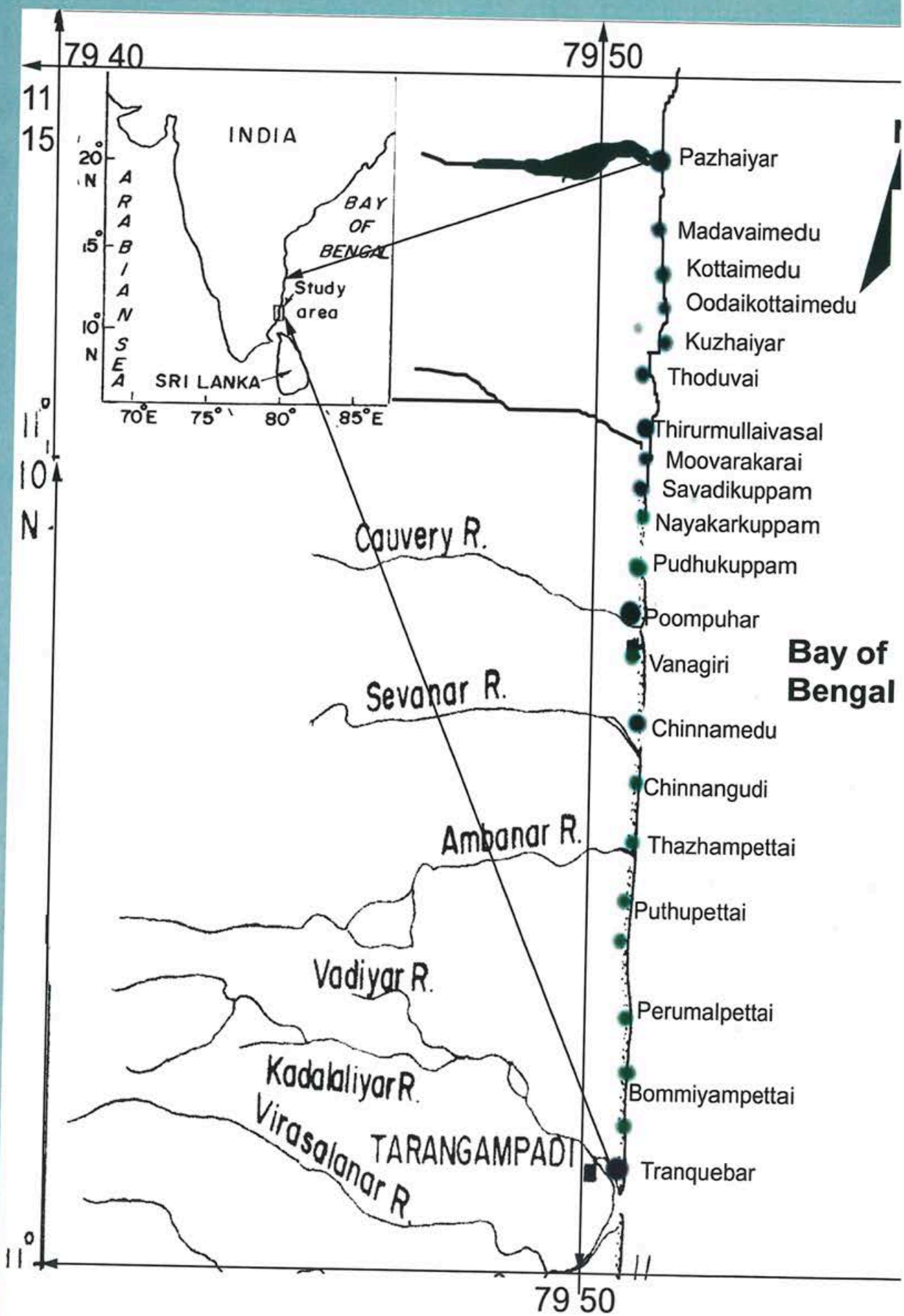
S. No.	Name of the Village	Human Population	Fishing Vessels
1.	Tranquebar	7000(2500)	244
2.	Bommiyampettai	1000(200)	74
3.	Perumal pettai	2000(500)	72
4	Pudhupettai	1500(300)	67
5	Thazhampettai	750(175)	48
6	Chinnangudi	4000(750)	135
7	Chinnamedu	1600(250)	49
8	Vanagiri	5500(1600)	241
9	Poompuhar	5000(1450)	197
10	Pudhukuppam	1400(250)	60
11	Madathukuppam	1100(300)	46
12	Nayakarkuppam	1900(500)	65
13	Savadikuppam	980(300)	30
14	Moovarkarai	1050(300)	38
15	Kizhakarai	160(50)	57
16	Thirumullaivasal	4600(1200)	228
17	Thoduvai	3600 (1100)	30
18	Kuzhaiyar	950(300)	40
19	Oodakottaimedu	940(300)	42
20	Kottaimedu	1150(400)	54
21	Madavaimedu	1600(500)	45
22	Pazhaiyar	4250(1400)	276

Numbers in parentheses indicate numbers of families in each village
Source: Census of India (2000)

2.4 OCCUPATION

Fishing and agriculture are major occupations of the inhabitants of the area. The availability of fishes likes *mathi* and *kavalai*, shrimps are abundant throughout the year catchment of these species vary according season. The approximate fish catch/year in the area is 203.6Ton (Table 2). The highest fish catch was recorded during March and by July, and the lowest during May and by April

Plate 2. Map showing villages and rivers along the Poompuhar coast.



(Table 2). Subsequent to Tsunami during December 26, 2004, the fish catch drastically reduced (1650 tons during 2005 compared to 4950 tons during 2004). However, the fish catch increased over the years (Table 2).

Local people use more then 15 types of net for fishing. Most of the people practice marine or back water aquaculture, and is the major source of income for them. About 850 hectares of coastal land is used for prawn farms in the study area, which also offers local employment opportunities and revenue generation.

Table 2. Data on fish catch (in Tons) in different months during the study period (2004 and 2010).

Year/ Month	2004	2005	2006	2007	2008	2009	2010	Mean Catch
January	316.8	105.6	184.8	211.2	264	396	528	286.63
February	594	198	346.5	396	495	742.5	990	537.43
March	792	264	462	528	660	990	1320	716.57
April	138.6	46.2	80.85	92.4	115.5	173.25	231	125.40
May	99	33	57.75	66	82.5	123.75	165	89.57
June	633.6	211.2	369.6	422.4	528	792	1056	573.26
July	673.2	224.4	392.7	448.8	561	841.5	1122	609.09
August	633.6	211.2	369.6	422.4	528	792	1056	573.26
September	396	132	231	264	330	495	660	358.29
October	277.2	92.4	161.7	184.8	231	346.5	462	250.80
November	198	66	115.5	132	165	247.5	330	179.14
December	198	66	115.5	132	165	247.5	330	179.14
Total	4950	1650	2887.5	3300	4125	6187.5	8250	4478

Source: Tamil Nadu Fisheries Department. (Poompuhar & Tranquebar)

2.5 COASTAL SET-UP

The coastal zone is the link between ocean and land margins. The coastal ecosystems involve in primary and secondary production, sustain the flora and fauna, store sediments and organic carbon, essential to the maintenance of food chains. The coastal ecosystems provide foods (fish and minerals) and services (natural defence against storms and tidal waves). The coastal ecosystems provide habitats to wildlife (Ramachandran *et al.*, 2005; Damotharan *et al.*, 2010).

The present study was carried out in 51 Km coastline between Tranquebar and Pazhaiyar. The coastal area of this district is criss-crossed by many rivers, streams and canals due to the deltaic area of the river Cauvery. The main water sources are Cauvery and its tributaries such as Manjalar, Rajendran canal, Perunthottam river, Chinnankudi and Sevaganar river. Over 3200 fiber boats, 900 engine boats and 4000 catamarans are being operated in the area on day to day basis (Table 1).

Mangroves interdependent with aquatic, inshore, upstream and terrestrial ecosystems support a diverse flora and fauna of marine, freshwater and terrestrial species. Interaction of mangroves with the physical environment is the basis for both species richness as well as the distribution of diverse animals in that ecosystem. These ecosystems are the most productive ecosystems of the world, both floral and faunal. They constitute a nursery for many pelagic fish and crabs that grow to maturity in the open sea. Biodiversity in mangrove is further enhanced as many species of fishes, crustaceans and birds either use or depend on this ecosystem during different stages in their life cycle (Saravanan, 2005).

The Pichavaram mangrove is located along the northern extremity of the study area (Pazhaiyar) and the Vedharanyam swamp and is found along the vicinity on the southern boundary. The Vedharanyam swamp is a Protected Area, Point Calimere Wildlife Sanctuary.

The Pichavaram mangrove is r in plant diversity with 76 species including 13 species of mangrove trees. Among them, *Avicennia marina* and *Rhizophora* sp are predominant. In all, 177 species of fish and 200 species of birds have been reported from this mangrove (Kathiresan, 2000).

The Point Calimere Wildlife Sanctuary is inhabited by 14 mammal species, 18 reptiles and nine amphibian species. This site is a mix of salt swamps, Mangroves, backwaters, mudflats, grasslands and Tropical dry evergreen forests. 364 of flowering plant species have been identified in the sanctuary of which 50% are herbs and the others are climbers, shrubs and trees. 198 of

these have medicinal properties. *Manilkara hexandra* is the dominant dry evergreen species. The most abundant undergrowth is *Memecylon umbellatum*.

The present study area is largely sandy without notable rocky (Bhupathy and Karunakaran, 2003). Rivers such as Cauvery, Thirumullaivasal, Chinnankudi and Sevaganar confluence with Bay of Bengal in the area, and these rivers may be under backwater influence.

2.6 SOIL

The soil along the coast is sandy loam in nature. Alluvial soil dominates the deltaic region; the coastal area of the Nagapattinam is rich in rare earth elements. Ilmenite and garnet sand deposits occur along the coast, and nearby Karaikal coast has an estimated reserves of 17,26,862 tones. The nature of the soil of the area undergone dramatic changes land degradation and environmental pollution (Chaudhari *et.al,* 2009). Notable changes in the soil have also been reported due to the tsunami that struck the coast on the morning of 26th December 2004.

2.7 CLIMATE

Monthly temperature variation of the study area is shown in Fig. 1. According to the Indian Meteorological report annual mean minimum and maximum temperatures are 23.4C to 33.1 C. May is the hottest (36.95 C) and December is the coolest (29.05 C). Daily variation of the temperature 8 C and 11.78 C. High humidity conditions prevailed during study period,, and annual mean relative humidity is 86%, with 78.16% in July and 92.19% in January (Fig. 2). Total annual rainfall intensity recorded was about 1200 mm. Maximum rainfall was received during in November and minimum in January (Fig. 3). This area is one of the cyclone prone coastal belts in the country.

2.8 FLORA

Vegetation types found along the coastline includes tree species like Casuarina (*Casuarina equistefolia),* Prosopis (*Prosopis sp.*), Coconut (*Cocos nucifera*) and Palmyra (*Borassus flabellifer*). Ground vegetations include the grass *Spinifex littoreus* and Ground glory *Ipomoea pescaprae* (Plate 3).

Plate 3. Major vegetations found along the Poompuhar coast.

Ipomoea pescaprae

Spinifex littoreus

Casuarina plantation

Acacia plantation

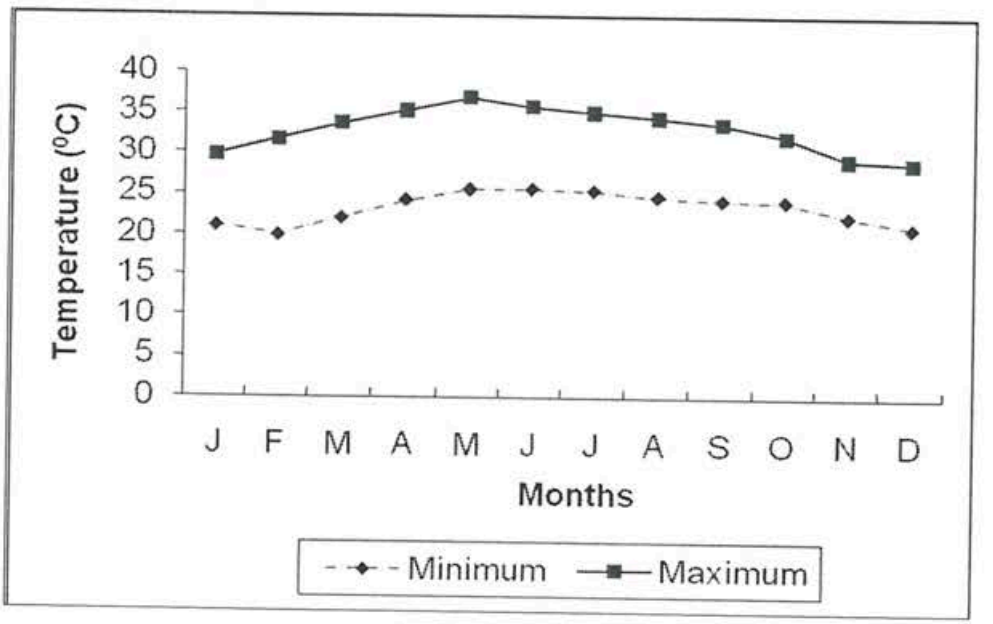
2.9 FAUNA

Common Terrestrial vertebrates found in the area include Jackal *Canis aureus*, Mangoose *Herpestes edwardsi*, Brahminy Kite *Haliaster indus*, gulls *Larus spp.* and crows *Corvus spp.* Two species of marine turtles, Olive Ridleys *Lepidochelys olivacea* and Green Turtle *Chelonia mydas* are reported from the area (Bhupathy and Karunakaran, 2003).

2.10 TSUNAMI

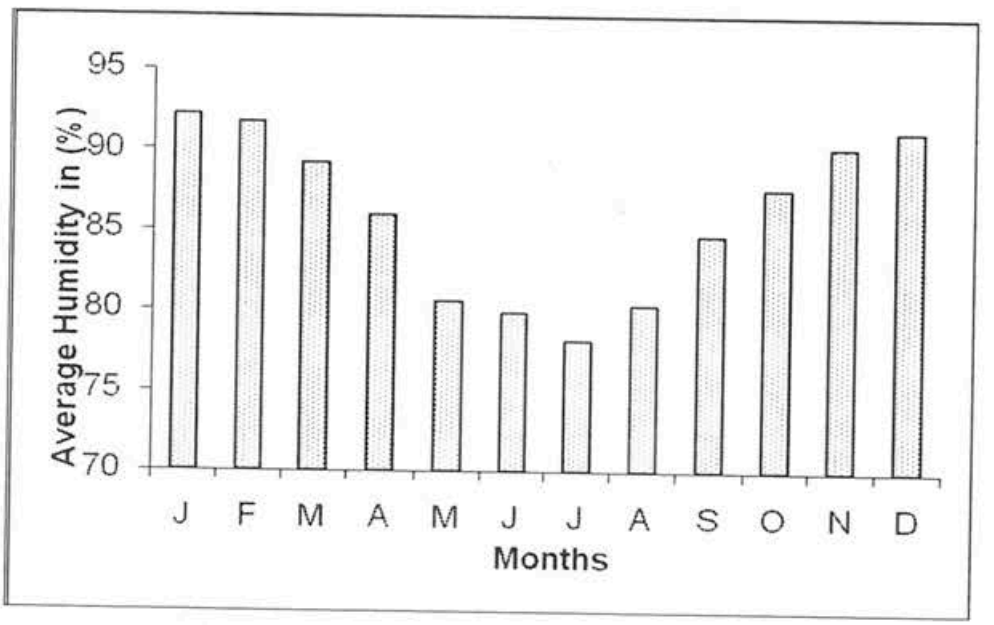
The coastal parts of India was stuck by tsunami 26th December 2004 which was triggered by a subduction of the Indian plate causing a massive earthquake of magnitude >9.0 led to the displacement of huge quantum of ocean water which resulted in giant waves. This caused devastation along the coast of India, especially in the states of Tamil Nadu, Andhra Pradesh and southern Kerala and the neighbouring Sri Lanka. Severe damage has been reported on mangroves, coral reefs, coastal wetlands, sand dunes, animal and plant biodiversity and groundwater (Kumaraperumal, 2007). Inundation of seawater due to tsunami caused severe damage to agricultural lands in Nagapattinam and Cuddalore districts of Tamil Nadu, soils of the coastal belt turned saline along with contaminated groundwater. On the whole, the tsunami disaster caused severe and long-lasting environmental effects by sedimentary deposits containing extremely high salt contents and salinity, as well as heavy metal pollution. The salt contents (detected as B, Na, Ca, Mg, Si and Cl), as well as the salinity levels (detected by electrical conductivity, EC) in tsunami impacted soils remained significantly increased compared to non-impacted soils, even after 1.5-year intrinsic bioremediation.

Figure 1. Monthly mean maximum and minimum temperature in the Poompuhar coast during 2004-2010.



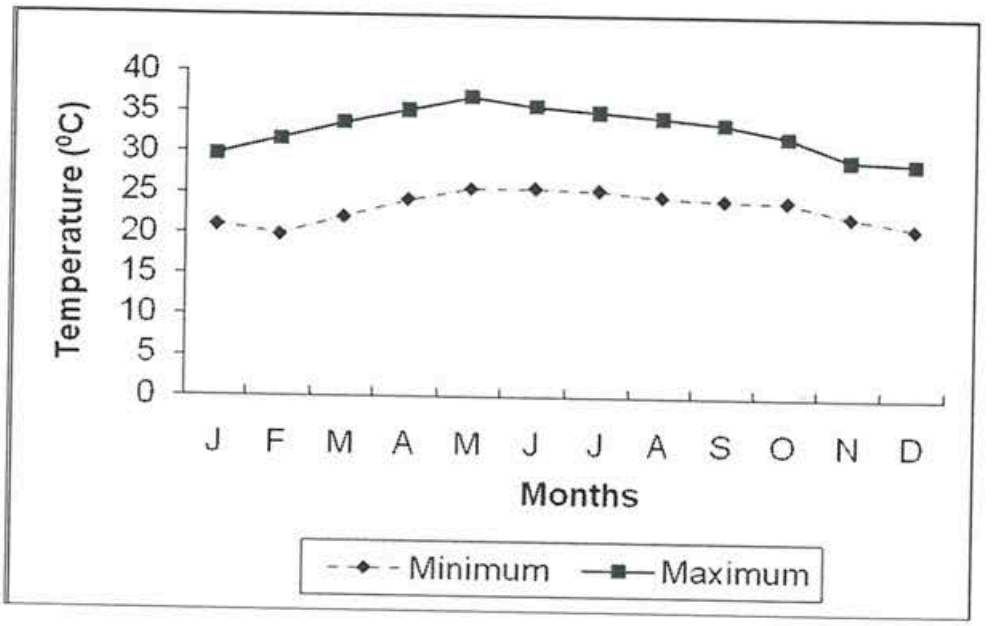
Source: Indian Meteorological Department

Figure 2. Monthly mean Relative Humidity (%) recorded in the Poompuhar coast during 2004-2010.



Source: Indian Meteorological Department

Figure 3. Monthly rainfall recorded in the Poompuhar coast during 2004-2010.



Source: Indian Meteorological Department

2.11 STUDIES FROM INTENSIVE STUDY AREA

Major researches in the coastal and marine biodiversity in India include fisheries, aquaculture, seaweeds and mangroves. Several educational institutions such as Sálim Ali School of Ecology, Puducherry, A V C College, Mayiladuthurai, Central Marine Fisheries Institute, Cochin (Chennai station), Annamalai University, University of Madras, Bombay Natural History Society, Mumbai and Sálim Ali Centre for Ornithology and Natural History, Coimbatore have conducted extensive researches in nearby areas, especially in Pichavaram Mangroves and Vendharanyam swamps. A few notable studies include, food web relationship of zooplankton (Godhantaraman, 2001; Damotharan *et al.,* 2010), vegetation (Saravanan *et al.,* 2008), long-shore current (Sanil Kumar *et al.,* 2002), coastal and marine biodiversity (Venkataraman and Wafar, 2005), post-tsunami scenario (Mascarenhas and Jayakumar, 2008), Physico-chemical parameters (Sundaramanickam, 2008) and coastal water bodies (Sivanappan, 2007).. However, no study is available in the present study area i.e. Tranquebar- Pazhaiyar coast, Tamil Nadu. The following short studies are available in the area, especially on marine turtles.

SACON has conducted marine turtle surveys along the Tamil Nadu coast under the auspicious of the UNDP-GOI-WII Olive Ridley project during 1991-2000 (Bhupathy and Saravanan, 2001; Bhupathy and Karunakaran, 2003) and CMS-MCBT during 2004-2005 (Bhupathy *et al.*, 2006). In these surveys, the present study area was also included, but only one breeding season of the Olive Ridleys was investigated.

RESEARCH METHODS

CHAPTER 3

RESEARCH METHODS

The present study was conducted along the Coromandel Coast between Tranquebar and Pazhaiyar, South-eastern Coast of Bay of Bengal, Tamil Nadu from November 2004 to May 2010. In addition to the field surveys, secondary information was also collected from local coastal villagers, fishermen, trawler owners and workers, Fisheries and Forest Departments and Non-Governmental Organizations. Landing sites were also visited and information on incidental catch was recorded from trawler owners and workers. Schools and colleges located in the coastal villages or towns were also visited to gather secondary information on marine turtles. Prior to regular sampling using standard techniques, a preliminary survey was carried out along the coast, between Tranquebar and Pazhaiyar for one month period (November, 2004). The following are field and laboratory procedures used in this study.

3.1 LABORATORY METHODS

Maximum- Minimum temperatures, Relative humidity and Rainfall (data obtained from the metrological unit -Government of India) located at Vedharanyam, Karikkal, Aaduthurai and Chidambaram.

3.1.1 Soil Analyses

The study area was affected by Tsunami (26 December 2004), and hence soil samples were collected only after February 2006 Soil samples were collected at every 500 m distance throughout the study area (51 km). From the samples only 15 of them were randomly selected for analyses due to the non availability of sufficient funding.

The soil samples were collected using a core sampler. The sampler is a PVC pipe with a diameter of 15.80mm and a length of about 100cm drilled to up to 40 cm. The Olive Ridley is a shallow nester and nest depth is recorded to be about 45 cm from the surface (Hendrickson, 1995). The sand samples were air dried

in shade at normal temperature (Jackson, 1958) and stored in air tight high quality zip lock polythene bags. Each dried sample weighed about 120-130g.

Grain Size

The grain size analysis is an attempt to analyze the relative proportions of the different grain sizes which makes a given soil mass. Fifty grams of sand from each sample was taken for analysis. This sample was sieved through a number of subsequent sieves in the order 710µ, 300µ, 250µ, 180µ and 105µ. The residue from the each sieve was weighed using an electronic balance (MonoBloc, Accuracy -0.01gm).

Colour

The soil colour depends on the content and the extent of decomposition. Iron gives soil a brown, yellow, or red colour, even shades of blue or green depending upon its amount of oxidation state and hydration state. When soil is saturated, iron can become soluble and easily removed, leaving the soil with "mottled" brown and gray colour. Complete removal of iron leaves the soil with a basic gray colour. Other factors affecting soil colour is the parent material, soil wetness and the extent of leaching in the soil.

Soil colour is compared with the Munsell soil colour chart, 1998. The Munsell system has three components namely hue, value and chroma. Hue is the dominant spectral wavelength, value is the degree of darkness or lightness and chroma is the purity of the spectral colour. All these three components were arranged in books of colour chips. Soil is held next to the chips to find out a visual match and assigned the corresponding Munsell notation. Some horizons may have more than one colour present and the percentage of each colour was recorded as well. In this case the dominant colour is known as the matrix colour (www.ngdc.wuv.edu).

pH

pH gives an indication of the acidity and alkalinity, which makes it valuable for soil characterization (Allen, 1989). Electrometric determination of pH involves measurements of electromotive force of a cell. pH was measured using a ELICO

Grip pH meter. A glass electrode in contact with hydrogen ions of the solution acquires an electric potential, which depends on the concentration of hydrogen ions.

A set of three buffer solutions was (pH 4.0, 7.0 and 9.2) prepared using the commercially available buffer tablets. One tablet each was dissolved in 100ml of distilled water and stored in 100ml reagent bottle. The resulting solutions were of pH 4.0, 7.0 and 9.2 respectively. About 1g of air dried soil sample was taken in a 100ml plastic beaker and 50ml of distilled water was added. The resultant suspension was left undisturbed for one hour and further taken for pH determination. The instrument was standardized using a set of buffers. The electrode was dipped in the suspension and the pH value recorded directly in a digital pH meter (model-Digisun-7007) at 30°C. The same suspension was used for the analysis of electrical conductivity.

Conductivity

Electrical conductivity is a measure of soil capacity to convey electric current. The electrical conductivity is directly proportional to the amount of mineral matter content in water or soil. The unit of conductivity is micro mhos Siemens/cm (μS/cm).

Potassium chloride (KCl) solution (0.01N): 0.0745g of potassium chloride was weighed using a mono-pan digital balance with accuracy 0.001mg and dissolved in a small quantity of distilled water in a 100ml volumetric flask. The final volume was made up to 100ml. The resulting solution was 0.01N potassium chloride standard, used for standardizing the conductivity meter. The soil water suspension was used. The instrument was standardized by 0.01N potassium chloride solution and the electrode was immersed in the suspension. The value was read from the digital conductivity meter (model-Digisun-D, 9001).

Alkali and Alkaline Metals

Alkali and alkaline earth metals extracted from the soil refer to the available portion of metals in the soil include both the exchangeable and water soluble fractions. It is determined in neutral ammonium acetate extract of soil.

Schollenberger introduced normal ammonium acetate at pH 7.0 in 1972 (Allen, 1989). The extract is suitable for the estimation of sodium, potassium, calcium and magnesium in neutral and acidic soils. It forms the first stage in the determination of cation exchange capacity. The ammonium ions provide a sharp and rapid separation from exchange complex, while other cations bring about a gradual replacement of either lesser or greater amount of element that gradually increases with the period of contact. The estimation of the element concerned in the extract is carried out with the help of flame photometer.

77.09g of ammonium acetate salt was dissolved in 1000ml of distilled water taken in a 1000ml in a flask and the pH of the ammonium acetate solution was adjusted to 7.0 using a digital pH meter. Air-dried soil sample (1g) was taken in a 100ml conical flask. Neutral ammonium acetate solution (25ml) was added and the content was shaken for half an hour on a rotary platform shaker (Rotek-LSV DT 2006). and filtered through Whatmann filter paper. Sodium, potassium, calcium were estimated using flame photometer (ELICO-CL361) and magnesium by EDTA titrimetric method.

Hardness

Hardness is determined the presence of calcium and magnesium salts in the soil. These ions form soluble complexes on reaction with EDTA and the completion of the reaction is indicated by Eriochrome Black-T indicator.

(1) Ethylene diamine tetra acetic acid (0.02N EDTA solution): 3.723g of AR grade disodium diamine tetracetate dihydrate (EDTA) was weighed accurately and dissolved in distilled water which was made up to 1000ml.

(2) Ammonia-ammonia chloride buffer solution: 16.9g of ammonium chloride was dissolved in 143ml of concentrated ammonia solution (solution A) 1.179g of disodium salt of ethylene diamine tetracetate and 780mg of magnesium sulphate was dissolved in 50ml of distilled water (solution B.) Solution B is added to solution A and diluted to 250ml with distilled water and stored in a stopper polythene container.

(3) Eriochrome Black-T indicator powder (dry powder mixture): 0.5g of the dye mixed with 100g of sodium chloride to obtain a mixture of dry powder.

10ml of the soil sample was taken in a conical flask. To it 1ml of ammonia-ammonia buffer solution and a pinch of Eriochrome Black-T powder was added results turned in wine red. That solution was titrated against standardized EDTA until the colour changed from wine red to blue and the results were tabulated using the formula.

$$\text{Total hardness} = \frac{\text{Volume of EDTA} * \text{Normality of EDTA} * 50 * 1000}{\text{Volume of sample (ml)}}$$

3.2 FIELD METHODS

3.2.1 Beach Characteristics

Prior to initiating the study, preliminary surveys were conducted in the costal areas to understand various features of the coastline such as the location of villages, river mouths, rocky out crops and fish landing stations (points). A total of 51 km of the shoreline (Tranquebar- Pazhaiyar) was divided into three sectors (Fig. 1); Tranquebar- Poompuhar (17 km), Poompuhar-Thirumullaivasal (18) and Thirumullaivasal-Pazhaiyar (16). Beach characteristics such as topography, plantations and human habitation close to the beach were evaluated. Global Position System (GPS), Garmin 12 Channel was used for recording Latitude and Longitude of any given point for further analysis and mapping.

3.2.2 Breeding of Olive Ridley

Offshore Activity of Olive Ridleys

Studies on the offshore activities of turtles were planned since the beginning of the study period December 2004, but due to the Tsunami hit (26th December 2004), data collection was started only from August 2005 to March 2010. The

offshore surveys were conducted using mechanised fishing boats with jet engine.

Sorties were made from three points; Tranquebar, Poompuhar and Pazhaiyar. From any of the above mentioned point (station), about 10 nautical miles (1 nautical mile = 1.825 km) were travelled perpendicular to the shore at about 5 km/ hour (speed); a turn was taken at right angle (left or right) and traversed for about 2-4 km, and returned back to the shore, This formed a rectangular transect of 2 km X 15 km each time. Every month including three points, six sorties were undertaken.

Turtles found within 25 m from the boat were considered for analysis and the same was reconfirmed using a pair of binoculars (Nikon 10x40) in most cases. Turtles including mating pairs in the area were shy for any moving/ approaching objects including boats. As over 99% of the stranded turtles along this coast was reported to be Olive Ridleys (Bhupathy and Karunakaran, 2003), all unidentified turtles observed during the sorties were also considered as Olive Ridleys. Starting location or point, date, number of turtles observed, GPS location (lat, long) and depth at each sighting were recorded. Depth of the sea was measured using a marked nylon rope attached with an iron ball.

Nesting

The shoreline was surveyed to quantify the nesting intensity once in a fortnight from November 2004 to May 2010. The study area was divided into five kilometre sector using a Global Positioning System (GPS), and surveys were done on foot between 0600 and 0830 hrs and each sector was covered on five consecutive days for locating turtle tracks and nests. Species involved in nesting was identified based on track pattern and width. The Olive Ridley is the smallest marine turtle of the world, and is reported to nest at about 60 cm in CC (Lutz *et al.*, 2002) and hence its track width is also narrow. This species also follow Hawksbills track pattern (Andrews *et al.*, 2003.)

Nesting was confirmed following tracks, nesting site, body pit and egg chamber, and status of the same was assessed based on signs of predation including

nest exploitation by humans (Bhupathy and Saravanan, 2006). None of the nest was opened as it would spoil the developing eggs and enhance predation. However, presence of eggs in the nest was reasonably confirmed. Crawls or nests counted during each surveys were considered new, as interval between surveys was 10-15 days and tracks were obliterated during the survey.

Up on locating a nest, data such as month, fortnight, global position (Lat and Long) of each nest, nearest vegetation, were recorded. Also, distance from High Tide Line, river mouth and village were noted down. Status of each nest (predated or intact) during the survey was also noted. First nest sighted in a season (i.e. December to April) was considered as arrival date of turtles for nesting. Similarly, the last nest observed was considered as departure date of the turtle. During the surveys, emergence of hatchlings, if any were noted and the same was considered as hatching time for Olive Ridleys. However, no nests were marked, protected and studied for incubation duration. Hatching success, hatchling morphometry were not studied due to difficulties in obtaining permission from department.

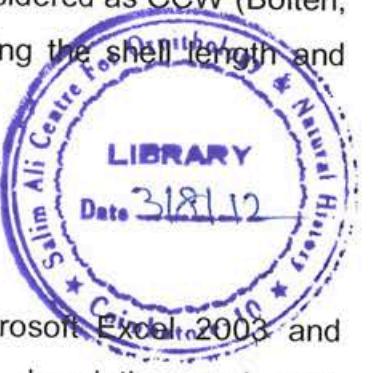
Nests with signs of disturbance and eggs robbed by villagers during surveys were considered as an index of exploitation. Enquiries were also made in the field with respect to the exploitation of turtles and their eggs.

3.2.3 Habitat Analyses

Vegetation types analysed at every 500 m along the entire beach using point sample method during April 2005. A total of 105 such points were sampled for vegetation. At each point vegetation type found along the perpendicular line from the high tide up to 25 m inland was noted. The natural beach flora along the study area comprised mostly of psammophytes, and *Ipomoea pescaprae*, *Spinifex littoreus* and *Casuarina*, spread over the sand dunes and along the beach platform. *Casuarina* plantations on the beach were planted after tsunami, undertaken by the Tamil Nadu Forest Department as barriers against cyclonic storms. Coconut and Pandanus have restricted some areas. Based on the single vegetation types or combination in the sample points, proportion of the same was calculated and considered as their availability in the area.

3.2.4 Mortality

Dead and stranded sea turtles found along the shore were accounted the mortality of turtles. Details on the number of dead turtles found on the beach, probable cause for the same and other relevant information were noted. Turtle carcasses were marked with enamel paint to avoid repeat count (Bhupathy and Karunakaran, 2003). On locating the stranded sea turtles, morphometry measurements such as Curve Carapace Length (CCL) and Width (CCW) were taken following Bolten (1999). The length between anterior at midline of the nuchal scute to the notch of the supra-caudals was considered as CCL (Bolten, 1999; Bjorndal and Bolten, 1989; Shoop and Ruckdeschel, 1986). Similarly, the width of the shell across the 4th vertebral scute was considered as CCW (Bolten, 1999). A twine and metal scale was used in measuring the shell length and width.



3.3 DATA ANALYSIS

Data compilation and analysis were done using Microsoft Excel 2003 and statistical programme SPSS (Version 10). Various descriptive and non-parametric tests were used for analysis.

Simple mapping was done for marking landscapes, beach characteristics, vegetation and sightings of turtles offshore and using GPS and maps modified from Google Earth facility.

- Descriptive statistics (mean, standard deviation and range) was used to describe morphometry of turtles and other basic data such as climate parameters.
- Variation between samples was tested using Mann Whitney U test. For instance, the level of significance between two sets of samples, i.e. variation in levels of a parameter (Physico-chemical) in random samples and turtle nesting location.
- Number of nests (estimated) along the beach surveyed during the study was calculated as

- $N = n X d X t$ (Bhupathy and Karunakaran, 2003),
- where, N = total nesting, n = average nesting of the day/5 km, d = number of sectors surveyed, and t = study period (in days).

- Ivlov Index of Selectivity (Ivlov, 1961) was used as calculate Preference of nesting sites by turtles with respect to vegetation, was calculated based on the availability and utilization of ground vegetations.
  - I = U-A/U+A,

where, U denotes proportion of utilization of species and A denotes proportion of availability of a particular vegetation. Ivlev's value range between -1 and +1, where -1 indicates avoidance, while +1 indicates high preference.

- Linear regression models were constructed to know the relationship between carapace length and width with respect to male, female and overall in the study area.
- Chi-Square analysis was used to know the variation in the number of nests located with respect to various distance classes from the river mouth.
- Number of nests located with respect to various distance categories from High Tide Level, village, road, was correlated using Pearson correlation (SPSS, version 10).

RESULTS

CHAPTER 4

RESULTS

4.1. STATUS OF THE COAST

Of the 900 km East coast shore of Tamil Nadu, the study area, Tranquebar to Pazhaiyar, covers about 51 km. This study revealed that majority of the coastline (82.35%) was sandy and the same appear suitable for nesting of Olive Ridleys (Table 3). The study area did not have any notable rocky stretches.

As mentioned earlier, the study area was divided into three segments, almost equal in length; Tranquebar, Poompuhar and Pazhaiyar (south to north). The Pazhaiyar region had relative fewer villages (due to the swampy nature of the area). The area has several distributaries of rivers Cauvery and Coleroon (Plate 2). About 3 of 18 km (18. 75%) of Pazhaiyar stretch had swamps largely due to formation of backwaters and mangroves in Coleroon river mouth. The Poompuhar region has notable swamp because of the formation of Thirumullaivasal River and Cauvery River. No notable river was found closer to Tranquebar and hence no swampy area was observed in this stretch. The more southern locations (Tranquebar and Poompuhar) had tourism, and several development projects (aquaculture, thermal power installations). All sectors had more than three fourth of the area with sandy beaches.

Table 3. Beach characteristics of the Poompuhar Coast, with reference to marine turtle nesting.

Coastal sector	Distance sampled (km)	Suitable for nesting	Unsuitable for Nesting		
		Sandy(km)	Rock	Development (km)	Swamp
Tranquebar	17	15(88.24)	0	2 (11.76)	0
Poompuhar	18	15(83.33)	0	2 (11.11)	1(05.56)
Pazhaiyar	16	12(75.00)	0	1 (06.25)	3(18.75)
Total	51	42(82.35)	0	5(9.80)	4(7.84)

Number in parenthesis indicates percentage

Subsequent to the Tsunami of 26th December 2004, several development programmes were executed by the government and non governmental agencies in the area as the same was severely impacted. Also, several industrial activities and habitat changes were observed between 2004 and 2010. A comparison of facilities/ activities increased several folds in the area.

4.1.1 Development Activities along the Beach

Thermal power plants installed in the area draw water from sea for their coolants, and these installations are source of light pollution during night. This would potentially disorient nesting turtles and hatchlings. Coal is being imported for these installations and hence activities of ship and boats are common in the area. Aqua-farms also draw and drain water into sea with added chemicals. In addition, explorations for petrochemicals are also in progress in the offshore areas. All these activities affect the current pattern in the sea, which result in beach erosion. Signs of such beach erosions were found in two locations during the beginning of this study (2004), which increased to 20 within five years and beach armouring is controlling these erosions. This would affect the sea turtle nesting as well.

Over three folds of fish landing centres were formed within 5-6 years. Number of fishing vessels (fibre boat, mechanised boat) etc has increased i.e. 71.6-vessels/ village to 112.68 vessels/village. These landing centres are connected by beach (*kaccha*) roads (Plate 6), which also increased from 2 to 16. Movement of several four wheelers with heavy load on the sandy beach would affect the nests due to compaction of the sand.

The Government of Tamil Nadu (TN Forest Department) initiated several coastal shield/ belt plantations after 2005. During 2004, these plantations were found only in two locations (Madavai medu to Pazhaiyar and Chinna medu – Chinnangudi), but later extended to over 20 areas (Plate 4 & 5). The exotic *Casurina* sp. planted in the area is invading towards sea side as well. The area occupied by these plantations is also increasing. The plantations were/ are also done covering up to the High Tide Line (HTL), leaving no space for turtle

Plate 4. Map showing developmental activities along the Poompuhar coast before 2004.

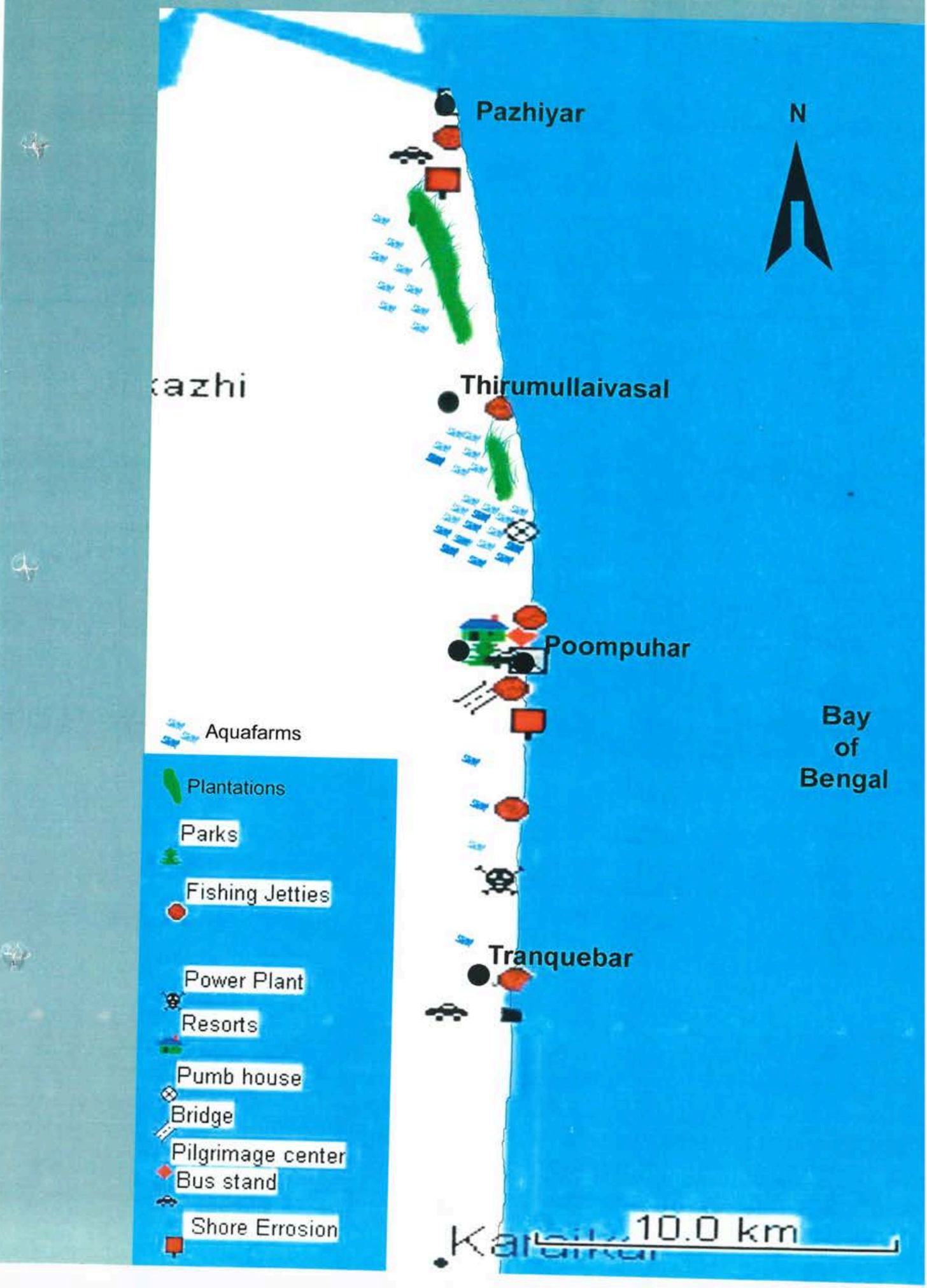


Plate 5. Map showing developmental activities alo the coastal area between 2004 and 2010.

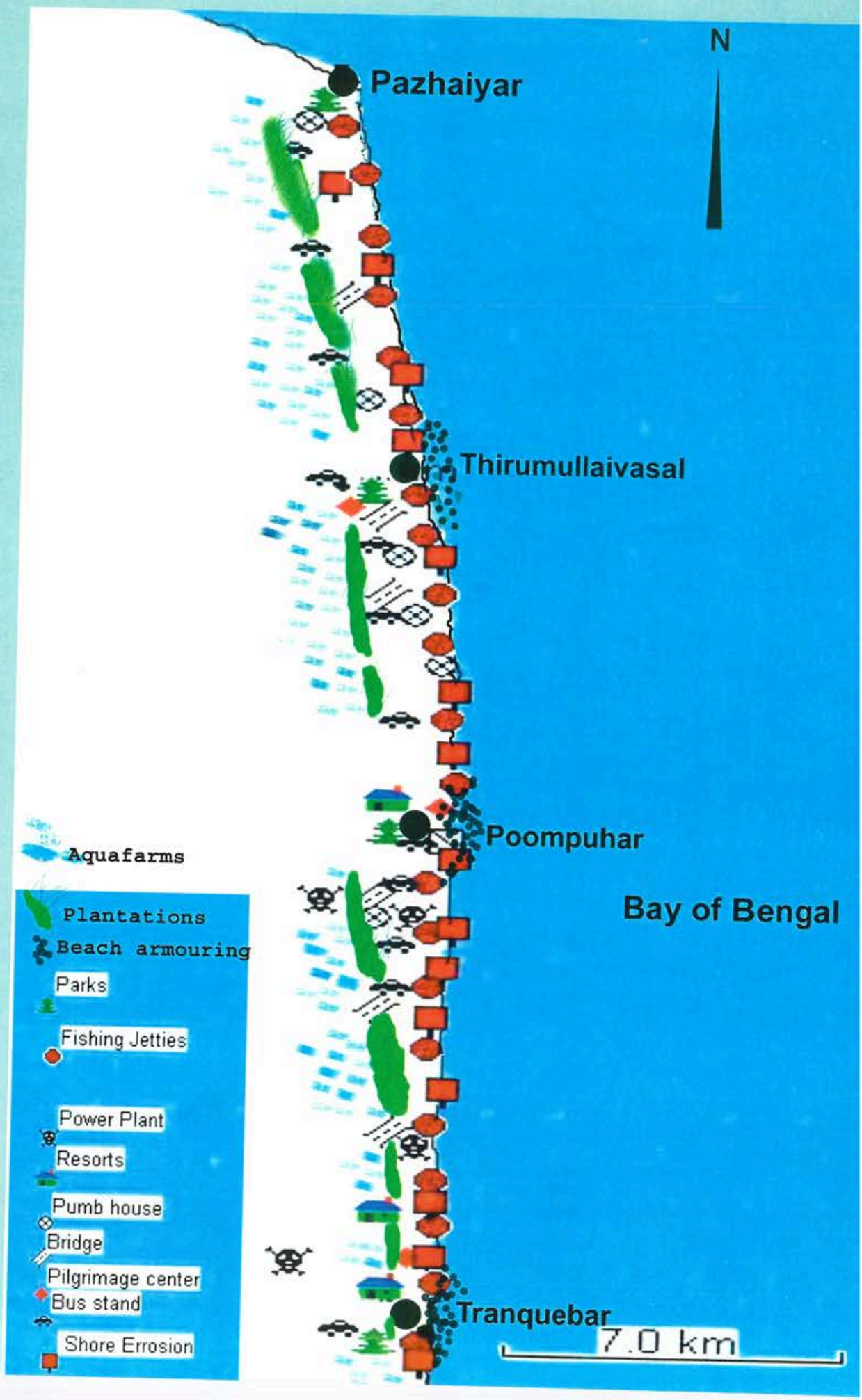
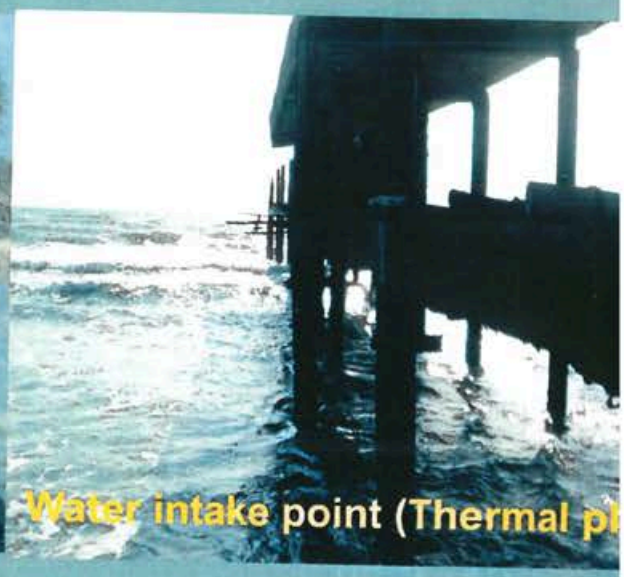
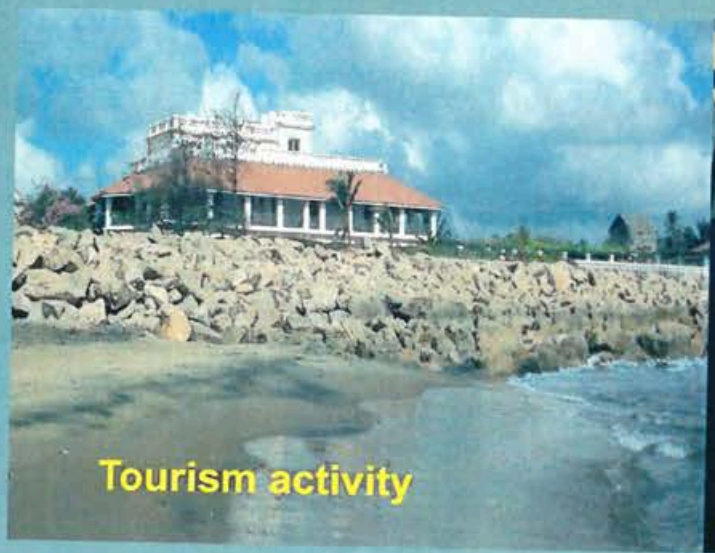


Plate 6. Status of the Poompuhar Coast

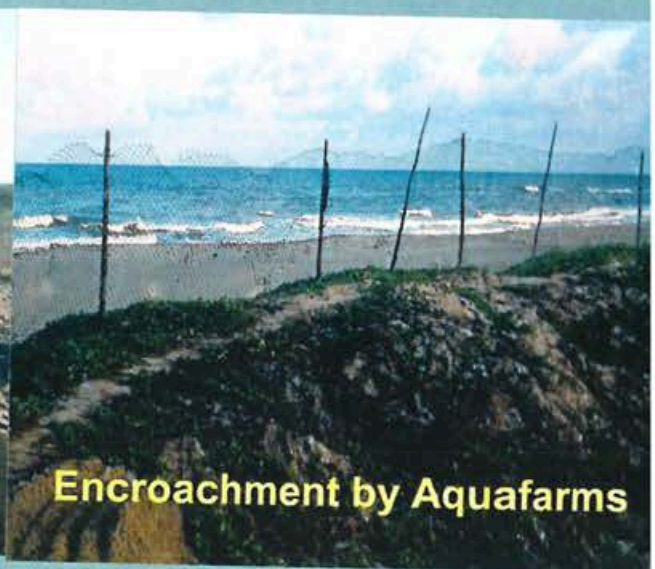

Sea wall (Beach armouring)


Water intake point (Thermal pl


Tourism activity


Fish preservation Centre


Beach (Kachha road)


Encroachment by Aquafarms

nesting, and this would potentially block the movement of nesting females and hatchlings.

It is suggested a comprehensive carrying capacity assessment of the area inventorying existing development projects and their impact should be done at the earliest.

Table 4. Development activities observed in study area between November 2004 and March 2010 along the Poompuhar Coast (Tranquebar- Pazhaiyar).

S. No.	Development Activity	2004	2010
1	No. of thermal plants	1	4
2	No. of aqua-farms	360	645
3	Aqua feed manufacturing units	0	5
4	No. of fish landing centres	6	22
5	No. of beach (*kaccha*) roads*	2	16
6	No. of bridges near sea front (within 200 m)	1	6
7	No. of patches of coastal belt plantations	2	20
8	Approximate area of plantations (in km)	6	27
9	No. of locations with beach erosion	2	20
10	No. of beach armouring found	0	4
11	No. of beach resorts	1	3
12	No. of ships parked as seen from the beach	0	4
13	No. of fishing vessels (boat, parked)/ village	71.4	112.7
14	No. of pump house (for development projects)	1	6
15	No. of fish preservation units	2	13
16	No. of pilgrimage centre	1	3
17	No. of bus depot	3	13
18	No. of parks(recreation centres)	2	4
19	No. of temples	3	9

*Transportation paths that connect fish land jetties through sandy beaches.

4.2. TURTLE FAUNA

Three species of freshwater turtles namely the Indian Black Turtle *Melanochelys trijuga*, the Indian Flapshell Turtle *Lissemys punctata* and the Asian giant Softshell Turtle *Pelochelys cantorii* and three species of marine turtles, the Olive Ridleys *Lepidochelys olivacea*, the Green Turtle *Chelonia mydas* and the Leatherback *Dermochelys coriacea* were observed during this study. Among the fresh water turtles, the Asian giant Softshell Turtle prefers sandy beach for nesting. Only one nest with 40 eggs was observed on July 2009 at

Thirumullaivasal during this study. No report on the nesting behaviour of this species along this coast is available.

All species of freshwater turtles were locally common, except the Asian Giant Softshell Turtle. All species of marine turtles and two species of freshwater turtles (Indian Flapshell Turtle and Asian Giant Softshell Turtle) are listed in Schedule I of the Indian Wildlife Protection Act (1972) as they are reportedly threatened due to various reasons. Rural people consumed all freshwater turtles, but only eggs of marine turtles were exploited in this region.

During the present study period, a total of 424 marine turtles were observed, including 419 Olive Ridley of which, 312 carcasses on the beach, 107 observed in offshore studies. Three juvenile/ subadult (CCL <60 cm) Green Turtles and two Leatherbacks (Plate 7) were recorded during this study. Among the 317 carcasses stranded along this coast during the sampling period, Olive Ridleys contributed about 97.8%. Local enquiry and questionnaire surveys revealed the presence of the Hawksbills (*Eretmochelys imbricata)* in the area, but could not confirmed during this study. Considerable numbers of Olive Ridleys were contributed by smaller sized turtles (see Results: Mortality). This indicates that the present study area could form as a partial development ground for Olive Ridleys, Green Turtles and Leatherbacks.

4. 3 NESTING OF OLIVE RIDLEYS

4.3.1 Offshore Activity

The offshore studies were initiated from August 2005, as fishermen were reluctant to venture into the sea due to Tsunami of 26th December 2004. The study continued up to July 2010. Fortnightly, three sorties (one each from Tranquebar, Poompuhar and Pazhaiyar) were made to about 10 nautical miles (1 nautical mile = 1.852 km) perpendicular distance from shore.

A total of 360 sorties were made from August 2005 to July 2010 for offshore investigations. In all, 107 turtles were observed on 73 occasions (Plate 8) higher number (58.9%, n=73) of turtles was observed as singleton followed by in pairs

Plate 7. Marine turtle and their tracks along the Poompuhar coast.

Olive Ridley (Adult)

Olive ridley (Juvenile)

Olive Ridley track with body pit

Leatherback

(Fig. 4). More than three turtles were seen occasionally. Turtles used the offshore area with depth ranging from 22.5 m. to 45 m. All sorties were made during day hours and turtles were not observed closer to the beach during the day.

The present study showed that turtles were observed almost in all months (Fig. 5). The highest offshore movements (17.8%) of turtles were observed during February and the lowest in July. Higher number of turtles along the offshore of the study area coincided with the intensity of turtles emerged out for nesting (January-March). As much as 56.0% of the offshore activity of Olive Ridleys was observed during the nesting season (December- March) of this species, and the rest during other months (non-breeding season). This could be due to the arrival of adult turtles for courtship and mating in close vicinity to the nesting ground.

The highest proportion (22.4%) of turtles was observed in distance about 14-16 km from the shore followed by 12-14 km category (Fig. 6). Only 31.8% of sightings were obtained within 10 km from the shore. In all, about 84% of turtles were observed between 6 and 16 km from the shore. Number turtles observed were up to 4km and increased with distance up to 16 km and declined thereafter.

Figure 4. Group composition of Olive Ridleys observed in the offshore areas of the Poompuhar coast.

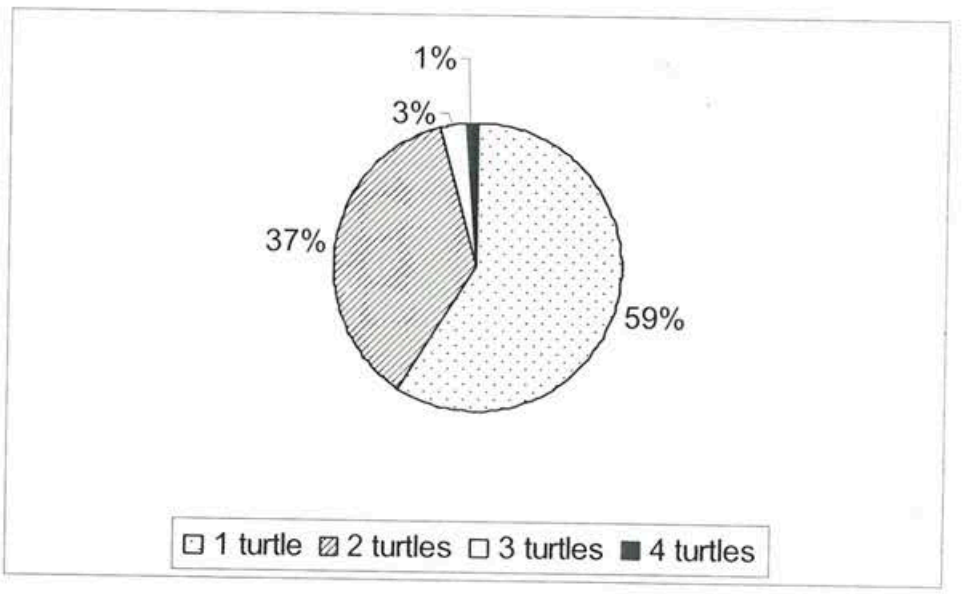


Figure 5. Sightings of Olive Ridleys during various months in the offshore areas of Poompuhar coast.

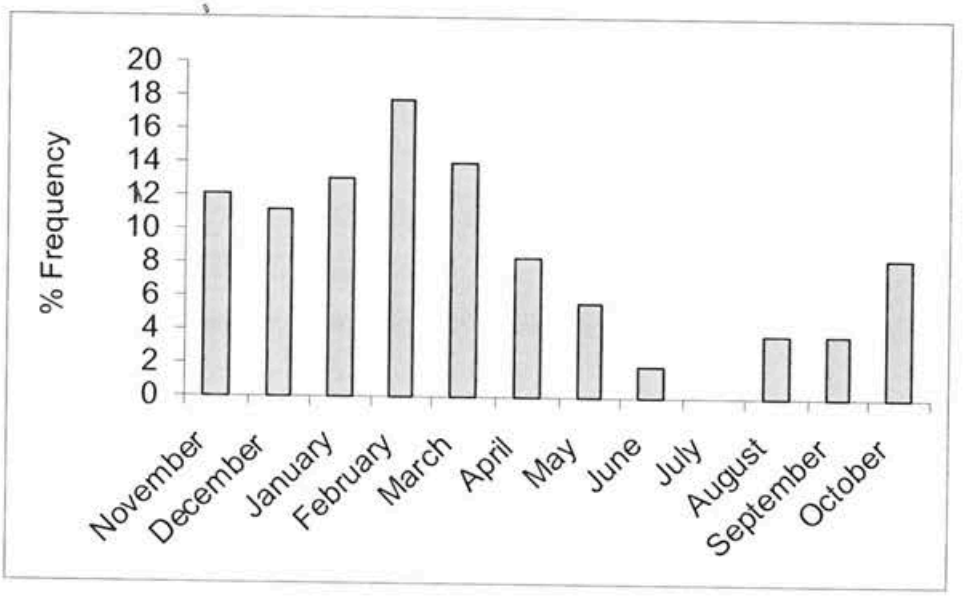


Figure 6. Group composition of Olive Ridleys observed in the offshore areas of Poompuhar.

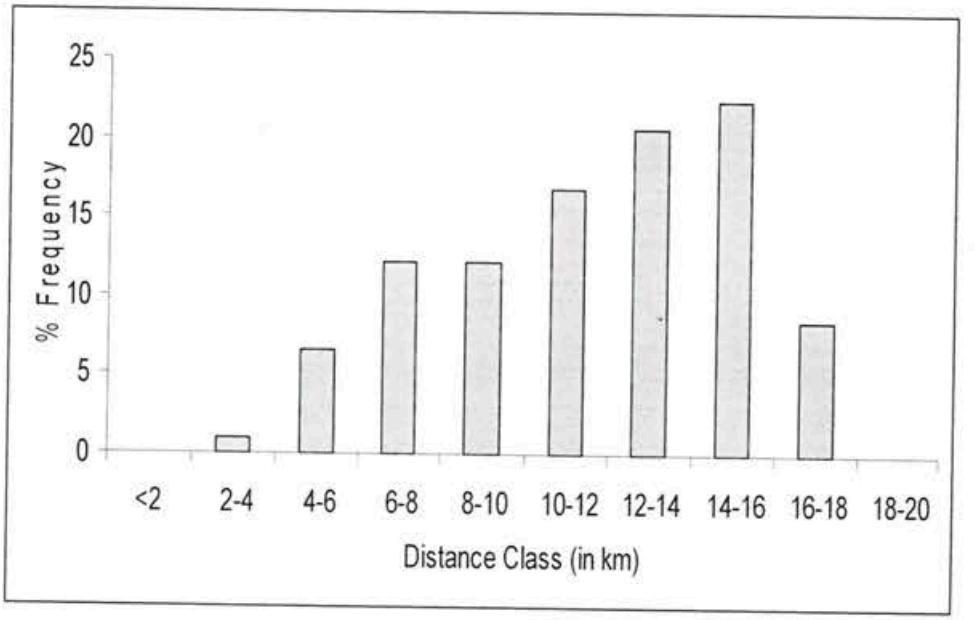
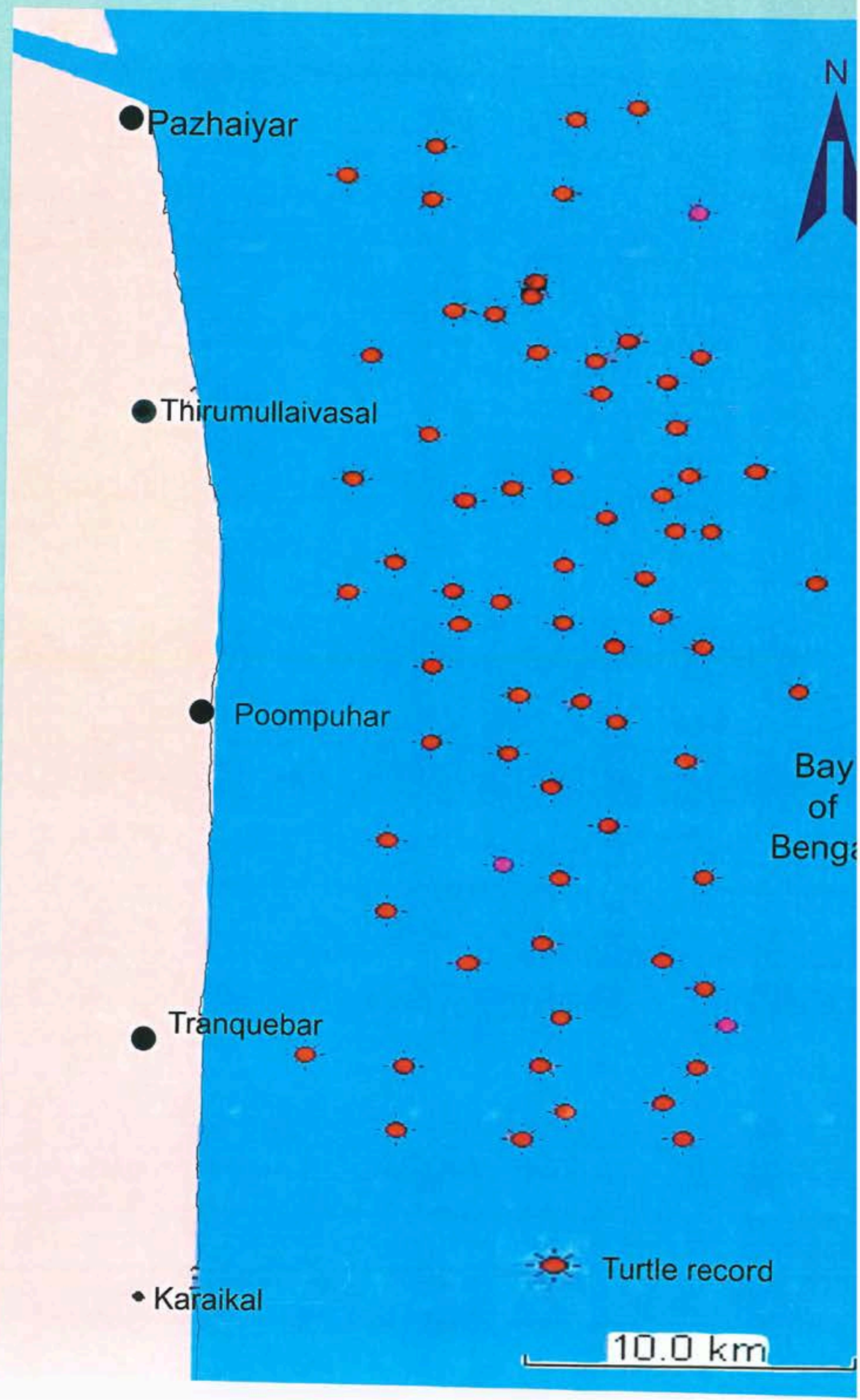


Plate 8. Offshore records of Olive Ridleys along the Tranquebar -Pazhaiyar area during 2005-2010



4.3.2 Nesting

Fortnightly surveys from December 2004 to May 2010 along the 51 km stretch of the coast yielded 530 tracks. One nesting crawl included emergence crawl which normally terminated with nest and the return crawl, both would form a V pattern. About 10% of the nest crawls had more than one nest pits (pseudo-nests). About 5% (27) of the crawls did not have nest pit i.e. did not lay eggs. In all, 248 nests were located during this study. Questionnaire survey and field work revealed that turtle nesting was restricted to night hours.

Based on track pattern i.e. flipper mark (see: Field Methods) and size, it was assumed that all these tracks were belonging to Olive Ridleys. It may be considered that 98.4% of the marine turtle carcasses found along the study beach belonged to Olive Ridleys. In addition, no record of other marine turtle species nesting along this coast is available. Number of crawls found on the shore during the sampling was considered as an index for nesting during the period.

Arrival and Departure of Turtles

Emergence (or arrival) of turtles to the shore, peak nesting and departure month/ fortnight of the Olive Ridley is given in Table 5. December to March may be considered as the nesting season of marine turtles along the study area. Except 2004-2005, turtles emerged out during December and returned by March. Peak nesting was observed either during January 2nd or February 1st. All the study years, except 2004-2005, the turtles emerged out and began nesting during December. In three years, turtles completed the nesting by March 1st fortnight, and in the remaining years it was during March 2nd fortnight. Among the six seasons included in the present study, arrival of turtles for nesting in 2004-05 season was considerable different i.e. the turtles started nesting late. However, the peak nesting and departure was similar to that in other years (seasons).

Nesting of turtles was observed subsequent to (post) Northeast monsoon. Northeast monsoon affect this area during September- November, and at times extend to December. No swelling of rivers due to flood was observed during the nesting season. The major river of the study area is Cauveri, which originates from the Western Ghats, and peak monsoon season in its catchments is during southwest monsoon (May-July). Overall ambient temperature during this period was mild (Fig. 1).

Table 5 Seasonal nesting activity of Olive Ridleys along the Poompuhar Coast, during 2004-2010.

Year	Beginning of nesting	Peak nesting	End of nesting
2004-05	January I fortnight	February I	March I
2005-06	December II fortnight	January II	March I
2006-07	December II fortnight	January II	March II
2007-08	December I fortnight	January I	March II
2008-09	December I fortnight	February I	March II
2009-10	December II fortnight	February I	March I

Nesting Intensity

During the six years of sampling (2004-2005 to 2009-2010), a total of 248 nests were observed during the fortnightly sampling. A minimum of 14 nests was observed in year 2004-2005 and a maximum of 60 nests in year 2007-2008. Number of nesting during 2006-07 and 2007-08 was almost similar (i.e. 56 and 60 respectively). Prior to and after 2007-08, number of nests decreased (Fig. 7). After tsunami 2004, the nesting increased till 2007-08, hence, an increasing trend was observed. On the other hand, development of the coastal area (new thermal plants, bridges in the river mouth) began in greater pace during 2007. This could be one of the reasons for the observed decreasing trend in the nesting of Olive Ridleys.

The study period (2004 -2010) covered six nesting seasons. The study area remained the same; i.e. the length of the coastal stretch covered was 51 km. The intensity of sampling (fortnightly survey) was also same. The area had an average of 41.3-nests/ year, which worked out to be 12.88 nests/ km. As

mentioned earlier, a range of 14 to 60 nests were obtained in the sample surveys. Based on observations, it is estimated a nesting 221 to 945 in 51 km shoreline during this study. This works out to be a density of 4.34 nests/ km to 18.53 nests/ km (Table 6).

Nesting Pattern

Overall nesting pattern of Olive Ridley nesting during various fortnights is given in Fig. 8. As mentioned earlier, turtles started nesting around 1st fortnight of December. There was a steep rise in the nesting by January 1st fortnight. In all, 83.9% of nesting happened in just two months (January and February). Peak nesting of Olive Ridleys was observed during February 1st Fortnight. January 1st fortnight to February 1st is important for turtle nesting in the area. Proportion of nests recorded during the sampling of various fortnights of study years is given in Table 7. Overall nesting pattern was similar in all years. The study shows that January 1st fortnight to February 1st fortnight is important for nesting of Olive Ridleys.

Figure 7. Olive Ridley nesting range along the Poompuhar coast during 2004-2010.

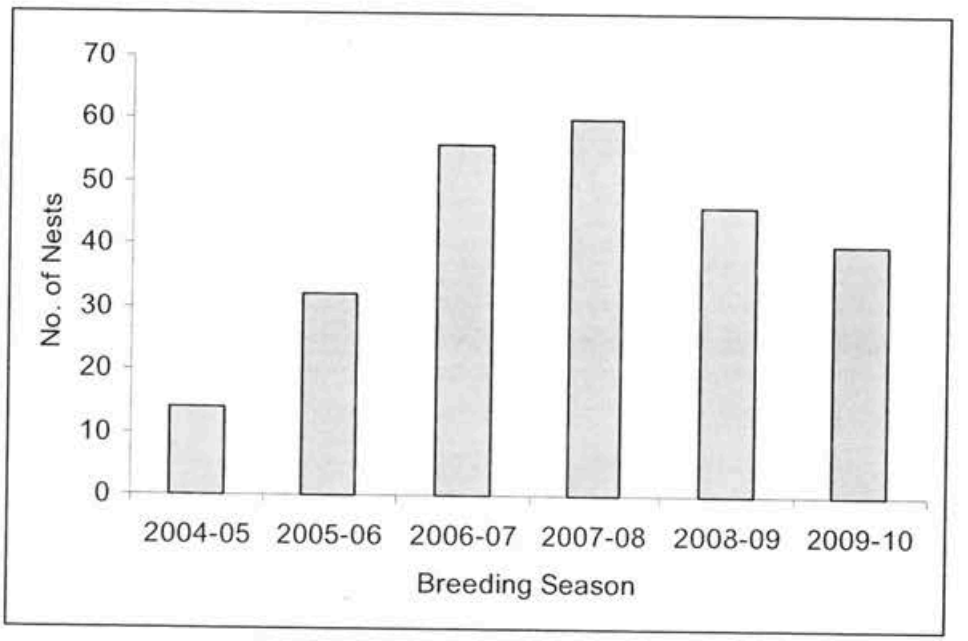


Table 6. Estimated Olive Ridley nesting during 2004-2010 along the Poompuhar Coast.

Year	Nest in the sample	Estimated nest	Estimated nest/km
2004-05	14	221.25	4.34
2005-06	32	510	10.00
2006-07	56	892.5	17.50
2007-08	60	945	18.53
2008-09	46	746.25	14.63
2009-10	40	626.25	12.28
Average	41.33	656.9	12.88

Figure 8. Cumulative nesting pattern of Olive ridleys along the Poompuhar Coast, during 2004-05 – 2009-10.

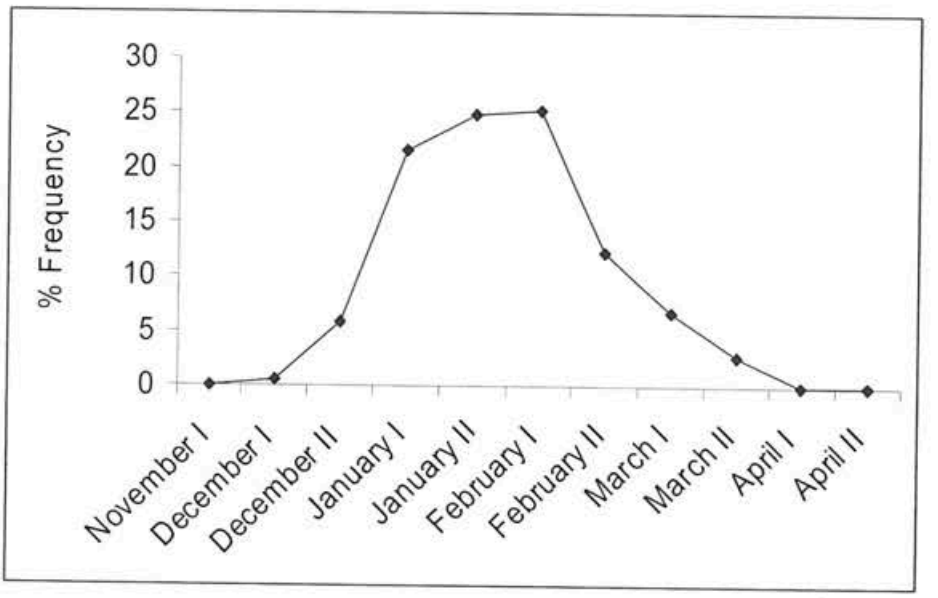


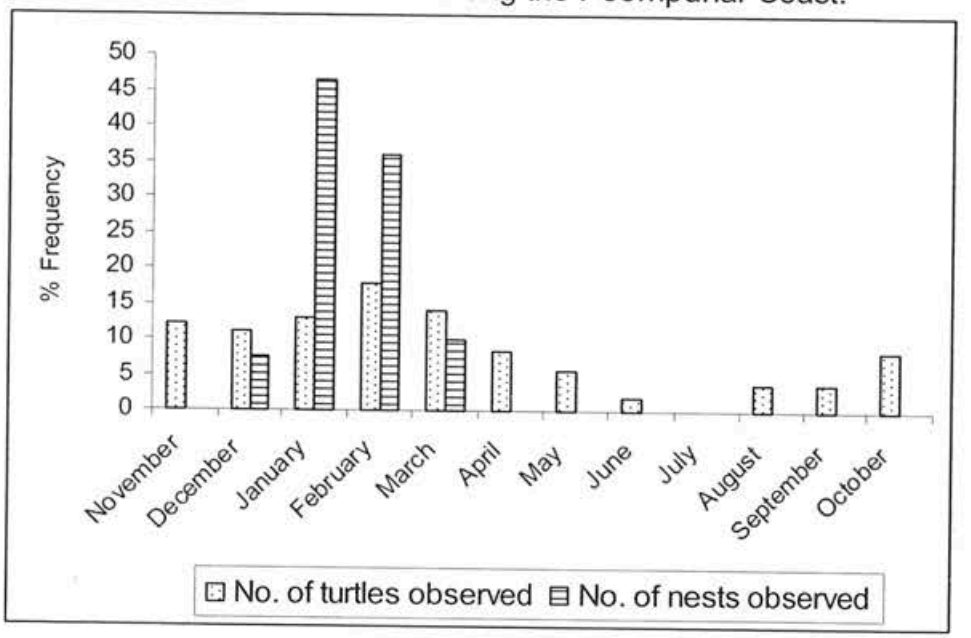
Table 7. Monthly nesting pattern of Olive Ridleys along the Poompuhar Coast, 2004-05 – 2009-10.

Month & Fortnight	Years					
	2004-05 I	2005-06 II	2006-07 III	2007-08 IV	2008-09 V	2009-10 VI
November I	0	0	0	0	0	0
December I	0	0	0	1.67	2.17	0
December II	0	6.25	7.14	10	4.35	7.5
January I	21.43	25	21.43	30	21.74	10
January II	28.57	34.36	30.36	25	10.87	20
February I	35.71	18.75	21.43	16.67	23.91	35
February II	7.14	9.38	10.71	8.33	15.22	22.5
March I	7.14	6.25	7.14	6.67	8.7	5
March II	0	0	1.79	1.67	13.04	0
April I	0	0	0	0	0	0
April II	0	0	0	0	0	0
Number of nests in the sample	14	32	56	60	46	40

Nesting in Relation with Offshore Activity

As mentioned earlier, 248 nests were observed in various months during this study and 107 turtles during various offshore surveys. Higher number of turtles in offshore areas coincided with the nests observed on the shore (Fig. 9). The relationship between number of nests recorded and turtles observed in the sea was positive, but was not significant. The week relation was due the arrival of turtles to offshore areas closer to nesting beaches much before (October-November-December).

Figure 9. Comparison of Olive Ridleys sighted in the offshore areas and number of nests observed in various months along the Poompuhar Coast.



Nest Predation

Of the 248 nests observed, only 45(18.15%) nests survived from predation by animals and exploitation by human during the first day. The survival of the nest varied from 14.29 to 18.75% (2007-08). This is the status of the nest on the next morning of nesting, and the status of the nest subsequent to this was not monitored (Table 8). Nest poachers traversed the shore early in the morning (0300- 0500 hrs) on daily basis to collect the eggs laid. They follow the tracks left by the turtles and trace the nests to collect eggs. These eggs are either used by the poachers them selves or sell to local liquor shop at about Rs. 3/egg. Egg poachers are from selected villages. They cover certain stretches of beach to collect eggs.

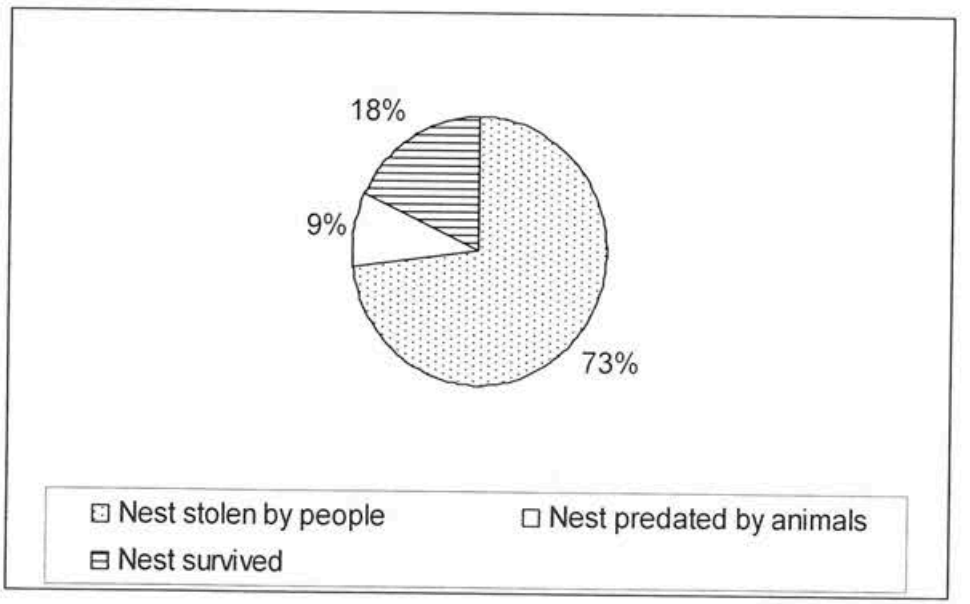
Major portion of the eggs laid (72.98%) was stolen by villagers on the same night of laid (Fig. 10). Of the 22 nests, 16 were destroyed by Domestic Dogs, five by Jackals and the rest by Monitor Lizards and Crows. Crows are secondary predators, which fed on partly exposed eggs dug by other predators. Apart from nest predators, the hatchlings of turtles have several predators. Crows, Gulls and Domestic Dogs were observed feeding on hatchlings along this coast during this study. Predators of the hatchling and juvenile turtles in the sea were not investigated during this study.

Both Dogs and Jackals are subsidized predators by anthropogenic activities along the coast. While the villagers rear Dogs and the Jackals inhabit the *Casuarina* plantations raised by the Forest/ other Government departments under shelter belt programme. It is to be noted that these plantations, as they grow would become denser and become home for a number of predators such as Jackals and Monitor Lizards.

Table 8. Predation on Olive Ridley nests during 2004-2010 along the Poompuhar Coast. Number in parenthesis is percentage frequency.

Year	No. of nests observed	No. of nests predated by animals	No. of nests stolen by poaching	Nests survival
2004-05	14	1	11	2 (14.29%)
2005-06	32	2	24	6 (18.75%)
2006-07	56	4	44	8 (14.29%)
2007-08	60	4	42	14 (17.39%)
2008-09	46	6	32	8 (17.50%)
2009-10	40	5	28	7 (18.15%)
Total	248	22 (9%)	181 (73%)	45 (18.15%)

Figure 10. Factors contributing to the predation of Olive Ridley nests during 2004-2010 along the Poompuhar Coast.



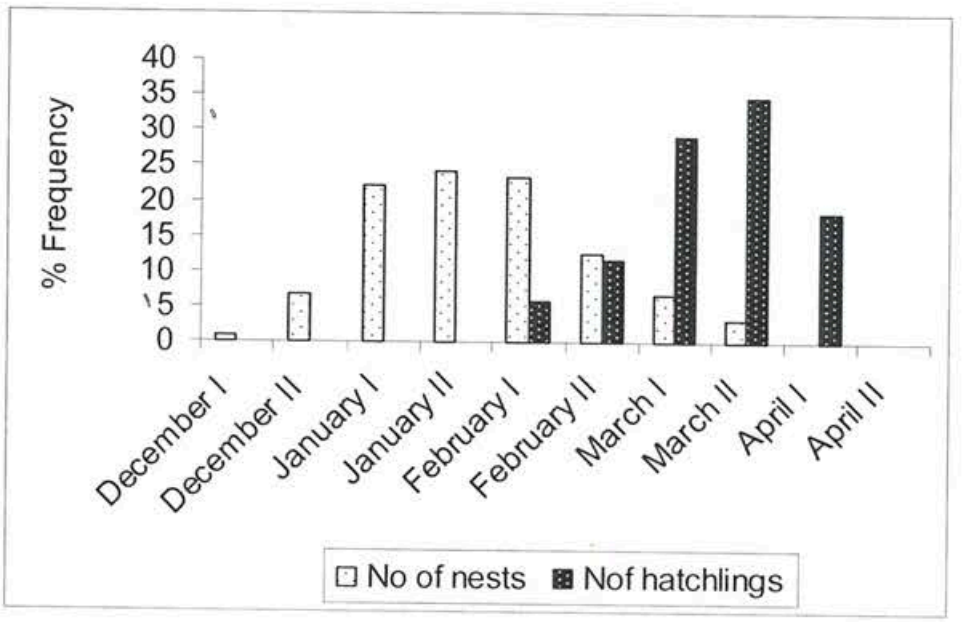
Hatching of Olive Ridleys

During the fortnight surveys, only in 19 instances of hatchings were observed (Table 9). During the sampling, first hatching in the area occurred on February 5th (2009-10 breeding season) and the last observation on April 5, (2007-08). The highest proportion of hatching (emergence of hatchlings from the nests) was observed during March 2nd fortnight followed by March 1st fortnight (Fig. 11). Considerable (15.79%) hatching also occurred during April 2nd fortnight. Overall, comparison nesting and hatching showed that peak nesting in January 2nd fortnight and the hatching during February 2nd fortnight. It showed about 45-55 days could be the incubation period in the given area. However, as exploitation of eggs was rampant, the observed nesting peak could be a distorted one. Also, the sample size with respect to hatching is small. The incubation period may vary depending on the nest substratum temperature as well; higher the temperature results in lower incubation area. Mean ambient temperature of January, February, March and April was recorded as 25.46, 25.86, 27.94, 29.83 ^{0}C respectively.

Table 9. Hatching of Olive Ridley nests during 2004-2010 along the Poompuhar Coast,

Year	Hatching		No. of observation
	First nest	Last nest	
2004-05	February 27	March 22	2
2005-06	March 3	April 1	3
2006-07	March 4	March 13	3
2007-08	February 27	April 5	6
2008-09	March 2	March 12	2
2009-10	February 5	March 28	3
		Total	19

Figure 11. Hatching pattern of Olive Ridley nests during 2004-2010 along the Poompuhar coast.



4.3.3. Nesting Habitat

In all, 104 points were sampled for quantifying availability of beach vegetation, which was done only once (during April 2005). The Tranquebar- Pazhaiyar beach was having a mosaic of open and partially vegetated area. Major shore vegetations of the area were *Spinifex littoreus* and *Ipomoea pescaprae*. Adjoining region of the beach (10-15 m, the distance from Mean High Tide Line) had plantations of *Casuarinas* in large patches. At a few locations, small *Acacia* plantations were also found. *Casuarina and Acacia* plantations are a part of the coastal shelter-belt programmes for protecting the mainland from natural calamities like Tsunami and Cyclones.

Signs of nest predators, such as Jackals *Canis aureus*, Domestic Dogs *Canis familiaris* and Indian Monitor *Varanus benghalensis* inhabiting the *Casuarina* plantations were found. Human settlements, aqua-farms, thermal plants, fish landing yards and agriculture largely affect the area beyond the study area. Major occupation of the inhabitants of these villages was fishing, and their fishing boats were left on the shore. Sand bar without any vegetation was common near river mouth that opened with sea.

Selection of Nesting Sites

As mentioned earlier, the vegetations found along the beach, *Casuarina* sp. (largely *Casuarina equisetifolia*) was very common and it is an exotic species. About 81.85% of the sample points had no vegetation, which included sand spits near river mouth. *Casuarina* was encountered the most followed by *Ipomoea* and *Spinifex* patches shared equally (22.22%) (Table 10). It may be noted that the plantations are just 3-4 years old, could become less conducive for turtles as they become older stocks with high litter fall and intense root system. Considerable proportions of nests were found closer to *Acacia sp.* (9.87%) and *Casuarina* (11.73%) as well. In all, higher proportion (34%) of nests was observed in open areas (i.e. without any vegetation).

Ivlev's Index of Selectivity (I) was used to determine the selectivity of major vegetation by turtles for nesting. This index considers both availability of vegetation and use by turtles for nesting. In all, turtles selected vegetated areas for nesting and open sandy areas were avoided (I= -0.414). Even though higher number of nests was found in open areas (use), when standardised using the availability, the negative value indicated avoidance of open areas. The index showed that highest preference was shown towards *Ipomoea pescapre* patches (I= 0.69) followed by *Spinifex* patches (0.66). Nests were also found under (shade) of *Acacia* sp distributed sporadically in the area (Table 10). Among the vegetation, *Casuarina* patches was least selected by turtles (I= 0.22).

The results show that plantations of *Casuarina* are not going to help the nesting turtles in long run. Selection of nest sites in shade and open locations would change the thermal profile of the nest, which would help in maintaining balanced sex ratio in the population. These results show that turtles do not choose the nesting sites randomly but prefer with respect to vegetation.

Table 10. Nest site preference by Olive Ridley to ground vegetation along the Poompuhar Coast.

Vegetation types	Proportion of Availability (A)	Proportion of Utilization (U)	Ivlev's Preference Index (I)*
Casuarina sp.	7.48	11.73	0.221
Acacia sp.	2.06	9.877	0.654
Ipomoea pescaprae	4.08	22.22	0.690
Spinifex and other grass species	4.53	22.22	0.661
Open	81.845	33.951	-0.414

* Ivlev (1961)

4.3.4 Factors Affecting the Nesting

Geophysical factors (distance from River mouth, High Tide Line and Village) Physico-chemical parameters (grain size, chemical parameters, etc) were considered with location of nests and the relationship.

River mouth

A total of 248 nests were found during six years of this study. Mean nest location with respect to distance to river mouth was 1137.267 m (Stdev 1130.674 Range 25-5000m N=248). In all, 17.7% of nests were found within 300 m from the river mouth. The highest of 77 (31.05) nests were recorded within 300-600 m from the river mouth. Distribution of nests decreased as we move away from river mouth however, higher number of nests was observed within 1500m (23%) category as well (Fig. 12). Overall, the relationship between nest location and distance from river mouth was negative, but it was not statistically significant (Fig. 13).

Figure 14 shows the pattern of nest distribution with respect to distance from river mouth in various years. It is observed that there was no particular pattern observed throughout the study period. In the first year (2004-5), highest proportion of turtles nested closer to the river mouth. In three years (2007-08, 2008-09, 2009-10), highest proportion of nest was found between 300 and 600 m from the river mouth. Number of turtle nest observed during 2005-2006 at various distance classes was nearly equal.

Chi-square test was used to find out, the significance of variation among various years with respect to nest location and distance from river mouth. It is found that the calculated x^2 value (203.45, df = 11, $p<0.001$), higher than the table value. This shows that turtles might nest anywhere does not show any consistent pattern. In other words, the observed value is consistent with the data or effective with river mouth. Anthropogenic activities were high near the river mouth during this study, and this would also have deterred the turtles from using such areas consistently(Plate 9).

Figure 12. Proportion of turtle nests observed in various distance classes fromRiver mouth along the poompuhar coast.

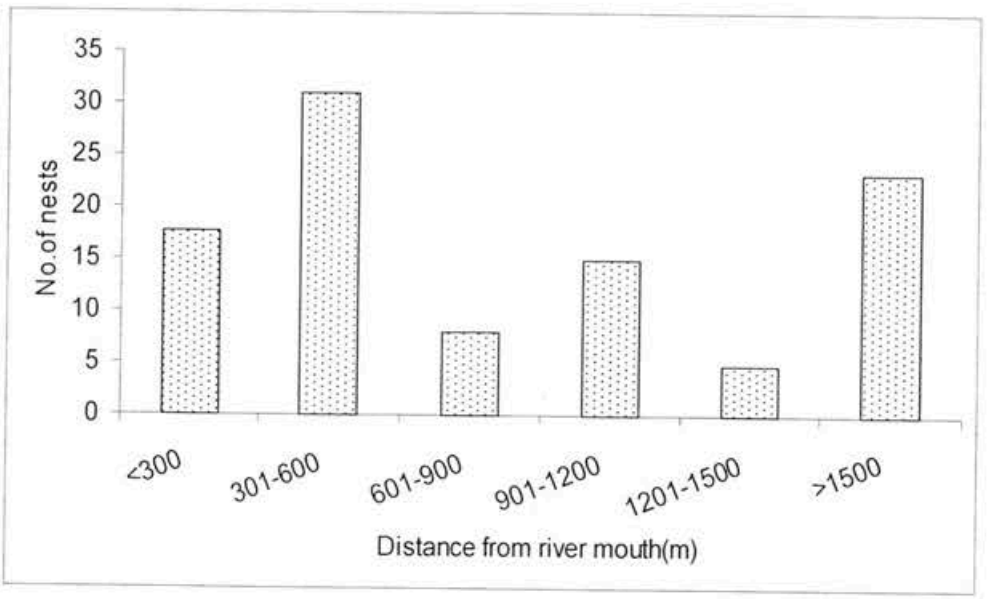


Plate 9. Intense anthropogenic activities in Olive Ridley nesting area.

Parking of fishing gears

Activities in river mouth

Figure 13. Relationship between Olive Ridley nests and distance from River mouth along the Poompuhar Coast.

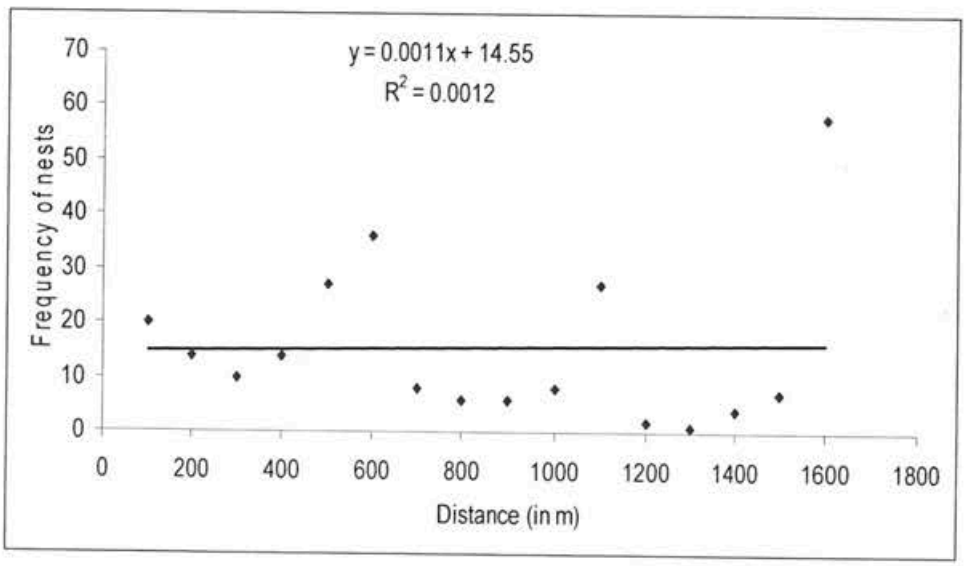
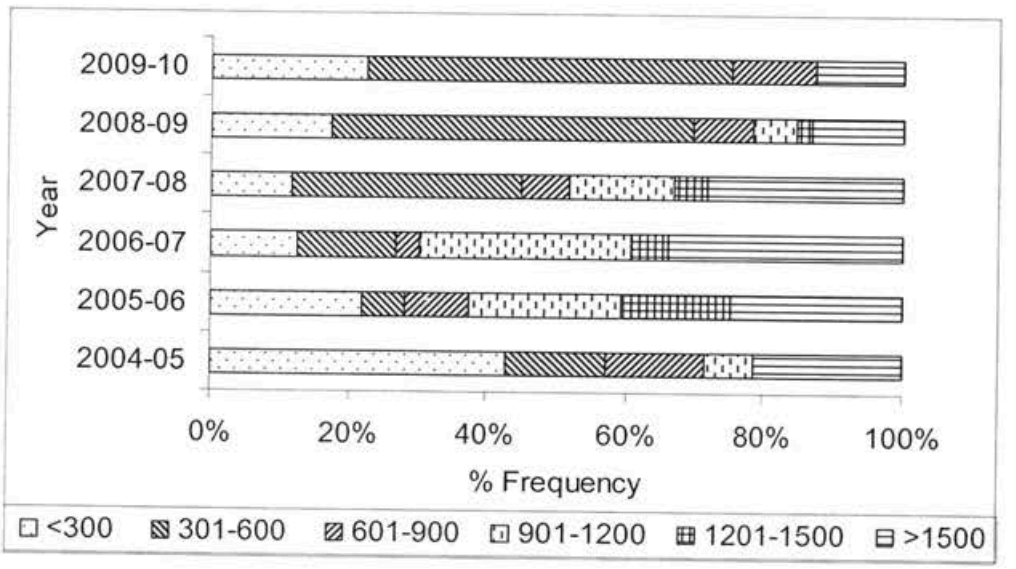


Figure 14. Distribution of turtle nests in various distance categories (m) from River mouth in various years along the Poompuhar Coast,



High Tide Line

The Olive Ridley nests were observed between 3 and 70 m (mean 29.48 ± 14.72 m, n=248) from the High Tide Line (HTL). The highest of 84 (34%) nests was recorded in 5-10 m from the HTL followed by 67 (27.5%) in 10-15 m from the HTL. About 77.7% of the nests were found within 20 m from the HTL. Only 18 (7%) out of 248 nests were found within 5 m from HTL. Number of nests decreased as distance increased from HTL (Fig. 15). Pearson correlation shows a negative correlation between distance from HTL and number of nests($r = -0.681$, $P<0.05$; $d = 11$) i.e. as the distance increased from HTL, the number of nests decreased.

Overall, the general pattern of nesting with respect to HTL was similar (higher nesting in 15-15m) except the year 2004-05. In 2004-05, the nests got distributed in many categories of HTL axis (sea to inland axis), higher nesting was observed in 20-25 and 40-45m (Fig. 16). No nest was found closer to the HTL during the year (2004-05).

Figure 15. Relationship of nests with distance from High Tide Line (in m) along the Poompuhar Coast,

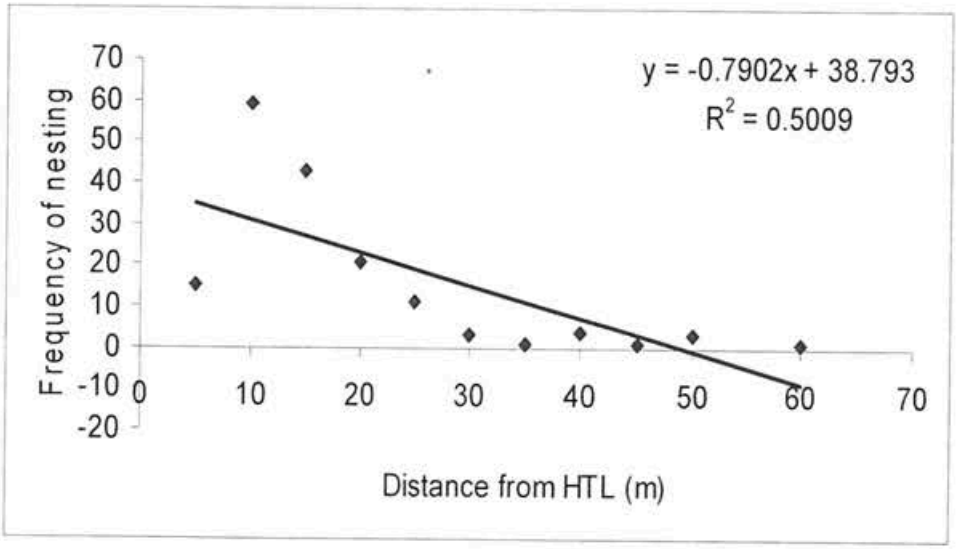
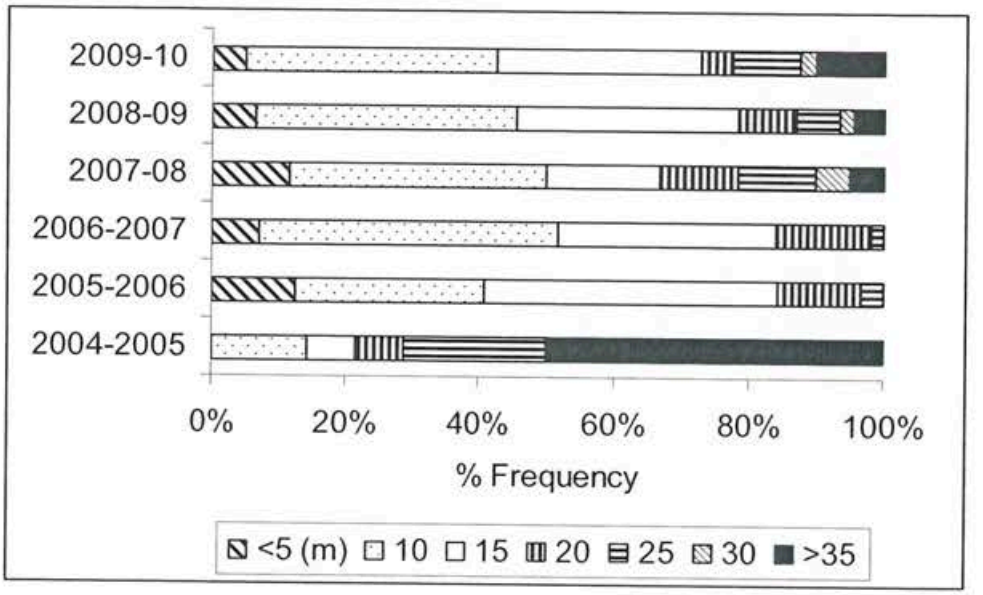


Figure 16. Relative abundance of nests in comparison with distance from High Tide Line (HTL) along the Poompuhar Coast,.



Distance from Village

Turtle nests were observed between 50 and 2060 m (mean 530.17 $\pm$ 597.14 m, n= 248) from the coastal village. The highest of 53 (21.37%) nests was recorded in 600 m from the village followed by 67 (27.5%) in 300 m from the village (Fig. 17). About 86.7% of the nests were found within 1000m m from villages. Pearson correlation shows a negative correlation between number of nests and distance from village ($r= -0.676$, $P<0.01$; $d = 16$); number of nests decreased as distance from villages increased i.e. turtles nested closer to villages (Fig. 18).

In nutshell with respect to geo-morphological and coastal development in the area, the following results were obtained.

(1) About 50% (n=248) of the nests was observed within 600 m from the river mouth.

(2) Higher number of nests (78%) was placed in close vicinity (20 m) to the HTL.

(3) Nests were found in close vicinity to villages, and

(4) *Casuarina* plantations were not selected by Olive Ridleys in the study area.

Figure 17. Proportion of turtle nests observed at various distance classes from villages along the Poompuhar Coast,

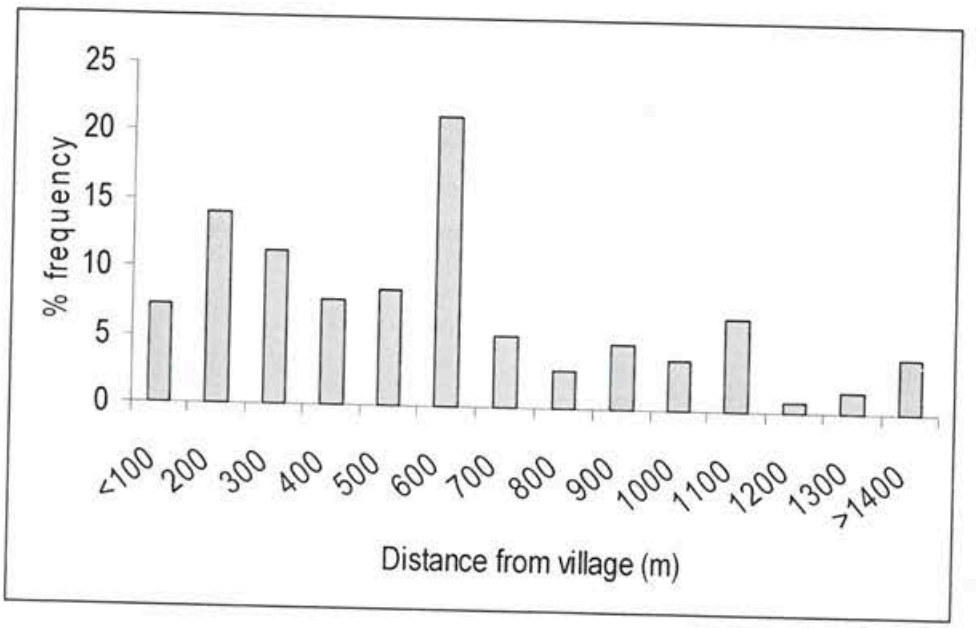
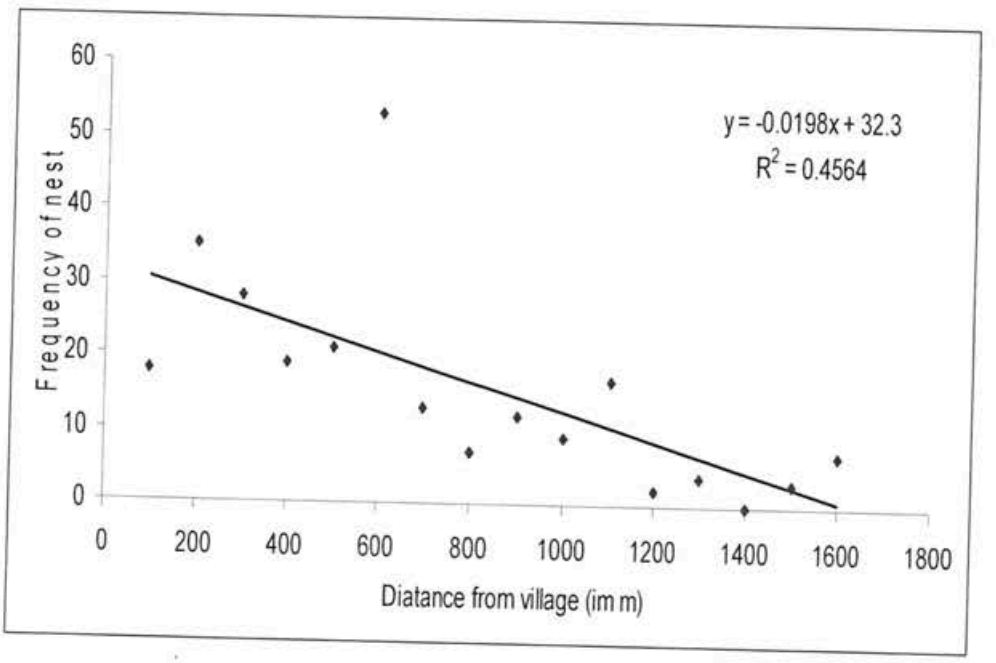


Figure 18. Relationship of nests with distance from villages (in m) along the Poompuhar coast 2004-2011.



4.3.5 Soil parameters

In all, 105 sand samples were collected one at every 500 m along the study area.

Grain Size

Fifteen samples were taken randomly for grain size analysis. The grain size of the sand varied from 105 to 300 microns. The coastal sand collected in non nesting areas had equal contribution of particle size of 105, 180, 250 and 300 microns. In the nesting area, the sand particles were finer; grain size 105 microns contributed the most (42%) followed by 180 microns (22%).

Colour

Sixty samples were randomly selected for analysis with respect to colour of the sand. Three categories of colours (black, very pale brown, light gray) were observed in the samples. Most of the soil (70%) was light gray in the random samples. Samples in turtle nesting areas varied from black to light grey, relatively darker colours (Table 11). Higher proportion of nests was found in area with very pale brown sand.

Table 11. Colour of sand samples collected along the Poompuhar Coast

Colour Category	non-nesting locations	nesting locations
Black	9 (15%)	18 (28.3 %)
Very pale brown	9 (15%)	24 (43.3%)
Light grey	42 (70%)	18 (28.3%)
Number of sample Analysed	60	60

Chemical Parameters

Fifteen samples each from non-nesting areas samples and nesting locations were selected randomly for analyses. Data pertaining to selected chemical parameters of sand sample collected along the Tranquebar- Pazhaiyar coast is given in Table 12. The following are salient results with respect to chemical aspects of the sand of the study area.

- The pH of the soil samples was almost neutral in most of the samples. However, in the turtle nesting areas, the upper limit was higher (8.35). Samples from the turtle nesting sites showed a higher pH compared to the random samples (Table 12).
- The highest mean electrical conductivity (56µmhos) was observed in the samples from turtle nesting locations compared to that from non-nesting sites (17.29µmhos). However, this variation was not statistically significant.
- High levels of Sodium, Potassium and Magnesium were found in samples collected from nesting locations compared to other areas.
- Higher concentration of Calcium was observed in samples from non-nesting compared to the nesting sites, but it was not statistically significant.
- The difference in Potassium and Magnesium concentrations between general locations and samples from turtle nesting sites was statistically significant ($N = 30$, $p < 0.001$).

Table 12. Chemical parameters of the soil samples collected from non-nesting and nesting areas along the Poompuhar coast.

Parameter (unit)	Non-nesting areas SD (range)	Nesting areas SD (range)
pH	7.1±0.44 (6.53-7.78)	7.4±0.36 (6.74-8.35)
Electrical conductivity (µS/cm)	17.29±8.4 (3-33)	56±58.46 (9-151)
Sodium (mg/l)	2.66+3.18 (0-8)	6.21+6.34 (1-17)
Potassium (mg/l)	0.129+0.159 (0-0.6)	0.807+0.651 (0-1.9)
Calcium (mg/l)	8.36+4.86 (3-15)	6.46+4.37 (0.4-16)
Magnesium (mg/l)	5.96+1.54 (3.2-9.2)	7.89+5.19 (3.3-20.6)

4.4 MORTALITY OF TURTLES

The mortality of turtles was assessed based on carcasses of turtles found along the coast during fortnightly surveys during 2004-2010. A total of 317 carcasses (1.036/ km/year) were observed in 51 km of the coastline studied. The lowest of 20 (0.39/km) carcasses and highest of 69 (1.35/ km) were observed during 2004-05 and 2006-07 respectively (Table 13). In six seasons of the study, on an average 52.8 carcasses were observed.

The highest mortality was observed in Poompuhar sector (1.5/ km) and the lowest in Pazhaiyar (0.52/km) (Fig. 19). The pattern of mortality of turtles was almost similar in all sectors. During the study, maximum of 41 carcasses were found along the Poompuhar coast during 2006-07. The Pazhaiyar coast had minimum dead turtles washed ashore during the study.

Turtle carcasses washed ashore was observed from November to April in each year (i.e. in each season breeding season). Higher number of dead turtles was observed during January and February. Relatively, fewer dead turtles were observed during November- December and March-April and May (Fig. 20). Turtle carcasses were observed along the coast from November to April and on the other hand nesting occurred during December to March (Fig. 21). During November and April only carcasses of turtles were recorded i.e. no nesting was observed. Peak nesting and mortality was observed during January.

It may be noted that carcasses of turtles in November is an indication of arrival of the nesting females to the near shore areas. The relationship between turtle mortality and nesting was linear i.e. as mortality and nesting incidences were high (Fig. 22) due to the movement of mating pairs and nesting females get entangled in the gill nets used by the fishermen.

Table 13. Mortality of Olive Ridley along different sectors of the Poompuhar Coast during November 2004- April 2010.

Year	Tranquebar Sector-I	Poompuhar Sector-II	Pazhaiyar Sector-III	Total
2004-05	10	6	4	20 (0.39%)
2005-06	14	24	7	45 (0.88%)
2006-07	21	41	7	69 (1.35%)
2007-08	17	34	10	61 (1.20%)
2008-09	21	28	9	58 (1.14%)
2009-10	22	29	13	64 (1.25%)
Total	105 (1.03)	162 (1.50)	50 (0.52)	317(1.04%)
Coastal line in km	17	18	16	51

Number in parenthesis indicates number of carcasses of Olive Ridley/ km.

Figure 19. Mortality of Olive Ridley along different sectors of the Poompuhar Coast, during 2004- 2010.

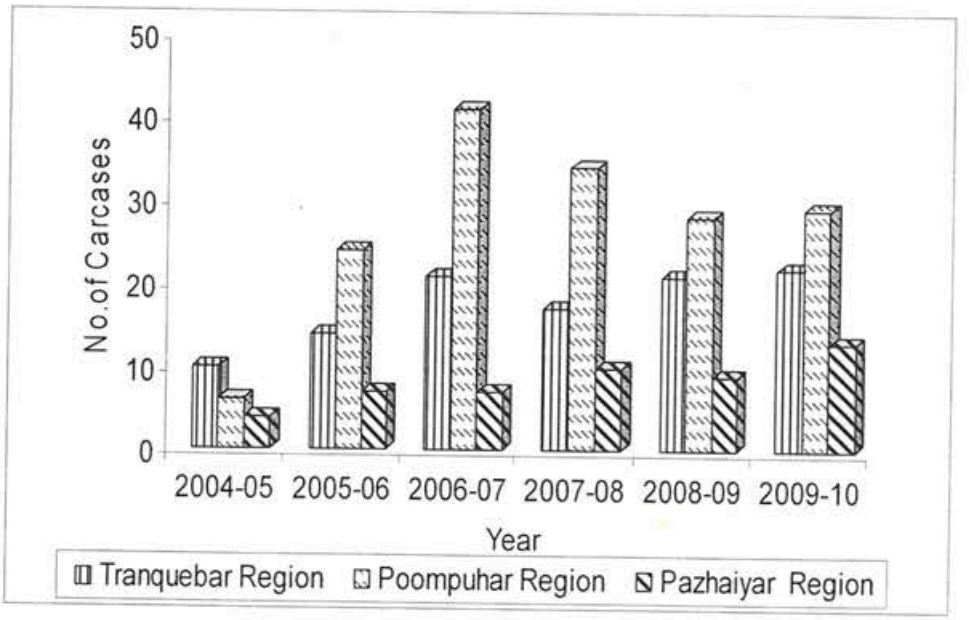


Figure 20. Mortality of Olive Ridleys during different months of the breeding season along the Poompuhar Coast during 2004- 2010.

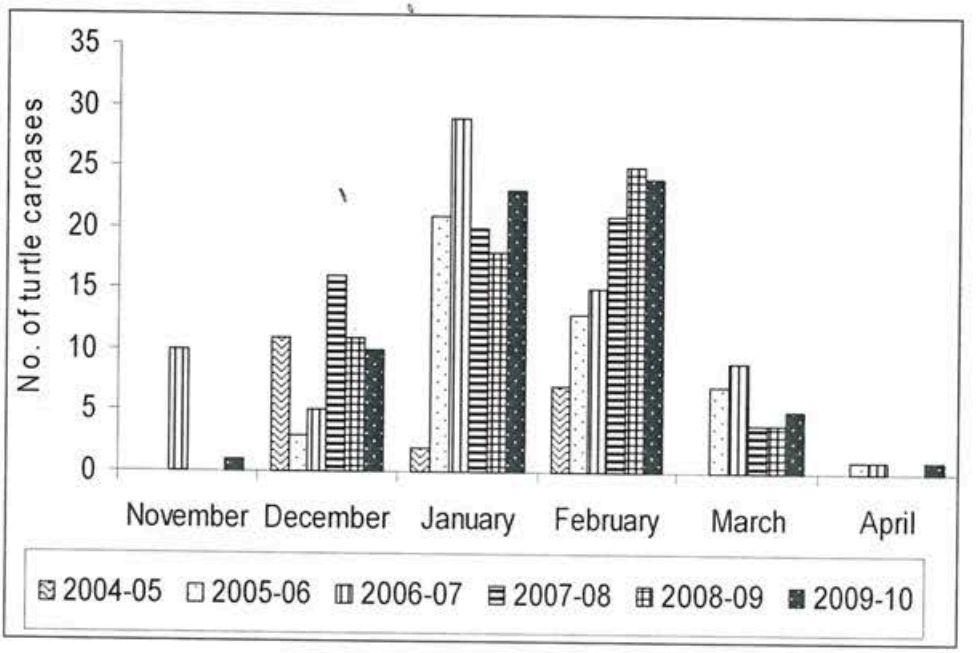


Figure 21. Nesting and mortality of Olive Ridleys in different months of the breeding season along the Poompuhar Coast, Bay of Bengal.

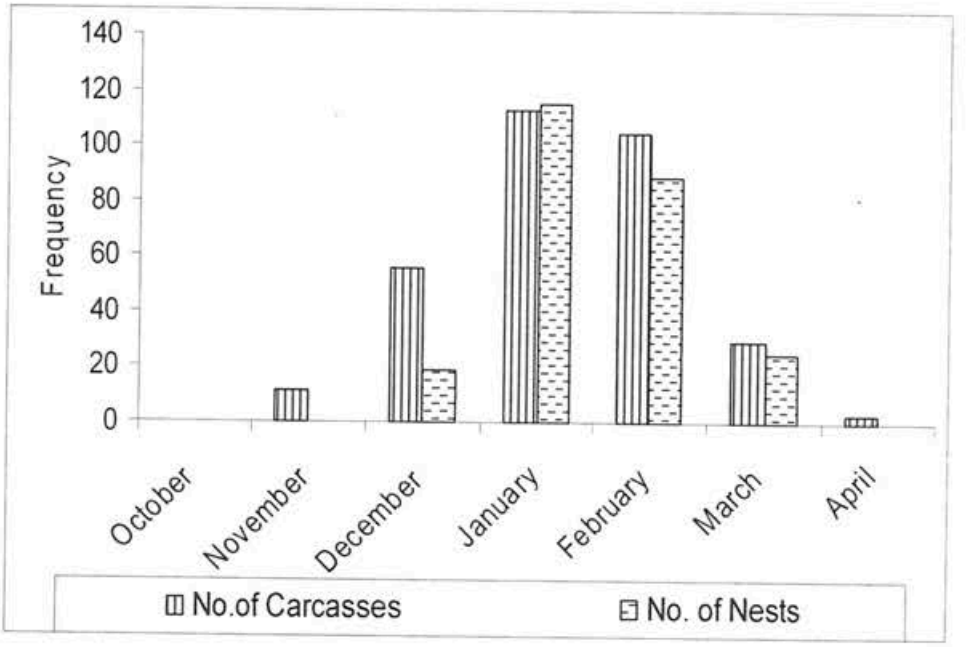
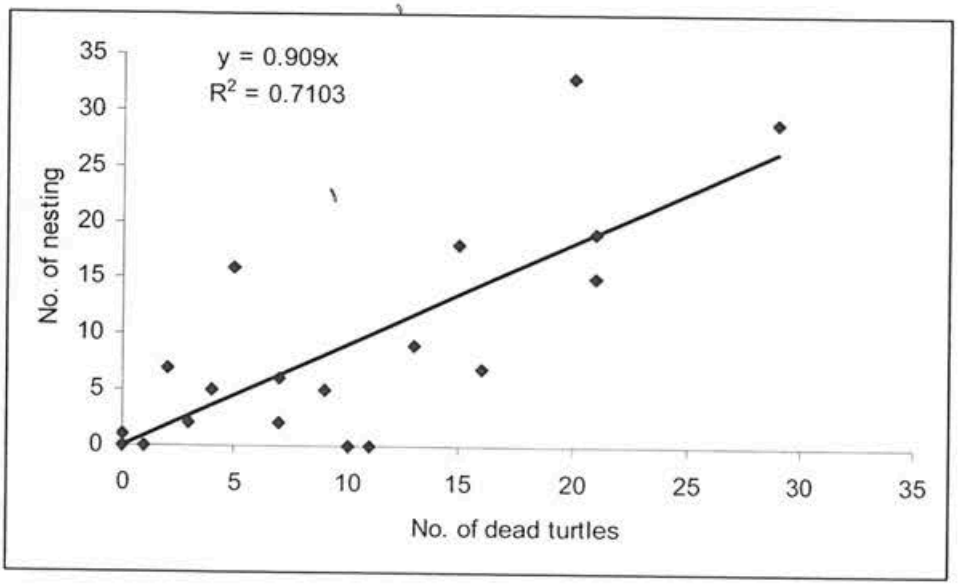


Figure 22. Relationship between nesting frequency and mortality of Olive Ridleys along the Poompuhar Coast during 2004- 2010.



Of the 317 carcasses of Olive ridleys observed during this study, only 65(20.5%) of them were without external injuries (Fig. 23). The remaining (79.5%) had injuries in various parts. Flipper injuries (fully severed flippers) were the most common followed by carcasses with head injuries (33.12%; cut, etc). Locals use gill nets for fishing in the region. Fishermen set their net in the shallow waters during previous evening and examine the same during the subsequent morning. It appears that turtles die due to suffocation or the fishermen cut the flippers or head to remove them from the net. As per the fishermen, removing the live turtle is Herculean task, and hence they go for cutting the flippers or head. It is not clear, if the turtles with no external injuries died due to suffocation or natural causes. It is felt that many carcasses were washed ashore after several days of death and many of them were found in decomposed state.

In all, 22 coastal villages were found (within 1 km) from the High Tide Line, which is about 0.42 villages or around 4 villages for every 10 km coastline.

People inhabiting these villages largely depend on sea for their livelihood. Total human population of these villages is 48430, fishing is their main occupation.

Three types of fishing vessels were used by fishermen in the area; Mechanized (local made) boat, Mechanized fibre boat and Catamarans (the local traditional vessel, primitive one). During this study, 2479 fishing vessel were found parked on the shore. Mechanized fibre boat dominated in number, while the mechanized (traditional boat) and Catamaran contributed almost equal. This works out to be about 112.68 vessels/ village or 48.61 vessels/ km (Table 14). Locals use gill nests for fishing and trawler fishing is rare in the area. Occasionally a few trawlers traversed the area from Pazhaiyar or Nagapattinam. The highest number of fishing vessels (138/ km) was observed Pazhaiyar and the lowest (90.13/km) Poompuhar sector (Fig. 24). However, the highest number of dead turtles was observed in Tranquebar (105/ 15 km) and the lowest in Pazhaiyar sector (28/12 km). Stranding of carcasses could be due to direction of current and offshore movement of larger vessels such as ships.

Figure 23. Injuries found on the stranded carcasses of the Olive Ridleys along the Poompuhar Coast during 2004-2010.

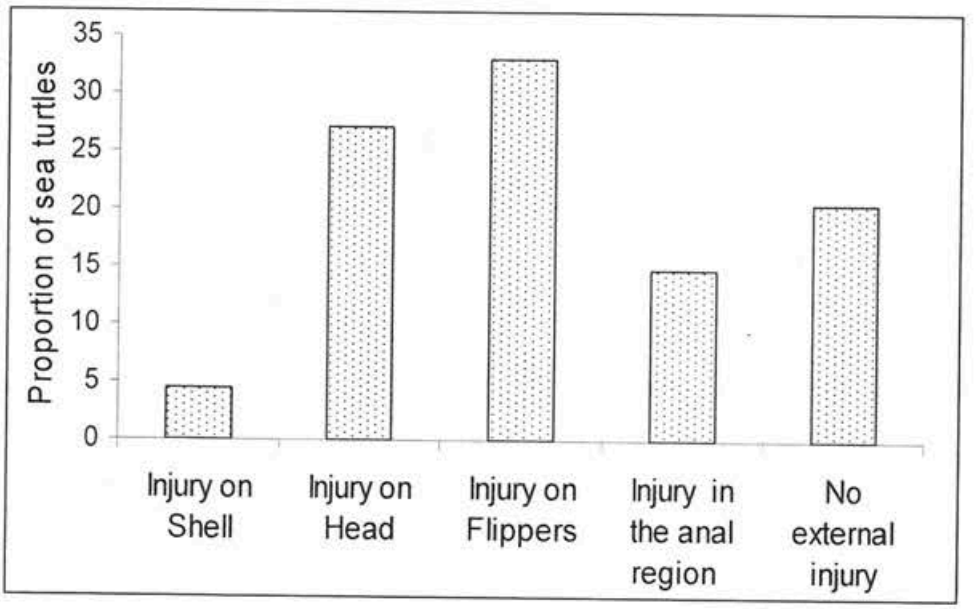
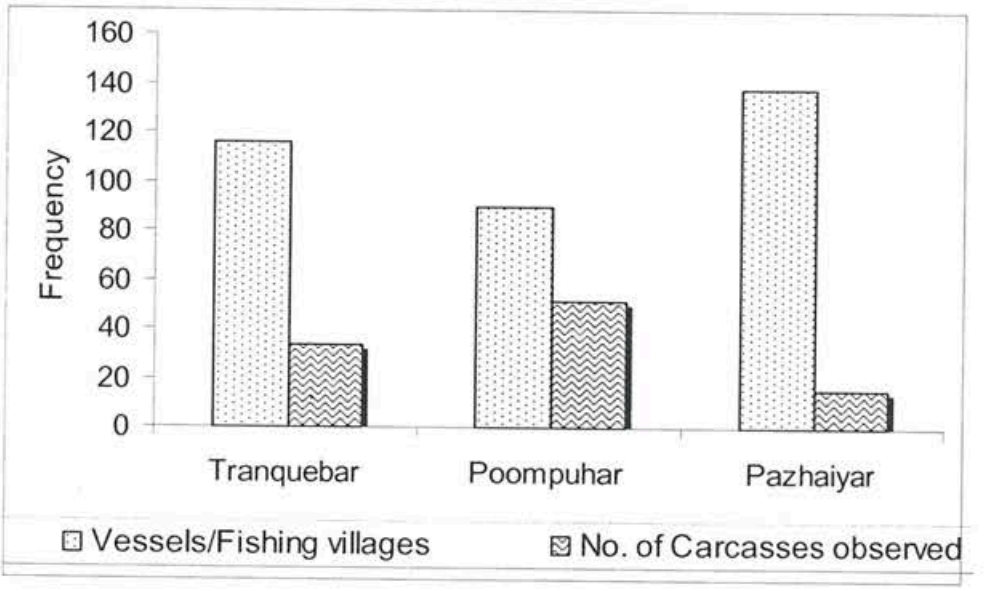


Table 14. Statistics of fishing villages and vessels used along the Poompuhar Coast 2004-2100; (Number in parenthesis is %)

Description	Tranquebar Sector-1	PoompuharSector-2	PazhaiyarSector-3	Total
Mechanized boat	146	91	245	482(19)
Mechanized fibre boat	596	487	462	1545(63)
Catamarans	188	143	121	452(18)
Fishing villages	8	8	6	22
Vessels/Fishing village	116.25	90.13	138	112.68

Figure 24 Frequency of fishing vessels and number of carcasses of Olive ridleys found along the Poompuhar Coast during 2004-2010.



4.5 SIZE STRUCTURE

Data on size structure of a species may provide information its population status. Sampling of all size class categories in the wild, especially those dwelling in sea is difficult. The size structure of turtles presented is based on carcasses washed ashore during 2004-10 (6 seasons). In all, 317 carcasses were observed, among them, 259 were intact. Mean Curved Carapace Length (CCL) of 259 turtle measured 61.32± 10.79 cm, and the shell length ranged from 25 to 79cm (Table 15). The lowest (mean) CCL was recorded during 2009-10 (mean 53.3 ± 10.74, n=40) and the highest during 2006-07 (mean 69.52 ± 3.58, n=54). In recent years (2008-09, 2009-10), the standard deviation was relatively higher (STD ±10) than other years (2004-05, 2006-07, 2007-08). Smaller i.e. juvenile and immature turtles were frequently seen during later years. Mean carapace length of the dead turtles showed some what decreasing trend (Fig. 25).

Sex could be identified based on length of the tail. Turtles with tail protruding out of shell were considered as males. This was observed in all carcasses with CCL of 55 cm and above. Hence, carcasses with CCL above 55 cm were considered for analysis. Mean Curved Carapace Length (CCL) of 82 males turtles measured 65.92± 5.04cm, and the maximum shell length was 76cm. Mean Curved Carapace Length (CCL) of 127 females measured 66.65± 5.47 cm, and the maximum shell length was 79cm. Overall, females were relatively larger than males. Higher Standard deviation in the case of females (± 5.47 cm) compared to males (± 5.47 cm) showed that females size is relatively variable. The sex ratio of 209 Olive Ridleys with over 55 cm in CCL was used for analysis. The population was dominated by females in number (sex ratio 1: 1.55).

The relationship of the Curved Carapace Length and Curved Carapace Width of turtle, overall, all male and all females have linear relationship (Fig. 26 and Fig. 27a & b). Almost near linear relationship was observed when the entire sample was pooled and analyzed, and the same is confirmed by high correlation as well ($r= 0.99$; $P<0.001$, $n=258$).

Table 15. Mean Curved Carapace Length (CCL) of Olive Ridleys recorded along Poompuhar Coast during 2004-2010.

Year	Sample	Mean CCL	STD	Range
2000-01*	199	68.70	2.5	50-77
2004-05	14	66.14	5.52	56-73
2005-06	45	55.34	9.55	25-72
2006-07	54	69.52	3.58	59-79
2007-08	60	68.37	5.31	42.3-75
2008-09	46	53.80	10.71	34-70
2009-10	40	53.3	10.74	25-70
Overall	259	61.32	10.79	25-79

* Source: Bhupathy & Karunakaran (2003)

Figure 25. Mean Curved Carapace Length (CCL) of Olive Ridleys recorded along the Poompuhar Coast during 2004-2010.

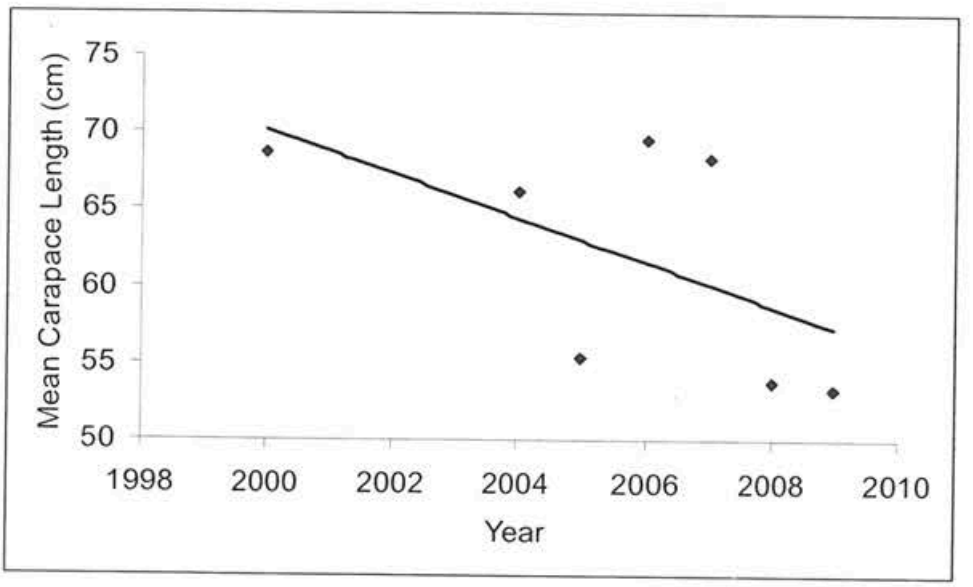
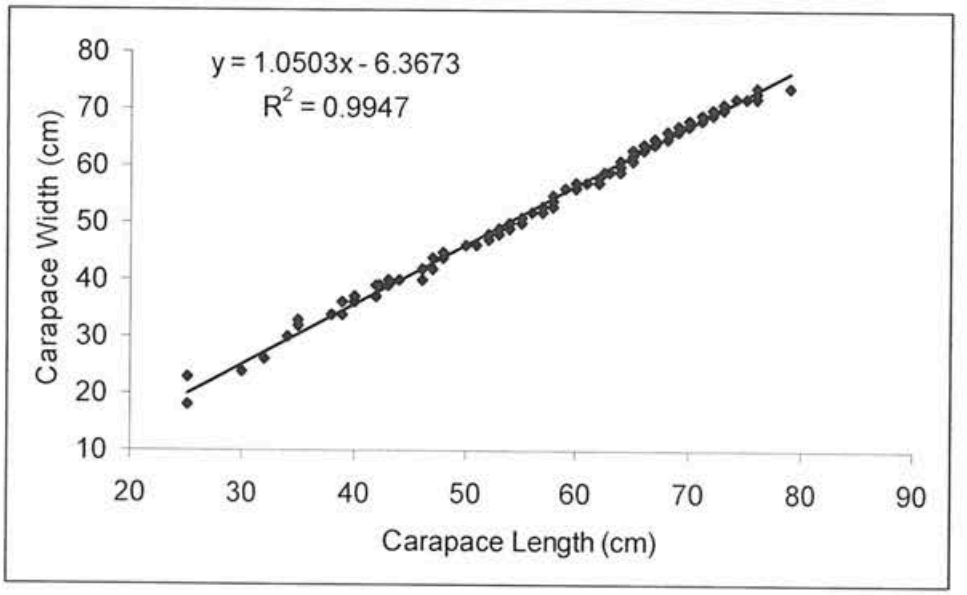


Figure 26. Relationship between Curved Carapace Length and width of the carcasses stranded along the Poompuhar Coast during 2004-10.

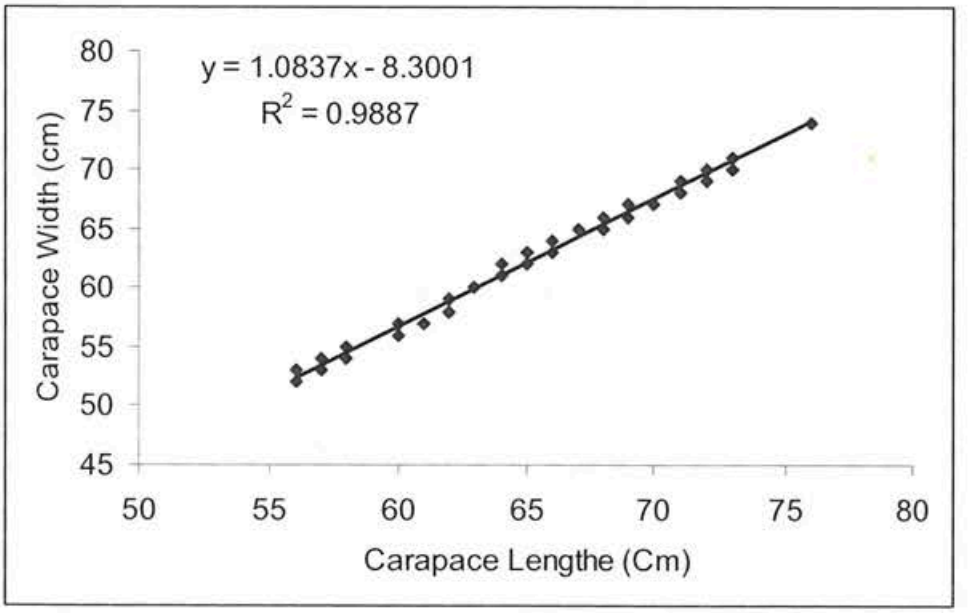


The size structure of stranded Olive Ridleys along the coast is given in Fig. 28. It showed unimodel right skewed pattern with low proportion of turtles on both right and left. The highest proportion of turtles stranded belonged to CCL 60-70 cm category. In all, about 62% of turtles belonged to CCL above 60 cm and the rest measured below 60 cm in CCL. According to the literature, Olive Ridleys mature when they are around 60 cm in carapace length. Turtles having CCL lower than 25 cm was absent in the sample. The result shows that the turtle population in the present area is largely comprised of adults; older turtles and juveniles are poorly represented.

The following observations are noteworthy with respect to size structure: (1) carcasses of smaller turtles were not represented in 2004-05 (2) all size class turtles were represented during 2005-06 (3) only two size class categories were represented during 2006-07 and (4) considerable proportion of smaller size class turtles represented during 2008-09 and 2009-10 (Fig. 29).

Figure 27. Relationship between Curved Carapace Length and width of the stranded turtle carcasses (a – male and b- female) along the Poompuhar Coast, during 2004-2010.

a-male



b- Female

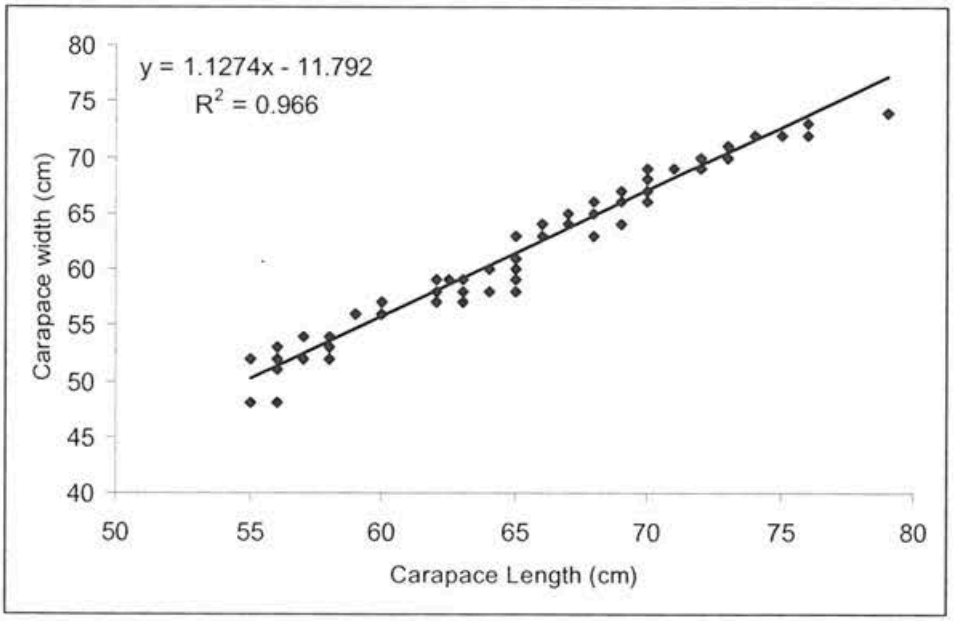


Figure 28. Size structure (curved carapace length) of Olive Ridleys (n=259) as revealed from the carcasses found along the Poompuhar Coast during 2004-2010.

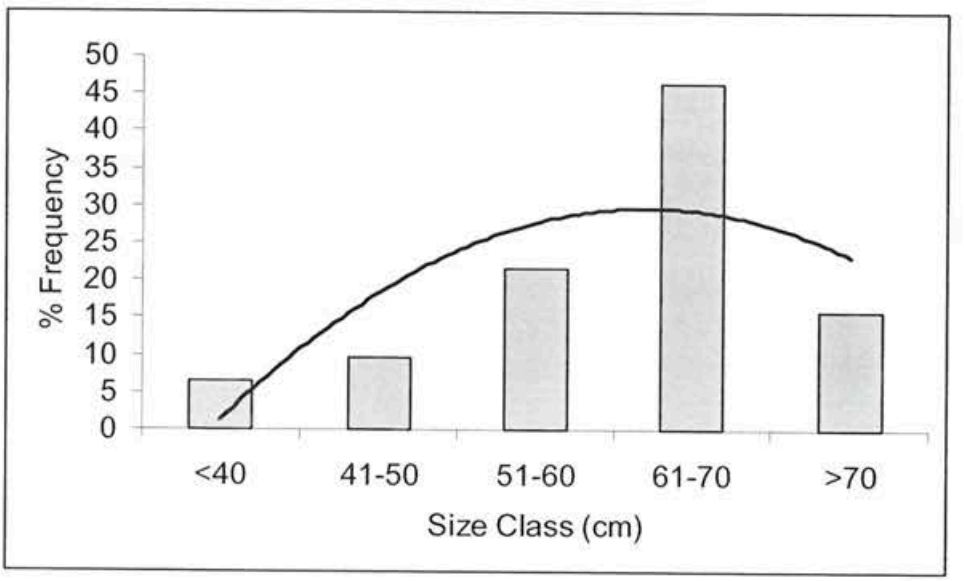
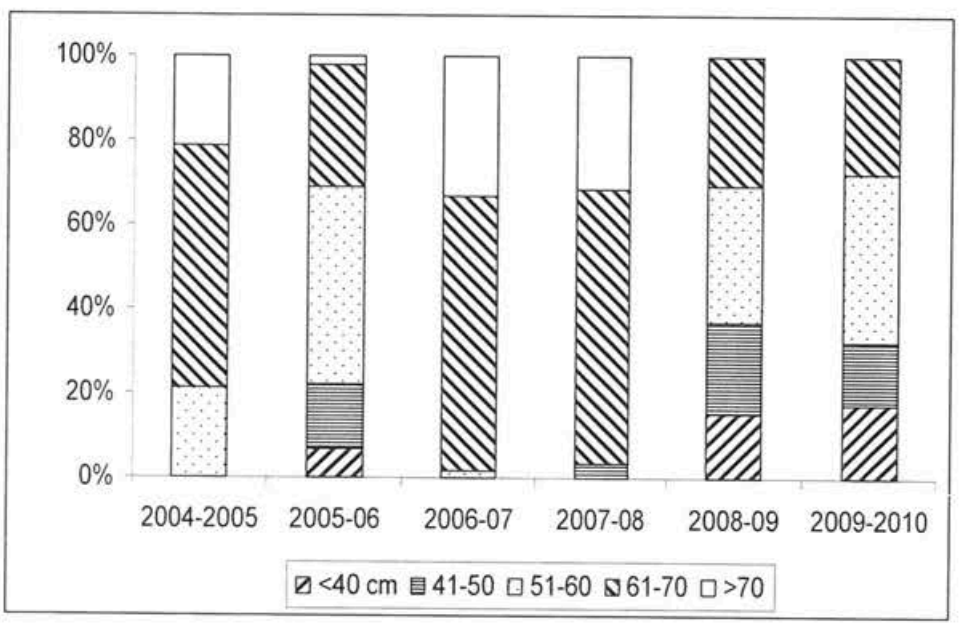


Figure 29. Representation of Olive Ridleys in various size classes during various years of study along the Poompuhar Coast during 2004-2010.



DISCUSSION

CHAPTER 5
DISCUSSION

5.1. STATUS OF THE COAST

Nagapattinam district is one of the 13 maritime districts of Tamil Nadu and most of the coastline of this district, including the intensive study area, Poompuhar (i.e. Tranquebar- Pazhaiyar) was reported to be suitable for Turtle nesting (Bhupathy and Karunakaran, 2003). The present study augments the above report i.e. 82.35% of the coast is suitable for nesting. Absence of rocky out crops along the shoreline also supports this view. The study area also has second highest sandy beaches (by proportion) along the entire Tamil Nadu coast, the first being Tuticorin – Mandapam with 89.5%.(Bhupathy and Saravanan, 2006).

The coastal areas of India was stuck by tsunami in the morning of 26th December 2004 which was triggered by a subduction of the Indian plate causing a massive earthquake of magnitude >9.0 led to the displacement of huge quantum of ocean water which resulted in giant waves. Severe damage has been reported on mangroves, coral reefs, coastal wetlands, sand dunes, animal and plant biodiversity and groundwater (Kumaraperuma *et al.*, 2007). Inundation of seawater due to tsunami caused severe damage to agricultural lands in Nagapattinam and Cuddalore districts of Tamil Nadu, soils of the coastal belt turned saline along with contaminated groundwater. Since then a number of activities have been undertaken along the coast to rectify the damaged soil, especially due to inundation (Rengalakshimi *et al.*, 2007).

Several development projects were initiated subsequent to tsunami, which include new thermal power plants and aqua-farms (Table 2). Signs of beach erosions were found in two locations during the beginning of this study (2004), which increased to 20 within 5-6 years. The beach erosion is controlled by beach armouring with concrete slabs and stones. This would affect the sea turtle nesting. Sea (wall) armour affecting sea turtle nesting in Kerala along the

west coast of India has already been reported (Kar and Bhaskar, 1982). Several fold increase in new fish landing centres (small jetties) within 5-6 years and increase in number of fishing vessels (fibre boat, mechanised boat) has been noted. These landing centres are connected by beach (*kaccha*) roads, which increased from 2 to 16. Movement of several four wheelers with heavy load on the sandy beach would affect the nests due to compaction of the sand. In turn, the compaction would lead to the destruction of nests i.e. eggs and hatchlings found in subsoil.

Number of fishing vessels has increased from 71.6 vessels/ village (Bhupathy and Karunakaran, 2003) to 112.68 vessels/ village. This would increase the incidental mortality of marine turtles. Number of vessels parked on the shore of each village was higher than officially permitted to use in fishing. For instance, as per an earlier study, 2110 fishing vessels were parked along the shore in 11 villages, but official permission was given only 1278 vessels to these villages (Bhupathy and Saravanan, 2006). This should be controlled; number of vessels operating in the area would directly affect the marine turtles. Local and global decline of marine turtles due to increase in fishing gears have already been reported (Limpus, 1995; Pandav, 2000).

New thermal power plants launched along the Poompuhar coast, require more raw materials (coal) and the same are being imported. The quantum (number) of fishing gears is also increasing in the area, which would lead to oil spills and pollution. The threats of risk oil spill and problems to turtles are described in Hall *et al.,* (1983) and Lutcavage *et al.,* (1997).

The Government of Tamil Nadu (TN Forest Department) initiated several coastal shield/ belt programmes with exotic *Casuarina equisetifolia*. The area occupied by these plantations has also increased from 2 to 20 patches during 2005 – 2010 covering almost entire coastline. Chaudhari *et al.,* (2009) noted a number of problems due to Casuarina to Olive Ridley nesting along the east coast. Bhalla (2007) reports several environmental problems with respect coastal belt plantations, and is not sure on the efficacy of these plantations in controlling natural calamities. Safe distance of about 50 to 100 m should be

given from High Tide Line for turtle nesting (Chaudhari *et al.,* 2009; see below in Habitat section).

Unplanned developments in the area lead to several problems

- Pollution of the marine ecosystem
- Increased mortality of marine turtles
- Compaction of sandy nesting beaches of turtles
- Beach erosion and beach armouring, and
- Reduction of nesting habitat due coastal/shelter belt programmes.

It is suggested comprehensive assessment on the carrying capacity of the area should be done at the earliest; unplanned development would lead to disasters including decrease in economy and productivity and decline or disappearance of species locally. Awareness programmes involving all stakeholders (government and non-government sectors, villagers, educational instates) must be planned at the earliest. This may partly help in revival and sustaining the damaged environment.

5.2 TURTLE FAUNA

The Indian Black Turtle *Melanochelys trijuga* and Indian Flapshell Turtle *Lissemys punctata* has wide distribution in Peninsular India (Das, 1995). The Asian Giant Turtle *Pelochelys cantorii* is a rare species and very few recent records area available on its occurrence in recent years (Das, 1995). Five species of Marine turtles have been reported along the Indian coast (Bhaskar, 1984; Shanker and Choudhury, 2006). Two species of marine turtles, Olive Ridley and Green Turtle have been reported along the Nagapattinam coast earlier (Bhupathy and Karunakaran, 2003; Bhupathy and Saravanan, 2006). Record of Leatherback *Dermochelys coriacea* during this study is note worthy as only few records are available along the coastal mainland of India (Das, 1995). As four species of threatened turtles (Asian Giant Turtle, Leatherback, Green Turtle and Olive Ridley) listed in Schedule I of the Indian Wildlife Protection Act 1972 (Anon, 2004) are found in the coastal belt of Poompuhar (Tranquebar- Pazhaiyar) region is important for turtle conservation in the country.

As in the present study, the predominance of Olive Ridleys along the Poompuhar- Pazhaiyar coast has already been reported by Bhupathy & Saravanan (2003). Similar pattern has been observed along the entire east coast (Chennai coast- Bhupathy *et al.,* 2007; Andhra coast- Tripathy *et al.,* 2003b). The data indicate that Hawksbill, Green Turtle and Leatherback are rare along the Tranquebar- Pazhaiyar coast. Barring Gulf of Mannar, Bay of Bengal, Tamil Nadu, records of Green Turtle and Leatherback are scanty along the east coast of India. All Green Turtles and one Leatherback recorded during the present study were juveniles, which indicate, the potential of this area as an intermediate development ground for these species. The known development ground (nursery for juvenile) marine turtle species along the main land India is Gulf of Mannar (Ahastheesapillai and Thiagarajan, 1979; Bhupathy and Saravanan, 2006).

Species composition of marine turtles of this study area is similar to that of east coast i. e. Chennai (Bhupathy *et al.,* 2007), Andhra coast (Tripathy *et al.,* 2006), Orissa and West Bengal coast (Dash and Kar, 1990; Chowdhury *et al.,* 2006), where Olive Ridley dominated in number. However, the faunal composition in the Gulf area is different, where Green Turtles dominated in number i.e. in Gulf of Mannar (Kuriyan, 1950; Ahastheesapillai and Thiagarajan, 1979). However, it is reported that the Green Turtle number on decline in Gulf of Mannar in recent years due to over-exploitation (Bhupathy and Saravanan, 2006). The composition of turtle fauna of an area depends on its geographical location and habitat. Gulfs with coral reefs and sea grass are reportedly suitable for several species, especially the Green Turtles (Ahastheesapillai and Thiagarajan, 1979). The present study area is not a gulf and does not support coral or sea grass; hence, it largely supported Olive Ridleys.

5.3 NESTING OF OLIVE RIDLEYS

5.3.1 Offshore Activity

The present study shows that turtles hardly congregate in the offshore area during breeding seasons, which is in contrast to the observations around mass nesting areas such as Gahirmata, Orissa (Pandav, 2000). Most of the Olive Ridleys was observed during December- March, and arrival of adults to the

offshore prior to nesting (October- December) may be due to reproductive activities such as courtship and mating in close vicinity to the nesting ground. Similar pattern was observed along the Orissa coast by Pandav (2000).

Pandav (2000) reported that mating pairs were observed within 5 km from the nesting beaches. However, in the present study, turtles were observed between 2 and 18 km. Even though turtles arrive at the same period to the offshore areas of the mass and sporadic nesting areas (Pandav, 2000; Pandav and choudhury, 2000; Present study), the aggregation pattern of turtles is different in these areas i.e. congregation in mass nesting area within 5 km from beach, on the other hand, few turtles spread in 2-18 km offshore areas in sporadic nesting area (present study). Turtles were observed in 5-10 km offshore along the Vizhagapattanam coast (Tripathy *et al.,* 2003a) and arrival of turtles was observed during November itself, which is almost similar to the present study. Turtles were observed in almost all months of the year. This could be due to the location of this study area i.e. on the migratory route of Olive Ridleys between Gulf of Mannar, Tamil Nadu and Sri Lanka and mass nesting area, along the Orissa coast. The activity/ behaviour pattern of turtles varied in mass nesting area and sporadic nesting area, and hence, conservation plans/ strategies should closely view these issues.

5.3.2 Nesting

Nesting Season

Based on dead turtles found on the shore, pattern and size of the flipper mark, and direct sightings of turtle nesting, it was presumed that only Olive Ridleys nested along this area. Past studies along the east coast shows that Olive Ridleys dominate in number (Tripathy *et al.,* 2003a; Shanker and Choudhury, 2006). Along the Poompuhar coast (the present study area), Olive Ridleys nested from December to March every year, which is similar to the earlier report by Bhupathy and Karunakaran (2003) in the same area. Nesting period (January –March) along the present study area is similar to other parts of the east coast of India, including the mass nesting areas in Orissa (Pandav *et al.,* 1997; Banugopan and Davidar, 1999; Pandav, 2000; Bhupathy and Saravanan, 2002; Chowdhury *et al.,* 2006). However, the nesting season is different from

that reported from the west coast of India i.e. August- January in Gujarat (Sunderraj *et al.*, 2006) and October- November in Kerala (Kar and Bhaskar, 1982). It appears that major nesting season of turtles of an area depends on rainfall pattern. Major turtle nesting season on the west coast is after Southwest monsoon (June- August) and it is after Northeast monsoon (September-November) in the East coast.

There were some differences in emergence of turtles to the shore among four years studied (2004-2008). For incidence, during 2004-05, the nesting got delayed by almost one month. It was in the first fortnight of January in 2004-05, but the emergence of turtles occurred during December I or II fortnights in the subsequent years (2005-06, 2006-07 & 2007-08). One possible reason for delayed nesting could be due to the Tsunami of December 26, 2004 that affected the area. Turtles would have sensed the Tsunami well in advance and avoided the nesting to protect the nest from inundation. It is also possible that the females were affected by the current or tsunami waves and would have stranded. Some information on the quantum and direction of sediment transportation along the Nagapattinam coast, Bay of Bengal is available (Kumar *et al.*, 2002).

Progressively advancing nesting emergence was observed over the years (2004 to 2008, i.e. January I, December II and December I fortnights). It is not clear, if happened due to climate change or advancement of breeding cycles and so on. Nesting of turtles occurred relatively higher number of days in all years except Tsunami year (2004-05). Changes in nesting pattern could be due to factors such as lunar cycle and rainfall pattern in the area (Law *et al.*, 2010).

Nesting Intensity

Minimum (14) number of nests was observed during the fortnightly samples in 2004-10 and maximum (60) during 2007-08. Number of nests increased till 2004-2008, but decreased since 2008 (14, 32, 56, 60, 46, 40). Wide inter-annual variation in nesting number was observed along the Chennai coast (Shanker, 2003). According to this author, distance surveyed in various surveys could be one of reasons for this observed fluctuation. The estimated number of

nests varied between 221 and 945 during 2004-2008, which is 4.25 nests/ km and 18.17nests/ km respectively. An estimated 10.8 nests/ km was recorded along the Chennai coast during January- March 2004 by Bhupathy *et al.*, (2007) and 20 nests/ km along the Nagapattinam coast, the same general locality of the present study (Bhupathy and Karunakaran, 2003). The shores of Visakapattinam, (northern) Andhra Pradesh had a density of 100-nests/ km/ season and about 15-20 nests in the southern parts of the state (Tripathy *et al.*, 2003a).

In India, only along the Orissa coast mass nesting of turtles has been reported and in other areas including Tamil Nadu coast sporadic nesting of Olive Ridley has been reported (Kar and Bhaskar 1982; Shanker *et al.*, 2003). It is reported that south of Orissa coast, number of nests get reduced (Tripathy *et al.*, 2003a). During the present study, the lowest of 14 nests were recorded during 2004-05 nesting season. This could be due to Tsunami that hit the shore on 26th December 2004, which is just prior to the nesting season of Olive Ridleys. The impact of Tsunami or natural calamities on the nesting of marine turtles is not understood.

Along the Nagapattinam coast, an estimated 20 nests/ km have been reported by Bhupathy and Karunakaran (2003), which is closer to the estimation (18.7 nests/ km) of the present study. An estimated 10.8 nests/ km were recorded along the Chennai coast during January- March 2004 by Bhupathy *et al.*, (2007). Kar and Bhaskar (1982) estimated 100 nests/ km along the southern Chennai coast during early eighties. Drastic reduction of nests within two decades was reported in the area, and this reduction was attributed to incidental mortality of a large number of adult turtles in fishing gears. Decline of Ridley populations worldwide have been largely attributed to incidental mortality (Limpus, 1995; Renaud *et al.*, 1997; Hays *et al.*, 2003a; Shanker *et al.*, 2003). Incidental capture in trawl and gill nets is a major cause of sea turtle mortality on the east coast of India (Rajagoplan *et al.*, 2001). This study also revealed high levels of fishery related mortality along the Nagapattinam coast.

Nest Predation

In the present study, about 82% of the nests were depredated; 73% by human and 9% by animals. Jackals and Domestic dogs depredating on the eggs of Olive Ridley have already been reported along several parts of Indian coasts (Das and Kar 1990; Das, 1995; (Bhupathy and Karunakaran, 2003); Bhupathy and Saravanan, 2006; Sunderraj *et al.,* 2006). Higher proportion (95.5%) of nest being stolen by people has already been reported along the Nagapattinam coast (Bhupathy and Karunakaran, 2003). Of the 36 nests observed along the south Chennai (Mamallapuram) coast, 25 (69.4%) were found depredated (Bhupathy *et al.,* 2007). Among the depredated nests, based on signs found nearby, Jackals and Domestic Dogs contributed 54.2% and 33.3%, respectively, and human about 12.5% of the nests pilfered eggs. Native communities such as Irulas consume turtle eggs occasionally. Sunderraj *et al.,* (2006) reported that 62% of Olive Ridley nests were depredated; 43.45% animals and 18.45% by Human. In Sunderban Biosphere Reserve (SBR), about 50.6% nests laid were depredated, all by animals (Chowdhury *et al.,* 2006). Economic importance of turtles, eggs and shell is rated high in Malaysia (de Silva, 1982). Exploitation of turtle eggs has been reported from various parts of Olive Ridley distribution (de Silva, 1982; Kar and Bhaskar, 1982; Frazier, 1982).

Predation of nests by people may depend up on the location of the area, socio-economic and cultural aspect of community of an area. For instance, in Sunderban Biosphere Reserve, where no human settlement was present, 50% of nests laid were depredated by only wild animals (Chowdhury *et al.,* 2006). In place, like Gujarat, most of the people are vegetarian in food habit. On the other hand, inhabitants along the south Chennai coasts belong to *Irula* community (native people) consume several animal products, and this could be one of the reasons for low consumption of turtle eggs in the area. People dwelling along the Poompuhar region belong to several communities, and a few from each village depend on turtle eggs for their subsistence. As higher depredation of nests has consistently been reported along the Nagapattinam coast i.e. 95% during 2000 (Bhupathy and Karunakaran, 2003) and 82% during the present study (2004-2010), involving local communities in turtle conservation is

important. Simple incentive plan and alternative livelihood options involving persons in collecting eggs would yield desired results.

It is found that turtle eggs were sold at local markets to a maximum of Rs 3/ egg. About 80% of the nest got depredated largely by people. An estimated (maximum) 1000 nests per season may be found in the area, considering an average of 100 eggs per clutch, a budget of Rs. 3.0 lakhs may be required for protection. A captive breeding programme involving locals (egg collectors) as suggested by Bhupathy and Saravanan (2001) is required. Annual commitment of about Rs. 5 lakhs for marine turtle research including hiring locals would help long-term survival of Olive Ridleys in the area.

The present study revealed that adult turtles were not consumed by people in the study area. Marine turtles are consumed by the locals of southeast Tamil Nadu and Sri Lanka (Kurien, 1950; Agastheesapillai and Thiagarajan, 1979). When turtles get entangle in the net, the fishermen of the present study area do some *puja* and leave the dead turtles in the sea. Local enquiries also revealed that even the poachers leave few eggs in the nests while egg collection for long term conservation and sustenance of the species. These local religious sentiments have some potentials/ relevance for the conservation of turtles in the area.

Hatching

During the sampling, first hatching in the area occurred on February 5th (2009-10 breeding season) and the last observation on April 5, (2007-08). The highest proportion of hatching (emergence of hatchlings from the nests) was observed during March 2nd fortnight followed by March 1st fortnight. Information on the hatching of Olive Ridley nests in the sporadic nesting areas (in natural condition) is not available. This small sample size showed that there is no synchronised hatching occurred in sporadic nesting area as that of mass nesting area (Pandav, 2000). Considerable hatchings were observed from 2nd February to April 1st fortnight. Nests are placed in the far apart in sporadic nesting areas and hence, synchronised hatching may not be functionally very useful. It is reported that synchronised hatching is useful to dampen the

predators (Eckrich and Owens, 1995), thus indicating predator satiation in the evolution of nesting behaviour of this species.

Incubation period for Olive Ridley nests in the present study area is unknown. It appears that the hatching of the nests (incubation) spread over two months in the present study area. Incubation period of reptiles may depend on local climate (rainfall, humidity and temperature and water condition of the nest substrate, (Hays *et al.,* 2001; 2003b; Margaritoulis 2005; Miller 1997; Valverde *et al.,* 2010). It is reported that sea turtles have Temperature-dependent Sex Determination (TSD), where the nest temperature determines the sex of the offspring (McCoy,1983; Morreale, *et al.,* 1982; Mrosovsky and Godfrey, 1995; Miller, 1997). Wider hatching and emergence period might ensure a balance sex ratio in the population. This type of adaptability would help avoiding adverse effects such as potential ill effect of global warming as inundation of certain portion of coast areas is predicted.

5.3.3 Nesting Habitat

Natural vegetation of the study area is largely psammophytes, which are similar to other parts of the east coast including the Chennai coast (Pandav *et al.,* 1997; Bhupathy *et al.,* 2007). The role of beach vegetations in nest site selection by turtles is unclear, but views on the same are contradictory (Mortimer, 1995). Even though highest area was covered by open sand, the same was not preferred by the turtles. On the contrary, the *Ipomoea pescaprae* patches were few and the same was effectively used for nesting (highest Selectivity Index (I) = 0.69). Bhupathy *et al* (2007) speculated that this species may help binding the sand and prevent collapse of nests while under construction. Turtle nesting near *Ipomoea* sp has already been reported in *Sangam* literature (Sanjeevaraj, 1958). The Selectivity Index showed that turtles did not select open areas as well, as open areas has obtained only minimum Index (0.22). Olive Ridleys avoided areas with *Casuarina equisetifolia* plantation as indicated by negative Selectivity Index (I= -0.411).

Pandav *et al.,* (2006) reported that *Casuarina* plantations have adversely affected nesting beaches along the entire coast of India. After that tsunami 2004, *Casuarina* has been planted extensively on the beach front to act as a barrier and shelter belt from cyclones and soil erosion (Chaudhari *et al.,* 2009). These plantations encroach upon the nesting beaches, because once *Casuarina* grows, it changes the beach topography by its root growth and deposition of litter, thereby restricting the area available to sea turtles for nesting. This adversely affects both sea turtle nesting and hatching. Although most of the nesting habitat at the Pazhaiyar region is now lost due to such plantations, sea turtles were observed nesting among recently planted and extended *Casuarina* at the Pazhaiyar and also near the Tranquebar region. These plantations also provide cover/ shelter to animals such as Jackals which feed on sea turtle eggs. On the positive side, a mixed age plantation of *Casuarina equisetifolia* is reported as effective light barrier that prevented disorientation of hatchlings (Karnad, 2008). However, it is suggested that plantations, if required, should be raised leaving a safe distance from the High Tide Line. Further studies are required in this regard.

5.3.4 Factors Affecting the Nesting

In the present study, the distribution of nests at various distance classes from the river mouth did not vary much. This is contradictory to the observations of Bhupathy *et al.,* (2007) along the Chennai coast, where positive correlation was observed, i.e. many nests were found closer to the river mouth. There is also a popular belief that Olive Ridleys nests closer to the river mouth. Tripathy *et al.*, (2006) also reported that the beaches adjacent to river mouths are preferred nesting habitats for olive ridleys. This could be due to the presence organic food source, sediment deposits, salinity and other physiographic features such as grain size , moisture content and chemical nature of the sand would also be deterministic in this regard (Wood and Bjorndal, 2000; Bhupathy *et al.,* 2007).

Two reasons may be attributed to this observed variation in the present study.
(1) The Poompuhar coast (Tranquebar- Pazhaiyar coast) is located between two estuarine habitats namely the Pichavaram mangroves and the Greater Vedaranyam swamp with several distributaries of River Cauvery. The tide

influence in the region and greater soil humidity would have made the turtles to nest away from the river mouth. Moisture content is reported as one of the potential factors in nest site selection by turtles (Wood and Bjorndal, 2000). This would perhaps help protecting nests from potential inundation.

(2) The other reason is disturbance in the river mouth during night, the nesting time of Olive Ridleys. Execution of several development projects, new thermal power projects, bridges and coastal roads could be reasons for the same. (i) Thermal projects require coal, are imported and transported through ships, and the same is down loaded using smaller vessels, which use jetties located near river mouth. Down loading of coal was largely done during night. (ii) Bridges were formed during the study across the distributaries near mouth. These activities were undertaken during night to avoid traffic congestion.

About 85% of the nests were found within 20 meter from the High Tide Line (HTL). Number of nests decreased with increasing distance from HTL. However, the pattern was different during 2004-2005, i.e. nests got distributed in many categories of HTL axis. The present observation is similar to the findings of a study on marine turtles along the Chennai Coast (Bhupathy *et al.,* 2007). Selection of nest sites close to high tide line would have greater chance of inundation, but farther inland would result in higher predation of hatchlings during their emergence and movement towards the sea (Mortimer, 1982; Chaudhari *et al.,* 2009). Apart from this, sites further inland from the high tide line may be dry and this condition would lead to desiccation of eggs and poor hatching.

In the present study, turtle nests were observed between 50 and 2060 m and Pearson correlation showed a negative correlation between number of nests and distance from village ($r= -0.676$, $P<0.01$; $df= 16$) i.e. number of nests decreased as distance from villages increased. The results show that (1) Most of the coastal villages in the area are located in good turtle nesting habitat (2) Several of them are underdeveloped i.e. without much development such as artificial light and (3) Turtles have adaptability or tolerance to the presence of Human.

Hirth and Carr (1970) and Hirth (1971) reported that the percentage of the grain size of the nesting medium varies from one nesting shore to another. Mortimer (1981) has stated that that grain size was not of over-riding importance to a turtle in choice of nesting beach. The present study augmented the above observation as both random sites and turtles nesting sites had almost similar grain size profiles. However, it appeared that turtles used marginally finer sand for nesting along the Nagapattinam coast.

The present result showed that colour of the sand from non-nesting (random) and turtle nesting areas varied, but was not significant, which is in consistent with previous reports (Stancyk and Ross, 1978). Use of finer and darker coloured sand for nesting by Olive Ridleys was observed in the present study. This could help absorbing heat from the environment and higher incubation temperature may be maintained in the nest. Nesting in substratum with various colours would help maintaining various incubation temperatures. However, this area needs further investigations.

The nests were present in more alkaline areas. This shows that pollution in the coastal area would alter the pH of the sand, which would affect the nesting in a long run. Stancyk and Ross (1978) reported that the EC of the soil does not influence the turtle in choosing nesting sites which is contrary to the result of the present study, where the mean EC was higher than the random sites. It is reported that clutch survival is negatively correlated with electrical conductivity (Mortimer, 1990). The impact of physico-chemical parameters is not consistent. Tidal influx, rain and discharge of freshwater by rivers such as Coleroon, Cauvery and their distributaries found in the study area would affect the Physico-chemical parameters of the sand of the shoreline. Variations in the levels of physicochemical parameters between random sites and turtle nesting sites could be due to the selection of sites by turtles near river mouths (Bhupathy *et al.,* 2007). Factors other tan the physiognomy of sand on nesting beaches may be an important, or more, in nest site selection (Mortimer, 1990). Further study including heavy metal and other parameters may through pertinent information on the nutrient dynamics in the coastal area.

The selection of a nest site by the female is based on several physical and chemical factors, such as sand grain size, dune configuration, compressibility of beach sand and smell; thermal variation in beach sand may also be an important environmental cue for nest site selection (Stoneburner and Richardson, 1981). Nest success is believed to be influenced by a number of interacting ecological factors such as sand temperature, sand grain size, water content and salinity (Mortimer, 1980; Horrocks and Scott, 1991; Sivasundar and Devi Prasad, 1996; Bhupathy *et al.,* 2007). For sea turtles, the survival of offspring may be strongly related to the distance at which the nest is laid from the sea, and from the supra littoral vegetation behind the beach (Mrosovsky, 1983). For nests laid too near the sea, there is a risk of egg loss due to erosion and mortality due to salt water inundation; for nests laid too far from the sea, there is a risk of disorientation of hatchlings into supra littoral vegetation. Sand texture and moisture must be such that females are able to dig an egg chamber without the walls of the chamber collapsing, and the hatchlings must be able to dig their way out of the nest (Mortimer, 1980).

5. 4 MORTALITY OF TURTLES

A total of 317 carcasses (1 turtle/ km/ season) were observed in 51 km of the present study area. Along the Chennai coast, 134 carcasses in 50 km (2.68/ km) were recorded during January-March 2004 (Bhupathy *et al.,* 2007). According to Pandav and Choudhury (2000), in six years (1993-1999) a total of 46,219 dead olive ridleys were counted during the periodic surveys in Orissa in 282 km coast line. This is about 27.3 dead turtles/ km/ season. Orissa coast harbours over 1.5 lakhs nests in a breeding season and proportionately has higher number of turtles (males and females) in the offshore areas. Tripathy *et al.,* (2003a) recorded 806 dead Olive Ridleys along Andhra Pradesh coast during November 2000 to April 2001. Significant relationship between mortality (number of turtles died) and nesting was found during this study. This indicates mortality is due to activity related to breeding. Similar pattern of nesting and mortality was reported from coastal parts of Orissa and Andhra Pradesh (Pandav, 2000; Tripathy *et al.,* 2003b)

In the present study, no relation was found between number of fishing vessels in a sector and corresponding mortality there i.e. the highest number of fishing vessels (138/ km) was observed Pazhaiyar, but the lowest number of dead turtles was observed in that sector. Stranding of carcasses could be due to direction of current and offshore movement of larger vessels such as ships. There are many factors that bias this index such as wind and ocean currents. Juvenile and adult turtles have a specific gravity greater than seawater and both adjust their buoyancy by inflating their lungs (Milsom, 1975). Consequently the dead turtles sink to the bottom and as a result of decomposition the animals eventually bloat and float to the surface only to sink again later. Thus probability of stranding at any given location on the beach is largely dependent on the near bottom current field (Epperly *et al.,* 1996). Based on studies along the Virginia, North Carolina and Gulf of Mexico coasts, it has been estimated that the number of dead turtles that have been washed ashore represented a maximum of 7–13% of the total mortality (Epperly *et al.,* 1996). Studies suggest that the number of dead turtles washed ashore represent a minimum estimate of mortality (Hillestead *et al.*, 1978; Murphy and Hopkins-Murphy, 1989). This indicates that carcasses found on the beaches are only a fraction of the number of turtles that died in high seas.

The highest number of fishing gears found in a sector did not correspond with higher number of stranding of carcasses. The Pazhaiyar region had highest number of fishing vessels, but had lowest number stranded carcasses. Pazhaiyar is the northern most point of the area and Poompuhar and Tranquebar are located southwards. According to Kumar *et al.,* (2002) sediment transportation in the region has north to south direction at $0.098X10^6$ m^3 per year. Hence it appears water current play a role in the drifting of carcasses along Tranquebar- Pazhaiyar area.

During the present study (in 6 years), the lowest of (20) turtles died during 2004-05 and highest (69) in 2006-07. As in the present study, Inter- annual variation in the mortality of turtles was also recorded by Pandav and Choudhury (2000) along the Orissa coast. On 26th December 2004, this coast was severely

affected by Tsunami and subsequent to this, fishermen did not venture into sea for fishing for more about one year or so. Hence, human induced mortality of Olive Ridley was low during 2004-05.

One of the major reasons for mortality of marine turtles in parts of the world is due to fishery related activities (Hillestad *et al.,* 1982; Robins, 1995). Fisheries related turtle mortality has also been reported for India as well (Silas *et al.,* 1983; Rajagopalan *et al.,* 2006). Number of fishing vessels operational in the area was 2479 i.e. 111.68 vessels/ village or 47.7 vessels/ km. During 2000, in the same area, 39 fishing vessels/ km were reported by Bhupathy and Karunakaran (2003). Almost 7% increase in the number of fishing vessels within 5-7 years, which is a matter of concern. During the present study (2004-10), the mortality of turtles was about 1 turtle/ km/ season, which was about 4-carcasses/ km during 2000-01 in the same study area (Bhupathy and Karunakaran, 2003). It is not clear, if this reduction is due to continuous death of adult turtles over the period and depletion. The mortality rate for adult females has increased over the past ten years causing a decrease in the number of nesting females as reported in South America (Spotila *et al.,* 1996). Coastal gillnet fisheries and shrimp trawling do occur in the coastal area and could be contributory to mortality (Chevalier *et al.,* 1999; Chevalier and Girondot , 2000).

Fortnightly surveys revealed that turtle carcasses were observed along the coast from November. This indicates the arrival of turtles near shore couple of months in advance, prior to peak nesting season (i.e. January- February). Peak nesting and mortality in the same period could be due to extensive movement of turtles during the period. It appears that due to the movement of mating pairs and nesting females get entangled in the gill nets used by the fishermen. Similar pattern of turtle mortality and nesting has been reported along the Chennai and Nagapattinam coast (Bhupathy & Karunakaran, 2003; Bhupathy *et al.,* 2007). The pattern of mortality of marine turtles along this area is similar to that reported from other areas of east coast (Orissa - Pandav and Choudhury 2000; Andhra Pradesh - Tripathy *et al.,* 2003a).

Of the 317 carcasses of Olive Ridleys recorded during 2004-2010, only 20.5% had no external injury marks. The remaining (79.5%) had injuries on flipper, head injuries. Locals use gill nets for fishing in the region. Fishermen set their net in the shallow waters during previous evening and examine the same during the subsequent morning. Turtles were active in the region i.e. for courtship; mate selection and mating get entangled in the nets. It appears that turtles die due to suffocation or the fishermen cut the flippers or head to remove them from the net. As per the fishermen, removing the live turtle is Herculean task, and hence they go for cutting the flippers or head. It is not clear, if the turtles with no external injuries died due to suffocation or natural causes. It is felt that many carcasses were washed ashore after several days of death and many of them were found in decomposed state. A study conducted during 2000-01 along this coastline had reported a similar result (70%, n=94; Bhupathy and Karunakaran, 2003).

5.5 SIZE CLASS

Mean Curved Carapace Length (CCL) of 259 turtle in the present study area measured 61.32± 10.79 cm, and the shell length ranged from 25 to 79 cm. Pandav and Choudhury (2003) reported that mean CCL of 2781 Olive Ridleys measured 66.5 62.9 (range= 49 to 79.4 cm) for Orissa coast. Similarly, along the Andhra coast, CCL of the stranded turtles measured as male 65.5 cm (n=41) and females 64.5 cm (n=35) and the carcasses ranged from 42.2 to 75.4 cm (Tripathy *et al.*, 2003a). Bhupathy and Saravanan (2006) reported CCL of 99 Olive Ridleys as 65.3 ± 6.5 cm (range 46 -74.5 cm). Mean CCL of Olive Ridleys studied in other countries also provided similar results; Oxaca, Mexico: in 62.9 (Range 52.5 – 73 cm, = 1,203; Sinaloa 62.2 (55 – 69; n= 190 (Marquez *et al.*, 1976) and Nancite, Costa Rica 63.6 (n=942; Cornelius and Robinson, 1985).

Pritchard (1969) reported that based on a sample of 120 females measured at Shell Beach (Guyana), Biji Santi (Surinam) and Eilanti (Surinam) the range of carapace length was from 66.0 to 72.12 cm. Zwingberg (1977) found the average carapace length of mature females from the beaches of Eilanti, Surinam to be 68.5 cm with a range of 63 to 75cm. Hasbun and Vasquez (1999)

quoted that the nesting olive ridleys in Santiago beach was having a mean carapace length of 68.9cm (range 60-85 cm, SD=4.52). It seems that there is some geographical difference in the size as opined out by Pritchard (1969) that the average size of olive ridleys was slightly larger in the Indian Ocean than elsewhere. Regression equations showed that relationship between carapace length and width followed a linear pattern with respect to overall population as well as sex. This relation is the most common pattern observed in many vertebrates.

The sex ratio of the dead turtles washed ashore in the present study was 1: 1.55 (male: female). Pandav and Choudhury (2003) reported, with a similar ratio (36.5% males to 55.6% females; 1: 1.52) for Gahirmatha coast, Bay of Bengal. Earlier studies in Andhra reported 26.5% males (1: 2.77; Tripathy *et al.,* 2003b) for this species. Female biased sex ratio has been reported in most species of marine turtles (Owens, 1997).

Juvenile and immature turtles were frequently seen in the study area during later years. It may be possible that the Poompuhar coast is could become a potential development (nursery) ground for Olive Ridleys, Green Turtles and Leatherback as juveniles of these species were observed during this study. The nearest nursery ground for marine turtles is Gulf of Mannar (Agastheesapillai and Thiagarajan, 1976). Data from 2000-01 in this area showed that mean carapace length of the dead turtles showed some what decreasing trend. The decrease in size may be related to the death of many adults as reported by Shanker *et al.,* (2003). Reduction in the female size in areas with over exploitation or hunting has been reported for several species of turtles (Shanker *et al.,* 2003; Munera *et al.,* 2004; Daza and Paes, 2007). Thus the Olive Ridley population is threatened and may decline drastically, if the present pressures (due to fisheries and development activities) continue. Hence, a careful monitoring and assessment of the development of the area is critical for long-term sustenance.

The present study shows that Tranquebar to Pazhaiyar, southeastern coast of Tamil Nadu is an important nesting area in Tamil Nadu. Awareness programme on the importance of the area with respect to marine life including turtles should be undertaken focusing various stakeholders. Methods of handling entangled turtles in the net must be demonstrated periodically or rescue teams should be formed and made operational in the area. The effectiveness of coastal plantations as barrier for cyclone/ storms and their impact on marine organisms should be studied. An integrated Coastal Conservation and Management Plan including various stakeholders such as Government and Non-Government Organisations, experts and people is required to ensure the long-term survival of Olive Ridleys along the Tranquebar- Pazhaiyar coast.

CONSERVATION OF OLIVE RIDLEYS

CHAPTER 6

CONSERVATION OF OLIVE RIDLEYS

The following are major conservation problems and suggestions with respect to Olive Ridleys along the Poompuhar coast, Bay of Bengal, Tamil Nadu.

6.1. CONTROL OF DISTURBANCE

The present study area, Tranquebar to Pazhaiyar coast (51 km) is predominantly sandy, and hence is suitable for turtle nesting. Co-incidentally, Tranquebar, Poompuhar and several other locations along the coast are tourist spots as well. Hence activities of tourists and people in the shore would compact the soil and may affect the nests and emerging hatchlings. Hence, activity of tourists in the beach should be restricted during nesting periods from January to April.

Only at two locations, beach was found eroded prior to 2004, but it was in 20 locations in 2010. This could be due to intense on and offshore activities in the area. Hence, beach armouring is being done in several places with stone pavements to protect properties. This would seriously affect the nesting of Olive Ridleys as nesting habitats are lost for once for all. Development activities such as land development; constructions such as resorts, bridges, thermal plants, fish preservation plants, pump houses and aqua-farms are rampant in recent years. All these would affect the local ecology.

Increased oil spills from transport containers (ships) and fishing gears and pollution from nearby urban areas and thermal projects would be detrimental to sea turtles. Aspects of sea turtle ecology should be taken into account while preparing development plans along the coastal belt. One of the simplest ways to conserve sea turtles could be done proposing Community Conservation Reserves (CCR) involving locals and officials. The local committee would monitor the development projects in the area.

6.2. REALIGNMENT OF COASTAL BELT PLANTATIONS

Subsequent to Tsunami of December 26, 2004, the coastal shelter belt (tree plantation) programmes were initiated in several locations in the area by the Tamil Nadu Forest Department. Tree species planted are largely of exotic *Casuarina* spp. This programme was initiated to protect the people and their properties from natural calamities. However, it is found that planting was done covering all parts of the shore i.e. up to High Tide Line.

The present study showed that 85% of the nesting occurred within 25 m from the High Tide Line (HTL). About 64% of the nests were found within 15 m from the HTL. This study also pointed out that turtles for nesting avoided patches of Casuarina.

It is suggested that coastal belt programmes, if required, to be undertaken 100 m or further away from the HTL. Chaudhari *et al., (*2009) also propose such plan for coastal belts. Study on species, especially the native ones, suitable for coastal belt conservation should be undertaken looking at the propagation of species in nature and colonizing adjacent areas. *Casuarina* sp. being an exotic species may spread faster occupying vacant niche and suppressing native species.

Many post-tsunami assessment studies claimed that the existing coastal shelterbelt plantations and bio-shields had protected life and property in certain areas (Kathiresan and Rajendran, 2005). Hence, large scale coastal aforestation activities were carried out from 2005 onwards by raising coastal shelterbelt plantations with *Casuarina equisetifolia.* These plantations have been done up to High Tide Line leaving no space for turtle nesting. Local species such as *Pandanus* may also be tried as coastal shield. Tamil Nadu Forest and Horticulture departments and other research institutes may be consulted in this regard.

6.3. AWARENESS PROGRAMME

Three out of five marine turtle species, Olive Ridleys *Lepidochelys olivacea*, Green Turtle *Chelonia mydas* and Leatherback *Dermochelys coriacea* were observed during this study along the Poompuhar coast. Among them, the nesting of Olive Ridleys is fairly common. Apart from this, a freshwater turtle, *Pelochelys cantorii* was observed using the sandy beaches for nesting in the area. All these species are listed in Schedule I of the Indian Wildlife Protection Act (1972) and are globally threatened.

Awareness programme on the importance of the area with respect to marine life including turtles should be undertaken. These programmes should be focused towards school and college students and fisherman community. The field staff of the Tamil Nadu Forest Department should also be trained in marine turtle identification and biology.

Annual Sea Turtle Festivals may be organized by the Tamil Nadu Forest Department involving research organizations, NGOs, students and villagers. These activities should be conducted every year during January- March. The coastal NGOs need to be brought into a network to participate in sea turtle conservation. Posters depicting figures of threatened species may be useful for creating awareness among locals and general public. The turtle groups formed by the CMS- MCBT marine turtle-monitoring programme during 2004-05 (Bhupathy *et al.*, 2006) should be continued.

Officials of the Port, Thermal and Highway development authority, and representatives form aquaculture, resorts and other business communities should also be included in the awareness programmes on regular basis. Strong public-private and government partnership is required for the conservation of our marine fauna.

6.4. PROTECTION OF NESTS AND EGGS

Of the 248 nests observed during the fortnightly sampling, 82% were depredated (72.98% human and 9% by animals). The remaining nests were assumed to have been survived. Natural nest predation along this coast is largely due to Domestic Dogs and Jackals. Domestic dog is subsidized due to the presence of Human near the beach. On the other hand, Jackals inhabit the *Casuarina* plantations raised by the Forest/ other Government departments under shelterbelt programmes after 2005. In a long run, the exotic *Casuarina* plantation would become denser and may spread towards sea side as well. This may help increasing the population of associated species such as Jackal. The effectiveness of these plantations as barrier for cyclone/ storms vis-a-vis their impact on marine organisms including sea turtles need to be assessed. Research on the view of *Casuarina* plantations effectively curtailing (artificial) light pollution in the beach (Karnad, 2008) should be undertaken.

Patrolling of beach by the staff of Forest Department would deter the poachers from traversing the beach and collection of eggs. It is found that these poachers involved in egg collection for very many years, and alternate livelihood options should be explored to involve them in conservation activities. Intensive beach patrolling for two months (February -March) on turtle nesting beaches of the east coast of Tamil Nadu may save majority of the nests from poachers.

According to Pandav and Choudhury (2000), 24469 eggs were collected from 277 nests (mean clutch size= 88.3 eggs) along the Orissa coast. Considering about 80 eggs in the clutch found along this study area, and maximum cost of an egg in the present study area was Rs 3/. A poacher would get about Rs. 240/ day (if he/she manages to get one nest). An estimated (maximum) 1000 nest could be obtained in a season (see results) may be sold at about Rs. 2-2-5 lakhs. An incentive programme to locals would help improving the situation.

Enquiry revealed that only few persons in the coastal villages collect turtle eggs. These villagers may be identified and the same may be involved in sea turtle conservation programmes and monitoring beaches. As higher proportion of

nests is under threat, a beachfront *ex*-situ conservation programme is required (Bhupathy and Saravanan, 2001). The ex-situ programmes must be done on the beach itself avoiding transportation of eggs to far off places. The identified villagers may be used for egg collection and maintaining them in the hatcheries. The hatchlings should be released in the sea soon after their hatching. It is to be noted that hatcheries should me maintained on the beach at about 25 m away from the High Tide Line anticipating possible inundation due to natural calamities such as cyclones.

6.5. CONTROL OF INCIDENTAL CATCH IN FISHING NETS

The present study found that about 79.5% (n= 317) dead turtles stranded along the shoreline of the study area had injury marks on head, flippers and shell. It is no clear, if the remaining turtles died due to diseases or suffocation due to entangling in the net. It appears that fishermen chop off the flippers or head of turtles that got entangled in the fishing net and remove them to protect their fishing nets from damage. Aquaculture has encouraged the unregulated use of shooting nets of small mesh sizes for the collection of tiger prawn seeds and small fishes.

It is to be noted that in sporadic nesting areas, such as this, mortality of turtles in this magnitude due to incidental capture in fishing net is alarming as largely adults are getting killed in the process. Proper awareness programmes should be conducted for the fishermen of the area. Methods of handling entangled turtles in the net must be demonstrated periodically or rescue teams should be formed and made operational in the area. This team may be organized by the Forest Department with the help of research organizations involved in the work. Information with respect to the protocol involved in rescuing of turtles are available in RAC/SPA (2004).

This study also revealed that peak in the mortality is closely correlated with emergence of turtles for nesting. Hence, close season for fishing during turtle nesting season January – March may help conserving them. This may be similar to the close season for fishing in force during April and May (fish breeding season, TNMFRA, 1983). However, consultation with stakeholders

must be done prior to proposing this type of acts. Also, alternative livelihood options should be thought out well in advance considering revenue loss to the stakeholders. This programme would get success only if people participation is guaranteed.

As over 75% of the adult turtle mortality occurred during January- February, a closed period for gill net (set net) fishing is suggested. This may be implemented for one/ two months (January- February) along the east coast. During this period, the use of alternate fishing techniques should be explored. Discussions with the concerned departments (forest and fisheries) and stakeholders are needed for active participation and effective implementation. Co-ordination among government and non-government organisations and local communities needs to be strengthened.

6. FURTHER RESEARCH

(i) Factors operating in the selection of nest site are poorly understood (Bhupathy *et al.,* 2007). Detailed investigation is required incorporating various biotic and abiotic factors to understand the issue.

(ii) The present study revealed that Olive Ridleys were common in the offshore areas of Tranquebar- Pazhaiyar during October- April. Due to non availability of resources, intensive study on the offshore activities and congregations of turtles could not be studied in detail. A detailed study is required to know the important turtle areas during the breeding season. These data are required to propose and implement 'no fishing zone' in the area.

(iii) It is reported that Olive Ridleys nest all over Indian coast and mass nesting occur along the Orissa coast (Kar and Bhaskar, 1982; Pandav, 2000). It is also reported that Olive Ridleys from Gulf of Mannar or south-eastern coasts of Tamil Nadu or Sri Lanka migrate to Orissa coasts for nesting (Pandav *et al.,* 1998; Pandav and chouduhry, 2000; Bhupathy and Saravanan, 2001). However, source populations for the sporadic nesting areas including Tranquebar-Pazhaiyar coast are unknown. Intensive turtle tagging programmes and Satellite

telemetry studies would provide information in this regard, which is critical for planning conservation strategies for this species.

(iv) Several development projects are being implemented along the Poompuhar coast. A comprehensive Environmental Impact Assessment involving carrying capacity of the area would provide information on the strategies to be adopted for the conservation of wildlife including marine turtles. A comprehensive EIA of the area would provide insights on Coastal Zone Management Plans.

An integrated Coastal Conservation and Management Plan including various stakeholders such as Government and Non-Government Organisations, experts and people is required for long-term survival of Olive Ridleys along the Tranquebar- Pazhaiyar coast.

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