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THE GROUND BENEATH THE WAVES

Post-tsunami Impact Assessment of Wildlife and their Habitats in India

Volume 1: The Mainland

Wildlife Trust of India

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INTERNATIONAL FUND FOR ANIMAL WELFARE
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The Rainforest Initiative

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Post-tsunami Impact Assessment of Wildlife and their Habitats in India

Volume 1: The Mainland

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The Wildlife Trust of India is a non-profit conservation organization committed to help conserve nature, especially endangered species and threatened habitats, in partnership with communities and governments.

WTI works through partnerships and alliances and its strengths lie in its multi-disciplinary team, quick reactions and its willingness to work with so far neglected issues like acquiring land for wildlfie rescue and rehabilitation.

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The International Fund for Animal Welfare works to improve the welfare of wild and domestic animals throughout the world by reducing commercial exploitation, protecting wildlife habitats, and assisting animals in distress.

IFAW and WTI formed a partnership in 2000 to strengthen the cause of wildlife conservation and animal welfare in India.

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GOVERNMENT OF INDIA
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R.P.S. KATWAL
ADDITIONAL DIRECTOR GENERAL OF FORESTS (WILDLIFE)

14TH SEPTEMBER, 2005

FOREWORD

Natural disasters are beyond any one's control and the damage caused by such unpredictable events is generally huge, mainly because of the suddenness with which they strike. The tsunami of 26 December 2004 was one such event.

The loss to human life and property became apparent very quickly and appropriate rescue and relief operations could be put into action almost immediately. However, the impact of this catastrophic event on the wildlife and their habitats could not be known immediately. Information on the damage ranged from being purely speculative to definitive. A study on the impacted areas of India was thus a need of the hour for it would provide invaluable first hand information about how the wildlife and the habitats generally fared.

I am very happy to know that the Wildlife Trust of India and the International Fund for Animal Welfare have conducted several studies on this subject and these are being brought out in the form of this report. I am sure that this report will provide useful information on the ground situation and will be of immense benefit to researchers, planners and policy makers.

(R.P.S. KATWAL)

जहाँ है हरियाली।
वहाँ है खुशहाली।।

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PREFACE

The tsunami that followed Christmas last year was the single largest natural calamity to have hit south and south eastern Asia in the recent past. While much of the following days and months have been focused on alleviating the human tragedy, the International Fund for Animal Welfare (IFAW) and the Wildlife Trust of India (WTI) pitched in with ecological and animal-related work. IFAW and WTI combined to provide limited veterinary support in India, Sri Lanka and Thailand. The support was limited only because the human tragedy was so great that animal rescue and veterinary work could only take a back seat.

This report presented in two volumes (The Mainland and The Islands) documents habitat impact and ecological systems damage as well as impacts on wildlife species, such as marine turtles, blackbucks and megapods. Luckily, it seems that most species have escaped great disaster. However, the habitat has been affected in some way positively (new islands and reefs have emerged) and in some way negatively (a lot of coastal habitats have been inundated or submerged). What is important now is what we do to restore human and non-human habitat. It looks like even though large-scale habitat interventions are not necessary, we must monitor over a longer time scale. Even more importantly, we must rebuild human habitats with care so that further damage is not caused to natural habitats. These studies, conducted by our partner organizations and eminent scientists therein, are a first cut in understanding the science that should dictate habitat reconstruction efforts.

WTI and IFAW both, believe in holistic conservation where the developmental needs of the local commuity, the conservation of endangered species and habitats and the welfare of individual living beings are all met. We hope that these reports serve the purpose of being the catalyst for such a scenario.

Vivek Menon
Executive Director
Wildlife Trust of India

INTRODUCTION

An earthquake epi-centered off the coast of Sumatra and measuring over 9 on the Richter scale caused a severe tsunami to strike parts of south-east Asia, India and Sri Lanka on 26 December, 2004. Sea water inundated several coastal towns and villages taking over 250,000 human lives and affecting close to five million people. The devastating impact of this tsunami on human life became immediately apparent and kick-started massive relief and rehabilitation efforts on a global scale. Its effect on wildlife and their habitats was much less known.

The word tsunami originates from two Japanese words - ‘tsu’ meaning harbour and ‘nami’ meaning wave, perhaps coined after the damage it caused to harbours in the past. Tsunamis are considered distinct from tidal and seismic sea waves as tsunamis can also be caused by non-seismic events , such as landslides or meteorite impacts.

Tsunamis are characterized by shallow waves with large wavelengths and long periods. Typically, a tsunami may have a period of over 60 minutes and a wavelength in excess of 100 km, whereas a wind-generated wave may have a period of 10 seconds and a wavelength of 150 m. A tsunami can be generated when the water column which is in equilibrium is vertically displaced and disturbed. These changes may be caused by the movement of tectonic plates, which causes water above them to be displaced. When large areas of the sea floor elevate or subside, a tsunami can be created. Tsunamis may also be caused by submarine landslides, collapse of volcanic structures or even a violent submarine volcano.

Due to their long wavelengths, tsunamis are shallow-water waves and because of this, they are able to travel great distances. For instance, in the Pacific ocean a typical tsunami travels at about 700 km/hr. Since the energy loss of such waves is less, they are able to travel transoceanic distances. Thus, after originating off the Sumatra coast, impacts of tsunami were felt even off the east African coast. As it travels to the coastline from the open ocean, the character of the tsunami changes. Because the water depth is directly related to the speed of the tsunami, it slows down as it approaches the coast. However, it still has the momentum and thus due to a "shoaling effect", its height grows and may result in a runup height of 10-30 meters.

Despite its reduced speed, a tsunami still has considerable energy and thus it has a potential to cause severe damage to structures on or near the coast. The bottom friction and turbulence caused by tsunamis have great erosional potential and may strip beaches of sand. Because of their ability to travel great distances without losing much of their energy, tsunamis are silent and often take people unawares and thus the potential for damage is very high.

Initial speculations suggested that extensive damage may have been caused to wildlife and their habitats in coastal areas. As first reports appeared, it was clear that the damage was variable. Certain areas close to the epicentre, like Sumatra, had suffered extensive damage to their coral reefs; nearly 30,000 hectares affected in the Aceh region and the western islands of Indonesia mainly due to damage by deposition of debris in the form of vehicles and tankers being dragged into the sea and also due to silt and mud. It has been suggested that the destruction of coral reefs will have dramatic consequences for fish systems in future. Reports of damage to mangrove forests appeared from Seychelles where sand and mud covering the roots of certain species caused "choking" of the forest. It was also estimated that about 100 million square meters of beach was eroded by the tsunami's force. Damage to freshwater ecosystems near coastal areas has also been reported as inundating seawater contaminated the habitat.

Several other kinds of threats to wildlife have been suggested. Washing away of fishing gear into the sea may harm marine life. Studies indicate that tens of thousands of nets may have been washed into the sea in Sri Lanka and Indonesia alone. Somalia's coastline has, in the past, been used as a nuclear dumping area and fears have now been raised that the tsunami may have washed these hazardous wastes into the sea causing serious health and environmental problems.

However, in other areas, the damage appeared to be significantly less than that anticipated. It was also noticed that areas which had natural vegetation were less damaged. Areas like Yala National Park in Sri Lanka, for instance, suffered little damage and the lack of any significant damage was attributed to the presence of vegetation along the coast.

While rescue and rehabilitation of the human populace got underway understandably, almost immediately, the status of damage to animals remained unclear, especially in India. Therefore , prior to active interventions, a need was felt to produce a first-hand account of the possible impacts of tsunami on wildlife of the affected areas in India. Wildlife Trust of India along with the International Fund for Animal Welfare (IFAW) got a series of studies done. These were in the form of rapid assessments, primarily aimed to produce information on the extent of damage to main wildlife habitats and the possible impact on wildlife.

India's mainland coastline was principally affected in the eastern and southern areas. In addition, extensive damage to human life and property was reported from the Andaman and Nicobar Islands and consequently, our impact assessments centered around these areas.

The main objectives of the study were to:

a) Assess the impact of the tsunami on wildlife in the worst affected areas in India.
b) Suggest any further kinds of interventions if required to secure the future of wildlife in those areas.

Six investigations were conducted, four on the mainland and two on the Andaman and Nicobar Islands. Whereas most assessments are of a general nature, the damage caused to coastal wildlife habitats necessiated one study specifically to monitor the possible impact of the tsunami on the mass nesting of Olive Ridley turtles in Orissa. The reports have been organized in two volumes, the first covering studies conducted on the impacts on the mainland and the second looking at impacts on the Andaman and Nicobar islands.

The reports have provided some recommendations and also some directions for future assessments and hopefully, will address some of the concerns of the planners and policy makers to help in the reconstruction process on sound scientific and ecological lines.

EXECUTIVE SUMMARY

The tsunami of 26th December 2004 brought in its wake untold human suffering, which initiated a series of rescue, rehabilitation and reconstruction initiatives directed to meeting the human needs. The damage to animals, their habitats and the environment had to, understandably so, take a backseat.

The Wildlife Trust of India, along with the International Fund for Animal Welfare initiated a series of rapid investigations to assess the damage caused by the tsunami to wildlife and their habitats in India. both on the mainland and the islands

The effects of tsunami were most severe in the Andaman and Nicobar Islands. On the mainland its effects were more pronounced in the state of Tamil Nadu on the south-eastern coast of India. The degree of devastation seemed generally to be linked to the bathymetry off the coast and the natural and man made structures on the coast. We conducted six studies and most concluded that the damages caused to wildlife were generally limited. Damage to coral has been limited on the mainland but quite heavy on the islands.

The report found that violations of the CRZ norms played a major role in the loss of human lives and property

Damage to wildlife habitats has been variable, depending upon the location. Certain beaches have been washed away, several inland fresh water habitats contaminated by salt water ingress. Most of these damages appear to be temporary as the habitats are expected to change and be flushed after the monsoons and many may be restored to their former state. Mangroves in Andaman and Nicobar islands have been damaged to a great extent. This executive summary applies to both, the mainland and the islands.

The studies call for a review of the CRZ (Coastal Regulation Zone) Enforcement.
The reports found that violations of the CRZ norms played a major role in the loss of human lives and property.

The studies suggest a survey of the east coast of Tamil Nadu for developing an Ecological Vulnerability Map
The recent tsunami has opened new avenues for ill-planned and human-centered restoration experiments along the coasts of Tamil Nadu. Such mis-guided actions can lead to irreversible ecological damages along the coast further endangering the already rare and threatened biodiversity.

Planting of exotics have not shielded the coast from the effects of the tsunami.
Faulty use of species for plantation activities in the name of restoration has been a bane of coastal areas. Post-tsunami field surveys have suggested that villages that were cradled with dense coconut groves have felt the impact of the rising waves much less than those behind casuarina and other exotic shelter-belts.

The surveys recommend monitoring of tsunami effects on grazing patterns of ungulates.
Grazing areas in Point Calimere Wildlife Sanctuary have been flooded with salt water and covered with sand, making it unsuitable for ungulates to graze.

Eco-restoration efforts are not required for mangroves and planting of casuarinas, as they cannot protect anything from the tsunami in Andaman and Nicobar Islands. Natural regeneration will take place and changes need to be monitored after this year's monsoons.
Instead, there is a need, in the Nicobars, for extensive planting of *Pandanus nicobarensis*, which occurs in the Nicobars, and grows very fast. As for *Nypa fruticans*, seeds and seedlings can be collected from the Andamans. This activity will also involve intensive surveys and assessments of islands and areas for planting should be fixed after due consultations with the Nicobarese.

The sea turtle beaches affected by tsunami will re-form after the monsoon in Andaman and Nicobar Islands.
New beaches will form and will need to be monitored as marine turtles will find new nesting sites.

The studies recommend monitoring of the natural mangrove regeneration and inland wetland habitat in Andaman and Nicobar Islands.
Monitoring of these habitats will have to be done for at least three years to conclude status and study permanent changes which may occur.

Coastal areas have undergone severe damage and are ecologically highly unstable.
Erosion, leading to further loss of land is the principal ecological concern.

The choice of construction material for reconstruction is critical.
The use of concrete can only lead to sand mining, legal or otherwise, leading to erosion and a further loss of coastal land.

There needs to be a five year moratorium on the use of concrete.
This will pre-empt any possibility of legal or illicit sand mining.

Livelihoods of the majority of people in Nicobar Islands have been seriously disrupted, or rendered defunct.
Efforts should be made to develop and modernize copra and arecanut economy.

Mangroves and coral reefs, critical to development of fisheries in the Nicobar Islands, have been affected.
This will impact the programmes being developed for fisheries as alternate livelihoods in the islands.

Impact to Wildlife and their Habitats in Coastal Areas of Andhra Pradesh, Tamil Nadu and Kerala as a Result of the Earthquake and Tsunami of December 2004

R. J. Ranjit Daniels,[1] Jayshree Vencatesan[2] and K. Moorthy[3]

Tsunamis are caused by earthquakes, volcanoes, landslides and asteroids. In 1883, the volcanic explosion of Krakatau (Indonesia) stirred up 130 feet (c. 40 m) high waves that killed 36,000 people. The 1958 landslide in Alaska sent waves up by 1720 feet (more than 500 m) sweeping the Lituya Bay. Seventeen major tsunamis have struck the earth's coasts since 1992. However, human fatalities have been relatively low with a total of 4000 until last year (Editor, 2005).

A team of scientists from the National Geophysical Research Institute (Hyderabad), National Institute of Ocean Technology (Chennai), Oregon State University (USA), Portland State University (USA) and Gunma University (Japan) have summarised the 2004 December 26 tsunami as follows:

"An earthquake of magnitude 9.0 occurred off the coast of Sumatra on 26 December 2004 at 06:28:50 AM (IST). The epicentre of the earthquake was located at 3.29°N and 95.94°E. The focal depth of the earthquake was 30 km. This earthquake generated huge tsunami waves which devastated the Andaman and Nicobar Islands, east coast of India, south Kerala in India and several other countries like Sri Lanka, Indonesia, Thailand and Somalia in the Indian Ocean. The tsunami claimed more than 250,000 human lives in these countries.

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The aftershocks of this earthquake numbering more than 250 in the magnitude range 5-7.3M were located for a length of 1300 km from Sumatra in the south to Andaman and Nicobar islands in the north, till 30 January 2005" (Chadha *et al*., 2005).

An independent report that appeared in the National Geographic magazine has described the aftermath highlighting the role that natural habitats have played in defending the coasts and human lives. It says "as reports from tsunami-stricken nations filtered in last December, a pattern emerged: Communities lying behind a fringe of shallow-water mangroves, like parts of India's coastline, or behind an intact coral reef, as in the Maldive Islands, suffered less damage and loss of life than places exposed directly to the brute force of the waves. Mangrove forests and coral reefs had proved their worth once again, helping deflect the enormous energy unleashed by the tsunami.

Not even reefs and forests, though, could escape serious harm off the north end of Sumatra, the landmass nearest the quake's epicentre. There, the waves damaged some 60,000 acres (c. 24,000 ha) of mangroves, 30% of the reefs and 20% of the sea grass beds - all vital fish habitats (UNEP, 2005).

Other grave problems stem from the onslaught of seawater laden with sediments and toxins. Aquifers, the primary source of drinking water, have been contaminated by saltwater, raw sewage, oil, and other pollutants. On the coasts of Indonesia and Sri Lanka, paddies and farm fields are smothered under a crust of salt and silt. Some areas may never recover, for others irrigation and one or more rainy seasons may be enough to flush out the soil. For now farmers are being encouraged to plant salt-tolerant crops, like pumpkins and kale.

While the massive cleanup and reconstruction efforts proceed, conservationists and community leaders are calling for a slowdown of development and a speedup in planting natural barriers. In recent decades shrimp farms, resorts, and industrial projects have levelled vast tracts of mangroves. The hope is now that a green wall will rise before the next crushing waves come again" (Editor, 2005).

The brief reviews presented here suggest that there is some irony about the whole event. First, a lot of human lives were lost throughout the impacted coasts. Second, where human lives were spared, the natural habitats took the brunt. Mangroves were lost. Coral reefs have been damaged. In the Andaman and Nicobar islands even primary forests were not spared. Many reports on the impact of tsunami on the natural habitats in India have been publicised since January 2005. A summary of some of the more recent reports is provided in Table 1.

When natural habitats like mangroves and coral reefs have been seen as 'life-savers' in the human context, there have been few efforts to study the impact that the loss of habitats could have had on wildlife. For instance, wildlife in Thailand was largely spared. Nevertheless, debris and silt that were left behind by the waves have littered natural areas (Editor, 2005). Elsewhere in Point Calimere, mammals were not affected by the seawater that spread through the sanctuary (Table 1). How valid are these conclusions? The real impact of the tsunami on wildlife could have been as follows:

- Kill wildlife and destroy their natural habitats
- Kill wildlife, yet leave their natural habitats intact
- Destroy natural habitats, spare the associated wildlife
- No visible impact, whatsoever

The analysis that follows is strongly based on the premise that the above four categories of impacts on wildlife and habitats may have been felt locally along the coast in varying intensities and forms depending on the geographical position, topography and the extent/condition of the available habitats. The main objective of the present study is, therefore:

- To assess the impact of the tsunami on wildlife habitats and critical species by comparing with previous known status of the same
- To compare the effect of tsunami on wildlife protected by mangroves, coral reefs, etc. and habitats that have been cleared for developmental purposes, i.e., localities that have in the past had mangroves/coral reefs/natural habitats that provided an ecological security function
- To outline projects for restoration of wildlife habitats and recovery of species that need to be taken up in the next 1-3 years with outline budgets.

Table 1: Samples of early reports on the ecological impacts of the tsunami

Summary of conclusions	Source
• Marine ecology of Bay of Bengal irrevocably altered • The seaweed and sea grass ecosystem between Rameswaram and Kaniyakumari have either been uprooted or submerged • Many associated organisms have been dislocated • Species composition changed • The worst affected is the benthic ecosystem comprising invertebrate animals • A huge population of sponges have been affected and animals such as crabs, lobsters and stomatopods displaced from their coral homes • The tsunami has changed their breeding area by dumping of silt and relocated the breeding population to other areas which may not be conducive to their survival • Increased turbidity may lead to mass mortality of fish • The breeding marine turtles have already been affected • The loss of sea grass which is the main food for endangered marine mammals like dugong may also lead to changing breeding habitat • Tsunami has benefited the river estuaries in Chennai by de-silting and opening the choked rivers by flushing sea water – may positively impact marine biodiversity	**The Hindu**, April 22 2005 based on the survey report of the Zoological Survey of India
• Developing a natural barrier reef using coral reef will serve the purpose to tackle any tsunami or storm • The live coral cover in the Gulf of Mannar reduced from 48.5% to 36% after the tsunami	**The Hindu**, April 26 2005 based on the survey of the Centre for Marine and Coastal Studies of the Madurai Kamaraj University
• Tsunami, a blessing to olive ridley turtles • Safe breeding thanks to cessation of fishing • The ecological changes wrought on the Chennai coast combined with the fact that human disturbance was minimal on some stretches has ensured a good season this year	**The Hindu**, May 5 2005 based on inputs by the Students' Sea Turtle Conservation Network and Member Secretary, National Biodiversity Authority
• Point Calimere escapes tsunami fury • Studies indicate that the animal population remains intact even after tsunami • The recent enumeration has concluded that there are 1796 blackbuck, 160 spotted deer, 42 feral horses, 40 wild boars, 28 foxes in the sanctuary • The sea water that entered the sanctuary had damaged the grass cover in the forest • The recent rain had helped removing the salinity from the soil allowing the grass to grow back again	**The New Indian Express**, May 2 2005 based on a survey that the TN Forest Department coordinated

Study area and Methods

Choice of localities

The impact of the tsunami was felt along the east coast of the Indian mainland between Srikakulam in Andhra Pradesh and Kanyakumari in Tamil Nadu and between Trivandrum and Cochin along the west coast in Kerala (Chadha *et al.*, 2005). For the purpose of the present study, we chose a coastline of nearly 1300 km that runs between Machilipatnam in Andhra Pradesh, through coastal Tamil Nadu and Pondicherry in the east and northwards along the west till Alapuzha (Allepey) in Kerala. This stretch was chosen mainly considering the greater impact on human lives and the short duration of the study (3 months between February and May 2005).

The study area was divided into 23 segments of 50 km each (see Figure 1). Within each segment, a focal coastal township or village was chosen such that the rest of the coast that lies within the segment may be accessed with the least difficulty (Table 2).

Rapid Surveys

The focal localities that were identified were visited at least once during the survey period that began in February 2005. Adjacent coastal areas were approached by road or water (boat) such that the ecological impacts were directly assessed in each of the coastal taluks in the selected study area (Table 3). A detailed data format/sheet was designed exclusively for the purpose and was used in the field (see Appendix 1). The data sheets were filled after direct observations in the field and interviews with local residents. Wherever relevant, information on the Coastal Regulation Zone status of the site was also obtained.

Case Study

Apart from the rapid surveys, two detailed case studies were carried out during the three months. The focus of the case studies was to understand the impact of tsunami on wildlife where there is a presence of mammals like deer, blackbuck and small carnivores and also in areas where there was the highest incidence of human deaths. For this purpose, the Point Calimere Wildlife Sanctuary and the adjoining Muthupet mangrove forests were chosen. Similarly, the coasts of Pondicherry and the 50 km segments lying north and south of it (i.e. the coasts of Tamil Nadu and Pondicherry between Kadambakkam and Parangipettai) were chosen. The field investigator spent one to two weeks in these localities.

Table 2: Distribution of focal localities within the study area

State	Segment number	Locality
Kerala	1	Alapuzha
	2	Kollam
	3	Trivandrum
Tamil Nadu	4	Nagercoil/Colachel
	5	Kulasekarapattinam/Kanyakumari
	6	Tuticorin/Tiruchendur
	7	Rameswaram/Kilakarai/Vembar
	8	Tondi
	9	Kattumavadi
	10	Vedaranniyam/Pt Calimere/Adirampattinam
Pondicherry	11	Karaikal
Tamil Nadu	11	Nagapattinam
	12	Parangipettai/Pichavaram
	13	Cuddalore
Pondicherry	14	Pondy
Tamil Nadu	15	Mamallapuram
	16	Chennai
	17	Pulicat
Andhra Pradesh	17	Pulicat
	18	Durgarajapatinam
	19	Muttukuru
	20	Kavali
	21	Alluru Kottapatinam
	22	Chirala
	23	Machilipatnam

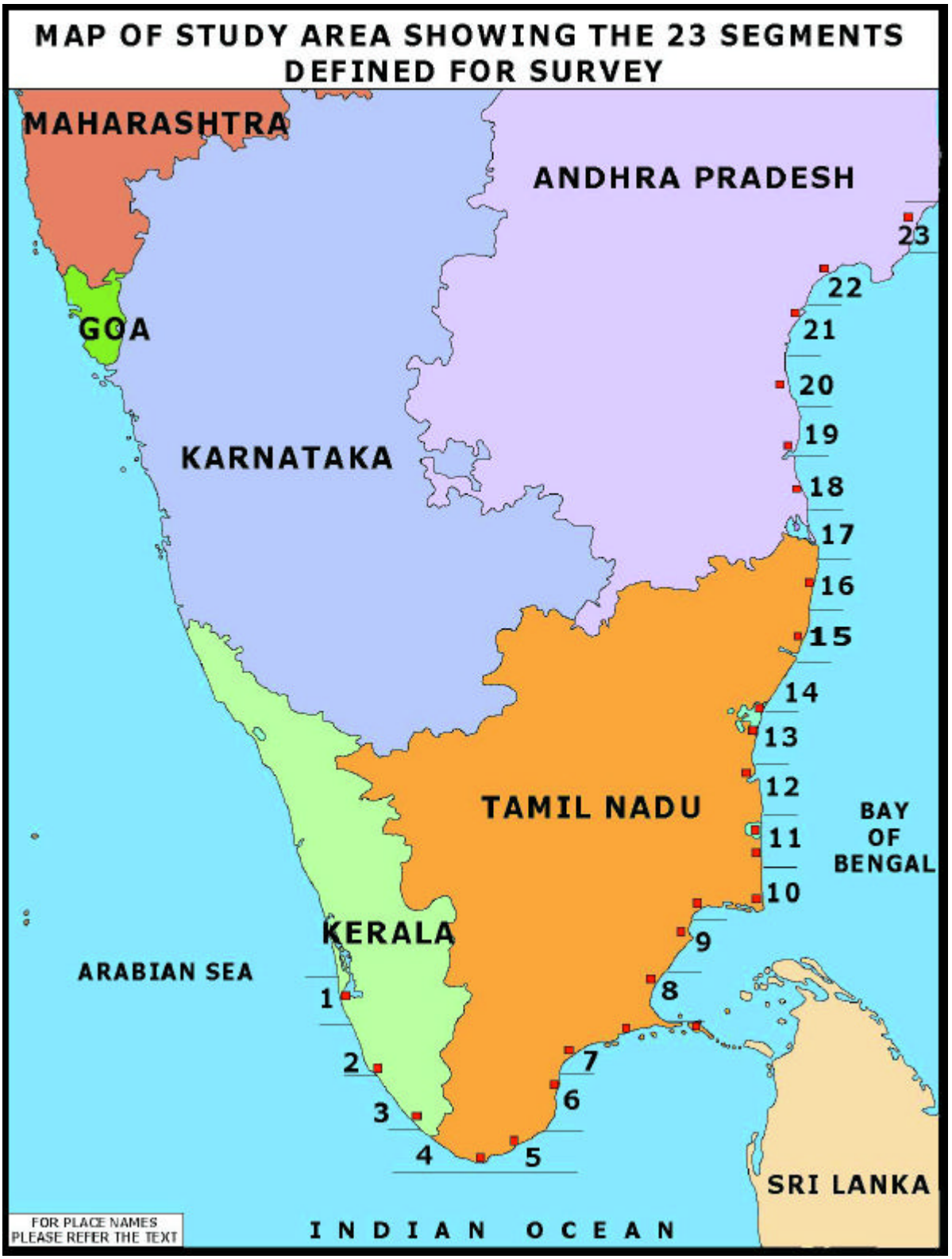

Figure 1: Map of study areas; for place names, please refer the text.
Map source: WTI

Data Quality and Analysis

Field data was scrutinised and wherever possible validated against existing information. Since the study was more of the survey type, the data is predominantly of the qualitative type. Qualitative data has been presented in the form of matrices (especially those of distribution of habitats and wildlife) only suggesting presence or absence of a habitat type or species of animal within the 23 segments. However, the impact of tsunami on the habitats and wildlife (as inferred in the field) has been presented on a scale of low, medium and high. The latter, is not free of subjectivity (as the field teams often worked independently) and hence has to be treated cautiously.

The quantitative data that is available has been presented in a form that makes patterns, if any, discernable. Much of the quantitative data pertains to Tamil Nadu and Pondicherry due to the fact that this part of the mainland faced the greatest impact of tsunami (Chadha *et al.*, 2005) and that the secondary sources of information are more complete for these segments. Considering these limitations, therefore, detailed statistical analyses have not been attempted.

Limitations

Field surveys were hindered by a number of factors. The first and major factor was the untimely rains in March 2005. These heavy rains (exceeded 50 cm one day in the southern coasts around the Gulf of Mannar region) that were considered unusual for the season flooded most of the coast and washed away debris and remnant clues that were reliable for drawing inferences in the field. In many segments, the excessive presence of relief workers has had its impact. Beaches and sandbars have been cleaned of debris in the name of village 'hygiene' thereby permanently removing much of the evidence (eg. seeds, seedlings, shells, broken coral, dead fish, etc). Due to local conflicts and resentment over the slow pace at which government aided relief packages reached the impacted communities, fishermen refused to take the team by boats in certain segments. In segments that fell within the state of Andhra Pradesh, access to certain beaches and coastal villages was denied by security personal and local police due to the movement of naxalites in the vicinity. Lack of facilities for underwater sampling limited the study of coral reef, near shore and estuarine aquatic fauna. However, the inferences drawn on fishes and other aquatic life are based on direct observations made where the waters were shallow and clear, in lagoons created by the tsunami and from remains of dead animals (fish, shells, echinoderms, coral skeletons, etc.) that littered the beach.

Table 3: Distribution of coastal taluks and human population in the study area

State (segment numbers)	District	Taluk	Human population*
Andhra Pradesh (17-23)	Nellore	Thada	1,00,000
		Alur	79,000
		Vakadu	92,000
		Muttukuru	1,01,000
		Indukurpet	1,50,000
	Prakasam	Singrayakonda	79,000
		Chirala	1,60,000
	Guntur	Bapatla	1,52,000
	Krishna	Divvi/Kruthivennu	88,000
		Bandar	2,59,000
		Nagayalanka	59,000
Tamil Nadu (4-17)	Kanyakumari	Vilvankode/Kuzhithurai	5,34,000
		Kalkulam/Thackalay	5,38,000
		Agastheeswaram/Nagercoil	4,94,000
	Tirunelveli	Radhapuram	2,65,000
	Tuticorin	Sattankulam	97,000
		Tiruchendur	2,91,000
		Srivaigundam	1,92,000
		Tuticorin	4,05,000
		Vattapidaram	1,15,000
		Vilathikulam	1,35,000
	Ramanathapuram	Kadaladi	1,25,000
		Rameswaram	69,000
		Ramanathapuram	3,51,000
		Thiruvadanai	1,88,000
	Pudukottai	Avidaiyarkoil	80,000
		Manalmelkudi	82,000
	Tanjore	Peravurani	1,18,000
		Pattukottai	3,70,000
	Tiruvarur	Tiruthuraipoondi	1,99,000
Tamil Nadu (4-17)	Nagapattinam	Vedarnayam	1,99,000
		Kizh velur	1,28,000
		Nagapattinam	2,60,000
		Tarangampadi/Poraiyur	1,86,000
		Sirkali	2,92,000
	Cuddalore	Chidambaram	4,09,000
		Cuddalore	5,06,000
	Vilupuram	Tindivanam & Vannur	4,13,000
	Kanchipuram	Cheyyur	1,86,000
		Tambaram	9,79,000
		Thirukazhukundram	1,73,000
	Chennai	Saidapet	-
	Tiruvallur	Ambattur	10,07,000
		Ponneri	3,31,000
Pondicherry (11&14)		Pondicherry, Karaikal, Yanam, Mahe**	9,73,800
Kerala (1-3)	Alapuzha	Chertala	3.02,200
		Ambalapuzha	1,58,100
		Karthikapalli	3,38,700
	Kollam	Karunagapalli	4,10,500
		Kollam	9,69,200
	Trivandrum	Chirayankizha	6,24,400
		Thiruvananthapuram	11,14,000
		Neyyatinkara	8,64,400
Total	**21**	**54**	**1,67,91,300**

*All figures rounded to the nearest 1000;

**Mahe is on the west coast as a small territory in Kerala outside the study limits; the population of Mahe has not been deducted from the total as all figures are rounded and by this inclusion the total is not likely to be affected significantly.

Results and Discussion

The major results of the rapid assessment are presented and discussed in this section of the report. The results, including some from secondary sources, are discussed under three broad categories, viz.,

- Distribution of natural and man-made habitats
- Impact of tsunami on natural and man-made habitats
- Impact of tsunami on human lives and livestock

Distribution of natural and man-made habitats

Natural terrestrial habitats

Tables 4-8 summarise the distribution of the different types of natural and man-made habitats in the 23 segments that were surveyed. Natural terrestrial habitats are the least diverse in the coastal areas primarily due to human interference.

As shown in Table 4, only three broad categories could be recognised because the 'beach' could not be demarcated as a unique habitat type. However, when the survey was designed, beach was included as a unique habitat type. However, except where they have been deliberately cleaned and maintained as recreation areas or when boats and fishing nets are 'parked', beaches are not easily discernable as a unique habitat type. Beaches are therefore treated as a unique habitat type only when they attract nesting sea turtles (see Table 7) and in the section on impacts where sites designated as beaches have been physically transformed.

Figure 2: Remnant dry evergreen forests on Kattupalli island

Figure 3: Remnant dry evergreen forests in a Dutch fort

Littoral forests are largely denuded and where they have been degraded by the removal of trees, the vegetation is in the form of grass and scrub. Extensive patches of coastal grass and scrub with occasional trees are seen in the Pulicat Lake environs (Segment 17) (see Figure 2). Here the Kattupalli Island (an island created after the Buckingham canal isolated it) has patches of the dry evergreen forests more typical of the Coromandel Coast (Late Fr K M Mathew, pers. comm.) (see Box 1). During our visit, we found that the dry evergreen forests are extremely patchy in a matrix of grass (that was largely burnt), cashew and casuarina plantations and agriculture (Figure 3).

With the exception of a few patches around Cuddalore and Pondicherry, the littoral forests are over-run by the invasive *Prosopis juliflora* (Figure 4). The coasts of northern Tamil Nadu starting with Pulicat Lake, through Andhra Pradesh, the dominant tree is of this invasive species. The single most extensive patch of littoral and dry evergreen forests in the northern segments is that found within the high security area of the Sriharikota rocket launching station. Remnant littoral forests in and around Cuddalore-Pondicherry (Segments 12-15; see Figure 1) are dominated by *Thespesia populnea, Lannea coromandelica, Ficus religiosa, Ficus hispida, Calophyllum inophyllum, Morinda coreia, Syzygium cumini, Pongamia pinnata, Azadirachta indica, Madhuca longifolia, Borassus flabellifer, Vitex negundo, Calamus rotang* and *Pandanus odoratissimus*. Small patches of littoral forests including species of Ficus are seen in the ruins of the fort at Alambarai, north of Pondicherry. Apart from these native species popular species of Indian trees that were common include *Terminalia catappa, Mangifera indica, Delonix elata, Moringa oleifera, Tectona grandis* and *Dendrocalamus strictus*.

Box 1 A description of the coastal dry evergreen forests

Tropical dry evergreen forests are unique to the coasts of Tamil Nadu, Pondicherry and southern Andhra Pradesh. They are these forests are patchy and the most significant fragments are those found within the Pt Calimere Sanctuary (TN) and the Pulicat Lake WLS (AP) (Gadgil and Meher-Homji, 1986). Many small fragments that have been traditionally protected as 'sacred groves' are found in an around Pondicherry.

The 'Flora of Tamil Nadu' (Botanical Survey of India) describes this type of vegetation as 'coastal dry evergreen' and as occurring along the coasts of Tamil Nadu northwards from the Tirunelveli district. These forests are with low trees (9-12 m) forming a complete evergreen canopy. The leaves are coriaceous (leathery) and the crowns spreading. The forests may have deciduous elements and without a canopy layer. The common woody plants are *Atlantia monophylla*, *Breynia vitisidaea*, *Calophyllum inophyllum*, *Canthium parviflorum*, *Carissa spinorum*, *Diospyros ferraea*, *Drypetes sepiaria*, *Ehretia aspera*, *Ehretia microphylla*, *Erythroxylum monogynum*, *Lannea coromandelica*, *Manilkara hexandra*, *Mimusops elengi*, *Mundulea sericea*, *Murraya paniculata*, *Pleurostylia opposite*, *Pterolobium hexapetalum*, *Sapindus emarginatus* and *Walsuria trifolia*. *Canavalia gladiata*, *Canavalia virosa*, *Mucuna atropurpurea* and *Mucuna pruriens* are the large climbers. *Canthium dicoccum*, *Capparis zeylanica*, *Cayratia carnosa*, *Hugonia mystax*, *Leptadenia reticulata*, *Memecylon umbellatum*, *Toddalia asiatica*, *Tylophora indica* and *Xeromphis malabarica* are the other common elements in this vegetation type. Parasites like *Cassytha filiformis*, *Dendrophthoe falcata* and *Viscum orientale* are frequently found. The epiphytic orchid *Vanda tessellata* is fairly common. A typical representation of this forest type is found in Vedaranyam and Talaignayar RF (Nagapattinam district; Segment no 10). This type of forest is degraded resulting in the disappearance of trees leaving only remnants of the tropical dry evergreen scrub alone wherever there is more biotic interference

(Source: Botanical Survey of India, 'Flora of Tamil Nadu').

Table 4 Distribution of natural terrestrial habitats

Segment no	Littoral forest	Dune vegetation	Grass/ Scrub
1			+
2			+
3			+
4	+	+	+
5	+	+	+
6	+		+
7	+	+	+
8	+	+	+
9	+	+	+
10	+	+	+
11	+	+	+
12	+	+	+
13	+	+	+
14	+	+	+
15			
16			+
17		+	+
18			
19			
20			
21	+		
22	+	+	
23	+	+	

Figure 4: Littoral forests over run by *Prosopis juliflora* in Andhra Pradesh

Figure 5 (inset): *Sitana ponticeriana* in the Marakanam RF

The littoral forests near Anumanthai (between Marakanam and Pondicherry) are largely replaced by casuarina plantations (despite their classification as Reserve Forests) with a few patches of stunted thorns and shrubs. This 'forest' is however a good habitat for species of coastal herbs and the fan-throated lizard (*Sitana ponticeriana*). The different age and size classes of the lizard that were observed in May 2005 suggest that these ground dwelling lizards were not affected by the tsunami (Figure 5).

Sand dunes have been traditionally used as fishing hamlets and as a result, most dunes support various kinds of domestic gardens or densely planted cashew orchards (Figure 6). However, where the dunes have not been transformed into human habitation, there were some of the typically sand-binding plants. Such vegetation includes *Pandanus odoratissimus, Spinifex littoreus* (grass) and *Ipomoea pes-caprae* (Figure 7).

Natural aquatic habitats

Aquatic habitats were more diverse throughout the study area (Table 5). All distinct aquatic habitat types have been listed in the table except coral reefs and the open sea. Since surveying the open sea was beyond the scope of the present study, no attempt was made. Coral reefs, however, were visited yet not treated along with the other natural aquatic habitats. This is mainly due to the fact that coral reefs in the mainland are restricted to the segments 6-7 where they are largely protected within the Marine National Park which is a part of the Gulf of Mannar Biosphere Reserve. Considering the short period of the survey and the fact that we were not equipped to do underwater surveys, we have largely relied on secondary information and inputs provided by coral reef experts who had visited the Gulf of Mannar Biosphere Reserve after the tsunami. Inferences on the impact of tsunami on coral reefs will be discussed in the later sections of the report.

Sea grasses belong to two families of flowering plants viz., Hydrocharitaceae and Potamogetonaceae. These plants stay submerged in the shallow coastal waters and often visible only at times of low tide. According to Parthasarthy *et al.*, (1991) there are 12 species of sea grasses along the coasts of mainland India. These are patchily found along the entire east and west coasts (Parthasarathy, pers. comm.). The presence of sea grasses along the coasts is determined by the nature of the substrata. These plants occur on many kinds of substrata ranging from coarse sand, fine sand (loam), silt to clay and also coral rubble. Exceptionally as in the case of the Krusadi Island of the Gulf of Mannar, sea grass beds are found within coral reefs (Parthasarthy *et al*., 1991).

Table 6 summarises the distribution of sea grasses along the coasts of Tamil Nadu. Of the 12 species, *Halophila ovalis* is apparently the one with the widest distribution. According to Parthasarathy *et al.*, (1991) this species is a generalist capable of surviving on a range of substrata and found even in the estuaries and backwaters of Pulicat lake and Kaliveli. The presence of sea grass is often betrayed by the leaves and uprooted plants that drift and are washed ashore. During our surveys, we did not come across any such secondary evidence and hence were able to confirm the presence of sea grasses only in segments 6-10 (Vedaranyam-Tuticorin). Information provided by the local fishermen that suggested the presence of sea grasses in the coasts of Andhra Pradesh and northern Tamil Nadu has not been presented in the Table 5 as the chances of possible confusion with sea weeds (algae) were quite high.

Saltwater habitats that were predominantly observed during the survey are estuaries, backwaters and creeks. Although the three are naturally distinct, throughout the coast these habitats have lost their ecological integrity due to the system of navigation canals and other modes of human utilization viz., coir retting (Kerala), saltpans and aquaculture. Saltpans along the east coast are age-old and have brought saltwater into the pans through a system of canals locally (Figure 8).

Figure 6: Dunes covered with cashew plantations, Cuddalore district

Figure 7: Extensive dune vegetation, Spinifex

Table 5: Distribution of natural aquatic habitats

Segment no	Estuary	Backwaters	Creek	Salt marsh	Mangrove	Sea grass	Rocky inter-tidal	Freshwater Pools/open wells
1		+					+	+
2	+	+						+
3	+	+						+
4	+	+	+	+	+		+	+
5	+	+	+	+	+		+	+
6	+	+	+	+	+	+		+
7	+	+	+	+	+	+	+	+
8	+	+	+	+	+	+		+
9	+	+	+	+	+	+		+
10	+	+	+	+	+	+	+	+
11	+	+	+	+	+			+
12	+	+	+	+	+			+
13	+	+	+	+	+			+
14	+	+	+	+	+		+	+
15								
16	+	+	+					
17								
18								
19		+						
20		+						
21		+						
22		+						
23		+						

Table 6: Distribution of sea grass along the coasts of Tamil Nadu*

Species	Range	Remarks
Hydrocharitaceae		
Enhalus acoroides	South of Pt Calimere	Not reported south of Tuticorin
Halophila beccarii	Pondicherry southwards	Patchy
Halophila decipiens	Tuticorin	Local
Halophila ovalis	Pulicat-Pichavaram; south of Pt Calimere	Not reported in the intervening coastal locations
Halophila ovata	Pondicherry southwards	More frequent south of Pt Calimere
Halophila stipulacea	Pt Calimere-Gulf of Mannar	-
Thalassia hemprichii	South of Pt Calimere	Not reported from the extreme south
Potamogetonaceae		
Cymodocea rotundata	South of Pt Calimere	-
Cymodocea serrulata	South of Pt Calimere	-
Halodule pinifolia	Pulicat to Kanyakumari	Not reported between Poompuhar and Pt Calimere
Halodule uninervis	South of Pt Calimere	-
Syringodium isoetifolium	South of Pt Calimere	-

* Parthasarathy *et al.,* (1991)

Aquaculture is more recent and is heavily aided by mechanised means of bringing in water from various sources. The system of navigation canals has had the worst impact on the saltwater habitats by linking them and forming a network. The oldest and longest of the canals is the Buckingham canal (completed by the British in 1876) that runs between southern Andhra Pradesh linking the Pulicat lake with the estuaries and backwaters of northern Tamil Nadu opening into the sea in the Kollidam (Coleroon) estuary in Cuddalore. The canal over most of its length is no longer navigable and silted with sewage, debris and agricultural/surface runoff making it shallow and spread laterally creating backwaters. Saltwater that thus spills over has flooded many parts of the northern coasts of Tamil Nadu and southern coasts of Andhra Pradesh making it difficult to delimit the boundaries of three habitats viz., estuaries, backwaters and creeks.

Figure 8: Salt pans close to Kaliveli estuary

Salt marshes are found along the periphery of estuaries, backwaters and creeks. These are seasonal and often dry during the summer months when they are largely grazed. Common plants that are found here include *Cyperus rotundus* (sedge), *Sesuvium portulacastrum*, *Suaeda nudiflora* and where there are pools of freshwater, the invasive *Ipomoea carnea* and species of water lilies (Nymphaceae) and lotus. All species of *Suaeda* are considered endangered (ZOO, 2000).

In India, the present extent of mangrove forests has been estimated as 487,100 ha. (4871 km^2). Of the total, 276,455 ha. (57%) are found in the east coast of India: West Bengal 212,500 ha, Orissa 21,500 ha, Andhra Pradesh 39,700 ha and Tamil Nadu 2755 ha. (Selvam *et al.,* undated). Mangrove habitats are patchily distributed along the study area. The total extent of mangrove forests is rather limited; the largest being in the Krishna delta - 15,600 ha. In fact, the mangroves in the State of Tamil Nadu (that are apparently extensive) contribute to only 0.5% of the country's mangroves. Data available at the Department of Environment, Tamil Nadu suggests that the Nagapattinam district has the most extensive mangrove forests of more than 1000 ha, followed by Cuddalore 700 ha, Tanjore 400 ha, Tuticorin 100 ha and Ramanathapuram 100 ha. The estimated 2100-2300 ha (which is much lower than the figure provided in Selvam et al, undated) of mangrove forests in the State are in various stages of degradation. About 1000 ha are considered as 'dense'. In most other estuaries and creeks where there had been mangrove forests in the past there are only short and shrubby growth of *Avicennia marina*, *Excoecaria agallocha* and *Acanthus ilicifolius.* Species of *Avicennia* and *Acanthus* are endangered (ZOO, 2000).

Restoration efforts in the mangrove habitats have largely concentrated on raising and planting species of *Rhizophora* and *Avicennia.* As a result, outside the protected areas and reserve forests, mangrove habitats are largely 'plantations' (Figure 9). Extensive (natural) mangrove habitats that have been protected by the State Forest Departments include those of the Krishna delta (AP - where between 1986 and 2004 the area of mangrove vegetation increased by 3,823 ha; online database of the M S Swaminathan Research Foundation), Pichavaram (Cuddalore/TN) and Muthupet (Nagapattinam/TN). These mangrove forests have been classified as 'river-dominated' (Selvam, 2003) suggesting that their continued survival largely depends on the quality of river water that flow in from the upper reaches.

The Pichavaram mangroves of Cuddalore district in Tamil Nadu have been studied over the past 100 years beginning in 1897 (Kannupandi and Kannan, 1998). Over the years the mangrove forests of this estuary have dwindled rather rapidly such that only 325 ha have been classified as 'dense' (Selvam *et al.*, undated). During the two decades starting 1970, 285 ha were lost. The present extent of the Pichavaram mangrove has been estimated as 400 ha. (Ramachandran *et al.*, 1998). These forests are in various stages of degradation, especially along the periphery despite their protection status as a Reserve Forest. Twelve species of trees have been listed as 'true' mangroves of which three belong to the genus *Rhizophora*, two are *Avicennia* and one each are placed in the genera *Acanthus, Aegiceras, Ceriops, Bruguiera, Excoecaria, Lumnitzera* and *Xylocarpus* (Selvam *et al*., undated).

The Muthupet mangroves in the Vedaranyam segment are more extensive (1855 ha; Selvam *et al.,* undated) and ecologically diverse. Sixty one species of plants have been listed as mangroves and associates. Besides there are six species of sea grasses, 6 species of freshwater plants and 10 species of marine algae (sea weeds). The habitat mosaic

Figure 9: Afforested mangrove habitats in southern Tamil Nadu

that comprises the Vedaranyam swamp attracts 160 species of birds, many being winter visitors, and is home to 73 species of fish, 14 crustaceans and 18 molluscs (Oswin, 1998). According to an earlier study, the Muthupet mangroves are characterized by just four species of mangroves viz., *Avicennia marina, Excoecaria agallocha, Aegiceras corniculatum* and *Acanthus ilicifolius*. The mangroves are however dominated by a single species *Avicennia marina* (Azariah *et al.*, 1992). Azariah *et al.,* (1992) concluded that *Rhizophora* species that were present in Muthupet more than 200 years ago (confirmed by palynological studies) disappeared due to the bad and unscientific management practices that were adopted in the past.

Kerala that had a mangrove cover of 70,000 ha in the past had a mere 1,700 ha about 15 years ago (Basha, 1991). Despite being supplemented through plantations, the mangroves of Kerala are highly degraded and fragmented throughout the State. A total of eight mangrove plant species and four mangrove associates are found in these areas. *Bruguiera gymnorrhiza* is abundant in low saline areas. Another common plant, viz. *Acrostichum aureum* (fern) also prefers areas of low salinity. Plants like *Sonneratia caseolaris* and *Avicennia officinalis* are the most widespread in the study area and elsewhere within the State (Thomas and Fernandez, 1993).

The segment of the study area that lies within the state of Andhra Pradesh has very little mangrove forests outside the Krishna delta. Here, the estimated mangrove cover is 15,600 ha. A total of 4340 ha of mudflats within the delta can be potentially re-vegetated with mangrove species. However, since the waters of the delta are more saline than the Godavari estuaries, the diversity of mangrove plants is lower. And despite the fact that legal protection has enhanced the mangrove cover by over 3000 ha during the 20 years starting 1986, the 20,466 ha of aquaculture farms (one of India's most extensive aquaculture) are placing heavy pressure on the delta and the mangroves (Selvam *et al*., undated and online database of the M S Swaminathan Research Foundation).

Rocky inter-tidal habitats support some of the most diverse coastal communities of algae and animals in tropical seas (McGuinness, 1987a & b). These habitats are however more a natural feature of the west coast and hence not significant within the study area. Rocky inter-tidal habitats are present only in the southern coasts especially in the Kanyakumari district of Tamil Nadu and Kerala.

Wildlife and habitats

Freshwater pools and open wells are not natural in the strict sense. However, these are largely in low lying areas where the water table is high, and as humans have over the years identified these natural sources and nurtured them, they are treated as natural habitats. Most of these are small and isolated, except during the monsoon season when the low-lying areas are flooded. These isolated pools and wells are ideal habitats for a variety of fishes, amphibians and reptiles. Most species of freshwater fishes that inhabit these habitats breed before the monsoons and are dispersed by the floods. These habitats are important in sustaining 'meta-populations' of smaller species of native fish.

Common species of fish that are found in these habitats are *Colisa lalia, Aplocheilus panchax, Aplocheilus blocki, Aplocheilus lineatus, Aplocheilus parvus, Macropodus cupanus, Anabas testudineus, Etroplus maculatus, Lepidocephalus thermalis, Channa punctatus, Oryzias melastigma, Macrognathus pancalus, Puntius sophore, Puntius vittatus, Rasbora daniconius, Mystus vittatus, Mystus gulio, Heteropneustes fossilis, Pseudeutropius atherinoides* and the invasive *Gambusia affinis* and *Oreochromis mossambicus* (Daniels, 2002). Interestingly, with the exception of *Lepidocephalus thermalis, Puntius vittatus* and *Rasbora daniconius*, these fish are tolerant of salinity and do well even in estuarine conditions. *Pseudeutropius atherinoides* is listed as an endangered species (ZOO, 2000).

Apart from fish these habitats are used by many species of anuran amphibians such as *Bufo melanostictus, Polypedates maculatus, Hoplobatrachus crassus, Hoplobatrachus tigerinus, Euphlyctis cyanophlyctis, Euphlyctis hexadactylus, Limnonectes limnocharis, Microhyla ornata, Ramanella variegata, Kaloula taprobanica* and *Tomopterna rolandae* (Daniels, 2005). Of these, the Indian pond frog (*Euphlyctis hexadactylus*) is an obligate inhabitant of the coastal freshwater pools and open wells. The typically green morph of this species is most commonly found in the coastal freshwater pools, especially in waters that are quite green due to eutrophication and where there is a dense growth of submerged aquatic plants. Adults of the Indian pond frog that have been observed in the eastern coasts of south India are known to feed on aquatic plants (Daniels, 2005).

Common reptiles in these habitats are the endangered flapshell turtle *Lissemys punctata* and water snakes such as *Xenocrophis piscator, Cerberus rhyncops* and *Atretium schistosum*. The flapshell turtle, a freshwater species, is protected under Schedule I (part II) of the Wildlife (Protection) Act of India, 1972. Amongst the snakes, *Cerberus rhynchops* (Dog-faced water snake) is an estuarine species. The other two generally avoid salt water habitats.

Wildlife habitat in the present study has been rather narrowly defined. It focuses on habitats of mammals, birds and sea turtles (nesting). The distribution of wildlife habitats in the study area was assessed directly (in case of turtles and birds) and indirectly by interviewing local people (mammals). Table 7 summarises the distribution of wildlife habitats. The greatest diversity of wildlife and habitats is found around the protected areas of Vedaranyam (Segment 10; includes Point Calimere WLS). This is the only location where the presence of ungulates including spotted deer (*Axis axis*) and blackbuck (*Antilope cervicapra*) has been confirmed. Wild boar (*Sus scrofa*) is also known in the Kattupalli Island (Pulicat Lake).

Blacknaped hare (*Lepus nigricollis*) and terrestrial rodents (*Tatera indica*) have been reported from many segments. Almost all the carnivores that were reported locally were either the Indian fox (*Vulpes bengalensis*) or the jackal (*Canis aureus*). Since local people tend to confuse the two species, secondary information on the distribution of the two species has been treated cautiously. There are reports of mongooses. Although there is a report of a dead leopard (*Panthera pardus*) that was found in Pulicat Lake (Kannan and Manakandan, 2004) during our surveys, there was no clue of the presence of any species of wild cats in the study area.

The field study began late in the season for migratory birds that visit the east coast. Although waders including curlews (*Numenius arquata*), grey plovers (*Pluvialis squatarola*) and others belonging to the genus Tringa were seen, they were not in large numbers anywhere. Waterfowl (storks, herons and egrets) were the most common birds during the season. Openbill stork (*Anastomus oscitans*) (abundant), painted stork (*Mycteria leucocephala*), greater flamingo (*Phoenicopterus ruber*) (occasional flocks in the northern Tamil Nadu coast) and egrets were seen over most parts of the study area. A few grey pelicans (*Pelicanus philippensis*) were observed in February in the Pulicat lake. The most numerous of the heron/egret group of birds were the great egret (*Casmerodius albus*) and the pond heron (*Ardeola grayii*). Gulls (*Larus spp.*) were seen in the backwaters of Kovalam (south of Chennai) and Porto Nova (Parangipettai, Cuddalore).

Table 7: Distribution of wildlife habitats

Segment no	Turtle nesting	Waders feeding	Waterfowl	Small carnivores	Hare and rodents	Wild boar	Ungulates	Feral horses and cattle
1								
2		+	+					
3		+	+					
4	+	+	+					
5	+	+	+					
6	+	+	+					
7	+	+	+	+	+			
8	+	+	+	+	+	+		
9	+	+	+	+	+			
10	+	+	+	+	+	+	+	+
11	+	+	+	+	+			
12	+	+	+	+	+			
13	+	+	+	+	+			
14	+	+	+	+	+			
15	+	+	+					
16	+	+						
17			+	+	+	+		
18				+				
19					+			
20		+						
21				+	+			
22				+				
23	+			+				

The survey coincided with the arrival of the Olive Ridley turtles (*Lepidochelys olivacea*) in Tamil Nadu coast. Nesting of this species was observed/reported throughout the coast of Tamil Nadu. Nesting was not observed in Andhra Pradesh since the survey was completed before the onset of the breeding of the turtles. No nests were observed or reported in the coast of Kerala where most of the beaches have been protected against sea erosion using boulders (dykes).

Man-made habitats

Coastal landscapes are known for their long history of human interference. Currently 20% of India's one billion people reside on the coasts. As a result most coastal habitats, as they are seen today, have either been degraded, modified or entirely created by human beings (Table 8). One of the most common man-made habitats that are seen along the entire coast of India is monoculture of casuarina trees. Although these are often called 'shelter-belts', information provided by local people suggests that a majority of these are private holdings in general. Few if any, have been planted with the clear purpose of protecting the beaches and coastal villages from sand erosion and storms. Mature plantations that can serve as shelter belts are found only in the west coast. Almost all the plantations that were visited during the present study were either young or coppices due to a harvest of casuarinas poles.

Cultivation of coconut and cashew (*Anacardium occidentale*) is prevalent. Around Cuddalore and Pondicherry, the dunes are more or less fully planted with cashew (Figure 6). These trees have a low and spreading canopy and have served the purpose of shelter-belts wherever they are. Other horticultural species including the palm (*Borassus flabellifer)* and a variety of fruit trees including jack are common in the coastal villages. Agricultural crops such as rice, groundnut and water melon were common in the study area.

Table 8: Distribution of man-made habitats

Segment no	Shelter belt/ plantation	Cultivation	Dykes/ groynes	Canals	Salt pans	Mangrove plantation	Aquaculture
1	+	+	+	+			
2	+	+	+	+			
3	+	+	+	+			
4	+	+	+	+	+		
5	+	+	+	+	+		+
6	+	+	+	+	+	+	
7	+	+	+	+	+	+	+
8	+	+	+	+	+	+	+
9	+	+	+	+	+	+	+
10	+	+	+	+	+	+	+
11	+	+	+	+	+	+	+
12	+	+	+		+	+	+
13	+	+	+	+	+	+	+
14	+	+	+	+		+	+
15					+		
16			+				
17	+						+
18							
19	+		+				+
20	+						+
21					+		
22					+		+
23				+	+		+

Dumping large boulders and concrete tripods to create dykes has been in practice for more than 20 years along the east and west coasts of India. This method of controlling sea erosion was probably first introduced in the west coast (Kerala and Karnataka) where the land close to the sea is quite sloped and prone to wave erosion. More recently, dykes of this nature have been built in many parts of the east coast, particularly along the ports and harbours where even groynes project into the sea (Figure 10).

The groynes play a role in creating newer beaches due to wave action and as they project deeper into the sea become habitats for algal growth and associated invertebrates like crustaceans and molluscs. In fact, groynes do resemble natural inter-tidal rocks in terms of the biological communities that they shelter. Dykes on the contrary have destroyed beaches and shore-life wherever they have been constructed and interfered with the nesting of sea turtles.

Canals that had been created along the coast for navigation (as discussed above) and for bringing in water for saltpans, aquaculture and mangrove afforestation have played the role of corridors for a long time, now that the ecology of the coastal waters has been drastically affected. Natural mixing of sea and freshwater during the monsoons and artificial flushing for the purpose of salt-making and aquaculture during the summer months have constantly impacted the coastal waters and ecologically homogenised them. Thus we find that there is hardly any ecological difference between an estuary, creek, lagoon and backwater along the coasts.

Salt pans are absent in Kerala. The most intensive salt-making is in Tamil Nadu, especially in the southern coasts. The salt pans near Marakanam have a historical exsistence and are extensive. Those that were functional in Kovalam (near Mamallapuram) were abandoned a few years ago due to the problem of migrating labourers. Salt pans were also observed in the northern limits of the study area (AP). Salt pans that have been studied elsewhere have proved to be ideal habitats for wading birds during the early season as the water is shallow and productive. However, later in the season the water gets so salty (more salty than the sea) that biological productivity drops to zero making the salt pans unfit for birds and other dependent organisms (Daniels, personal observation). Interestingly, the salt pans are classified as CRZ I (Coastal Regulation Zone I) along with natural habitats such as mangroves, estuaries and wildlife habitats as that in Vedaranyam and Pt Calimere.

Despite the ban imposed on large-scale coastal aquaculture, shrimp farms and hatcheries under various guises continue to violate CRZ I restrictions throughout the east coast. Although not popular in southern Kerala, this industry is widespread in Tamil Nadu and Andhra Pradesh. There are aquaculture ponds and units even in the Pulicat Lake. More recently, there has been a spate of jellyfish (*Rhopilema sp*) processing units in the CRZ I of Tamil Nadu. These concrete units that use sea water and beach space were found in the seaward side of the Pulicat Lake and Cuddalore. More sophisticated jellyfish processing factories were found in Marakkanam (near Pondicherry).

Along the coasts of Tamil Nadu, mangrove afforestation has been attempted where there had been mangroves in the past and in areas where there are flat and low-lying mudflats. Mangrove species including *Rhizophora* and *Avicennia* have been planted here after a series of straight canals were dug. The mangrove plants are currently at in various stages of growth and establishment. The few patches (outside protected areas) that are tall and well established include the plantations in Pondicherry (Pondy-Cuddalore road) and the experimental plantations raised by the Centre for Advanced Studies in Marine Biology of the Annamalai University in the estuaries and backwaters of Parangipettai (Porto Nova).

Impact of tsunami on natural and man-made habitats

The impacts of tsunami on natural and man-made habitats have been summarised in Tables 9-14. Data provided in Table 9 has been reproduced from a recent issue of Current Science - the results of a detailed study undertaken by Chadha *et al.,* (2005). According to the study the wave run-up in the coasts of Tamil Nadu ranged between 2.5 and 5.2 m (Nagapattinam). The wave run-up in Andhra Pradesh did not exceed 2.5 m. Segments where the wave run-up exceeded 4 m are 11-13 (Nagapattinam-Cuddalore) and 15 (Mamallapuram-Kalpakkam). Segments that experienced a wave run-up of 3-4 m are 10 (Vedaranyam), 14 (around Pondicherry) and 17 (Pulicat Lake). Wave run-up did not exceed 3 m anywhere else in the study area (Table 9).

Figure 10 (inset): Groynes in northern Chenai

Figure 11: Sand dunes washed down by the tsunami

Lateral inundation of sea water varied between 145 and 800 m (Table 9). The maximum inundation was experienced by Nagapattinam, followed by Parangipettai, Tarangampadi (Tranquebar), Kalpakkam and Devenampatnam. The inundating water carried with it large quantities of sand and silt. The maximum distance the sand was carried inland was 430 m in Nagapattinam followed by Parangipettai (400 m). Interestingly, Nagapattinam and Parangipettai have the widest beaches (300 m) whereas in most other parts of Tamil Nadu beaches are between 30 and 50 m in width (Chadha *et al*., 2005).

Chadha *et al.*, (2005) have stated that 'small differences in local run-up and topography have resulted in large differences in tsunami inundation and associated loss of life and property in coastal Tamil Nadu'. According to their observations and report, water that rushed inland spread via the river mouth and estuaries and spread laterally wherever there were sand dunes that ran parallel to the shore or breached the sand dunes and inundated the low lying areas behind.

Impact on natural terrestrial habitats

Our surveys assessed the impacts qualitatively using a 3 level scale - high (H), medium (M) and low (L) (Tables 10-13). Impact on the beaches were generally low or medium except in Cuddalore (Segment 13) where the sand that washed the beach has stayed increasing the overall height locally by about 1 m. The result of the sand deposition had led to the closure of the mouth of a natural creek that the fishermen used to take their boats into the sea. Subsequently, the sand bar created across the mouth was opened using a dredge.

Impact on littoral forests was low or medium in most parts surveyed (Table 10). In general, no trees were uprooted although roots (especially those with adventitious roots as in the palm *Borassus flabellifer*) were exposed due to the soil erosion that was caused when the waters receded. Similarly, there was low or medium level of damage that grass and scrub habitats experienced. Since the water inundated and quickly receded, there was only temporary wilting (browning) of grass and scrub. Such an impact was felt even in the Point Calimere WLS. However, since therewere good rains during the month of March, 2005, most of the grass and scrub recovered (Table 11).

Table 9: Details of tsunami run-up survey along the coast of Tamil Nadu

Location	Latitude (N) & Longitude (E)	Run-up elevation (m)	Lateral inundation (m)	Maximum sand distance (m)
Pulicat	13°23.040' 80°19.984'	3.2	160	90
Pattinapakam	13°01.263' 80°16.722'	2.7	145	120
Kovalam	12°47.455' 80°15.003'	4.3	180	120
Kalpakkam	12°30.378' 80°09.88'	4.1	360	190
Periakalapet	12°01.544' 79°51.888'	3.9	170	130
Puttupatnam	11°51.618' 79°48.926'	2.6	-	-
Devenampatnam	11°44.576' 79°47.230'	2.5	340	180
Parangipettai	11°30.965' 79°45.947'	2.8	700	400
Tarangampadi	11°01.620' 79°51.350'	4.4	400	150
Nagapattinam	10°45.785' 79°50.928'	5.2	800	430
Vedaranniyam	10°23.597' 79°52.014'	3.6	-	-

Source: Chadha *et al.*, (2005)

Sand dunes that were covered with tall woody vegetation (including the planted cashew) were the only ones that were not damaged by the tsunami. Those covered with the grass *Spinifex littoreus* were washed away (breached) allowing the water to enter the low-lying areas in the hinterlands (Figure 11). Extensive patches of the soil binding creeper *Ipomoea pes-caprae* wilted due to the inundation as their roots were exposed. However, in most places the rains have helped them re-establish in a lush manner.

The moisture left behind in the beach sand by the tsunami has only favoured the rapid establishment of certain species of coastal and salt-tolerant herbs. In the coasts of Andhra Pradesh, the excessive growth of the herb *Heliotropium curassavicum* has been felt as an 'unusual' phenomenon by the local fishermen. Many other species of plants were observed sprouting on the silted beaches. From the seeds (and seedlings) identified, it was evident that these have been washed ashore from far away habitats. The presence of seeds of *Entada sp* (lianas found in evergreen and moist deciduous forests), *Nypa fruticans* (a mangrove palm whose present range in India is limited to the Sundarbans and Andaman and Nicobar islands) and a few unidentified ones (evidently of species that use seawater for dispersal) suggests that there is a lot of scope for natural establishment of a new community of plants on the impacted terrestrial habitats (Figure 14).

In Parangipettai and further south in Vedaranyam, large uprooted trees believed to be of Andaman teak have been washed ashore. Similarly, there are instances of coconuts (of a possibly Sri Lankan variety) that have been washed ashore on the coasts of Tamil Nadu. These plant materials are dead and they cannot establish on the coasts of Tamil Nadu. However, there are chances that they brought with them smaller animals that might eventually colonize the mainland coasts. Rodents, reptiles and arthropods are quite capable of colonising newer areas sailing across the sea. This is a possibility that has to be carefully assessed throughout the tsunami impacted terrestrial habitats.

In many segments, the tsunami has created new lagoons. Near Mamallapuram (Segment 15) a lagoon thus created was silted with red earth. While it is not clear as to how this change could have taken place, what is interesting is that these shallow lagoons have created new habitats for a number of species of fishes. We shall discuss this further under the section on natural aquatic habitats.

Table 10: Impact of tsunami on natural terrestrial habitats

Segment no	Littoral forest	Dune vegetation	Grass/scrub	Beach
1			L	L
2			L	L
3			L	L
4	L	M	M	M
5	M	M	M	M
6	M		L	L
7	H	L	L	M
8	M	M	M	L
9	M	M	M	M
10	M	H	M	M
11	M	M	H	M
12	M	H	H	M
13	M	M	H	H
14	M	H	M	L
15				
16			L	
17		H	H	
18				
19				
20				
21				
22				
23				

Impact on natural aquatic habitats

Aquatic habitats have generally been spared by the inundation except the freshwater pools that have been salted in some segments (Table 11). Sea grasses were reported as uprooted in the Gulf of Mannar Biosphere Reserve (Table 1). During our surveys we did come across strands of sea weeds that were washed ashore. However, there was no evidence of sea grasses being uprooted and washed ashore. The medium impact reported from Segment 6 is based on the leaf debris that was washed ashore on the beach. According to Dr N Parthasarathy, this is normal. Apparently dead and decaying sea grass blades are constantly washed ashore and in habitats as in the Gulf of Mannar where they are very diverse and dense, tonnes of such debris litter the shores (NP *pers. comm.*). Sea weeds get detached and washed ashore due to the fishing operations close to the shore. Therefore it is difficult to infer that the tsunami was responsible for the debris on the beaches.

Rocky inter-tidal areas are sparse. They were all already lost in most parts (especially in Kerala) where they have been covered with large boulders due to the construction of dykes to protect the shore from wave erosion (see photo). Further, subsequent to the tsunami, more embankments have been created in an attempt to protect human lives and property in the event of a future catastrophe.

Reports of coral reefs being damaged (Table 11) are premature. Although our study could not directly assess the impact on coral reefs, we did come across broken coral skeletons near Ennore (north of Chennai) and in Cuddalore where there are no recent reports of reefs. And as these coral skeletons were rather old (completely discoloured), it may be inferred that they were washed ashore from somewhere far away long after they had died. Many species of gastropods (sea shells) and echinoderms were washed on the beaches where they had not been reported earlier. The echinoderm 'sand dollar' (*Echinodiscus auritus)* was found in good numbers on the beach of Parangipettai. All were bleached, suggesting that they died much before the tsunami. Of the many sea shells that were observed (and collected) on the various beaches, two species are of significance. The first is *Tudicla spirillus* (two individuals) found in Pulicat and Parangipettai. The other is a single *Murex palmarosae* found in Parangipettai (see Figures 12 and 13). According to Deepak Apte (1998) both species are endangered. The shells had lost all the soft tissues within. Yet the strong stench

Table 11: Impact of tsunami on natural aquatic habitats

Segment no	Estuary	Backwater	Creek	Salt marsh	Mangrove	Sea grass	Rocky inter-tidal	Freshwater pools
1		L						
2	L	L						L
3	L	L						
4	M	M	L	M	L		M	H
5	L	M	L	M	L		M	M
6	L	L	L	L	L	M		L
7	M	H	L	L	M			L
8	M	M	H	M	H			L
9	M	M	M	H	M			L
10	M	M	M	H	M			L
11	L	M	L	M	L			H
12	M	M	L	H	H			H
13	L	M	L	H	M			H
14	L	L	L	M	M			H
15								
16								
17								
18								
19								
20								
21								
22								
23								

in the Murex shell suggested that it had died recently. Since Apte (1998) has mentioned that there have been only two live records of the species on the coast of India, the present collection assumes significance. The species is known in India, Sri Lanka and Southeast Asia.

As shown in Table 13, very little could be assessed about the impact of tsunami on wildlife and habitats. Studies in the Point Calimere WLS, the mainstay of wildlife along the east coast south of Bhitarkanika WLS, have reported that the impact of tsunami on terrestrial mammals including the blackbuck and spotted deer was negligible (Table 1). Observations reported by foresters present at the time of the inundation suggest that the animals ran to safer areas. The damage caused to the grazing areas was also minimal and temporary.

Much of the damage to natural aquatic habitats that tsunami might have caused has come from the accumulation of material and debris (Table 12). The organic and inorganic debris have choked natural waterways and channels in mangroves. Whereas wood and thatch, tile and bricks and fallen trees and branches would eventually degrade, inorganic material such as plastic bags, bottles, floats used in fishing nets, torn and abandoned fishing nets and damaged boats and vehicles could pose serious problems to biodiversity in estuaries, creeks, marshes, backwaters and mangroves by polluting the water and soil. What is the most serious of these is the 'ghost fishing' by the abandoned nets. These are buried deep in the bottom with one end drifting. The drifting end catches and kills fish wherever the nets occur. Large-sized marine catfish in the genus *Arius* were found trapped and struggling in these nets in the Pulicat Lake (Figures 15 and 16).

Elsewhere in Segment 17 (Pulicat), wildboar that inhabited the forested islands ran and escaped the inundation. However, the blacknaped hare was a victim. Local volunteers who have been involved in the restoration of the Katupalli Island reported of the many hares that drowned. These animals were probably taken unawares as they were resting during the day. Mr John Burton (World Lands Trust, UK) an expert on rabbits and hares felt that the drowning of these animals was due to the fact that they are poor swimmers.

The suggestion that the tsunami proved to be a boon to the nesting turtles (Table 1) is not entirely correct. The absence of fishing boats and nets along the coasts of Tamil Nadu did spare a number of olive ridley turtles that arrived to breed on the beaches. At the same time, 300-400 turtles were observed being caught by fishermen around Machilipatnam in Andhra Pradesh (Segment 23) and sold in the local fish markets. According to the fishermen the presence of turtles in their seas was rather unusual. Elsewhere in the coasts of northern Tamil Nadu coastal people deprived of fish were harvesting all the eggs laid by the turtles. A number of nests that were excavated by humans were observed closer to Mamallapuram (Figure 17).

Birds have been affected for the better or worse by the tsunami. Huge amounts of silt that were brought in by the inundation have been trapped within the existing lagoons and backwaters rendering these habitats shallow and ideal for wading birds. This complimented by the fact the fishing operations and tourism (boating) in these habitats had come to a stand still, has attracted a large number of egrets. The Kovalam backwaters (near Mamallapuram) are one such location where the transformation of habitat into a shallow one and the absence of fishing and tourist boating have proved to be a boon to birds. Unusually large gatherings of the great white egret have been observed along the coasts between Kovalam and Marakkanam (Segments 14-16). Another instance is the Adyar creek in Chennai. This creek used to be a local birding area that attracts a large number of migrant waders and the blackwinged stilt (*Himantopus himantopus*). A few years ago, the Chennai Corporation as part of an effort to beautify the city had dredged and deepened the creek. The waders that had since left the creek had made a re-appearance after the tsunami brought back all the silt!

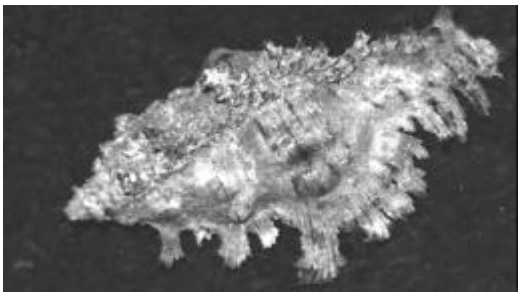

Figure 12: *Murex palmarosae*, an endangered species

Figure 13: *Tudicla spirillus*, an endangered species

Table 12: Nature of damage due to material/debris accumulation caused by tsunami

Segment no	Wood/thatch	Tiles/bricks	Fallen trees	Plastic	Thermocol/ floats/rubber	Cloth/leather	Fishing net	Damaged boats	Damaged vehicles
1									
2	+	+				+		+	
3									
4	+		+	+		+	+	+	+
5	+	+	+	+	+	+	+	+	
6									
7	+	+		+	+	+	+		
8	+		+			+	+	+	
9	+	+		+	+	+	+		+
10	+	+	+	+	+	+	+	+	+
11	+	+	+	+	+	+	+	+	+
12	+	+	+	+	+	+	+	+	+
13	+	+	+	+	+	+	+	+	+
14	+	+	+	+	+	+	+	+	+
15									
16									
17							+		
18									
19									
20									
21									
22									
23									

Adverse impact, if any, on birds have been where the water depth has changed making it unfit locally for the swimming and diving waterfowl. The accumulation of floating material and debris has also locally interfered with the foraging of birds. It is however felt that the impact on birdlife, if any, can only be temporary. The next rainy season will cleanup the debris in all probability. Further, since the study coincided with the return migration of most of the waders and waterfowl, an exact assessment of their diversity and abundance could not be made in most of the segments that were visited. For instance, when the Pulicat Lake was visited in February-March 2005, there were hardly any birds to be seen. Recent reports in the newspapers suggest the arrival of greater flamingos in Pulicat. As flamingos do not breed in Pulicat, they may be on their return migration and will not stay for long or they could be non-breeding birds that prefer to stay on. A few (5-10) such birds were observed in May 2005 in the backwaters between Kalpakkam and Marakkanam (Segment 15).

Impact on wildlife habitats - fish

The tsunami has had a rather interesting impact on coastal and marine fish species and communities. These impacts are apparently positive - proving a boon to fishes. The first major change that the sea and the coastal saline aquatic habitats have experienced is enhanced productivity. Although the productivity in the seas and coastal waters have not been directly assessed, it can be inferred that the large quantities of dead and decaying material that have gone into the waters can enrich the water leading to eutrophication and an explosive growth of plankton. This assumption has proved to be real in that throughout the coasts of Tamil Nadu, there have been bumper harvests of the plankton feeding

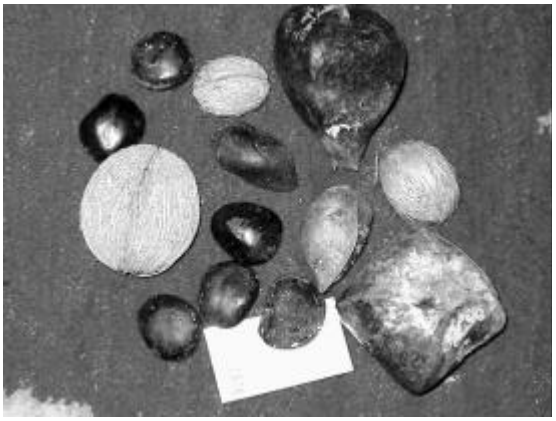

Figure 14: Seeds washed ashore during the tsunami

Figure 15: *Arius* catfish, one of the victims of drifting nets

Figure 16: Fish trapped in abandoned nets

fish - sardine in the months of March and April, 2005. Our study observed huge catches of sardines being dried on the beaches of Parangipettai (Cuddalore) to be sold to the poultry feed industry (Figure 18). Similar observations were reported by Prof S. Lazarus, a marine biologist (Chairman, Institute for Environmental Research and Social Education, Nagercoil), in the seas of the Kanyakumari district (*pers. com.*).

The explosion of plankton in the shallow waters and the fact that there has been little fishing using mechanised boats during the last six months have together benefited fish communities that start breeding around summer and before the rains in the Bay of Bengal. Post-tsunami observations of dolphins swimming close to the shore near Chennai reported in local newspapers could be attributed to the mammals following the schools of smaller fish like sardines that they feed on.

The tsunami has created newer habitats (Figure 19). The creation of coastal lagoons was discussed earlier. These lagoons are quite full of marine fish that the local people could subsist by catching these in many areas. What is most important is that both the newly created lagoons and the existing ones including the navigation canals that run behind the dunes in northern Tamil Nadu and southern Andhra Pradesh had been over-run during the tsunami inundation. The inundating water has brought with it, amongst other living organisms, fish that are not known locally. Local fishermen did confirm the presence of 'exotic' fish in the waters of Pulicat Lake and elsewhere in coastal Andhra Pradesh although they could not identify or show any examples. Nevertheless, during our surveys we were able to confirm the presence of reef fishes in the Pulicat Lake! Sea water that had inundated the low-lying sand bars had filled some of the abandoned concrete tanks. These tanks were earlier used to process harvested jellyfish. Led by the local children, we observed reef fishes trapped in the tanks that held clear sea water. The fish were identified as *Dascyllus survanus* based on information available at the Centre for Advanced Studies in Marine Biology of the Annamalai University. This beautifully patterned reef fish is known in the seas around the Great Nicobar Island (as suggested by

Table 13 Impact of tsunami on wildlife habitats

Segment no	Turtle nesting	Waders feeding	Waterfowl	Small carnivores	Hare and rodents	Wild boar	Ungulates	Feral horses and cattle
1								
2		L	L					
3		L	L					
4	L	L	H					
5	L	L	H					
6	L	L	L					
7	M	M						
8	L	M						
9	M	M						
10	M	M						
11	M	M						
12	L	L						
13	M	M						
14	L	M						
15	H	M						
16	L	M						
17					H	L		
18-22								
23	H							

a study undertaken by Prof L Kannan of the CAS in Marine Biology). The presence of this species in the seas around Chennai has not been reported by earlier surveys (Samal and Misra, 1972; Venkateshwarlu *et al.*, 1975).

Impact on man-made habitats

Crops, especially groundnut were lost in many coastal areas (Figure 20). Similarly aquaculture ponds were also breached and silted. In southern Tamil Nadu (Segment 8) dykes had been damaged (Table 14). Salt pans were over-run by silt in a few segments. The so-called shelter belts, especially those of casuarinas were damaged in many parts of

Figure17: Harvested turtle nests

northern Tamil Nadu. Some trees were uprooted (as in Parangipettai) and where they stood, both young and older trees have wilted. Whereas natural mangroves had withstood the inundation, young plantations were damaged as they had been uprooted in some areas and in others the beds where they had been planted were over-run by silt (Figure 21).

Very little information could be obtained on the impact of tsunami on domestic animals. In general, interviews of local people suggested that coastal human communities (especially fishermen) do not rear livestock. The only authentic information on actual number of deaths of livestock is that provided by the local government agencies of Cuddalore district in Tamil Nadu (Table 15).

Two hundred and seventy-three domestic mammals including cattle, buffaloes, sheep and goats is a fairly high number for a single locality such as Parangipettai. Maximum deaths have been in sheep. That only four buffaloes died might suggest that they survived the inundation being good swimmers. However, based on direct field observations it was inferred that buffaloes are not commonly maintained by the coastal people.

Evidence of death in domestic animals is easily lost due to scavenging by a range of smaller animals (especially crows and kites) in the beach and the washing away of the remains by the waves. Interestingly, shore crabs have proved efficient in scavenging on the beach. A dead cat that was observed on the beach near Mamallapuram had been largely scavenged by hundreds of shore crabs that swarmed. Although the cat was not a victim of tsunami, it provided some clues to what could have happened to the dogs, cats and poultry that had been killed during the inundation.

Impact on human lives and property

District-wise statistics compiled for the sake of offering relief services available for the three impacted states viz., Andhra Pradesh, Tamil Nadu and Kerala have placed the number of persons dead or missing along the coasts between 7,500 and 8,000. Only 106 were confirmed dead in Andhra Pradesh of which 27 were from the Krishna district and another 35 from the Prakasam district (Chadha *et al.*, 2005). Less than 200 lives were lost in Kerala with 118 from Kollam district and three from Alapuzha. Of those dead in Kollam, all 118 were in one village Azhikkal. In Pondicherry, 591 people lost their lives and another 75 were reported as 'missing' (UN Country Team-India, 2005).

In Tamil Nadu, the greatest loss of human lives was in Nagapattinam followed by Kanyakumari, Cuddalore and Kanchipuram districts. Over 6,000 deaths were reported in Nagapatinam district alone, of which 3378 were from Nagapattinam taluk. Only six deaths have been reported in the Ramanathapuram district. In Kanyakumari district 824 persons were reported dead. Of the 9 deaths reported from Tiruvallur, only one occurred within the district (Ennore) the others are of persons who hailed from there but were killed in Andaman Islands (1), Nagapattinam (4) and Nagore (3). Twenty four persons reported missing from Tiruvarur district had not died there but instead were lost at Velankanni (18) and Nagapattinam (6).

The available statistics of the district-wise distribution of human mortality due to tsunami are not 'unbiased'. As shown above, many people who lost their lives did not actually die in their home villages. They were killed elsewhere. And from the available information, there is evidence that most people lost their lives in areas that attracted

Figure18: Oil sardines being dried for poultry

Figure19: A typical newly created lagoon

tourists/pilgrims such as Kanyakumari, Nagapatinam, Cuddalore and Kanchipuram. These districts are also among the six districts in the state with a coastal population that touches 10 lakhs or more (Table 16; also see Table 3). Added to this the local population at the time of tsunami inundation had locally swollen due to tourism - December being the month of tourist rush in Tamil Nadu (Kanyakumari), Velankanni Church drawing crowds coinciding with Christmas and New Year, etc., have all contributed to the massive loss of human lives.

The coast of Tamil Nadu has been divided into four geographical segments: the Coramandel (Segments 17-10; the longest 350 km between Chennai and Point Calimere), Palk Bay (Segments 10-7; 275 km between Point Calimere and Pamban), Gulf of Mannar (Segments 7-5; 315 km between Pamban and Kanyakumari) and West Coast (Segments 5-4; 60 km westwards from Kanyakumari) (see Figure 1 and Table 2 in the section on Study area and Methods for details of Segments). Evidently the impact of tsunami on human lives and property has been the most on the Coromandel Coast lying between Pulicat Lake and Vedaranyam (Chadha *et al.*, 2005) and the West Coast in Kanyakumari. While the suggestion that the island of Sri Lanka took a major part of the impact thus buffering the southern peninsula (the Palk Bay and Gulf of Mannar segments) is quite simple and readily acceptable, there are other factors that seem to have played a role in distributing the impact of the tsunami rather unevenly along the coasts of Tamil Nadu.

Chadha *et al.*, (2005) have summed up their study in a rather suggestive manner. According to them, 'loss of life and property was reported in the first 100 m from the shore where small settlements were washed away (a pointer to the fact that CRZ regulations had been grossly ignored). Small differences in local run-up and coastal topography resulted in large differences in tsunami inundation and associated loss of life and damage within the Tamil Nadu coastal areas. The combination of local high run-up, low topography and dense development apparently accounted for the large loss of life and property'.

Figure 20: Wilted groundnut crop

Table 14: Impact of tsunami on man-made habitats

Segment no	Shelter belt/ plantation	Cultivation	Dykes/ groynes	Canals	Salt pans	Mangrove plantation	Aquaculture
1	L	L	L				
2	L	L	L				
3	L	L	L				
4	M	M	M		M		
5	M	M	M		M		
6	L	L	L		L		
7	H	L	M	H	H	L	L
8	M	M	H	M	H	H	M
9	H	L	L	M	L	L	M
10	H	L	L	L	L	L	H
11	H	H	L	M	L	L	M
12	H	H	L	M	L	H	H
13	M	H	L	M	L	M	H
14	M	M	L	M	L	L	H
15		M		M		L	M
16							
17							
18							
19							
20							
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Note: During a post-tsunami national workshop in April 2005 at Chennai a number of researchers presented their observations and preliminary inferences on the impact of tsunami on coral reefs and other natural habitats. Dr Rohan Arthur (reef biologist) who was present, after seeing a photograph of silt on coral heads and broken arms of the common stag horn coral (*Acropora sp*), remarked saying the 'observed impact is much less than that observed after the monsoons in the Lakshadweep reefs or that caused by one of those cyclones in the east coast during the northeast monsoon'.

Figure 21: Casuarina plantations of different ages, destroyed by the tsunami

Table 15: Loss of domestic animals in Parangipettai, Cuddalore District (Segment No 12)

Category	Number dead
Cows	72
Buffaloes	4
Sheep	177
Goats	20
Total	**273**

Despite the limited data, Table 16 brings out some of the conclusions drawn from the study of Chadha *et al* (2005) rather vividly. In the state of Tamil Nadu, 97 lakh (9.7 million) humans live within what have been classified as coastal taluks. Considering the 1000 km coastline of the State (equal to 1000 x 1000m = 1 million metres), it may be inferred that for every 10 persons living along the coast, there is 1m of shoreline available. In other words, the per capita shoreline available in the coasts of Tamil Nadu is merely 10 cm! Table 16 further suggests that for every 3 km of the coast, there is one village in the State. Either way, what the simple analysis suggests is that the coasts of Tamil Nadu are very densely inhabited by human beings that they are vulnerable to natural calamities that originate in the seas.

The districts such as Tiruvallur, Ramanathapuram, Tuticorin and Tirunelveli where the least number of people were killed by the tsunami, all have a per village coastline of 5 km or more which is greater than what it is for the entire State (Table 16). Although Ramanathapuram has the highest per capita coastline of 37 cm per person, the second highest of 26 cm being in the Pudukottai district has made it difficult to assume that there is any correlation between the availability of per capita and per village coastlines. As suggested by the Tuticorin and Nagai-Tiruvarur districts that have comparable coastal populations, the number of coastal villages in the State does not determine the total coastal population. Fewer, though densely populated, villages as in Tuticorin district with a large stretch of uninhabited coastline (the Gulf of Mannar part) might be an ideal pattern of human distribution along the coasts that could have minimized loss of life and property. The gross nature of the present data set does not permit finer analysis in this regard and hence the trends that have emerged in Table 16 could at best be considered as pointers or clues to future investigations.

Table 16: Distribution of human habitation along the coast in the state of Tamil Nadu

Name of district	Segment number	Length of coastline (km)@	Number of taluks*	Number of coastal villages*	Human population in coastal taluks	Relative length of coastline	
						Per village (km)	Per capita (m)
Kanyakumari	4-5	68	3	20	15,66,000	3.4	0.04
Tirunelveli	5	50	1	09	2,65,00	5.6	0.18
Tuticorin	6-7	121	3	12	12,35,000	10.1	0.09
Ramanathapuram	7-8	271	4	47	7,33,000	5.8	0.37
Pudukottai	9	42	2	23	1,62,000	1.8	0.26
Tanjore	10	35	2	13	4,88,000	2.7	0.07
Nagai-Tiruvarur	10-11	165	6	77	12,64,000	2.1	0.13
Cuddalore	12-13	89	2	30	9,15,000	2.2	0.08
Vilupuram+	13	-	1	20	4,13,000	-	-
Kanchipuram	14-15	87	3	36	13,38,000	1.9	0.06
Chennai	16	22	1	03#	-	-	-
Tiruvallur	16-17	50	2	10	13,38,000	5.0	0.04
Total	-	1000	29	300	97,17,000$	3.3	0.01

@ Fisheries Statistics of Tamil Nadu 1998-99; * Government of TN- Directorate of Town and Country Planning; # zones; $ excludes Chennai; + number of villages and human population split equally and added to Cuddalore and Kanchipuram for the analysis.

Summary and Conclusions

A tsunami is a natural occurrence that can bring about changes not only to the topography of the coasts and the seabed but also to the natural communities of plants and animals that are found in the sea and the associated ecosystem. However, not all natural 'calamities' that cause environmental changes are to be treated as 'adverse' as many have contributed to the local increase of biological diversity. The study of disturbance on biological communities was popular in the 1970s after some of the classical works of Connell (1978). Connell and contemporaries recognised disturbance as a strong influence on marine and terrestrial communities. Events called 'disturbances' range from vast geological phenomena, such as earthquakes, affecting hundreds of hectares, to biological phenomena such as grazing, which may damage less than a few square centimetres. Communities may experience more than one type of disturbance and the same type of community may also experience different rates or regimes of disturbance in different places. Many patterns in the diversity of communities and in the abundances of particular species are assumed to be due to disturbance (McGuinness, 1987a).

Local increase of fish populations and community diversity

Connell (1978) in his classical study of tropical rainforests and coral reefs rather emphatically brought out the role of moderate levels of disturbances in increasing the species diversity in biological communities by preventing one or a few species from dominating resources (Mc Guinness, 1987b). Our assessment of the impact of tsunami on the coasts of Andhra Pradesh, Tamil Nadu and Kerala has suggested that it was only 'moderate' and that there is the likelihood of local increase in biological diversity at least in the coastal (estuaries, lagoons, creeks) and shallow near-shore waters. The first indication that there is indeed an increase in biological diversity in the shallow seas along the coast is the sudden boom in the sardine catches. While the catch of sardines involved a single species (*Sardinella longiceps*), the Clupeoid fish species was only responding to the positive changes in the coastal and near-shore food chain.

Clupeoids (sardines, herrings, anchovies, etc) are among the world's most important food fish. In 1971 they made up 35% of the world's fish landings (Lowe-McConnell, 1987). These plankton-feeders are known to exploit upwellings in the sea and locally become extremely abundant. The sardines in turn are a main source of food to many other species of marine fish and birds (Lowe-McConnell, 1987).

There may be other such impacts on fish communities that have not yet been noticed (mainly due to the lack of fishing in the seas). Accumulated debris of boulders and broken coral, etc can simulate 'reefs' in shallow coastal waters that can lead to a temporary increase in local fish diversity. Such a diverse fish community is however unstable and may soon succumb to predation (Lowe-McConnell, 1987).

Some of the newer fish habitats and communities that the tsunami created in coastal lagoons in particular (those in creeks and estuaries may not have stayed as they have access to the sea) are likely to adapt locally and diversify. Such lagoons are 'natural experiments' and would offer a lot of scope for the scientific study of succession in marine and coastal fish communities. Unfortunately however, the lagoons are already being fished rather intensely as the fishermen have not been going to the sea. Elsewhere, the lagoons (when small) are being used as local garbage disposal pits.

Changes in the topography of the seabed

The tsunami has certainly brought about topographical changes in the seabed. Although not yet confirmed, the spate of local inundations reported in southern Tamil Nadu and Kerala (waves lashing closer to the human habitation than normal) during the six months that followed the 2004 December 26 event may be the result of permanent changes caused to the topography of the seabed. One of the pointers to the seabed change 'theory' comes from our study. Fishermen in Pulicat who were reluctant to enter the sea admitted that they were 'scared' (although initially they had blamed the government for not having quickly and equitably distributed relief material) as they are no longer familiar with the seabed depth contours. Changes in the topography of the seabed can interfere with the local currents, light penetration and temperature. This could result in local changes in the structure of near-shore biological communities - coral reef, inter-tidal zones and the associated macro-invertebrate and fish communities.

Fishing holiday

Closed fishing seasons have been more or less strictly followed throughout the coasts of Tamil Nadu and Kerala. While this practice has proved a boon to spawning fish, the no-fishing period is generally brief (not exceeding a month or so) (Daniels, 1996), the nearly six-month long fishing holiday imposed by the tsunami has certainly helped in reducing the high 'predatory' pressure on several species of fish at least temporarily. Not only the fish, but also many other non-target organisms including sea turtles and invertebrates that inhabit the seabed that get killed in large numbers due to the intensive trawling have been spared locally.

Since June 1992, there has been a great fishing pressure on sea horses (*Hippocampus* spp.) along the Palk Bay segment of the east coast. This marine fish that has attracted a lot of international demand has been exploited to the tune of 300-400 kg (dry weight) per month. The average dry weight of a sea horse collected being 4.2 g, thousands have been thus lost from their natural habitats - sea grass and sponge beds over the years along the Palk Bay. The most exploited species is *Hippocampus kuda* - around 75,000 individuals were harvested per month in 1992. No seasonal pattern has been reported of the harvest as divers who hand pick the sea horses are in the sea almost round the year subject to local weather conditions (Marichamy *et al.,* 1993).

Several other species of lesser known marine organisms, especially molluscs and echinoderms were harvested for various ill-defined purposes along the coasts. These species (and hence the communities that they were a part of) might have enjoyed the fishing holiday imposed by tsunami. As no information has emerged as yet on these aspects, this could be an area for future studies.

Sea turtles

That the tsunami proved to be a boon to the nesting turtles is not entirely correct. The absence of fishing boats and nets along the coasts of Tamil Nadu did spare a number of olive ridley turtles that arrived to breed in the beaches. At the same time, 300-400 turtles were observed being caught by fishermen around Machilipatnam in Andhra Pradesh and sold in the local fish markets. According to the fishermen the presence of turtles in their seas was rather unusual. Elsewhere in the coasts of northern Tamil Nadu coastal people deprived of fish were harvesting all the eggs laid by the turtles. A number of nests that were excavated by humans were observed closer to Mamallapuram. Around Chennai, one or two nests were observed that had not been excavated by people. However, a local volunteer of the Students Sea Turtle Conservation Network (SSTCN) felt that normally one would encounter at least five nests in these beaches. It is too early to conclude that there has been any impact on the nesting behaviour of the sea turtles. Monitoring the nesting beaches along the tsunami hit coasts in future will provide better insights on the fate of the sea turtles.

Birds

The December 2004 tsunami coincided with the second half of the season in which the coasts are alive with migratory birds - waders and waterfowl. This is also the period when the migratory birds start returning to their breeding grounds both in the north and elsewhere locally (eg egrets, storks, herons, etc) and as such are not easy to sample. They make an appearance at a site on a particularly day and often disappear the next day. Erratic movements of migratory birds are a characteristic of the second half of the winter season (also coincides with the drying of shallow coastal wetlands) that inferences drawn based on one-season sampling can be misleading.

Despite the limitation imposed by season, it emerges from the study that waders and waterfowl were impacted for the better by the tsunami. As mentioned earlier, estuaries that were dredged and deepened such as the Adyar estuary in Chennai, and those that were over-used by humans for fishing and recreation (the Kovalam creek and backwaters) have since become ideal wader and waterfowl habitats. The dredged habitats got refilled with silt that the water has become shallower attracting waders. Fish-eating water birds, such as egrets, herons, gulls and terns were locally very abundant after the tsunami in many sites after the fishing and recreation boats stopped plying.

Ducks were generally absent in most of the aquatic habitats that were visited (Pulicat, Adyar creek, Kaliveli tank, Cheyyur backwaters and Marakkanam (between Mammallapuram and Pondy). Since earlier studies that we had undertaken in the inland wetlands of Tamil Nadu suggested a greater abundance of wintering ducks in the northern wetlands of the State (Daniels and Vencatesan, 2002), and while travelling along the east coast road (before tsunami) the presence of ducks in some of these extensive backwaters was noticeable (RJR Daniels, *pers. obs.*), the general absence of this group of aquatic birds in the study area after the tsunami is rather intriguing. Since lists of birds (with abundances) are available for many of the coastal wetlands, it should be possible to monitor the post-tsunami changes in the water bird community in selected localities.

Wild mammals

Studies in the Point Calimere WLS, the mainstay of wildlife along the east coast south of Bhitarkanika WLS, have suggested that the impact of tsunami on terrestrial mammals including the blackbuck and spotted deer was negligible. Observations reported by foresters present at the time of the inundation confirm that the animals ran to safer areas. The damage caused to the grazing areas was also minimal and temporary. A detailed study of the impact of tsunami on wildlife and habitats in the Point Calimere WLS and adjoining habitats of the Vedaranyam landscape has further substantiated the above observations.

Elsewhere in Pulicat (Kattupalli Island) wild boar that inhabited the remnant dry evergreen forests ran and escaped the inundation. However, the blacknaped hare was a victim. Local volunteers who have been involved in the restoration of the island reported that many hares drowned after brief efforts to stay afloat. These animals were probably taken unawares as they were resting and the limitation that they cannot climb trees. It is likely that young of mammals that stayed within burrows may have been killed by the inundation. This may include rodents, especially rats and mice. The general lack of information on the distribution and abundance and breeding habits of these small mammals within the study area offers little scope for any reasonable conclusions in this regard.

Human preparedness

There are 54 coastal taluks along the nearly 1500 km of shoreline available within the study area. In this narrow belt, 1.68 crore (16.8 million) human beings are resident - not less than 11,000 people per kilometre of shoreline on an average (Table 3). Loss of human lives and property was highest along the coasts of Tamil Nadu. The first and foremost reason for the immense loss of human lives and property in this segment of the east coast of India is due to 'overcrowding' (high local densities augmented by tourism) and a total lack of 'preparedness'. Throughout the coastal length that was studied, humans had locally violated the CRZ norms. Thus a combination of high human densities (augmented by those not used to the sea; officiall records identify only 556 villages as 'marine fishing' and 8.53 lakh people as 'fishermen' - less than 10% of the total coastal population in the State) and dangerous proximity to the sea was the prime factor that determined the loss of human lives and property locally.

The nature of the tsunami (magnitude) was such that even natural habitats locally succumbed to the impact. It is therefore a myth that natural habitats could have served as 'shelter-belts', 'bio-shields', etc. Firstly, much of the so-called shelter-belts in the east coast (study area only) were not meant to be barriers. They are on private and village lands with a motive of harvest - small timber and fuel. Mangroves are rather limited and patchy as shown earlier. Except in Cuddalore (Pichavaram mangroves) in Tamil Nadu, the fragments of well-established and dense mangroves (as that in the Krishna basin and Vedaranyam swamps-Muthupet) did not take the brunt of the tsunami for geographical reasons - this part of Tamil Nadu's coast has a east-west orientation unlike the rest of the coast that runs north-south and the Sri Lankan land mass had played a role in deflecting the direct impact. The Coromandel, Palk Bay and West Coast segments of the Tamil Nadu coasts that faced the most severe impact of tsunami had all lost their mangrove forests many years ago (except Pichavaram). For instance, the name Pulicat is a colonial distortion of the traditional Tamil name '*Pazha-ver-kaadu*' that literally means 'forest with rooting fruits' essentially pointing to the viviparous mangrove forests. Today there is hardly any sign of mangrove forests anywhere in the lake's vicinity.

Detailed topographic maps that were prepared by the US Army in the 1950s based on the Survey of India topo-sheets of 1932 show the distribution of coastal forests within the study area. These forests are more extensive along the west coast and rather fragmented in the east coast where they are localized within a few segments - around the Krishna river mouth and Pulicat lake of Andhra Pradesh and Marakkanam-Cuddalore coast of Tamil Nadu. From the nature and composition of the remnant patches that were observed during the present study, it may be inferred that the 'green-belt' of the 1930s and 1950s were a combination of littoral forests and mangroves. Even here, it is only the few patches of protected mangroves that have retained the naturalness while the littoral forests have all been reduced to coastal scrub or to a standing mosaic of cultivated native trees and monocultures of exotic trees such as cashew, casuarina and even eucalyptus.

Areas where the tsunami originated (Indonesia) and those in the immediate vicinity (Thailand and A & N Islands of India) mangroves and littoral forests were brought down by the impact (Editor, 2005). To argue that mangroves and natural habitats had saved human lives in the mainland of India is not therefore justified. Unlike in Bangladesh and West Bengal where extensive coastal swamps are reclaimed for human habitation, the coastal swamps of the study area despite the loss of mangroves have not attracted significant human colonization. Swampy low-lying coastal lands are not as densely inhabited by humans as are the beaches the east coast.

The situation is different in the west coast where the Western Ghats have limited the distribution of extensive coastal swamps to a few localities where the coast is wider as in northern Kerala and southern Karnataka. The overall differences in topography, the higher rainfall and the run-off from the Western Ghats have together created deeper backwaters (often in the form of brackish water lakes) in the west coast. The three coastal districts of Kerala that were surveyed during the present study Trivandrum, Kollam and Alapuzha are amongst the districts (with the highest human population density of over 1000 people per square kilometre) in the State. Nevertheless, the relatively low number of deaths in the State could be due to the fact that the tsunami's impact had started diffusing as it reached the coasts of Kerala. Further, the inundation did not carry with it humans and their belongings as the habitations were sheltered by the dense groves of coconut palms that are traditionally maintained throughout the west coast.

Ironically, the Kanyakumari district of Tamil Nadu which shares the west coast with Kerala and in most respects identical landscape features, has suffered a major loss of human life and property (especially when compared to Trivandrum the neighbour with nearly twice the human population size). While it is true that tourism had played a role in enhancing the number of 'local' deaths in the district, the other factors that played a role in magnifying the impact are not immediately clear. In the coastal villages of Cuddalore the presence of littoral forests (of taller trees) and the horticultural groves (including mature coconut palms) around habitation seem to have protected human lives. In general, sand dunes that were covered with trees (natural and planted) had shielded the habitation inland whereas those that had only sand binding herbs as the vegetation cover had breached allowing the inundation into the low-lying villages (Chadha *et al.*, 2005).

Groynes and dykes had already been erected in many coastal villages throughout the study area. Along the coasts of northern Chennai, human lives and property were lost despite these structures. In Kerala, the Azhikkal village of Kollam district where the maximum number of human deaths was reported, there was a boulder-dyke along the beach even before the tsunami. Apparently, the water had swept over this barricade and inundated the village killing over 100 people locally.

The role of natural and man-made habitats and barricades in protecting human lives and property along the coasts of Andhra Pradesh, Tamil Nadu and Kerala has not emerged as anything direct or significant. Our study has suggested that there is considerable variation in the way that the existing natural and man-made coastal structures have locally responded to the impact of tsunami. There is a clear suggestion that a combination of factors including the human population density (resident and immigrant), the topography and the distribution of natural and man-made barriers have played a role in destroying or protecting human lives and property. However, unless a case by case study is undertaken in future, a reliable coastal vulnerability map cannot be generated for sound management of both natural habitats and human habitation in the coastal areas. Till such time, efforts to restore natural habitats and establish artificial barriers (groynes, dykes, shelter-belts, etc) for saving human lives and property can prove to be pre-mature.

CRZ norms and inadequacies

The Central Government after considering the need for protecting the coastal areas and the need to ensure the use and activities in the coastal areas declared the following areas as Coastal Regulation Zone (CRZ) under sub-section (1) read with clause (V) of sub-section (2) of section (3) of the Environmental Protection Act, 1986 (29 of 86). As per the CRZ, the coastal stretches of sea, bays, estuaries and creeks which are influenced by tidal action (in the landward side) up to 500 metres from the high tide line and the land between the low tide line and high tide line have been classified into four categories for regulating developmental activities. These are CRZ I, II, III and IV. Whereas the first three categories pertain to the mainland, the fourth is exclusive to the Andaman and Nicobar Islands (see Appendix II).

All the states of India that have a coastline have exercised the CRZ in theory and practice and some like Tamil Nadu have detailed reviews and action plans for implementing the CRZ with suggestions for reassigning certain localities into categories other than that was originally assigned. While the debates and reviews are on, the tsunami has clearly shown that the 500 m limit that the CRZ recognises beyond the high tide line is not only ad hoc but also deficient.

Chadha *et al.,* (2005) have measured the run-up heights in the different segments of Tamil Nadu and also the inundation and clearly shown that at least in two locations the inundation exceeded the 500m CRZ limit laterally, spreading 700-800 m inland (see Table 9). While it did emerge from our analysis that violations of the CRZ norms played a major role in the loss of human lives and property, our study also calls for a review of the Regulation as such.

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To them we dedicate this report.

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1(a): DATA SHEET FOR THE RAPID ECOLOGICAL IMPACT ASSESSMENT

Date:
Team:

State: Andhra Pradesh/Tamil Nadu/Kerala
Total Number of Districts in the state abetting the Coast:
Number of Districts that have had any impact of the Tsunami:

Name of the District:
Number of Taluks/Blocks abetting the coast within the District:
Number of Taluks that have had any impact of the Tsunami:

Name of the Taluk:
Length of the coastline:
Approximate proportion of land within CRZ (I-III) to the total area of the Taluk:
Population of the Taluk:
Population within the CRZ (I-III):
Density (coastline/no. of persons):
Location of the habitations within the CRZ (I-III):
Number of habitations within the CRZ (I-III) impacted:

1. Sampling information

Name of District	Name of Taluk	Number of coastal villages	Coastal villages visited

II. Geographical Information-Taluk-wise

Name of District	Name of Taluk	Total area (sq. km)	Total coastline (km)	Human population

III. Habitat Information

Name of village	Taluk	Major habitats present	Nature of impact on habitat	Wildlife observed	Nature of impact on wildlife

1(b): Matrix for inventorying presence/absence of ecological units (independently for each of the CRZ Zones - with emphasis on CRZ I, II and III)

CRZ I, II and III

Unit	Present			Absent	Remarks / Additional features
	Minimum	Moderate	Abundant		
Coral reefs*					
Sea grass beds*					
Littoral forests					
Beach					(provide details to include nature – flat, sand dunes etc)
Creeks (within or in immediate proximity)					
Estuaries					
Tidal Backwaters Mangroves					(provide details on predominant species, area and spread)
Wildlife					(provide details)
Turtle breeding sites					(provide details)
Shore bird habitats					
Shelterbelts					(Write extent and species)
Dykes / Groynes/ Walls/ Sandbags					
Man-made canals /navigation channels					
Other plantations					
Agricultural lands/ salt pans/aquaculture					(provide details)
Domestic animals					(to include dogs, cats, horse, donkey, cattle, pigs, goats, poultry, ducks, other poultry etc)

* in the immediate vicinity

1(c): Matrix for inventorying presence/absence of ecological units (independently for each of the CRZ Zones - with emphasis on CRZ I)

1.1 CRZ I

Unit	Impact of the Tsunami (Assessed on a scale of 3)	CRZ zone	Population density of the Area	Remarks
Coral reefs*				
Sea grass beds*				
Littoral forests				
Beach				
Creeks (within or in immediate proximity)				
Estuaries				
Tidal Backwaters				
Mangroves				
Wildlife				
Turtle breeding sites				
Shore bird habitats				
Shelterbelts				
Dykes / Groynes/ Walls/ Sandbags				
Man-made canals / navigation channels Other plantations				
Agricultural lands / salt pans/aquaculture				
Domestic animals				

* in the immediate vicinity

1(d): Checklist of visible impacts on wildlife habitats*

Unit	Impact of the Tsunami (Assessed on a scale of 3)	CRZ zone	Population density of the Area	Remarks
Coral reefs*				
Sea grass beds*				
Littoral forests				
Beach				
Creeks (within or in immediate proximity)				
Estuaries				
Tidal Backwaters				
Mangroves				
Wildlife				
Turtle breeding sites				
Shore bird habitats				
Shelterbelts				
Dykes / Groynes/ Walls/ Sandbags				
Man-made canals / navigation channels Other plantations				
Agricultural lands / salt pans/aquaculture				
Domestic animals				

* in the immediate vicinity

Coastal Regulation Zone (CRZ)

Under sub-section (1) read with clause (V) of sub-section (2) of section (3) of the Environmental Protection Act, 1986 (29 0f 86), the Central Government after considering the need for protecting the coastal areas and to ensure the use and activities in the coastal areas, consistent with the principles and requirements of environmental conservation, has declared the following areas as Coastal Regulation Zone.

The coastal stretches of sea, bays, estuaries and creeks which are influenced by tidal action (in the landward side) up to 500 metres from the high tide line and the land between the low tide line and high tide line as Coastal Regulation Zone.

This Coastal regulation Zone has been classified into four categories for regulating developmental activities. These are

Category I (CRZ I): Areas that are ecologically sensitive and important such as National Parks, Sanctuaries, Reserved Forests, Mangroves, Estuaries, Corals, areas close to breeding grounds of fish and other marine life, areas of outstanding natural beauty.

Category II CRZ II): The areas that have already been developed up to or close to the shoreline. For this purpose, developed area is referred to as the area within the municipal limits which is already substantially built up and which has been provided with drainage and approach road and other infrastructure facilities, such as water supply and sewerage mains.

Category III (CRZ III): Areas that are relatively undisturbed and those which do not belong to Categories I and II. This will include coastal zone in the rural areas (developed and undeveloped) and areas within municipal limits where substantial development has not taken place.

Category IV (CRZ IV): Applies to Andaman and Nicobar Islands only.

Impact of the Tsunami on Coastal Habitats and Livelihoods: A Case Study of Pondicherry and Adjoining Districts of Tamil Nadu

Jayshree Vencatesan

An extremely powerful earthquake rocked northern Indonesia on Sunday, December 26, 2004 that sent massive tsunamis crashing into several countries including India. The U. S. Geological Survey reported a quake of magnitude 9.0, about 100 miles off the west coast of the island of Sumatra. This caused multiple tsunamis that struck and ravaged coastal regions all over the Indian Ocean, and even as far away as Somalia and several other countries of Africa (4500 m or more west of the 'epicenter': Portrait of a Disaster, Rapid Assessment report of the Tsunami Crushes on Srilanka, Disaster Management and Information Programme, 2004).

Tamil Nadu and the Union Territory of Pondicherry were the worst affected with multifarious damage to human life and habitats

Amongst the coastal states of India that were impacted by the tsunami, Tamil Nadu and the Union Territory of Pondicherry were the worst affected with multifarious damages to human life and habitats. Apart from the widely reported loss of human life, the damages included loss of habitats that supported a number of livelihoods and common property resources that buffered the existence of marginal communities in the coasts etc.

Also, the post tsunami situation has witnessed unprecedented relief and rehabilitation operations involving the State, NGOs, civil society and others. The focus for the first few weeks after the tsunami was on relief - essentially meeting the food and shelter requirements of the affected human populations. This was followed by a period where financial and material relief was given to the affected communities. The focus during this period was on providing assistance and mitigating loss.

Six months after the tsunami, the need to place emphasis on rebuilding lives and livelihoods is emerging across all organisations engaged in the relief and rehabilitation initiatives. Along with this realization, certain lacunae in operation are also being recognized. The most significant of these are the following:

1. The singular absence of coordination amongst various organisations; and the contradictory nature of functioning
2. The lack of expertise or scientific thought in the rehabilitation process

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3. A non-recognition of the cultural plurality and ecological diversity that typify coastal habitats.
4. The limited undertaking of systematic investigations on the nature of impact and the possible areas / points of intervention.

Scope of the case study

Recent perspectives in anthropological research define a disaster as a process/event involving the combination of a potentially destructive agent(s) from the natural and/or technological environment and a population in a socially and technologically produced condition of vulnerability. From this basic understanding, three topical areas of enquiry have been evolved:

(a) a behavioral and organizational response approach,
(b) a social change approach, and
(c) a political economic/environmental approach, focusing on the historical-structural dimensions of vulnerability to hazards, particularly in the developing world (Anthony Oliver-Smith, 2004 in Anthropological Research on Hazards and Disasters, University of Florida, Gainsville).

Against this background, the WTI supported rapid assessment study on the possible damage caused to wildlife and their habitats on the east Coast of India due to the tsunami provided an opportunity to investigate the historical and structural dimensions of vulnerability of coastal communities. It is envisaged that the study would be able to provide leads to the rebuilding process.

The current case study, set in the academic domain of socio-ecology, is limited to addressing the following questions:

1. How are human communities distributed in coastal habitats especially with regard to the CRZ stipulations?
2. How do these communities use, regulate and manage their land and water resources?
3. What has been the impact of the tsunami on these habitats, and what do people perceive as priorities for their habitats?

Methodology

Study sites:

The study was located on the East Coast of India, within a 50 km radius of Pondicherry. This entailed 100 km of the coastline , encompassing a major part of the Union Territory of Pondicherry and three districts of the state of Tamil Nadu.

Tamil Nadu has a coastline of 1,076 km (15% of the total coastal length of India) under 13 maritime districts (DOF, 1999). The total marine fisherfolk population forms about 1% of the total state population (DOES, 2003). When compared to the 1986 survey of fishing communities in Tamil Nadu, there has been an increase in population by 47% (DOF, 2000). The Union Territory of Pondicherry (UTP) has a coast line of 44 km under four administrative divisions, of which Pondicherry (24 km) and Karaikal (20 km) are located within the state of Tamil Nadu. The total fisherfolk population of the Union Territory is about 4.95% of the total population. (DOFFW, 2000).

Details of coastal habitations were compiled from the District Environment Plans and Gazetteers. In all there are 62 major habitations within the immediate proximity to the sea, on the 100 km stretch i.e. a habitation every 1.6 km. Every fourth habitation on the list was selected as a potential study site to ensure coverage every 4.8 km.

The basic unit of study was the human habitation and the area in the immediate vicinity. Certain field constraints limited the process of inquiry and these are as follows:

1. The fragmented distribution of the Union Territory of Pondicherry meant that a sequential arrangement of habitations was not feasible.
2. Certain habitations fall under the administrative jurisdiction of both Tamil Nadu and Pondicherry although they exist as one geographical entity. This meant that while two streets of the habitation were part of Tamil Nadu, the rest would be part of Pondicherry. One habitation was so organized that the TN portion was encompassed by the Pondicherry portion.
3. In certain cases, two or three habitations co-existed with amorphous boundaries. In such cases, the cluster had to be considered rather than individual habitations.

[1]The East Coast of India within the administrative boundaries of the state of Tamil Nadu and the Union Territory of Pondicherry is divided into four broad zones viz. a) Coromandel Coast that stretches from North of Chennai to Kodiakkarai in Thanjavur district, covering the districts of Thiruvallur, Chennai, Kanchipuram, Villupuram, Cuddalore and Nagapatinam and also includes Pondicherry. b) Palk Bay that stretches from Kodikarai to Pamban in Ramanathan Puram district c) Gulf of Mannar that stretches from Pamban to Tiruchendur and includes 13 islands and d) West Coast that covers the entire district of Kaniyakumari (DOF, 1999).

4. Field investigations revealed that habitations that are located within the immediate proximity of the sea are completely and exclusively dominated by one fishing caste that is under the generic category of meenavar, although coastal livelihoods include multi-caste groups notably the Scheduled Castes. To overcome this lacuna, two additional habitations that are located within three km from the coast were included in the study.

Methods and tools

The study used the mixed methodology research design for concurrently achieving high external validity, ensuring accuracy in measuring constructs and creating a realistic environment for observation of behaviour. One of the approaches within mixed method research is complementarity research, also called elaboration. The goal of complementarity is to use the strengths of one method to enhance the performance of the other method. While some have labeled this method as being 'patronizing', there is substantial evidence of the methodology offering strength to arguments and providing opportunities for newer and multiple perspectives on a given phenomenon. In this approach, one study typically dominates, and a lesser study is conducted to provide additional clarification.

This design also recognizes that data can be in multiple forms, ranging from verbal responses to images, impressions, gestures, or tones which represent real events or reality as it is seen symbolically or sociologically.

For the selection of methods, factors such as resources, the time available and expertise of the investigators were considered Structured interview, participant observation and focus group discussion were the three methods that were used in parallel. An interview schedule and a checklist of variables were developed for eliciting data.

Structured interviews were conducted at the level of groups and local leaders (with a minimum of 15 participants). A total of 15 such profiles were generated covering all the study sites. Observations and outputs of focus group discussions were recorded as notes.

The following secondary sources of data were also utilized for the study:

Census, 2000 of Government of India- district and taluk profiles
CRZ Records, 2000 of the Department of Environment/Department of Town and Country Planning, Government of Tamil Nadu
Records of the Department of Fisheries and Fishermen's Welfare, Government of Pondicherry
Records of the Wildlife Department, Government of Pondicherry
District Administration Records on Tsunami Relief, Government of Tamil Nadu and Records of Tsunami Relief Operations, Government of Pondicherry.

Results

General profile:

The 100 km stretch of the coast that was studied constitutes one of the most densely populated areas of south India encompassing the districts of Kanchipuram, Villupuram, Cuddalore (population of 2666000) and a major portion of the Union Territory of Pondicherry. In addition to the 62 major habitations (Annexure 1) three major towns ie. Pondicherry, Cuddalore and Cuddalore OT (harbour and fish landing centre) are located within this stretch. Historically, the area has served as an important trade zone for the British, French and the Dutch. Multiple waves of 5-10 m height struck the area during the tsunami, with the southern portion of Cuddalore district experiencing the maximum impact (Chadha *et. al*., 2005).

The region is drained by rivers such as the Malattaar and Gingee. A network of small rivulets that drain into the sea serve as nodes for human habitations that depend extensively on them for subsistence. Other notable ecological features of the region include estuaries such as Yedayanthittu, Ariyankuppam, Malattaar, Penaiar and Pannithittu, Alambarai backwaters and Kaliveli wetland, which are the major sources of water for cultivation of paddy and groundnut.

Socio-cultural characteristics:

The demographic profile of this region is characterized by the presence of four major caste groups viz. fisherfolk who are generically referred to as meenavars, the land owning *vanniars*, the Scheduled Tribes who are known as *Pazhankudimakkal* of which the *Irulars* are the most dominant and the Scheduled Castes who prefer to be addressed as *Adi-dravidars*.

The domicile of the caste groups follows a typical pattern. The meenavars reside within the immediate proximity of the coast in habitations called *meenavar kuppams* and wield absolute and customary ownership over the marine resources. The Vanniars reside in the 'main villages' and largely control freshwater sources. Scheduled Castes live in the intermediate zone, playing a subordinate role to the meenavars and the vanniars. The Irulars are concentrated in the northern portion of the stretch, close to Mammallapuram and Cheyyur, and derive their livelihoods from hunting and gathering. As an exception, there are Muslim landlords in parts of Villupuram and Cuddalore, who use the Scheduled Castes as share croppers or tenants. All four caste groups have been impacted by the tsunami, with the Meenavars and Scheduled Castes being the most significantly affected. These two caste groups have not only suffered personal losses, but have also lost their immediate habitats which was important to them for a multitude of reasons.

Table 1: Basic details of the habitations in the study area

Habitation	Predominant Caste	Commune/ Taluk	District	State	Distance from Pondicherry
Alambarai	Meenavar (Fisherfolk)	Cheyyur	Kanchipuram	Tamil Nadu	46
Eggiyar kuppam		Tindivanam	Villupuram	Tamil Nadu	32
Anumandai kuppam		Tindivanam	Villupuram	Tamil Nadu	28
Bommarapalayam		Vannur	Villupuram	Tamil Nadu	20
Pillaichavady		Ozhuvakarai	UT of Pondicherry		12
Vambakeerapalayam		Uppalam	UT of Pondicherry		0
Pudukuppam		Ariyankuppam	UT of Pondicherry		10.5
Nallavadu		Bahour	UT of Pondicherry		14
Murthikuppam		Bahour	UT of Pondicherry		20
Sonankuppam-Singarathopu		Cuddalore	Cuddalore	Tamil Nadu	28
Chittiraipettai		Cuddalore	Cuddalore	Tamil Nadu	35
Periakuppam		Cuddalore	Cuddalore	Tamil Nadu	40
Samiarpettai		Chidambaram	Cuddalore	Tamil Nadu	50
Sangolikuppam	Adi-dravidar (Scheduled Caste)	Cuddalore	Cuddalore	Tamil Nadu	30
Manjamkuppam		Tindivanam	Villupuram	Tamil Nadu	30

Description of the habitations

The following series of tables highlight the basic features of the 15 habitations that were studied. Table 1 details the location of habitations in the study along the 100 km stretch.

As detailed in Table 2, all the habitations are spread over an area ranging between 2.25 -12.12 ha (excluding the common property resource area). All habitations have access to the common resources (rivers, estuaries, wastelands) although the extent and spread was not known to the inhabitants in six study sites. The CPRs have multiple uses, including food, fuelwood, water etc. and the access to these is strictly regulated by the caste councils. The sea and the marine resources are considered as natural capital, with ownership bestowed to the meenavars by the coastal dwelling communities.

Table 2: Area profile of the habitations

Habitation	Extent in ha.	Change from traditional boundary		Extent of CPR /land	Presence of RF	
		Y	N		Y	N
Alambarai	2.25		+	5 ha		+
Eggiyar kuppam	4.45		+	10 acres		+
Anumandai kuppam	12.14		+	10 acres	+	
Bommarapalayam	6.3		+	-		+
Pillaichavady	4.2	+		5 acres		+
Vambakeerapalayam	6.75	+*		-		+
Pudukuppam	4.9	+**		10 acres		+
Nallavadu	5.25***	+		-		+
Murthikuppam	10.0		+	River		+
Sonankuppam-Singarathopu	10.4		+	10 acre		+
Chittiraipettai	10.5		+	150 acre	+	
Periakuppam	12.12	+		6 ha		+
Samiarpettai	15.0		+	3 acre		+
Sangolikuppam	8.5 acres		+	river and 2.5 acres		+
Manjamkuppam	7.5 acres		+	estuary and 6.0 acres		+

* land diverted to develop a common purpose ground and access to harbour
** also includes 2 wells and 4 acres of land that has been left un-utilised
*** 0.75 ha. Of land under contention - between UT of Pondy and Tamil Nadu

Only two of the 15 habitations were within the immediate vicinity of a Protected Area and both these habitations were part of the state of Tamil Nadu. The Union Territory of Pondicherry does not have Reserve Forests. Four of the five habitations studied within Pondicherry have had altered boundaries since a portion of the habitation has been diverted to developmental purposes.

Table No. 3 highlights the location of the households with respect to the CRZ. Except for the two inland Scheduled Caste habitations, the rest of the study sites are located within 100 m of the High Tide Line, with seven of them within 20 m of the sea. Preference to stay close to the sea is indicated by the presence of large clusters of households within 100 m of the sea in all the households. The total number of households in the 15 habitations is 6720.

Table 3: Location of households within the CRZ

Habitation	CRZ Classification	Distance of habitation From the HTL in m	Presence of hh within 500 m HTL	Number of hh within 500m HTL	Total number of hh in the habitation
Alambarai	I and III	100	+	500	500
Eggiyar kuppam	III	10	+	450	550
Anumandai kuppam	III	10	+	350	350
Bommarapalayam	III	17	+		250
Pillaichavady	I	20	+	200	256
Vambakeerapalayam	II	15	+	250	1500
Pudukuppam	I	60	+	25	370
Nallavadu	III	100	+	50	172
Murthikuppam	I	100	+	250	310
Sonankuppam-Singarathopu	III	50	+	100 220	250 850
Chittiraipettai	III	50	+	200	200
Periakuppam	III	20	+	150	350
Samiarpettai	III	20	+	39	510

Within the habitations, the households are so organized that thatched houses are within the first 20 m from the HTL followed by houses that are tiled or roofed with reinforced concrete. Additionally, coconut plantations are present in all the 13 habitations within the 20 m mark. These trees are owned jointly by the community and thereby used by all the inhabitants for a variety of purposes. No damage was suffered by coconut trees within a habitation.

Also typifying this stretch are casurina plantations (with no legal status) that are used for obtaining biomass and as toilets. Portions of this stretch have customarily been earmarked as lands for making nets (peria valai - that is made of cotton threads) fish drying and selling.

All 13 habitations stated that they were aware of the stipulations of the CRZ, and had considered the same as a deterrent to their traditional rights over the sea. However, in the post tsunami situation, all 13 habitations state that they would be willing to relocate to areas above 1 km from the HTL, but at the same time retain their hold over their current habitation so that it can be used for their fishing operations.

With the exception of the two habitations that fall within two administrative boundaries, all other habitations are organized around a single median road (Table 4). 33.5% of the total households in the study sites are thatched (kutcha houses), and 67.3% have electricity available at the household level (excluding the resettlement area of Sonankuppam-Singarathoppu). 56.1% of the households use biomass for cooking and other domestic purposes (excluding festivities or celebrations) derived from multiple sources such as forests, private lands, market and wastelands. 13 of the 15 habitations studied rely heavily on wastelands for biomass requirements, with coconut thatch, bark and shell and casurina being most preferred. Local inhabitants in at least two habitations viz. Anumandai Kuppam and Chittiraipettai recalled that dense littoral forests were present even 25 years ago within the immediate proximity of their habitations, and that these were systematically denuded for meeting timber and fuelwood demands by the local residents. Some residents also stated that much of such land has been encroached upon and converted into agricultural areas.

Table 4: Household characteristics

Habitation	No. of main roads	No. of bylanes	No. of pucca houses	No. of kutcha houses	Electricity connection	No. of houses using fuelwood	Sources of fuelwood
Alambarai	1	6	50	450	180	500	Wastelands, forests, private lands and market
Eggiyar kuppam	1	3	450	100	350	450	Wastelands, forests and market
Anumandai kuppam	1	3	270	80	350	350	Wastelands, forests, private lands and market
Bommarapalayam	2	3	110	150	250	100	Market
Pillaichavady	2	10	80	130	256	256	Wastelands, forests, private lands and market
Vambakeerapalayam	1	25	650	850	1500	200	Wastelands and market
Pudukuppam	1	5	200	176	366	330	Wastelands, private lands and market
Nallavadu	3	12	80	92	172	172	Wastelands and market
Murthikuppam	1	5	-	-	310	310	Private lands and market
Sonankuppam-Singarathopu	1	6	*	*	*	250	Wastelands, forests, private lands
Chittiraipettai	1	3	100	100	200	200	Wastelands, forests, private lands
Periakuppam	1	10	200	100	350	350	Private lands and market
Samiarpettai	1	10	361	50	320	490	Wastelands, private lands and market

Table 5: Seasonal variations of traditional gears and catch in Tamil Nadu

Season	Nets	Kinds of fishes caught
Jan-July	Peruvalai	Anchovy, Seer, *Chirocentrus dorab, C. nasus*, Sardines, Pomfrets, Carangids
Mar-July	Madavalai	Perch, Mackerel, Sea Perch, *Caranx affinis*, *Caranx* spp., small Pomfrets, Sardines
Jan-March	Thurivalai	Prawn, *Lactarius* spp, Silver Bellies, Cockup, Clupeids, *Thryssa* spp.
Slack-season Aug-Dec	Thurivalai, Valavalai, Kolavalai, Kannivalai, Agnivalai All	Pellona spp., *Lactarius*, small shrimp varieties
Uncertain	Eda valai	Mackerel

All 15 habitations had the following service establishments: Balwadi (kindergarten schools), Primary Schools, Public Distribution System units and Fishermen's Cooperative units. Availability of medical facilities within the habitation is rather poor with only one habitation having immediate access to medical facilities.

Use and management of resources in coastal habitats

As mentioned in the earlier sections of the report, coastal habitats are densely populated, with a considerable proportion of the population deriving their livelihoods from natural resources. The range and scope of this use is so varied that while there are habitations that specialized in deep-sea fishing for sharks, there are also households that earn their livelihoods through tree-climbing. Marine fishing is this region is characterized by small-scale fishing that involves the use of small- sized fishing vessels and season/species specific nets. The most common fishing vessels are the catamarans, dug-out canoes or vallams, boats and small scale trawlers. August to December is the slack season for fishing operations, although it is during this period that jelly fishes are caught in great numbers. Table 5 highlights the availability of different fish species across seasons and the kind of nets that are used.

Small-scale fishing communities require community members' sustained access to fisheries capital. In this regard, the important types of fisheries capital include the following:

(a) natural capital, that is, marine ecosystems and the living species they support;
(b) physical capital, including fishing vessels, gear, landing sites, and processing and marketing facilities;
(c) financial capital for sustaining operations, provisioning various items of physical capital, and supporting other social and economic activities, and sometimes for sustaining or enhancing natural capital as well; and
(d) human social and cultural capital, including human skills and information utilized in fisheries activities, as well as broader accumulated knowledge containing guidance for how to go about living in general.

The tsunami has impacted all four capitals that these communities possess, some in the material sense and others in a psychological sense. Fear of death, followed by fear of the unknown is a major deterrent to the renewal of fishing operations. Marine fishing and its allied activities involve a range of operators from multifarious backgrounds, often invisible in their contribution to the overall process. Much of this invisibility arises out of the fact that these people are often part of the immediate family or community and derive combined benefits. Also pertinent is the fact that some of the operators represent the most under-privileged castes of the Indian society. The following table attempts to capture the range of operators in marine fishing and elaborates their role in the operations. It also seeks to highlight those operators who were significantly impacted by the tsunami and the protection or relief that they have received from the government and non-governmental organizations / charity organizations and individuals.

Table 6: Effect of the tsunami on various occupations

Player	Role	Post-tsunami relief and security
Fishermen (Owners – of trawlers/ multiple boats/catamarans)	Often performing dual roles as owners and drivers – largely in areas abetting docks/ vessel landing areas. Usually the most influential meenavar leaders. Many of such leaders in villages adjoining Pondicherry and Cuddalore lost their vessels because they had contracted out their boats to places such as Cuddalore, Chennai and Colachel. Involved in specialized deep sea fishing.	Well covered by the Tsunami relief. Estimates by the government suggest significant losses to fibre glass boats.
Fishermen (Owners of one boat/catamarans)	Middle level players in the operations. Often owning one set (6) catamarans and nets. Level of operation is dependent on the buyers. Entirely a meenavar operation – in fact it marks the initiation of young men into marine fishing. Includes specialized and seasonal fishing.	Well covered by the Tsunami relief – through subsidies, loans and charity measures.
Fishermen (employed as assistants / team members)	Often the immediate family members of the fishermen. While the younger men may perform in addition to fishing, activities such as preparing the nets, women are involved in the process of extracting the fish from the nets and trading. Largely non-monetised form of labour.	Not adequately recognized as distinct operations. Women traders have been in some instances, provided with baskets to procure fishes.
Other assistants	Are drawn from other castes (excluding the dalits). These are vetted and employed by the fishermen to carry out fishing related activities – paid on per diem basis. Also function as additional labour in loading operations.	Only meenavars have been recognized – leaving out the sizeable number of the assistants from the relief net. In an attempt to ensure livelihoods, the state government has conditioned that catamarams will be provided to only groups of fishermen (5). Many of the fishermen who fall into these two categories are therefore trying to become part of the groups and ensure partial ownership of the catamaram.
Headloaders	Entrusted with the job of carrying the fish from the landing centres to the auction centres or godowns and finally to the transport systems. Some of them are from other castes – function as daily wage labourers.	
Local buyers	Usually the women from the fishing castes. Operate in nearby towns. Most of them represent the female – dependant households of the habitation.	Inadequate coverage because of non-recognition of female dependent households.

Player	Role	Post-tsunami relief and security
Cycle / two-wheeler traders	Usually from the dalit castes, low level operations on cycles. Buy small quantities of fish and market within 30 km radius.	Many of them perished or lost their assets during the tsunami – but left out of the tsunami relief operations.
Auctioneers Brokers / commission agents	Can be men or women, also involving money lending and brokering contracts. While the auctioneering is the meenavar domain, other aspects can draw upon other castes.	Although impacted, relief cover not requested or felt necessary.
Other traders	Providers of ice, other freezing agents, bags etc.	Although impacted, not recognized to be part of the relief operations.
Transporters	Hired by the fishing communities to transport fresh and dry fish to immediate, and long distance destinations. Range from trucks to auto rickshaws.	Although impacted, relief cover not requested or felt necessary.
Medium – large scale buyers and contractors	Large-scale buying for hotels, restaurants, catering units etc. – with very selective preference of fish.	Impacted due to temporary unavailability of fishes.
Fish collectors	Appointed by the agents, they are paid employees for taking care of the collection, storage and transportation of catches. Mostly from non-fishing communities.	Impacted significantly, not covered by the relief net due to non-recognition of their presence.
Boat owners (non-fishing community)	Wealthy merchants / traders who lease out the boats.	No data
Poultry feed processors	Women from the fishing communities – beaches are used to dry sardines. These are then sent to poultry centres in Tamil Nadu and Andhra Pradesh such as Namakkal, Salem and Chittoor. Includes the involvement of players such as agents, brokers, money lenders, transporters etc.	Impacted by the tsunami and not included specifically for relief. This activity marks the rejuvenation of local livelihoods currently.
Shell collectors / traders Sea horse collectors / traders	Incidental catch during fishing operations feeding into ornamental trade / chuna industry.	Impacted by the tsunami and not included specifically for relief.
Inland fishermen	Usually the activity restricted to children and families that are under- previleged. Non-monetised activity in areas predominantly thriving on marine fishing. Although least preferred in terms of taste, this is an activity essentially to meet the food needs of the family	No data

The second major use of natural resources in coastal habitats involves the use of wetlands for agriculture that is dominated by the cultivation of paddy and groundnut. Large tracts of land that were under paddy cultivation were inundated during the tsunami, not only damaging the standing crop but also rendering the land unsuitable for further cultivation. Such damage however is restricted to Kanchipuram and Villupuram districts. Local inhabitants state that the structure and dynamics of the estuaries have changed drastically due to the tsunami due to siltation, deposition of debris and in certain instances breaching of bunds. In parts abulting Cuddalore OT and Parangipettai, there has been a significant loss of Casuarina and palmyrah plantations. However since these are common resources, the loss has not been reflected at the household level.

The tsunami also impacted inland fishing considerably since the mouths of the estuaries were silted or blocked. This has caused considerable damage to marginal castes such as the Scheduled Castes and Tribes who collect clams. While the flesh is used as food, the shells are sold to the local lime (chuna) industry or for ornamental trade.

Priorities for Action

Apart from geological factors and wave height, location of the habitation was a key factor that determined the impact of the tsunami on humans and habitats. Although all the 13 habitations were located within 100 m of the HTL, impact was differential and the reasons are highlighted in the following table:

Table 7: Effect of the tsunami on different habitations

Habitation	CRZ Classification	Distance of habitation from the HTL in m	Key ecological features	Level of Impact
Alambarai	I and III	100	• Presence of backwaters and river • Small and isolated patches of littoral forests with palm, pandanus and thespesia • Hermit crabs, mullets and terrapods in good numbers • Habitation within 500 m of the coastline buffered with coconut plantations	Low
Eggiyar kuppam	III	10	• Habitation on a sand bar – with a good number of dunes scattered all over • Approach road has dense patches of cashew and thespesia trees • Habitation surrounded by extensive agricultural lands	Low
Anumandai kuppam	III	10	• Significant number of Ficus trees along the approach road • Historical presence of littoral forests – denuded for construction of dwellings, boat accessories and most significantly, fuelwood.	Medium
Bommarapalayam	III	17	• Data not available	
Pillaichavady	I	20	• Data not available	Medium

Habitation	CRZ Classification	Distance of habitation from the HTL in m	Key ecological features	Level of Impact
Vambakeerapalayam	II	15	• Habitation located within the city limits of Pondicherry	Low
Pudukuppam	I	60	• Extensive beach with scarce littoral vegetation	High
Nallavadu	III	100	• Extensive beach, with the Ariyankuppam river draining into the Bay of Bengal. Presence of mangroves	Medium
Murthikuppam	I	100	• Village is located between two estuaries – thereby also being flanked by the rivers. Historical presence of mangroves. • Water gushed along the river to a distance of about 1.5 km.	Medium
Sonankuppam-Singarathopu	III	50	• Village on low elevation within the Cuddalore harbour – even the sandbar was completely flattened by the tsunami • The channel to the harbour served as the conduit for the water • Extensive growth of prosopis which was being used as a substitute for casurina.	High

Habitation	CRZ Classification	Distance of habitation from the HTL in m	Key ecological features	Level of Impact
Chittiraipettai	III	50	• Habitation on a series of sand dunes • Presence of littoral forests and dense plantations of cashew, coconut and palymrah trees. • Presence of a river that connects to Parangipettai.	Low
Periakuppam	III	20	• Village located on a sand dune with a good number of smaller dunes with dense vegetation harboring the village. Vegetation comprising of cashew, palmyrah and casurina. Also a number of thespesia trees within 20 m from the sea. • Beach protected by a coconut plantation – inhabitants state that the tsunami washed in a number of coconuts from the Andamans and Sri Lanka, which they have planted locally. • Area immediately adjacent to the habitation is low – inhabited by the labourers who work for the rich fishermen – completely washed away by the tsunami. • Also people on the dunes were saved while those residing close to the estuary were heavily impacted .	Medium
Samiarpettai	III	20	• Presence of lagoons, palmyrah and casurina plantations Extensive beach	High

Table 8: Relief needs (villagers' opinion)

Most important object wanted for the habitation	Number of responses
Habitat	55
Drinking water	48
No opinion	31
Sanitation	31
Fishing equipments	30
Roads	21
Transport	10
Hospital	7
Light	4
Food	3
Auction center	2
Community facilities	2
Fish drying platform	2
Fishing boats	2
Aid	1
Alert system	1
Household equipment	1
School	1

It is being slowly recognized by local inhabitants that habitat improvement has to be a key feature of the post-tsunami rebuilding process. It is also being understood that individual or household based relief alone is not adequate for the revival process as local livelihoods are inextricably linked to the use of natural resources. In a study that was conducted during the same period covering 283 households in 15 habitations (Puyravaud and Vencatesan, 2005) restoration of habitat emerged as the definite priority.

For instance when the respondents were asked the open question 'What is the most important object you would want for your habitation?', the most recurrent priority was the improvement of the quality of the habitat, including developing shelter belt plantations, desilting, removal of debris,etc.

Conclusion

The stringent enforcement of the CRZ in terms of location of households above 500- 1000 m from the HTL, supported by facilities and mechanisms to enable the continuation of fishing operations is required. Further, the rebuilding process should focus on improving and sustaining coastal habitats. Such a process is to be undertaken with the support of expert groups. Only a coordinated rebuilding effort would enable the quick recovery of habitats and livelihoods in the Tsunami impacted regions of the state of Tamil Nadu and the Union Territory of Pondicherry.

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Puyravaud , J. P. and Vencatesan, J. (2005). Needs Assessment Study-Unpublished Report submitted to the British High Commission by ITPI (India) Pvt. Ltd.

Comprehensive list of fishing hamlets along a 100 km stretch of the East Coast of India with Pondicherry as the mid - point - covering the districts of Kanchipuram, Villupuram and Cuddalore of Tamil Nadu and Pondicherry of the Union Territory of Pondicherry

	Fishing Village / Hamlet	District
1.	Panayar Periakuppam	Kanchipuram district
2.	Vilampurkuppam	
3.	Kadapakkamkuppam	
4.	Alambarai fort and backwaters	

1.	Muttukadu asakan kuppam	Villupuram district
2.	Vasavan kuppam	
3.	Kaippani kuppam	
4.	Eggiyar kuppam	
5.	Bandevaipudukuppam	
6.	Kilettai	
7.	Gomutti Chavadi	
8.	Anumandai kuppam	
9.	Chettinagarkuppam	
10.	Nochikuppam	
11.	Kunimedu kuppam	
12.	Mudaliar kuppam	
13.	Anichankuppam	
14.	Pudukuppam	
15.	Pillai Chavadi	
16.	Bommarapalayam	
17.	Mudaliar Chavadi	
18.	Tendirayar kuppam	
19.	Nadukuppam	
20.	Sodhanaikuppam	

Villages highlighted in grey: study villages

1.	Kanagachettykulam	UT of Pondicherry
2.	Periakalapet	
3.	Chinnakalapet	
4.	Pillaichavady	
5.	Solai Nagar	
6.	Vaithikuppam	
7.	Kurusukuppam	
8.	Vambakeerapalayam	
9.	Veeranampattinam	
10.	Chinnaveeranampattinam	
11.	Pudukuppam	
12.	Nallavadu	
13.	Pannithittu	
14.	Narambai	
15.	Murthikuppam (Pudukuppam)	

1.	Moolaveli	Cuddalore district
2.	Thalanguda	
3.	Devanampattinam	
4.	Sonankuppam	
5.	Singarathoppu	
6.	Akkaraigori	
7.	Sothikuppam	
8.	Rajapettai	
9.	Chittiraipettai	
10.	Thammanampettai	
11.	Nanjalinampettai	
12.	Naickerpettai	
13.	Periakuppam	
14.	Petiodai	
15.	Ayyampettai	
16.	Maniarpettai	
17.	Reddiarpettai	
18.	Annapanpettai	
19.	Madavapallam	
20.	Kumarapettai	
21.	Samiarpettai	
22.	Velingarayanpettai	
23.	Pudukuppam	

Villages highlighted in grey: study villages

A Study of the Impact of the Tsunami on the Point Calimere Wildlife and Bird Sanctuary and the Muthupet Mangrove Forest

C. Sivasubramanian[1] and R. Sivakkumar[2]

On 26th December 2004, a tsunami triggered by an earthquake killed thousands of people and devastated hundreds of villages in different parts of the east coast of Tamil Nadu. Since Point Calimere Wildlife and Bird sanctuary also comes under the Coromandel coast in Nagapattinam district, the researchers have taken up this project.

The vast saline marshes of the Point Calimere Wildlife and Bird sanctuary form a major refuge for migratory and resident birds. The sanctuary has the second largest congregation of flamingos in India after the Rann of Kutch. The sanctuary is also known for a population of blackbuck (*Antilope cervicapra*). The sanctuary comprises the single largest patch of a unique dry-evergreen forest in the country. A notable feature of the sanctuary is the presence of feral horses. Olive Ridley turtles have also been regularly nesting on the sanctuary beach. During winter, dolphin sightings are common along the sanctuary coast. The ruins of a 1000 year old Chola lighthouse stand at the point known as Point Calimere.

The Muthupet mangrove forest is a part of the Point Calimere Wildlife Sanctuary, which runs along the coast line from Koddikarai over a distance of 60 km up to Adirampattinam.

The Muthupet mangrove forest is a spawning and nursing ground for commercially important maritime prawns and fishes. The coast of Point Calimere is an important fish-landing site for fishes and prawns. The main objective of this study is to investigate the ecological effect of the tsunami on the mangrove forests, and the wildlife habitat of the sanctuary. The study also highlights the threats to the sanctuary and suggests measures for its conservation.

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Study area

The study was conducted in the Point Calimere Wildlife and Bird sanctuary. It is one of the largest (approx. 349 km^2.) and a major wintering refuge for water birds in south India (Ali 1963). The sanctuary is located on the Coromandel coast in Nagapattinam district of Tamil Nadu and is bounded by the Bay of Bengal in the east and Palk Strait in the south. The sanctuary forms one of the seaward apexes of the Cauvery river delta. Point Calimere or Kodiyakarai (10°18' N, 79° 51' E) is the headquarters of the sanctuary. The main contribution to the rainfall is from the northeast monsoon, and to a lesser degree, the southwest monsoon. The highest temperature (34°C) is in May, and the minimum (25°C) in January and February. Relative humidity remains high throughout the year due to coastal influence. Strong winds are prevalent during certain months, especially in May and June.

The habitat of the sanctuary is varied. It has the tropical dry evergreen forests at Point Calimere, and the Muthupet mangrove forest at Muthupet.

The northern boundary of the Point Calimere forest starts about six kilometers south of Vedaranyam and extends further south for about four kilometeres till the Palk Strait. It is bounded on the east by the Bay of Bengal and by the Muthupet mangrove on the west. The forest is not continuous but interrupted by many tidal inlets and creeks of varying lengths and widths, which are flooded during the monsoon and in May and June with the coming of the westerly winds. The forest is classified as a tropical dry evergreen forest. It harbours many species of medicinal plants (Balasubramanian, 1994 and Balasubramanian & Bole 1993). There are also broken stretches of open grazing lands, especially at the southern and western portions.

The Muthupet mangrove forest comprises "bar-built" estuaries and is estimated to be around 2000 years old (Tissot 1987). It is located in the southernmost end of the Cauvery delta, extending from Adirampattinam in the west. The Muthupet mangrove forest is bounded in the south by the Palk Strait. On the northern side, extensive mud flats are present, which are prone to floods during the monsoon. Many of the drainage arteries of the Cauvery delta, namely Nasuviniyar, Pattuvanachi, Paminiyar, Korayar, Kilathangiyar and Marakakoryar empty their water into the mangrove forest.

Methods

To know the impact of the tsunami on the Point Calimere Wildlife and Bird sanctuary, a detailed survey was made along the seacoast from Adirampattinam to Kodiakarai. This area encompasses all the habitats of the sanctuary like evergreen forest, grassland, open area, marshy area, reservoirs, mangrove forest, fresh water ponds, croplands, mudflats, estuaries, beach etc., The survey was conducted between April and May 2005. The area was accessed by motorbike as well as on foot. In Muthupet mangrove forest, the study was conducted by boat. Local enquiries were made from the fisherman community, Forest Department staff, and local village people who live along the sanctuary.

Results and Discussion

The tsunami has caused widespread damage to the lives and property along the coast of Nagapattinam district. Point Calimere Wildlife and Bird sanctuary is located right next to the sea. The study showed that the sanctuary and Muthupet mangrove forest escaped from serious damage and that in the sanctuary, animals and birds largely survived the killer wave.

A wave as high as of 10 feet had hit the Kodiyakarai coast first around 9:10 am on December 26th and later again around 12:30 pm (K.R. Ramachandran, *pers. comm*.) The threat of another tsunami was high and the seawater gushed into the sanctuary and the entire sanctuary was under four feet of water. However, water receded within a few hours. Most parts have turned slushy, with ankle deep muddy water, and the sanctuary was closed to the public. During our field study at Point Calimere sanctuary, we made the following observations:

Damage to vegetation:

In the Point Calimere Wildlife and Bird Sanctuary, some of the shelterbelt plantations of casurina have been damaged. More than fifty uprooted accacia trees were found near the old Chola lighthouse. We did not see any uprooted vegetation in the evergreen forest area .

Blackbuck habitat:

The blackbuck of Point Calimere represent one of the three isolated populations of blackbuck existing in Tamil Nadu, with the other populations being in the Guindy National Park (Chennai) and near Satyamangalam (Erode district). The blackbucks of Point Calimere are unique in that males do not attain the black colouration of adults, as in parts of central and northern India, and they remain a dark tan throughout their lives.

Blackbuck inhabits the open stretch of grazing lands (700 ha), south and west of the forest of Point Calimere. The population fluctuates and around 400 to 500 animals are seen here (Natarajan 1994). There is little possibility for further increase in numbers due to the limited habitat.

On the day of tsunami, blackbucks were seen running away from the coast just 10 minutes before the waves struck (Jaganathan, watcher, *pers. com.*). The movement of the blackbuck from the coast minutes before the tsunami struck presents a very interesting phenomenon. Animals have been known to behave abnormally before the incidence of a natural calamity. Unusual barking by dogs and restlessness among domestic and wild animals before an imminent natural disaster have been well documented especially in the case of earthquakes.

We had carried out an animal census of the sanctuary on 26th and 27th March 2005 and a large number of blackbuck were seen inside the sanctuary. Herds numbering up to 150 were observed. However, most of the animals were avoiding the coastal tract and were seen grazing about two kilometers inland. The reason is that most of the grassland areas were dried up because of the inundation. Many parts of the grassland areas were silt-laden, and in some places salt deposits and congregation of molluscan shells were noticed. There was no sign of any abnormal behavior among the blackbuck. We had conducted another survey on 29th and 30th April 2005 and we counted 35 blackbucks in the coastal tracts. The reason could be of attributed to the appearance of new sprouts of grass following the rains.

Waterbird areas:

The tsunami struck at the height of the bird season, which lasts from October to March. A large number of migratory birds had arrived here this season. Most of the water birds, specially both the species of flamingos that inhabit the Old World, viz. the greater flamingo *Phoenicopterus raseus* and lesser flamingo *Phoenicopterus minor* inhabit the Point Calimere Wildlife and Bird sanctuary and have been observed to feed about three kilometers further west.

Flamingos inhabit highly alkaline and saline lakes and are considered to be partial to salt works. The greater flamingo is attracted to reservoirs and low salinity condensers of industrial salt works in the Point Calimere Wildlife and Bird sanctuary during the monsoon, due to increase in food availability. The lesser flamingo avoids the salt works all through the year. The main reason for this is that the greater flamingo is a generalist feeder (plant and animal) and can shift to feeding on different species of food, depending on abundance, while the lesser flamingo is a specialist feeder (blue green algae) and cannot shift to such opportunistic feeding (Manakadan 1994, 1995). There was no records of any observations made on the changes in the feeding habitat and feeding behavior among waterfowl due to the tsunami.

Turtle nesting site:

The sanctuary has also been experiencing regular nesting by Olive Ridley turtles *Lepidochelys olivacea*. Their nesting site is in the beach area, from the old Chola lighthouse to the jetty. The tsunami did not affect the turtle breeding area as seven successful nests were found in this area and more than 300 eggs were collected for the artificial hatchery (Anandan, Research, Biologist, *pers. com.*). During our survey, we found accumulation of debris, such as fallen trees, rubber, fishing nets, thermocol, leather, plastic, coconuts, woods etc., on the turtle breeding habitat.

The 1000 year old Chola lighthouse inside the sanctuary, which was in ruins even before the tsunami, was damaged further and reduced to half its size.

Muthupet mangrove forest:

The Muthupet mangrove forest also escaped the tsunami wave. During our survey, we interviewed many fishermen in Muthupet village. They said that they were virtually saved by the forest cover. When the first tidal waves attacked the region, the forest is said to have reined in the speed of the waves. Only a few fishermen have lost their fishing nets in the lagoon area. During our boat survey inside the mangroves, we did not see any damage but in some areas large debris from the Suaeda plants were seen.

The importance of mangrove vegetation and its role in protecting the human habitation from the tsunami:
The significance of mangrove forest and its role in conserving the ecology and socio economic life of human beings are multifold.

i. Mangroves act as land builders. They stabilize newly formed mud and silt deposits in the river mouth.
ii. They also play a key role in protecting human habitation from devastating tsunami cyclones and tidal waves.
iii. Mangrove vegetation restricts and slows down the erosion process. The trees are well equipped with branched root systems, pneumataphores or breathing roots (*Avicennia* sp.,), and stilt root systems (*Rhizophora* sp.,).

Selvam and Karunagaran (2004) described the root system of mangrove plants and their function. In growing *Rhizophora* species, roots diverge from the tree as long as two metre above ground and penetrate the soil some distance away from the main stem. Because of their appearance and because they provide the main physical support of the trunk, the aerial roots of *Rhizophora* are often called stilt roots. On reaching the soil, absorptive roots grow from the stilt roots vertically downwards into the soil. A secondary aerial root may loop off and penetrate the soil still further away from the main trunk. The aerial roots of neighbouring trees often cross, and the result is the development of an impenetrable mesh of stilt roots.

In species like *Avicennia*, shallow horizontal roots radiate outwards, often for a distance of many meters. At intervals of 15 to 30 cm, vertical structures known as pneumatophores emerge as lateral branches from horizontal roots and stand erect, up to 30 cm above the soil. A single *Avicennia* tree of two to three meter height may have more than 10000 pneumatophores. The presence of aerial roots is one of the reasons that mangrove forests function as an effective wall against strong winds and cyclones.

Mangroves play an important role in moderating coastal storms at the interface between the land and sea. The coastal belt, particularly near and along the foreshore, is a zone of intense atmospheric turbulence due to the interplay of land and oceanic atmospheric influences. The impact of cyclones on densely populated deltas can be tragic. In November 1970, a cyclone combined with high tide, killed more than 200,000 people in Bangladesh. The 1991 cyclone reportedly killed over 100,000 people and rescue work was hampered by high tidal floods. In December 2004, the earthquake and tsunami severely affected many villages and killed thousands of people and devastated hundreds of villages in different parts of the east coast of Tamil Nadu. Without the moderating influence of the forest, the loss of human life and property would have been catastrophic. Environmentally, therefore, the coastal mangroves are vital shelterbelts, which afford protection to inland homesteads, agricultural crops, livestock and aquaculture.

Along the coasts, a belt of protective mangrove vegetation should always be retained not only to reduce the damaging effects of tidal waves and storms but also to reduce the severity of tidal flooding.

Threats

During the interviews with the village as well as with the field staff of the Forest Department we were informed that a few families of the fishing and farming hamlets regularly collect firewood from the mangroves. Almost the entire firewood requirement of Kodikkarai and Kodikkadu is being illegally obtained from the forest.

Besides firewood, there is illegal collection of forest produce, such as fruit of *Manilkara hexandra, Zizyphus mauritiana, Carissa carandus, Syzigium cumini, Sapindus emarginatus*, rhizomes of *Gloriosa superba*, and leaf litter for use as manure for the tobacco crop.

In the Muthupet mangrove forest, almost all the fishermen interviewed stated that there has been considerable reduction in the quantity and size of the fish caught in the last 15 to 20 years. They attribute the decline in the fishery resources to the silt deposits in the lagoon mouth as well as in the lagoon, over exploitations of the fishery resources in the nearby neritic water by trawlers, pollution by prawn farm and reduction in the area of the mangrove forest.

Point Calimere Wildlife and Bird sanctuary has a long history of salt work operations, in its vicnity. A number of domestic and industrial salt works operate in the Vedaranyam swamp.

Manakadan (1994) showed that the impacts of salt works on water birds depend on many factors and can be beneficial to some species. The overall impact of a salt complex of such a magnitude will definitely alter the ecosystem, affecting the flora and fauna of the sanctuary, besides having possible repercussions on the fisheries of the coast.

The other two major problems are over-fishing and poaching. There are no restrictions on fishing and, as a result of which fishes of small size and non-target species are also caught. Poaching of water birds in the Muthupet mangrove forest is a serious problem that confronts the Forest Department. A study by the Salim Ali Wild Wings Trust (Daniel *et al*. 1999) found that certain families in the villages that border the Great Vedaranyam swamp depend on bird trapping for their livelihood.

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A Status Survey of mass-nesting sites of the Olive Ridley Turtles in Orissa

S. K. Dutta

It is hypothesized that nesting actually has been intensive in 2005 due to less human interference on the coasts as a result of the tsunami

Three major mass nesting sites of the Olive Ridley sea turtle (*Lepidochelys olivacea*) are reported from India. These include the Devi River mouth, the Rushikulya River mouth and the largest known mass nesting ground for this species, the Gahirmatha area (Dhamra river mouth). The nesting beach at Gahirmatha is a protected area which forms part of the Bhitarkanika Wildlife Sanctuary and National Park. Due to the large number of nesting turtles, the Gahirmatha nesting site has also been declared as a marine sanctuary, namely the "Gahirmatha (Marine) Wildlife Sanctuary".

There was considerable interest and speculation about the possible impact of the recent tsunami that struck eastern India, on marine turtles. One of the ways to assess the impact of the tsunami on this species is by monitoring the mass nesting on these three beaches of Orissa. This would lead to two sets of information - the number of adult nesting turtles and the number of hatchlings.

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Survey areas

The survey was undertaken at three prominent nesting sites. A brief description is provided below.

1. Gahirmatha Marine Sanctuary

This mass-nesting rookery is located in the northern part of Orissa and was discovered by Dr H. R. Bustard in 1974. Though this phenomenon was known locally much earlier, protection measures to the turtles were implemented after 1974.

Gahirmatha marine sanctuary is situated between 86°45'57"-87°17'36" E longitude and 20°17'52"-20°46'58" N latitude in Kendrapara district. The total area of the sanctuary is 1435 km^2, which includes 725.50 km^2 of core area and 705 km^2 of buffer zone. In the sanctuary area two rivers i.e. the Barunei and the Chinchiri drain northwards.

Currently the mass nesting area is confined to two islands; Nasi-I and Nasi-II about six km long and about 10 km north of Gahirmatha Marine Sanctuary. These islands fall under the jurisdiction of Defense Research and Development Organization (DRDO). Due to co-operation shown by the DRDO in the form of reduced anthropogenic activities and regulation of light sources at night towards the beach, more female Olive Ridley turtles have been nesting in this area.

2. Rushikulya River Mouth

Dr Bibhas Pandav of Wildife Institute of India (WII) discovered this rookery in the year 1994. The nesting area is located between Kantiagarh and Puruna Bandh village near the Rushikulya river mouth. This year the mass nesting occurred 25 days earlier than previous years.

3. Devi Island and River Mouth:

This is the third mass nesting site of the Olive Ridleys in Orissa and is located in the district of Puri. For the first time studies aided by satellite telemetry were carried out at this locality. Though the mass nesting at Devi was not as intensive as that of the other two places, the nesting beach appears to be quite conducive for the sea turtles.

Observations

1. Gahirmatha

The phenomenon of mass nesting of sea turtles, in particular the Olive Ridley, in Orissa came into limelight after the discovery of the Gahirmatha rookery (Bustard, 1974). This led to various long-term research activities to conserve the animals and their habitat. After the enactment of Wildlife (Protection) Act, 1972, all marine turtle species have been included under Schedule I of the Wildlife (Protection) Act, implying that there is complete ban on any type of activities that threatens the life of these animals.

Nesting record for 2004-2005

The major mass nesting sites are located at the Nasi Islands (I and II), Babubali, Ekakula and Barunei river mouth to Agarnasi. Nesting started on 7 January 2005 at the Dobandhi area, near Barunei River mouth. Initially, during January, turtles laid less number of eggs (38-62), but later, the number increased. The maximum-recorded clutch size in this area was 202 (as per the statement of a Forest Guard). Main nesting occurred in an area of about two kilometers from Dobandhi to Barunei river mouth probably because the water is deep and the beach is flat and wide above the high tide line. There was also lesser erosion which could have hindered turtle nesting.

On 3rd February 2005, the first mass nesting of the year occurred in this two kilometer stretch of area. About 1200 turtles came for egg laying. The nesting process was sporadic throughout the sanctuary except on the islands.
In Babubali and Nasi Island II, 26,000 turtles came on 6th March 2005 for nesting. During this year nearly 5,00,000 turtles emerged to complete the ritual of mass nesting. Fourteen individuals were found, which had been tagged at the Devi River mouth in 2002.

Hatchery

The biggest hatchery of the sanctuary is in Dobandhi, which measures 60' x 15'. In all, there were more than 700 nests laid. Till 29th March 2005, 82000 eggs had been laid. Hatching started in the first week of March. Till the end of March, eggs of more than 500 nests had hatched. According to forest staff the hatching success in the area is 80-85%. At Ekakula there is another hatchery where nearly 100 nests were laid. By 15th March only nine were left to hatch.

Table I: Year-wise nesting figure (for some of the previous years) of Olive Ridley turtles at Gahirmatha Coast, Orissa.

Year	Total emerged	Number of Arribada (Mass nesting)
1983	2,00,000	
1984	5,00,000	
1984-85	292,000	4
1985-86	50,000	1
1986-87	636,000	2
1987-88	No mass nesting	-
1988-89	318,000	1
1989-90	207,000	1
1990-91	659,000	2
1991-92	384,000	2
1992-93	672,000	3
1993-94	695,000	3
1994-95	339,500	2
1995-96	290,000	4
1996-97	No mass nesting	-
1997-98	No mass nesting	-
1998-99	298,000	3

Trawler and other disturbances

The major threat to the turtles in Gahirmatha marine sanctuary is the nearby fishing port and a prawn culture facility, which may adversely impact the Bhitarkanika sanctuary and the largest arribada beach. On 29th March 2005, more than 50 trawlers were seen near Dobandhi coast about 1.5-2 km offshore during the night. It is thus obvious that trawler fishing is still prevalent in the sanctuary. In Ekakula too, a number of trawlers were seen in the month of March when turtles use the off-shore waters. More dead turtles were seen near Ekakula, probably due to unchecked fishing activities by gill nets and trawl nets in Dhamra, Paradeep, Balasore and nearby areas. Due to continuing fishing activity, fresh turtle carcasses were frequently seen. Though there are strict laws under OMFRA and CRZ regulations and the mandatory use of turtle excluder device, not a single trawler follows the rules due to weak enforcement. During the month of December three trawlers were seized by forest department, but after that there have not been any instances of raid of trawlers. Death due to incidental catch is ever increasing, specially in the Gahirmatha marine sanctuary during the turtle migration period due to lack of interest in conserving the sea turtles and poor enforcement of law.

Predators

Hyenas, wild boar, jackal, dogs, crows and stray dogs are the major predators of turtle eggs. There were 1,000 dogs in the Nasi Islands during nesting but a majority were driven away by people to prevent the eggs being eaten up.

Beach erosion

Beach erosion is amongst the most significant natural disasters for many rookeries throughout the world. It has been found that turtles like Olive Ridley need a critical area of 0.5 km^2 for mass nesting. One of the reasons turtles abandoned Gahirmatha rookery for two consecutive years during the last decade was, changes in the physical characteristics at the rookery. The habitat was under severe stress due to erosion by successive cyclonic impacts, increasing the length of the site but reducing the nesting habitat space. The nesting area from Kanpura till Habellikhati is narrow due to beach erosion. Also, there are some muddy areas on the beach, where there were mangrove forests earlier. There are remnants of mangrove trees from Satavaya till Habellikhati which may be acting as an obstruction for the turtles which prefer the beach for nesting.

Mortality report

Turtle casualty in Gahirmatha marine sanctuary in the present season is not less than 3,000. It has been reported that just before mass nesting (on 27th February 2005), there were 1,700 turtles caught in a trawl net, while fishing near the coast at Nasi-II Island. This may be due to large congregation of mother turtles, ready for egg laying, near the coastline. The trawler was fishing 0.5 km from the coastline. The net became so heavy that four trawlers dragged the net out of the sanctuary towards Dhanra and Talachua side to free the dead turtles. It took 40 people (of four trawlers) two days to free the dead turtles.

There were nine dead turtles between Barunei and Chinchiri river mouth, according to forest staff. However, more than 1169 dead turtles (on 15th April 2005) were counted from Nasi till Chinchiri river mouth. On 16th March 2005 and 17th March 2005 another 29 fresh dead turtles were washed ashore.

NGOs working in the area

There are no external agencies working in the area. The state forest department works with local people in guarding nests, monitoring movement of prohibiting trawlers and fishing near offshore water and rescuing disoriented turtle babies during hatching time. National Institute of Ocenographic Technology (NIOT), a premier institute on beach profile study, is working on beach erosion in Ekakula Nasi area. Babubali and Nasi Islands, where mass nesting took place is under the DRDO, where disturbance due to tourists is very less. Only forest personnel and those with special permission are allowed.

2. Rushikulya

Nesting

Nesting started in Rushikulya rookery on 30th January 2005 and the nesting figure had increased to its peak by 16th February 2005 (30,000). Mass nesting occurred from 16-18 February.

Table 2: Mass nesting data of Olive Ridley turtles at Rushikulya from 1995

Year	Date of mass nesting	Estimated number
1995	20-21 March	50,000
1996	21-25 February	55,000
1997	1-3 February	35,000
1998	21-24 March	25,000
2003-04	15-20 March	2,10,000
2004-05	16-19 February	95,000

Table 3: Nesting of Olive Ridley turtles at Rushikulya during 2005

February	94,656
March	130
April	39

Hatchery

There is no hatchery, government or non governmental, in Rushikulya. Forest department staff along with other local people were involved in guarding and rescuing disoriented baby turtles. Till April a few turtles were seen nesting sporadically.

Hatching and rescue

The mass hatching of turtles started from 6th to 11th of April. It rained twice during the incubation period. On 8th of March 700-800 nests emerged. The local people working in rescue operation are from near by villages; Gokharkuda, Puruna bandh and Podampeta. They work on daily wage basis and are not well trained, and as a result they accidentally do a lot of damage to the hatchlings by digging them out from the nests and pulling out the babies by their neck. Also, the forest department staff was seen encouraging people to take part in these activities. Some forest staff were seen throwing baby turtles into the sea.

Threats to the turtles

There are not many major threats prevailing in this rookery. Trawling activities were under control in this area because of which the turtle casualty was reduced to 52 in this area. Some of the major predators are jackal, stray dogs, hyena, crow, eagles, kites, monitor lizards and crabs. Major disturbances are anthropogenic in nature due to easy access to the area. A number of people walk on the beach causing damage to the nests. Many discarded fishing nets are seen on the beach in which many baby turtles get entangled.

Beach erosion

There is beach erosion (6 feet) near Gokharkuda village. Also, there is formation of an artificial pool due to wind. A number of young turtle babies get disoriented and go to the pool and subsequently either get killed by predators or die of exhaustion.

NGOs working in the area

Operation Kacchapa: Wildlife Society of Orissa operates this programme in collaboration with Wildlife Protection Society of India for sea turtle conservation. There have been several awareness campaigns in fishing villages and schools on the protection of endangered species. Operation Kacchhapa staff is seen during mass nesting, guarding the nesting beach and helping in rescue operation along with the forest department.

Wild Orissa: This organization was seen spreading awareness messages in the rookery.

Rushikulya Sea Turtle Protection Samiti: A local NGO consisting of young boys and girls, who are sincerely involved in protection of the nesting beach and also participate in the rescue operation of the hatchlings during mass emergence. This NGO has worked in 2004-05 withthe Wildlife Trust of India in protecting sea turtle nests.

Threats to Sea turtles at Rushikulya

1. Marine fishing related incidental mortality (Every year, thousands of dead Olive Ridley sea turtles and gravid females are washed ashore along the Orissa coast. This can be attributed as the single most important cause for declining sea turtles.
2. Light Illumination from buildings, factories, towns and houses along the coast misdirects the hatchlings.
3. Predation of eggs and hatchlings.
4. Plantation along the coastline destroys the nesting beach profile.
5. Coastal pollution.
6. Sand mining and
7. Coastal prawn culture

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3. Devi River Mouth

Devi River mouth was discovered during 1981, when an estimated 1,00,000 olive ridley turtles nested in the four km stretch of Akashdiha Island (Kar, 1981). Several changes have happened since then. Major change was the opening of a new river mouth after the super cyclone of October-November, 1999. After the discovery of the rookery the number of turtles coming for nesting has depleted possibly due to the following causes:

1. Reduced beach area due to casuarina plantation.
2. Intensive fishing activities by trawl netters and gill-netters.
3. Disturbances in the area due to collection of prawns and tourist activities.

Other than this, each year an average of 5,000-10,000 turtles come for nesting in the 15 km stretch of coastline between Devi River mouth and Kadua river mouth. During 1999-2000, turtles emerged for the ritual of egg laying between Gundalava village and Kadua river mouth.

Nesting

11,477 turtles emerged for nesting between Devi River mouth and Kadua river mouth during 2004-2005. The nesting process was sporadic and continued for a period of five months from January till May. The nesting frequency was more between Sahana fishing village and Devi river mouth. A maximum number of 9,524 nestings were observed during the month of February.

Hatchery

There are three hatcheries made on behalf of forest department to protect the eggs from predators. The largest is located at Jahaniapira and the other two are located near Sahana fishing village in Devi river mouth. 32,800 eggs of 243 nests were implanted in front of the Jahaniapira beat house, 12,576 eggs of 140 nests in Sahana beat house, and 9279 eggs of 78 nests were implanted at Devi river mouth area. Out of the implanted nests nearly 56% of babies emerged successfully and returned back to their feeding ground. The numbers of eggs implanted in the three hatcheries and the number of babies that emerged are given in Table 4.

Collection of eggs

Eggs were collected during early mornings with the help of local people employed for the purpose by the forest department. Five to six nests were collected in each plastic bag and implanted immediately to the hatchery.

Collection of hatchlings

In the hatcheries, hatchlings were collected by the light trap method. As the babies are highly sensitive towards light, this is an easy method of collection of turtle hatchling which group into one corner of the hatchery. The babies were then collected in tubs and released into the sea.

Predators

The casuarina forest near the coast line offers a suitable habitat for predators like jackals, hyena, monitor lizards etc. However, the major predator in the area is feral dog in addition to other hatchling predators like crows, sea gulls, crabs, and eagles which are also seen in this area.

Table 4: Data on Translocated eggs at Devi Rookery

No. of eggs in each hatchery at Devi rookery during 2005				
Sl. No.	Location	No. of nests	No. of eggs	No. of hatchlings
1	Jahhania pir	243	27,600	18554
2	Sahana	140	12,576	8,553
3	Devi river mouth	78	9,279	7,015

Trawlers and gill net activity

Though fishing activity by trawl nets and gill nets is banned in this area during the turtle nesting season intensive fishing goes on due to less attention of forest department and coast guard.

Mortality report

A total of 1,739 turtle carcasses were found in the stretch of Devi river mouth to Kadua river mouth during the year 2004-2005. 424 male and 1,306 female turtles were found dead in the area. Male mortality was the maximum during the month of January (229), followed by December (178) and February (17). Maximum number of dead turtles was reported during the month of March (623) and all of them were gravid females. The death rate was high due to many getting caught in trawl nets and gill nets.

Other Agencies working

There are no agencies working on turtle conservation directly in this rookery except the forest department. This department has banned any type of hatchery work, which was done earlier by volunteer sea turtle conservationists. "Operation Kacchappa" carries out conservation awareness campaign in the near by villages through school rallies, posters and wall paintings.

Evaluation of possible changes and damages due to the tsunami

The above assessment and survey do not indicate any direct affect of tsunami on the nesting activity of the olive ridleys. However, several side effects were observed due to tsunami. Some minor changes were found in the beach profile (beach erosion at Gahirmatha), but not at the site of the nesting. It is hypothesized that nesting activity has been intensive during 2005 due to less human interference at the nesting localities. In fact, after tsunami, the local fishermen and outsiders involved in illegal fishing were afraid of fishing during January and February 2005. That is perhaps why the turtles could mate safely in the sea and the ultimate end product was a successful mass nesting.

Existing acts and rules for protection of sea turtles and their habitats in Orissa

The Wildlife (Protection) Act, 1972 (Amended, 1991)
The Wildlife (Protection) (Orissa) Rules, 1974.
The Central Water Pollution Act, 1974.
The Central Water Pollution (Amendment) Act, 1978.
The Environmental (Protection) Act, 1986
Coastal Regulation Zones (CRZ I, II & III).
The Orissa Marine Fishing Regulation Act, 1982.
The Orissa Marine Fishing Regulation Rules, 1983.
Coastal Zone Illumination (Prevention & Control) Act, and Rules (Proposed).

Threats to sea turtles along the Orissa coast

A. **Indirect threats:** Includes loss of marine habitats, loss of nesting beaches (erosion, sand mining and beach armouring), pollution and lighting (which disorients the adults and the hatchlings).
B. **Direct threats:** Accidental catch/trapping in mechanized fishing activity, destruction (depredation) of eggs by feral animals found around the nesting beach.

Generalized Action Plan for Conservation of Sea Turtles In Orissa

Habitat Protection: Identification and designation of additional conservation areas (other than Gahirmatha, Devi and Rushikulya). Artificial lighting near nesting beaches to be regulated, specifically at Rushikulya Rookery.

Research management: Periodic monitoring to establish population trends of turtles in the Bay of Bengal and evaluation of migratory route through satellite telemetry and tagging method.

Public awareness measures: Though there are enough public awareness measures undertaken at Rushikulya, they appear to be insufficient at Devi Rookery, where there is lot of resentment among the local fishermen community. Public awareness and education programs should be developed to involve the local communities in sea turtle conservation programs.

Offshore patrolling: Offshore patrolling is necessary to check the fishing activity in and around the nesting and mating areas to minimize incidental capture.

Threat to turtles by dogs

A young volunteer releasing turtles on the beach of Orissa

Rescue and rehabilitation: There is still large scale mortality of turtles during the season, so a rescue and rehabilitation operation with skilled veterinarians is essential.

Conservation Measures

A. General Conservation Initiatives

In January 1997, the Northern Indian Ocean Sea Turtle Workshop was held in Bhubaneswar, Orissa, under the auspices of Marine Turtle Specialist Group of IUCN, CMS, NOAA, the Forest Department of the Government of Orissa and Utkal University. Representatives from nine Northern Indian Ocean countries and other international experts discussed the status of sea turtle conservation and management in the Northern Indian Ocean and drafted a Marine Turtle Conservation Strategy and Action Plan for the Northern Indian Ocean. As a follow up action, the Ministry of Environment and Forests, Government of India, has come forward to support the management of sea turtles and their habitats through a variety of centrally sponsored schemes such as development of National Parks and Sanctuaries, eco-development in and around Protected Areas and the GEF-assisted ecodevelopment to Parks and Sanctuaries.

Realizing the global concern for sea turtles and for the urgent need to take immediate action to conserve the marine turtles of this region, the Central Government launched 'Project Turtle' along the Orissa coast in particular and the Indian coast in general with funding support from UNDP/GEF. This project derives its legislative support from the Government of India's National Biodiversity Action Plan, the Wildlife Action Plan and also the Action Plan for Conservation of mangrove forests, coral reefs, and wetlands. The primary objective of the project is to conserve globally significant marine turtle populations through a participatory approach. The Marine Turtle Conservation Project aims to devise and facilitate the implementation of sustainable marine turtle conservation strategies through education, extension, and research and community participation. The main objectives of the project are to curtail the mass mortality of Olive Ridley sea turtles along the Indian coast in general and Orissa coast in particular, the identification and protection of critical sea turtle habitats, the use of Turtle Exclusion Devices, effective enforcement to regulate fishing and trawling, and simultaneous implementation of eco-development plans through participatory approach by local communities. Other objectives include survey and evaluation of nesting sites and nesting seasons, breeding and feeding areas, regulation of fishing by trawlers and gill netters, control of beach erosion, control the damage by predators, control poaching of eggs from nesting beaches as well as poaching of adults from offshore coastal waters.

B. Specific measures undertaken up by the State Government of Orissa for conservation of sea turtles

1. Awarding Protected Area status from Dhamra Muhan to Barunei, Gahirmatha on 22 April 1975.

2. Effectively protecting the Gahirmatha mass nesting beaches since 1975/76.

3. Including local people in data collection and conservation efforts since 1975/76.

4. Trade of adults through Passenger/Express trains was banned in 1975/76.

5. Trade of adults through goods trains was banned in 1977/78.

6. Trade of adults (as fishery products) was banned since in the 1980s.

7. Increased vigilance in the early 1980s stopped the illegal trade of adults through roadways. From 1977/78 to 1982/83 poaching of adults in the high seas was curbed through the involvement of the Navy, Coast Guard and other law enforcement agencies through 'Operation Geeturt'.

8. Public awareness campaign started via media services involving NGOs such as WWF.

9. 20 km offshore Gahirmatha coastal waters declared as a 'No Fishing Zone' in 1993.

10. 20 km offshore from Jatadhar Muhan to Devi river mouth, and Chilika river mouth to Rushikulya mouth declared as a 'No Fishing Zone' in 1996/97.

11. The Northern Indian Ocean Sea Turtle Workshop held at Bhubaneswar in 1997 that resulted in the 'Orissa Declaration' and drafting of the 'Marine Turtle Conservation and Action Plan for the Northern Indian Ocean'.

12. High Power Committees set up under the Chairmanship of Chief Minister, Orissa in 1996.

13. The Gahirmatha Marine (Wildlife) Sanctuary was declared in 1997.

14. Aerial Surveys, as well as onshore/offshore patrolling strengthened by Coast Guard during 1998/99 through 'Operation Olive'.
15. "Operation Kachhapa" was jointly initiated in 1998/99 by the Wildlife Wing of Orissa Forest Department, through the Wildlife Protection Society of India with the cooperation of local conservation groups.

16. Demonstrations of Turtle Exclusion Devices were carried out at Paradeep and Dhamra involving the Trawler Owners Associations, Fisheries Department and local conservation groups.

17. Awareness programmes were launched involving local people, especially the fishing Communities, and bringing together local conservation groups and all law enforcement agencies of the State and Central Governments.

Rapid Assessment and Veterinary Aid as an Immediate Response to the Tsunami

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Natural calamities can cause major damage to ecosystems, but the way they alter the vegetation may be beneficial for the ecosystems to regenerate. Sometimes, the nature of damage is such that it takes many years for the ecosystem to recover. Major natural calamities include: landslides (Walker *et al.*, 1996), earthquakes (Wells *et al.*, 2001), extraterrestrial objects like meteors/comets (Alvarez *et al*., 1980), fires (Saha & Howe, 2003), volcanic eruptions (Whittaker *et al.*, 1989; Whittaker *et al.*, 2000), hurricanes (Dittus, 1985) and tsunamis.

The total force released was enough to jolt the entire planet, and has been estimated as equivalent of almost 200 million tonnes of TNT.

The 26th of December 2004 was the day that changed Asia forever. Trillions of tonnes of water roared across the Indian Ocean, and the force with which it struck the surrounding coastlines is all too apparent. Seaside resorts and villages have been reduced to mud; entire beaches are gone. The disaster has left a blot on the landscapes of Indonesia, Thailand, India and Sri Lanka, both physically and in terms of the 150,000 lives that it has claimed so far.

The earthquake, measured at magnitude 9.0, actually consisted of three events within seconds of each other. The initial slip, which occurred to the west of Sumatra's northern tip, triggered two further slips to the north. The total force released was enough to jolt the entire planet, and has been estimated as equivalent of almost 200 million tonnes of TNT.

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The seafloor bulge unleashed a wave that surged throughout the Indian Ocean, hitting Indonesia and Thailand within an hour, Sri Lanka and India within four hours, and ultimately causing deaths as far away as East Africa. The swell would have been imperceptible in the open ocean, but as it entered shallower coastal waters it reared up to several metres in height, destroying seafront villages and resorts, and washing through farms up to five kilometres inland.

In the aftermath of the waves that devastated the coastlines around the Indian Ocean, claiming more than 70,000 lives, experts are piecing together the details of the seismic slip that sparked the fatal tsunami. The quake, the world's biggest for more than 40 years and the fourth largest since 1900, has literally redrawn the map, moving some islands by several metres.

While the human injuries and death toll from the Asian tsunami are still being counted, experts are beginning to take stock of the injuries suffered by the environment. Reaching and helping survivors clearly remains the top priority for aid agencies after the catastrophic waves of 26th December. But environmentalists say that rescuing the ravaged coral reefs and mangrove swamps will also be vital for rebuilding coastal communities.

Damage to the plants and animals in these ecosystems could have knock-on effects for the human communities that depend on them. Coral reefs and mangrove swamps are vital feeding and breeding grounds for fish, so their destruction could cut local fishing and food supplies over the longer term, and leave coastlines more exposed to erosion and storm damage. Swamped beaches may also have wiped out nesting sites for sea turtles. Researchers are also keen to assess whether mangrove swamps cleared prior to the tsunami, to make way for hotels or other coastal developments, may have flattened a natural wave barrier, leaving the coastline more vulnerable.

It is under these conditions that a rapid assessment was made to assess the damage caused to the wildlife habitats along the coastal regions of Tamil Nadu, in the aftermath of the tsunami that struck the Indian mainland on the 26th of December 2004. The areas assessed were the Gulf of Mannar Biosphere Reserve, Point Calimere Wildlife Sanctuary and the Pichavaram mangrove forests.

1. Gulf of Mannar Biosphere Reserve

Coral reefs are often referred to as the rainforests of the sea, with amazing beauty and incredible biodiversity. They are also the life support system for millions of coastal inhabitants who derive their livelihoods from them and benefit from the multiple services that reefs provide, such as shoreline protection, nutrient cycling, recreation, tourism and fisheries. Increased pressures on reefs brought about by demographic growth in the coastal zone, expanding tourism, changes in agricultural practices, destructive fishing and the influence of climate change, all contribute to threaten the coral reefs.

The coral reefs of India are widely scattered, from the Gulf of Kutch in the north-west, the Gulf of Mannar, Palk Bay, and the Lakshadweep Islands to the islands of Andaman and Nicobar. Patchy out-crops and deep-water formations can also be found along the western coast.

Stringent measures need to be undertaken with immediate effect to ban coral mining

The Gulf of Mannar Biosphere Reserve covers an area of 1,050,000 hectares (10,500 km^2) on the south-east coast of India across from Sri Lanka. It is one of the world's richest regions from a marine biodiversity perspective. The biosphere reserve comprises of 21 islands with estuaries, beaches, forests of the nearshore environment, including a marine component with algal communities, sea grasses, coral reefs, salt marshes and mangroves. Among the Gulf's 3,600 plant and animal species are the globally endangered sea cow (*Dugong dugong*) and six mangrove species endemic to peninsular India.

Sea grass beds are dominated by Hydrocharitaceae and Potamogetonaceae, *Halodule uninervis*, *Cymodocea rotunda*, and *C. serrulata*. Mangroves include *Rhizophora conjugata*, *Avicennia alba*, *Bruguiera gymnorrhiza*, *Ceriops tagal* and *Lumnitzera racemosa*.

In the Gulf of Mannar and the Palk Bay, coral and sand extraction are persistent problems. Some coral reefs off Tuticorin in the Gulf of Mannar are reported to have disappeared completely due to coral mining. The recent event of coral bleaching has adversely affected the shallow reefs in the Gulf of Mannar, Lakshadweep and Andaman Islands. In the Gulf of Mannar, 85% of the corals were bleached during May-June 1998. A subsequent survey revealed that mortality was 72.6%.

About 117 hard coral species have been recorded in the Gulf of Mannar (hhtp://oceanatlas.org). Sea turtles are frequent visitors to the gulf as are sharks, dugongs, and dolphins. However, the combined effects of 47 villages, with a total population of around 50,000 has meant that over-harvesting of marine species has become a problem. Near shore and off-shore fish catches have declined, as have pearl oyster, gorgonian and acorn worm populations.

Assessment :

The Gulf of Mannar Biosphere Reserve was not affected by the tsunami. The flora and fauna were intact and the coral reefs were also saved. The survey was done on the 6th of January 2005.

Though the tsunami hit coastal regions with destructive power, it has not caused damage to coral reefs, as many environmentalists feared, in areas between Tuticorin and Rameswaram. This was revealed in an assessment over the last few days by Suganthi Devadason Marine Research Institute (SDMRI), affiliated to Manonmaniam Sundaranar University, in collaboration with Tuticorin Port Trust, in the Gulf of Mannar.

A five-member team of SCUBA (self contained breathing apparatus) equipped divers, led by J.K. Patterson Edward, director, SDMRI, conducted the assessment at 11 sites chosen randomly.

Talking to The Hindu, Dr. Edward said, "Our team found that the tsunami has not had any major impact on reef areas, as there was no significant damage to sea grass beds engulfing the reefs. Water near the coral reef collections was clear without any turbidity."

Dr. Edward said due to strong waves some branching corals, such as *Acropora cytherea* were tilted a bit and a few branches of *Acropora Intermedia* were broken. He, however, added, "it is not alarming considering that such a damage is transitional and has occurred to just one or two per cent of the total live branching coral cover in the area."

The members noticed that reef fish such as snapper, jacks, emperor breams, rabbit fish, groupers, parrot fish, spiny lobsters, cuttlefish, eels and soldier fish were found in abundance in areas where the survey was conducted.

(Source: THE HINDU dated 7th January 2005.
Available at: http://www.hindu.com/2005/01/07/stories/2005010710150100.htm)

Recommendations :

- It is necessary to create awareness among the coastal communities in the study area, in order to protect and conserve the coral reefs through effective involvement of educational institutions and NGOs.
- Stringent measures need to be undertaken with immediate effect to ban coral mining and to take to task those involved in or those who encourage the exploitation of corals for any purpose. Patrolling the coast to check coral mining should be carried out.
- Law should be enacted to regulate and stop trawl boat operation in the zone earmarked for non-mechanized boat. The Department of Forest and the Department of Fisheries should take steps to stop anchoring of vessels on coral reefs, pair trawling and dynamite fishing.
- Indiscriminate picking of budding seaweeds needs to be banned.
- Commercial shell collection should be controlled and closely monitored.
- Marine Resources Management Centres should be established to improve the skills of fishermen communities in areas other than coral mining, which in turn will lead to efficient management of coral reefs.
- Initiatives to train the coastal fishermen in mechanized boat operation, shell collection, seaweed collection and conservation of coral reefs need to be taken up so that they could find alternate sources of livelihood.
- Deforestation along the coast and islands of Gulf of Mannar should be banned. The Forest Department should take up afforestation along the coast and islands of Gulf of Mannar to protect soil erosion.
- Discharging of untreated sewage and urban wastes into the coastal waters should be totally banned.
- Dumping of any kind of material that would affect the coral reef ecosystem should be banned.

2. Point Calimere Wildlife Sanctuary

The Point Calimere Wildlife Sanctuary, Nagapattinam District extends from Point Calimere (Kodiyakarai) in the north to Adirampattinam in the south to a distance of 60 km. It forms one of the major refuges for migratory as well resident water birds in the Indian Peninsula. This sanctuary comprises of tidal swamps, dry evergreen and mangrove forests.

The area with a stretch of 37,000 ha comprises mangrove forests and lagoons in the Muthupet-Adirampattinam area and mudflats interspersed with numerous islets in the Seruthalaikadu-Kodiyakarai area. Of the total area, 10% is dry evergreen forests, 20% is lagoon and the rest of the areas are open mudflats that include various islets. The elevation of the islets range from one to four m. The entire swamp is screened off from the Palk Strait, which forms the southern boundary, by a long sandbar breached at various places for water flow.
It is bestowed with population of varied wildlife such as chital (*Axis axis*), wild boar (*Sus scrofa*), bonnet macaque (*Macaca radiata*), blackbuck (*Antilope cervicapra*), jackal (*Canis aureus*), flamingos (*Phoenicopterus sp.*) and several other species of birds. Special attractions are close encounters with dolphins and turtles which often come quite close to the shore.

The effect of brackish water on the micro-organisms and its effect on water birds has to be studied

Assessment:
All the deer and blackbuck are apparently safe. An hour before the tsunami-hit, the ungulates were seen running towards the hinterland. On the contrary, the birds were found to be in panic two hours before the tsunami. The fresh water areas were inundated by sea water and hence, they have become brackish. The fate of the birds that are dependent on fresh-water organisms is presently questionable. The fate of the organisms that are stenohaline is yet to be assessed. The sanctuary is marshy and slushy. The animals are facing a critical situation for their drinking needs. The other problem ungulates face is the sand deposition on their traditional grasslands. The tropical dry evergreen forests, that are unique to the Coromandel coast, seem to be safe and secure.

About 1700 blackbuck survived the Asian tsunami because they sensed it before it struck an Indian wildlife sanctuary, officials said on Sunday. "On the morning of December 26, our lighthouse watchman saw the blackbucks running away from the seashore. He found it unusual. About five minutes later the first wave hit the coast," said forest officer Akash Deep Baruah.

The waves killed at least 10 people in an adjoining village - but no animal deaths were reported in the sanctuary, which also has deer, wild boar, civet cats, jackals and more than 100 bird species.
"We did a thorough search in the area. We didn't find a single carcass of any animal or bird," Baruah said.

The December 26 tsunami killed 10714 people in India and at least 168000 across a dozen countries along the Indian ocean. Tens of thousands of livestock also perished. However, there have been several reports of wild animals heading to higher ground shortly before the giant waves struck.

Baruah said the behaviour of the animals in the 30 square kilometre reserve has changed. The blackbucks now stay away from the shore in herds of hundreds, instead of splitting into smaller groups as usual, Baruah said.

The sanctuary's bird watcher, A Kripananda, said some migratory birds have flown away, but he believes they're searching for food and may return soon. The reserve is at a wetland called Point Calimere, about 380 km south of Madras, capital of the southern state of Tamil Nadu.

Source: http://www.news24.com/News24/World/Tsunami_Disaster/0,,2-10-1777_1647638,00.html

Recommendations:

- Considering the fact that this area is a wildlife sanctuary and thus adequate protection already exists, there is no need for specific recommendations/interventions.
- The effect of the tsunami on the grazing patterns of ungulates needs to be monitored and adequate fodder provisioned if necessary. The grazing areas have been covered with sand.
- The effect of brackish water on the micro-organisms and its effect on water birds has to be studied.
- The breeding behaviour and success of these water birds should be monitored this year, with special emphasis on nest and chick mortality.
- Phenology of the dry evergreen forests and the grasslands to be studied, at least, for a period of two years and compared with the existing data.
- Census of the water birds, and ungulates to be done and compared with the previous years' data.
- The availability of fish, benthic fauna and plankton to be studied urgently.

3. Pichavaram Mangrove Forests

Mangroves occur in the waterlogged, salty soils of sheltered tropical and subtropical shores. They are subject to the twice-daily ebb and flow of tides, fortnightly spring and neap tides, and seasonal weather fluctuations. They stretch from the intertidal zone up to the high-tide mark. These forests have salt tolerant trees of twelve genera comprising about 60 species. With their distinctive nest of stilt and prop-like roots, mangroves can thrive in areas of soft, waterlogged, and oxygen-poor soil by using aerial and even horizontal roots to gain a foothold. The roots also absorb oxygen from the air, while the tree's leaves can excrete excess salt. Associated with the tree species are a whole host of aquatic and salt-tolerant plants. Together they provide important nursery habitats for a vast array of aquatic animal species.

Mangrove ecosystems are most diverse in South Asian seas and least diverse in the Caribbean. Mangrove forests on the western coast of Madagascar support a number of endemic bird species that are endangered. In some tropical countries, such as India, the Philippines and Vietnam, over 50 per cent of mangrove ecosystems have been lost in this century.

The Pichavaram mangrove forest protected six hamlets from the fury of the tsunami

According to a status report of the Government of India publication, the total area of the mangroves in India, was reckoned at about 6740 km^2. This covered about 7% of the world mangroves and 8% of the Indian coastline. But recent Indian remote sensing data showed that the total area of the mangroves has decreased to 4474 km^2.

Recent data available with the Forest Survey of India, Dehra Dun shows an extent of 4827 km^2 mangrove areas in India. Out of the total area, 57% of the mangroves are found on the East Coast, 23% on the west coast and the remaining 20% on the Bay Islands (Andaman and Nicobar).

Mangroves in Tamil Nadu exist on the Cauvery deltaic areas. Pichavaram has a well-developed mangrove forest dominant with *Rhizophora spp*., *Avicennia marina*, *Excoecaria agallocha*, *Bruguiera cylindrica*, *Lumnitzera racemosa*, *Ceriops decandra* and *Aegiceras corniculatum* as the dominant flora. Mangroves also occur near places like Vedaranyam, Kodiakarai (Point Calimere), Muthupet, Chatram and Tuticorin.

Pichavaram mangrove forest is located about 200 km south of Chennai (Madras) city on the southeast coast of India. This mangrove is actually sandwiched between two prominent estuaries, the Vellar estuary in the north and Coleroon estuary in the south. The Vellar - Coleroon estuarine complex forms the Killai backwater and Pichavaram mangroves.

Pichavaram mangrove is present in the higher land of Vellar-Coleroon estuarine complex. The mangrove extends to an area of 1100 ha. representing a heterogeneous mixture of mangrove.

The whole of the mangrove comprises about 51 small and large islands, with their sizes ranging from 10 m^2 to 2 km^2. The mangrove soil usually consists of alluvium derived from the mangrove plants. About 40% of the total area is covered by waterways, 50% by forest and the rest by mud flats, sandy and salty soils. There are numerous creeks, gullies and canals traversing the mangroves with a depth ranging from 0.5 to 1.5 m and discharging freshwater into the system. A major irrigation channel discharges mainly agricultural waste water from the entire upper reaches to this mangrove.

Pichavaram mangrove is one of the rare mangrove forests in India and it represents 14 exclusive mangrove species. *Avicennia marina* alone constitutes nearly 30% of the total population followed by *Bruguiera cylindrica* (17%) and *Avicennia officianalis* (16%). The population density of other species is poor and many of the species are on the verge of total extinction (Kannupandi and Kanan 1998).

Mangroves require relatively intact hydrographic and salinity regimes. Without these conditions remaining intact, the persistence or restoration of mangroves is difficult or impossible. Alterations of hydrography and substrate have considerable impact, but restoration potential is high; mangroves are susceptible to pollution, particulary oil and other petroleum compounds; alteration of salinity levels can have dramatic impacts on mangroves.

Assessment:

The damage caused to the Pichavaram Mangrove Forest in terms of vegetation is around 5-10%. Dead and decaying *Avicennia sp.* were seen towards the area open to the sea. The dead animals that were observed were a cow and a sea snake. The forest officials have observed a carcass of a small cat that had apparently died due to the tsunami. The locals have seen a lot of jackals being swept away during the tsunami, but we did not come across any carcass. The tsunami has reduced the depth of the estuary; hence navigation has become a problem. This could alter the present distribution of the *Avicennia* spp. for good.

Recommendations:

- Joint Mangrove Management should be done along with Joint Forest Management.
- The Forest and Fisheries departments should jointly frame guidelines for sustainable harvest of fishery resources.
- Sewage from nearby villages should not be let into the Pichavaram Mangrove forests.
- Fishing in and around the mangrove forests should be monitored and regulated.

The investigation team also joined with a Thanjavur based NGO, League for Education and Development (LEAD), who were vaccinating livestock and companion animals in the coastal villages of Cuddalore district affected by the tsunami. Dr. Sanjib Deka and Kadambari Mainkar of WTI assisted the LEAD team in their vaccination operations in the following areas:

January 9, Chinnur South: The LEAD team with the assistance of the team from WTI vaccinated 29 cattle against Foot and Mouth Disease (FMD) and dewormed 34 goats and one goat was treated for enteritis. One suspected case of anthrax was encountered, where the cow was lying in prostration with unclotted blood present in all natural orifices. The owner was first requested for permission to euthanise the animal to which he declined. Then he was instructed to incinerate the animal once it died in the presence of the local veterinary staff, to whom this case reported.

The WTI team assisted the LEAD team in vaccination and treatment of livestock and companion animals

Jan 10, Samiyarpettai: The WTI team assisted LEAD in vaccinating 53 cows and 73 goats against FMD, and deworm 110 goats. Two cows were treated for enteritis.

Jan 10, Ramanathakuppam: The WTI team assisted LEAD in vaccinating 56 cows and 42 goats and deworming 36 goats. One cow was treated for wounds.

Jan 11, Ariyacosti: The WTI team assisted LEAD in vaccinating 174 cows, 3 calves, 101 goats against FMD and 4 dogs against rabies. 228 goats were dewormed, 5 cows were treated enteritis, anorexia and two goats for enteritis and wounds.

5. Nagapattinam

WTI Programme Officer visited Nagapattinam, which is the worst hit area by tsunami. Nagapatinam and the surrounding areas of Vellankani, Kallar, and Akraipatti have been completely devastated as these areas had most of the settlements on the beach itself. The fishermen have lost their homes their families, their boats and of course, their livestock and pets. However due to fear of being struck by more tsunamis, most survivors had not returned to their devastated homes on the beach and were still at the mainland relief camps. As a result, many pets, such as dogs, cats, cows and goats were homeless and lost. Most of these animals were initially on the beach where their owners used to live, in the hope that the owners would come back; however, the animals had by then started moving inland. The animals encountered were not found be emaciated as they were feeding on the rotting garbage and debris everywhere.

Domestic animal welfare organisations, such as Friendicoes, Wildlife S.O.S and the Blue Cross have been active in the area since 30th December. They were concentrating on feeding the cattle and the dogs and providing treatment and shelter to ill or wounded animals. The LEAD team had not visited Nagapatinam while the WTI team was in Tamil Nadu.

The human relief efforts at Nagapattinam and other devastated coastal areas were then ongoing at a massive scale as the damage to human life and property was unimaginable. Whatever one saw in the news or read in the newspapers was not a patch on the real situation. Nagapattinam and Vallankani had turned into ghost villages where the homeless sat on the beach where their thatch settlements used to exist and talk to the dead! The team found it extremely difficult as well as inappropriate to approach affected people and question them about lost animals. There were times when little children would come to the team and ask to be adopted since they had no parents. One was at a loss for words and actions while encountering such situations.

Suggestions and recommendations:

Upon visiting all the tsunami affected areas, a general observation was that the WTI and TRI team had arrived too late for damage assessment. Relief efforts, both human and animal were already in full swing and had reached their second and third phases. The team was therefore unable to contribute much, as most of the affected animals which were primarily domestic stock had already been addressed in terms of treatment, vaccinations and provision of shelter. In the future if any effective disaster relief is to be provided to wildlife or domestic animals a team must be on the spot as soon as possible. This effort should also be part and parcel of human relief efforts in order to make the task of helping animals easier as in such disasters, relief to human beings is the top priority and help to animals has to be hand in glove with that.

Also the human relief efforts were mostly very well coordinated, with team leaders of the various NGOs meeting each evening and addressing and chalking out amongst different teams areas and needs addressed and those which still needed to be addressed. Therefore, there was better time management and utilization of resources. However, none of the animal welfare organisations working in the affected areas were registered or coordinated at any level. Almost all the NGOs were out on their own and definitely there was a wastage of time and duplication of resources, which could have been avoided if the efforts were coordinated and information shared!

A tragic episode was the extermination of some 270 odd stray dogs in Nagapattinam, as they were found to be apparently digging up and feeding on the carcasses of dead human beings. It was reported that these stray dogs had become "man-eaters" and turned "wild". This highlights the as ignorance and negligence of the local administration about hygiene, burying the dead and animal welfare laws. Inspite of the numerous local animal welfare NGOs functioning in the area, this episode occurred, which was appalling.

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CONSERVATION ACTION SERIES

Reports on the damage suffered by wildlife and their habitats due to the tsunami of 26 December, 2004 were at best speculative with very little first-hand information. The Wildlife Trust of India and the International Fund for Animal Welfare, along with its collaborators, conducted rapid assessment surveys of the impacted areas in India. The six studies covered the coastal areas of Andhra Pradesh, Tamil Nadu, Kerala and the Andaman and Nicobar Islands. Each volume of this Conservation Action Report documents several recommendations useful for ecological restoration and re-construction activities of the mainland and the islands respectively.

Wildlife Trust of India