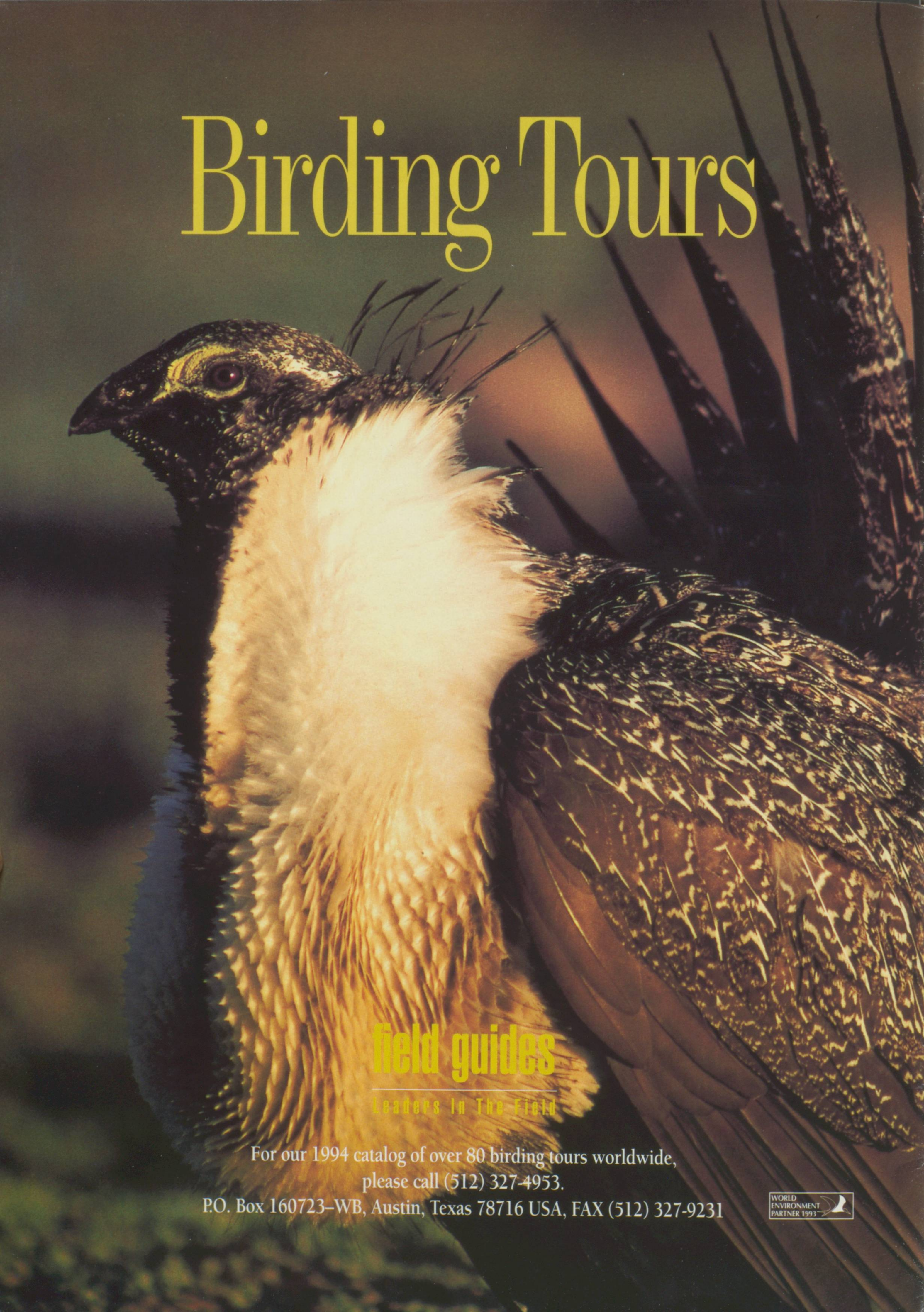
# World Birdwatch

VOLUME 15 NUMBER 4 DECEMBER 1993

## The Calling of Cranes
## Secrets of Sumba

BirdLife INTERNATIONAL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## From the Director-General

E. Imboden/BirdLife

# The vagueness of conservation

What do conservationists mean when they talk about 'nature being destroyed by man', 'habitat destruction' and 'loss of biodiversity'? I am increasingly concerned about such vague expressions when advocating conservation. They address real and serious problems, but contain an emotional and subjective overtone that is not helpful when arguing the case for conservation with decision-makers in politics and business.

I am even more disturbed by the conservation community's loose and imprecise terminology when it comes to formulating its own ultimate aims. What do we actually want to achieve? Reflecting on the recent European conservation conference in Maastricht, sponsored by the Dutch and Hungarian governments, I am convinced that there are widely differing opinions among conservation experts as to our exact conservation goals in Europe. The lack of an agreed and clearly formulated vision, with measurable targets, on the type of 'natural heritage' we would like to maintain is concealed by relatively vague descriptions and concepts accepted by everyone because they offer so much room for individual interpretation.

Take the example of 'sustainable use' – or 'sustainable forestry', 'sustainable farming policies' – which have become the conservationists' favourite expressions. How do we measure sustainability and in relation to what? The biosphere, the living world, has been around for several billion years, and life is unlikely to disappear as a result of any wounds mankind could ever inflict on mother Earth. One can think of many parameters of sustainability (even increasing consumption, to go by those economists who still use the term 'sustainable growth'), but, surely, what conservationists need to advocate is to measure sustainability in relation to biological diversity.

This leads to another question: what level of biodiversity? Should we preserve the present status? Or should we re-create the status of twenty or fifty years ago? We continue to avoid coming clear about this. Two more factors then need to be defined before we can formulate clear conservation goals. Firstly, over what time span should something be sustainable? An action can be sustainable in the short-term, but not the long-term. Secondly, over what geographic area should we measure sustainability? Something can be unsustainable locally, but could well be sustainable regionally or globally.

As long as we cannot reach full understanding and agreement on such fundamental questions we will go on with our imprecise formulation of conservation objectives, playing into the hands of those advocating economic development. They always seem a step ahead of us and present their goals in much clearer terms than the conservation community. They keep us largely preoccupied with reacting to them. Instead, we should be setting the agenda by putting forward a clear and unambiguous vision of the world we would like to pass to our children.

Christoph Imboden

*Christoph Imboden Director-General*

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Cover photo: Red-crowned Cranes by Orion Service and Trading Co. Inc./Bruce Coleman Ltd

## From the Editor

*The importance of islands for conservation is widely acknowledged - not only do they hold large numbers of unique species but they are also particularly vulnerable to the effects of humans, particularly the foreign animals that so often accompany them.*

*The two articles in this issue of World Birdwatch that focus on island conservation show many similarities, but also illustrate an interesting contrast. Both the Seychelles and Sumba are important for the amazing number of endemic birds and other organisms that they hold. However, the Seychelles have been the subject of international attention for many years, and conservation there is fairly well-established. In Sumba, conservation as we know it is in its infancy, although the potential for real achievement is huge.*

*Perhaps the most important similarity between the two areas is that in both, the will of the people to conserve their natural heritage is enormous. This is a spirit that emerges again and again in the areas with the most pressing conservation problems, and surely gives the greatest hope for the future.*

Georgina Green

*Georgina Green* *Editor*

# Fabulous forty

D. Hosking/FLPA

A world population of 40 may not sound like much to celebrate, but in the case of the Seychelles Magpie-robin it is a major achievement, representing an increase of 82% since BirdLife International launched the recovery programme for the species in July 1990.

The Seychelles Magpie-robin survives only on Fregate Island, having disappeared from the rest of its former range, largely because of introduced cats and rats. Fregate has always been free of rats, and all cats were removed in a BirdLife-sponsored programme in 1981.

On Fregate, the birds declined because of the decrease in suitable habitat – originally natural woodland, and then, in the 1980s, the plantations to which the species had become at least partially adapted. The exact all-time low is not clear, but the population may have dropped below 15 birds in 1965.

The BirdLife International Recovery Programme, funded by RSPB, has involved habitat improvement by scrub clearance and the planting of native trees, and supplementary feeding and provision of nest sites to maintain and increase the population in the short-term.

Neil McCulloch, the Recovery Programme Coordinator, said 'This excellent increase in numbers on Fregate allows us to consider reintroduction to another island that is free of introduced predators. Species occurring only in single, small populations are always vulnerable, and the re-establishment of the species on a second island is an important step towards securing the long-term future of the Seychelles Magpie-robin'.

J. Sultana/BirdLife

*Hunters' debris.*

# Malta moves – but not far enough

New laws governing bird hunting in Malta were announced on 29 October. Under the new laws, which come into force on 1 January 1994, hunting and trapping is only permitted between 1 September and 31 January i.e. spring hunting is no longer allowed. However, a special license may be granted for the hunting of European Turtle-dove and Common Quail between 10 April and 20 May. Hunting at sea may only take place between 1 November and 31 December, at least 3 km from the shore and from registered craft launched from specific sites. The list of species that may be hunted and trapped has also been reduced, with herons, egrets, nightjars, curlews, moorhens and Rufous-tailed Rock-thrush now protected.

The new laws have been welcomed by the Malta Ornithological Society (MOS), the BirdLife partner in Malta, who have been campaigning for the introduction of new legislation. They are disappointed, however, that they do not go further. Paul Portelli, Director of MOS, said 'These laws are a step in the right direction, but they are still not tough enough. If Malta wishes to enter the EC, better bird protection legislation in line with EC standards will have to be introduced'.

The new regulations have met with fierce opposition from the hunters, who have staged several angry protest demonstrations, and the Maltese Association for Hunting and Conservation has called on its members to boycott local council elections. Two Environment Department officials, one of them MOS Council Member Joe Sultana, have had overnight police protection for several months after receiving threats to their safety.


# Nene needs new approach

Management efforts for the wild population of the Nene need revision and expansion, otherwise two of the three flocks could go extinct within 100 years. This is the conclusion of a recent computer simulation of the Hawaiian and Maui flocks, which currently number 340 and 180 birds, respectively.

The Nene, reduced to just 30 birds in 1952, has been the subject of a captive breeding and release programme since the early 1960s, and a five year research programme set up by The Wildfowl & Wetlands Trust. Although the computer predictions are gloomy, researchers are optimistic that a new management plan for the birds currently being developed by the US Fish and Wildlife Service will improve prospects for the species.

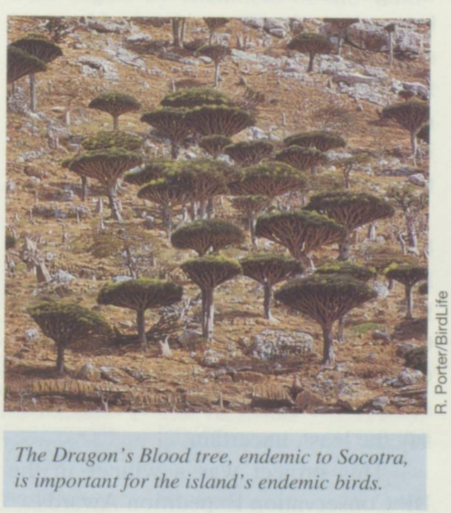
On a more positive note, numbers of the third flock on Kauai island, established in 1982 when 12 birds escaped from captivity, have topped 100 this year, and the birds are clearly doing well.

# Socotra island specials

Endemic birds – Socotra Sunbird, Socotra Cisticola, Socotra Starling and Socotra Bunting – were high on the agenda when the little studied island of Socotra was visited this spring by members of the Ornithological Society of the Middle East. The endemics were found to be in good numbers, except for the bunting – only two were found.

The two month survey, which also covered large areas of southern Yemen, was supported by BirdLife International and Yemen's Environmental Protection Council. On the mainland, time was spent studying the 13 species endemic to the region. Of these, the Yemen Thrush and the Arabian Accentor were the cause for most concern.

Seventy seven sites were surveyed in detail and over 20 new sites were identified for inclusion in the forthcoming *Important Bird Areas of the Middle East*, to be published by BirdLife International in 1994.




*The Dragon's Blood tree, endemic to Socotra, is important for the island's endemic birds.*

# In Brief

**A survey of the Caucasian Grouse** in the Kackar mountains in Turkey has revealed that it is more common than previously thought – 134 males were counted at six sites. The survey was a runner-up in the BP Conservation Expedition Awards.

**It has emerged that the records of Vaurie's Nightjar** reported in *World Birdwatch 15,2,* were in fact European Nightjar. Vaurie's Nightjar therefore remains known from just one specimen collected in 1929.

**A Takahe egg** incubated by a Purple Swamphen has successfully hatched. The Takahe is one of New Zealand's most critically threatened birds, and scientists at Otago University are attempting to persuade female Purple Swamphen, a closely related but commoner species, to foster Takahe young.

**Burdur Gölü in Turkey,** wintering site for up to 70% of the world's White-headed Ducks, has been declared a Waterfowl Protection Area. The designation follows the release of results of research on the White-headed Duck conducted by DHKD, The Wildfowl & Wetlands Trust and the Burdur Municipality.

**The Greater Flamingo** has bred for the first time ever in Italy this year, with over 800 pairs nesting at Stagno di Molentargius, Sardinia.

**Khor Dubai,** the most important coastal wetland for birds in the United Arab Emirates, including 20% of the western population of the Broad-billed Sandpiper, is threatened by artificial afforestation of the natural mudflats with mangroves. BirdLife International has written to Sheikh Mohammed Al Maktoum, Emir of Dubai, in protest.

A. Compost/Bruce Coleman Ltd

# Prawns too profitable for Mekong Delta

The Mekong Delta in Vietnam, once the world's largest mangrove forest, is being rapidly destroyed by shrimp-pond development, report staff from the WWF Development of a Protected Area System project.

The mangroves were seriously damaged during the Vietnam War, but natural regeneration and the replanting efforts of the Vietnamese government had resulted in some recovery. Now, large areas are being cleared by people eager to profit from the boom in the tiger prawn industry. Demand for land in the delta is so great that new settlers are building homes up to 5 km into what is now sea, to stake their claim to currently submerged but rapidly accreting land.

For the abundant birdlife of the area, the shrimp farms spell disaster. The increased human occupation of the delta is affecting wildlife in other ways too: WWF staff recently caught nest robbers with 30 Little Egret and Javan Pond-heron nestlings, undoubtedly destined for the pot.

*Javan Pond-heron occurs in the Mekong Delta.*

# European eco-blanket

The value of BirdLife International's approach to and data for European conservation received wide acclaim from government and NGO officials from throughout the continent at a recent conference.

The conference, *Conserving Europe's Natural Heritage: Towards an Ecological Network (EECONET),* hosted by the Dutch and Hungarian Governments, was to discuss a proposed ecological network of protected areas, habitat corridors and buffer zones designated on agreed criteria, known as EECONET.

As one of the key speakers on the opening day, Dr Christoph Imboden, BirdLife's Director-General, pointed out that despite high conservation awareness in Europe, the degradation of biological diversity continues unabated. Conservationists are still addressing the symptoms at technical levels, not the causes at policy level. Dr Imboden suggested that rather than creating a 'net' with lots of holes, we should opt for an 'eco-blanket' approach.

Dr Graham Tucker of BirdLife presented results of the organisation's work on the status of all European birds, and the conclusions on required policy changes. It was recognised that BirdLife had a unique set of European-wide data from which to develop coherent policy recommendations, and is a major conservation force in Europe.

# Merganser in serious trouble

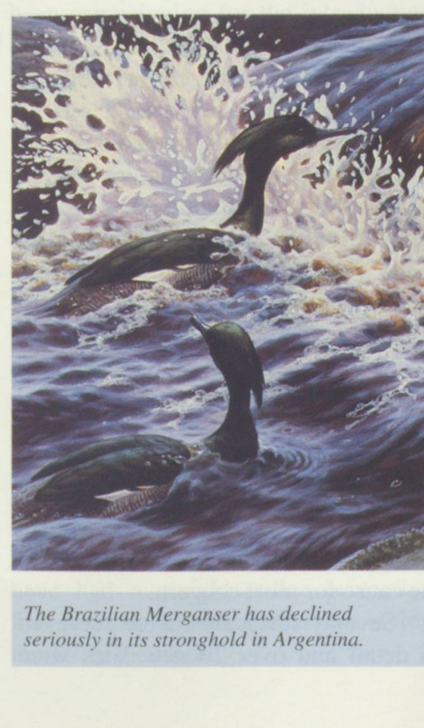
Concern is mounting over the Brazilian Merganser, after a search for the species in northern Argentina recorded just a single bird.

The Brazilian Merganser only ever occurred in south-central Brazil and the neighbouring regions of Paraguay and Argentina, but it has declined dramatically in recent times, and may have disappeared completely from Paraguay. Prior to this recent survey, it was estimated that 250 birds remained in three small and isolated populations, one in Argentina and two in Brazil.

Despite extensive searching in Misiones Province by a British/South American team, only one bird was seen, at the edge of the area believed to be the species' stronghold in Argentina. It is thought that the core of this region has been adversely affected by the Urugua-í dam, which was completed in 1989 and flooded around 80 km of the Urugua-í river. Other threats include an increase in river turbidity following deforestation, hunting and human disturbance.

Whilst the populations in Brazil are both at least partially within National Parks, (the Serra da Canastra National Park, Minas Gerais State, and the Chapada dos Veadeiros National Park, Goiás State), they are by no means secure. The future of this species is, to say the least, uncertain.

This project was a winner in the BP Conservation Expedition Awards.



Painting: C. Rose

*The Brazilian Merganser has declined seriously in its stronghold in Argentina.*

T. Andrewartha/Survival Anglia

## Yet another threat to Europe's steppes

Plans for an international airport at Kiskunlacháza in Hungary are threatening the northern part of Kiskunság National Park, the second largest puszta (steppe) in Hungary and home to 250 Great Bustards.

The proposed airport would handle 48,000 flights, 10.5 million passengers and 120,000 tonnes of cargo annually by the year 2005. Expansion at Hungary's only current international airport at Ferihegy is limited because of its proximity to Budapest.

In addition to the Great Bustards, the area is important for Montagu's Harrier, Red-footed Falcon, Stone Curlew and many others. As well as direct destruction of the habitat (over 1 million $m^2$ would be paved), the demand for water and the waste produced, the increase in road traffic and the noise levels are causing environmentalists great concern.

The Hungarian Ornithological Society (the BirdLife partner in Hungary) are campaigning against the development, supported by other BirdLife partners. *If you would like to object to the proposed airport, write to Minister Gyîrgy Schamschula, Minister of Transport, Telecommunications and Water Management, H-1077 Budapest, Dob u. 75/81, Hungary.*

*Kiskunság National Park is important for the declining Stone Curlew.*

## Flores forest proves its worth

Fieldwork in the island of Flores, Indonesia this summer has resulted in observations of two endemic species both known only from two or three records each.

Flores Monarch was only described in 1977, but had not been seen since. Wallace's Hanging-parrot was known solely from a specimen collected in the nineteenth century and two subsequent records. Both species were found by members of the Cambridge Flores/Sumbawa Conservation Project (one of the winners of the BP Conservation Expedition Awards) in moist forest at Selah Legium in the west of the island. A third endemic species, Flores Crow, was also seen there.

The forest at Selah Legium has been proposed as a protected area and this work highlights the need for its rapid gazettement.

**Species in World Round-up**

| | |
|---|---|
| Seychelles Magpie-robin | *Copsychus sechellarum* |
| European Turtle-dove | *Strepropelia turtur* |
| Common Quail | *Coturnix coturnix* |
| Rufous-tailed Rock-thrush | *Monticola rufocinereus* |
| Nene | *Branta sandvicensis* |
| Socotra Sunbird | *Nectarinia balfouri* |
| Socotra Cisticola | *Cisticola incanus* |
| Socotra Starling | *Onychognathus frater* |
| Socotra Bunting | *Emberiza socotrana* |
| Yemen Thrush | *Turdus menachensis* |
| Yemen Accentor | *Prunella fagani* |
| Caucasian Grouse | *Tetrao mlokosiewiczi* |
| Vaurie's Nightjar | *Caprimulgus centralasicus* |
| Eurasian Nightjar | *Caprimulgus europaeus* |
| Takahe | *Porphyrio mantelli* |
| Purple Swamphen | *Porphyrio porphyrio* |
| White-headed Duck | *Oxyura leucocephala* |
| Greater Flamingo | *Phoenicopterus ruber* |
| Broad-billed Sandpiper | *Limicola falcinellus* |
| Little Egret | *Egretta garzetta* |
| Javan Pond-heron | *Ardeola speciosa* |
| Brazilian Merganser | *Mergus octosetaceus* |
| Neotropic Cormorant | *Phalacrocorax brasilianus* |
| Great Bustard | *Otis tarda* |
| Montagu's Harrier | *Circus pygargus* |
| Red-footed Falcon | *Falco vespertinus* |
| Stone Curlew | *Burhinus oedicnemus* |
| Flores Monarch | *Monarcha sacerdotum* |
| Wallace's Hanging-parrot | *Loriculus flosculus* |
| Flores Crow | *Corvus florensis* |
| Ultramarine Lorikeet | *Vini ultramarina* |
| Chaffinch | *Fringilla coelebs* |
| Brambling | *Fringilla montifringilla* |
| Satanic Eared-nightjar | *Eurostopodus diabolicus* |
| Lesser Kestrel | *Falco naumanni* |

# In Brief

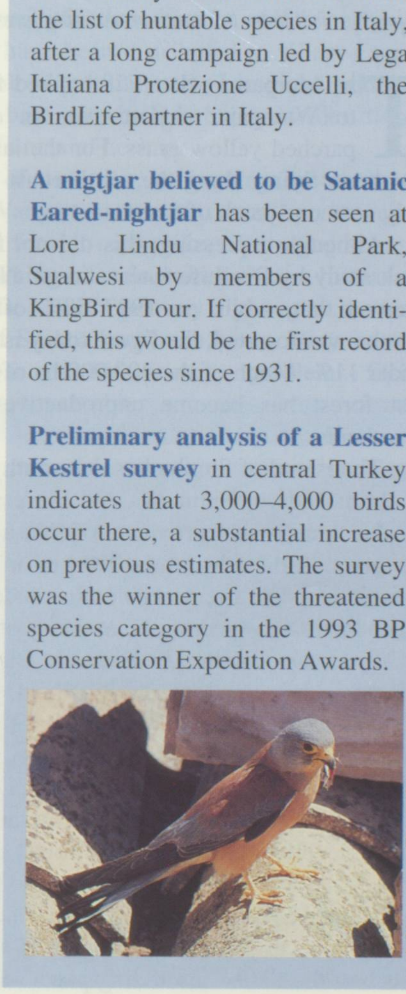
**Seven Ultramarine Lorikeets** have been translocated from Ua Huka in the Marquesan Islands, where they are threatened by human activities, to the neighbouring island of Fatu Hiva. This move, carried out by the Delegation of the Environment for French Polynesia and the Zoological Society of San Diego, follows the transfer of seven birds in August 1992, which appears to have been successful.

**The Polish Wetlands Project** received a boost in December with the presentation of cheques for £40,000 and £30,000 from the British Birdwatching Fair and the in focus County Bird Race, respectively. Next year, both events will raise money for Project Halmahera.

**The Chaffinch and Brambling** have finally been removed from the list of huntable species in Italy, after a long campaign led by Lega Italiana Protezione Uccelli, the BirdLife partner in Italy.

**A nigtjar believed to be Satanic Eared-nightjar** has been seen at Lore Lindu National Park, Sualwesi by members of a KingBird Tour. If correctly identified, this would be the first record of the species since 1931.

**Preliminary analysis of a Lesser Kestrel survey** in central Turkey indicates that 3,000–4,000 birds occur there, a substantial increase on previous estimates. The survey was the winner of the threatened species category in the 1993 BP Conservation Expedition Awards.



A. Manzanares/Bruce Coleman Ltd

BirdLife

# Secrets of Sumba

***The island of Sumba in Indonesia is a true biodiversity hot-spot. Sadly, it has suffered very severe deforestation, making it also a true conservation priority. BirdLife International and the Indonesian Directorate General of Forest Protection and Nature Conservation (PHPA) are embarking on a joint project to try to save the remaining forest and its birds. Paul Jepson describes some of the issues and problems the project will have to tackle.***

The Merpati Focker F28 banked for its final approach to Waingapu airport over an extensive plateau of parched yellow grass. For the last fifteen minutes we had been flying along the north coast of Sumba and I had only seen one patch of forest.

Although depressing, this did not really surprise me. A desk study by BirdLife International's Indonesia Programme showed that, whilst in 1927 50% of Sumba was forested, the figure today is under 11%. Much of the 400,000 ha of lost forest has become unproductive grasslands.


The island of Sumba lies due south of the islands of Sumbawa and Flores in the Indonesian province of Nusa Tengarra. Although just 11,000 km$^2$ in area, it supports a remarkable nine endemic bird species and 22 endemic sub-species, the majority of which are dependent on forest. One of the 23 Endemic Bird Areas identified in Indonesia by BirdLife International, conservation of the remaining forest and its birds is of the highest priority. Consequently, BirdLife International's Indonesia Programme is collaborating with the Indonesian Directorate General of Forest Protection and Nature Conservation (PHPA) on a project to develop and implement a forest conservation plan.

As the plane made its final approach my thoughts were that Sumba looked a hopeless case. Such feelings were short lived, however. Within half an hour I was sitting in the local office of the PHPA discussing plans with an enthusiastic and able staff, headed by Pak Alex B. Ora. Their understanding of the problem and determination to do something about it gave me hope that Sumba's remaining forest and its endemic birds could be saved.

Over the next couple of days Pak Alex introduced me to various officials on the island who all gave me a similar message, and the true spirit of Sumba came through loud and clear. These were not people who were ruthlessly ruining their environment, but a community with a strong sense of identity, and with leaders who understood that traditional land practices were no longer tenable and that new solutions needed to be found. Their problem was that they lacked the necessary skills and expertise in conservation, and they were delighted that BirdLife wanted to help.

The PHPA/BirdLife project recognises that forest conservation must focus on the needs of the community as well as national and international concerns for bird and biodiversity conservation. The initial aim of the project is to prepare an island-wide conservation plan, which will explain the importance of forests and set an agenda for practical action to secure their long term future.

Before the start of the project in July 1992, very little was known about Sumba's forest and its birds. The brief surveys conducted for the National Conservation Plan in 1982, an expedition from Manchester Metropolitan University, UK in 1989, forestry maps and a recent satellite image, provided some preliminary information, but more detailed knowledge was necessary in order to develop a comprehensive forest conservation plan. The first phase of the project was therefore concentrating on surveys and studies of the island, and an initial reconnoitre of potential study sites was essential.

The first area Pak Alex and I visited was Luku Melolo forest in the east of Sumba. This once extensive forest is now reduced to a 1–2 km wide river valley whose steep limestone escarpments have put a brake on forest clearance. In less-steep areas the forest has been, and still is being, cleared for cassava, maize, peas and pinang.

Our arrival at the area was marked by two splendid Sumba Hornbills flapping sedately across the road – a timely reminder of the riches of the ever-diminishing forest. Discussion with people in the village of Pabera Manera shed some light on the reason for forest clearance. Areas under cultivation were exhausted after three to five years, after which they were abandoned and more land cleared. It also emerged that the people were unclear of the forest boundaries (all forest is owned by the Ministry of Forestry and therefore people are technically not allowed to clear it). This lack of clarity on boundaries is almost certainly because they lacked tenure of their land. During our future travels it became clear that land tenure was a key conservation issue. Without land ownership villagers were reluctant to invest effort and money in land husbandry. Instead, they simply moved on to new land when the old was exhausted, thus eating relentlessly into the remaining forest.

From Luku Melolo, Pak Alex and I trekked across to an adjacent forest called Lulundilu, which is classed as protection forest. Here the forest edge was defined by a topographical feature, a small river. Forest clearance had ceased because local people, although not clear of the precise boundaries, knew that west of the river was protection forest.

At our next stop, the village of Karanga on the other side of a small range of hills, we gleaned some interesting information on the Yellow-crested Cockatoo. This attractive species, of which Sumba has a distinct sub-species, has been extensively trapped for the wild bird trade and has suffered a great decrease in numbers. According to the villagers, the birds were once common in the area and used to raid their maize crops. They also described the methods used to trap them, using a decoy bird and a web constructed around the top branches of a dead tree.

J. Mackinnon/Bruce Coleman Ltd

*Yellow-crested Cockatoo was once common on Sumba and used to raid crops.*

During this discussion, the villagers asked me why I was so far from my home and so interested in their cockatoos. My answer caused astonishment. They had assumed that cockatoos occurred in Europe and America; the whole concept of certain animals occurring only in restricted areas was new to them. It is sobering to remember that, while biodiversity conservation may appear to be on everybody's lips, people living in many endemic bird areas are unaware that their birds are special or important – the restricted range, endemic and threatened species about which conservationists are concerned are familiar, everyday animals to them.

Prompted by this experience, on returning to Bogor I initiated the production of a poster with the message *These beautiful birds have no other home in the world but Sumba*. Over 1,000 of these have been distributed to villages across the island and have already stimulated widespread pride and interest, providing a base on which to build a wider discussion about the island's natural heritage.

The next stage of our plan, to continue south to the forests on Gunung Wangameti, was thwarted by a complete unavailability of fuel for our motorbike, illustrating some of the difficulties of working in such remote places. Instead we headed west, along the island's primary highway to the main agricultural region of Sumba known as Lewa. Here we witnessed first-hand one of the primary problems facing

*Fire is one of the primary problems facing Sumba's forest.*

P. Jepson/BirdLife

*Characteristic Sumbanese house, or uma; sacred heirlooms are stored in the roof.*

about this forest provide possibly the best safeguard against clearance the area could have.

Since these beginnings just over a year ago, the Sumba Forest Conservation Project has progressed significantly. An international team of scientists comprising ornithologists and ecologists from MMU, two botanists and a socio-economist from the Universitas Katholic Wilyha and the Universitas Nusa Cendea in Timor, and an undergraduate from the University of Indonesia, has studied five forest areas on Sumba, providing vital baseline information for the forest conservation plan. All birds on Sumba are now protected by decrees of the two regents (local governors) and the smuggling of cockatoos out of Waingapu airport has been severely reduced. Thirty cockatoos confiscated by the authorities are currently being prepared for release back into the wild.

Sumba's forest: fire.

Fire is considered by many to be the principle cause of deforestation on Sumba. The dry savannah forest that was once common on the island burns easily, and the fresh grass shoots provide good grazing for livestock. There is a strong tradition of livestock rearing on Sumba, fine angole cattle and sturdy ponies being central to the island's rich and fascinating culture. But the thin calcareous soils are quickly exhausted and grasslands lose their productivity rapidly. In the past the answer has been to burn more forest, and it is only in the last decade that this agricultural system has reached its finite limits. The project's key challenge is to find a solution to this problem.

The village leaders in this area added further insights into the complexity of the burning issue. Traditional Sumbanese society was structured into three strata comprising Maramba (aristocrats), Kaoisu (middle class) and Ata (slaves). The last class has now disappeared due to increased understanding that everybody has a right to freedom. Yet the higher social strata remain the main livestock rearers, and it is they who are primarily responsible for the burning. Starting fires is often done discreetly so that the person who starts it cannot be blamed if it gets out of control. One method is to start a fire inside a length of bamboo, so by the time it burns through and sets the vegetation alight, the person responsible has fled.

An interesting feature of this area is the attractive traditional Sumbanese houses, known as uma (uma means both house and the patrilineal line through which ownership of the house is passed). An uma has a roof shaped like a truncated pyramid, inside which the sacred heirlooms, the objects through which contact is made with ancestors, are stored.

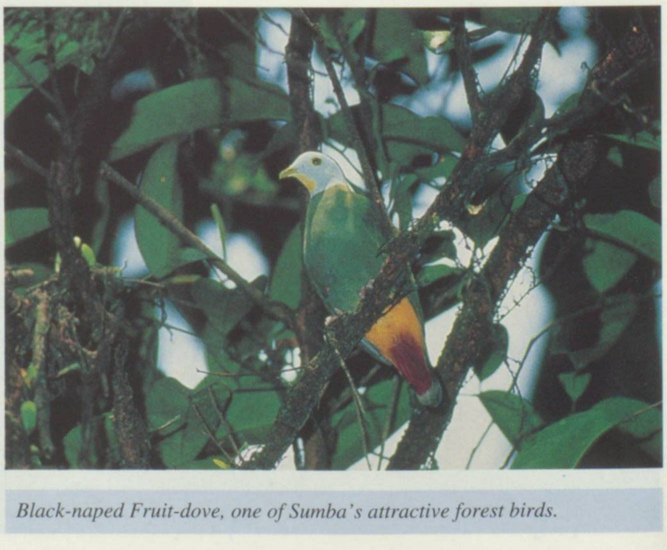
From Langaliru, we travelled to the forests of Manupeu. Here, from another of Sumba's high mountains Gunung Manupeu, the forest descends into a steep bowl-shaped valley with a spectacular waterfall. This valley is believed by the people of west Sumba to be a place of bad spirits. Although the majority of Sumbanese are registered Christians, it is estimated that more than half continue to practise animists beliefs, or Marapu, as the traditional religion is called. The beliefs

Public awareness has also advanced, and Pak Alex and his team have visited over twenty schools and villages to talk about the need for conservation. Following once such visit a child travelled over an hour by bus to report that people were catching turtles near her village. The culprits are now doing time in Waingapu jail. The PHPA office in Waingapu has been upgraded, and a new PHPA office is under construction in west Sumba. The forestry department has transferred two additional staff to Sumba to man this office.

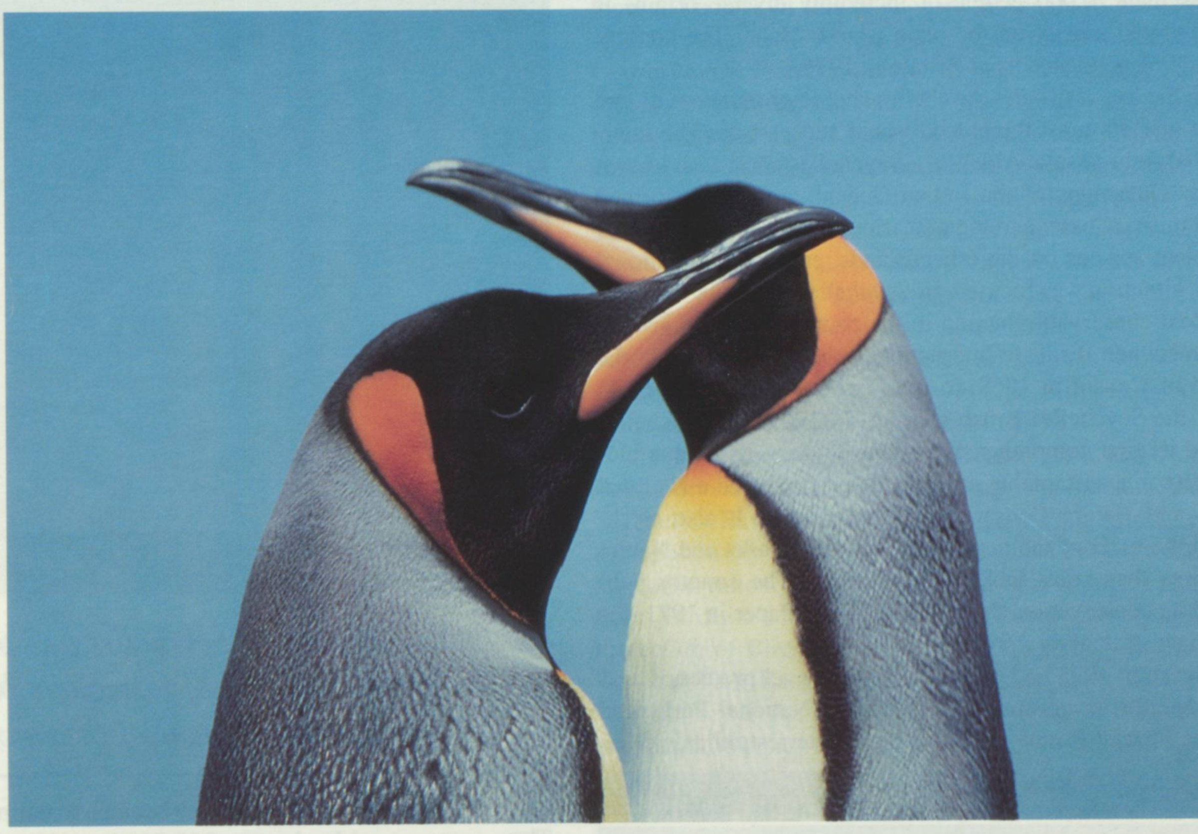
At the time of writing (August) PHPA and BirdLife staff are preparing a series of community workshops to seek the views, insights and ideas of local people concerning forest conservation. In the newly extended Waingapu PHPA office the scientific studies, the experience of international and local conservationists, and the knowledge of the people of Sumba will be woven into a forest conservation plan to benefit the people, forests and birds of this unique island.

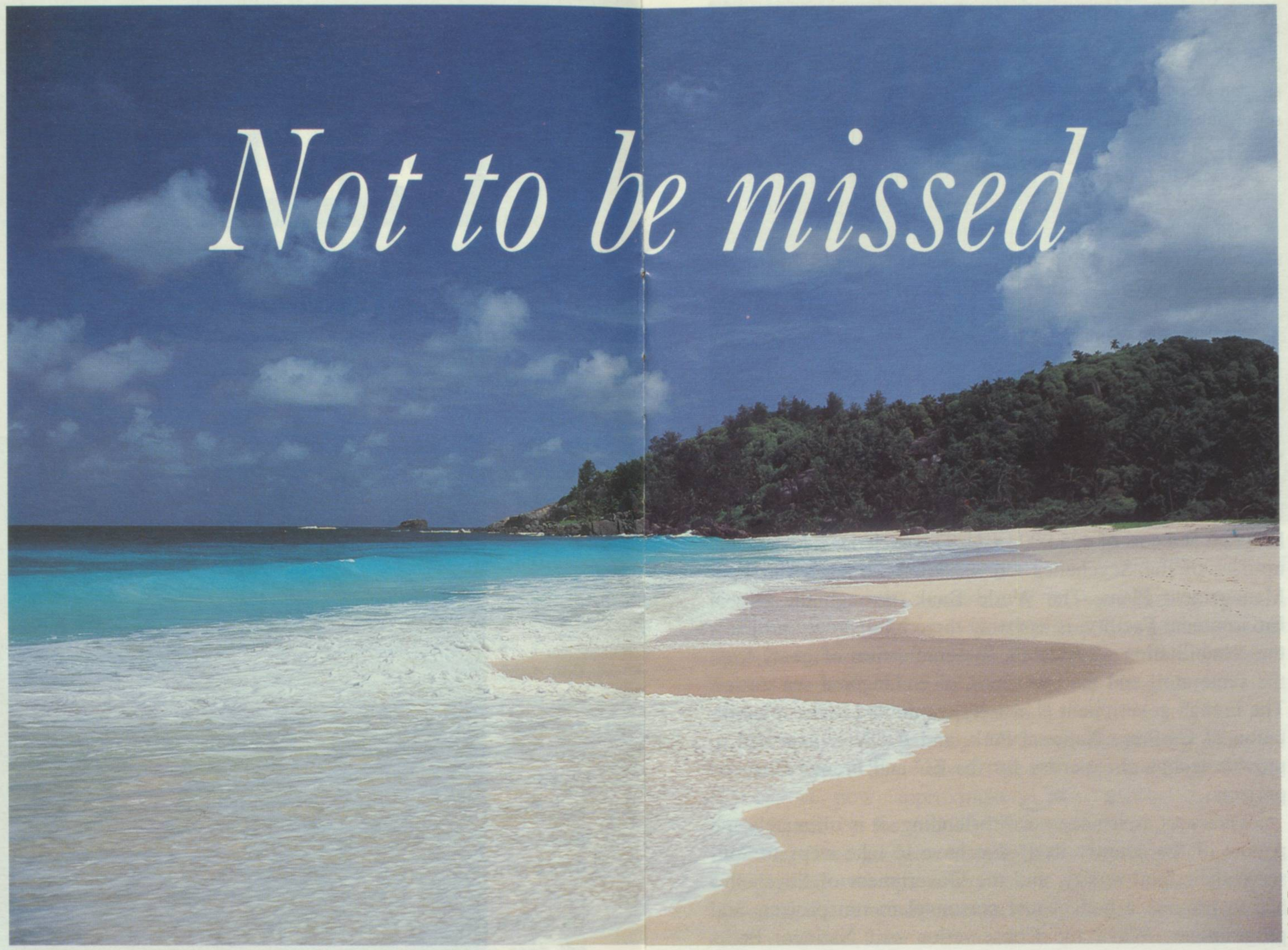
| | | | |
|---|---|---|---|
| Sumba Hornbill | *Aceros everetti* | Black-naped Fruit-dove | *Ptilinopus melanospila* |
| Yellow-crested Cockatoo | *Cacatua sulphurea* | | |

*Paul Jepson is Programme Coordinator of BirdLife International's Indonesia Programme.*



*Black-naped Fruit-dove, one of Sumba's attractive forest birds.*





# Not to be missed

J. & E. Forder

*The tiny republic of Seychelles has played a leading role in island conservation since the 1960s, initially with the help of foreigners but now, increasingly, led by Seychellois. Nirmal Jivan Shah reviews the development of the country's capacity to manage and protect its own biodiversity.*

The flight had been pleasant. John Collie, Conservation Officer, and I were returning to the Seychelles after a biodiversity seminar in Nairobi, Kenya, and I was looking forward to landing in a few minutes. Half an hour later we were still airborne, and a few whispered words with a passing air hostess confirmed a nagging suspicion. We had inadvertently overshot the Seychelles and the pilot was now doubling back!

I suppose it is easy to miss the Seychelles. A few dots on a world map, most people only know the country from the almost ethereal photos of balmy tropical beaches in advertising brochures. An archipelago spread across the Western Indian Ocean between 4°S and 11°S, the Seychelles are made up of 41 granite islands and 74 coralline sand cays and atolls, with a total land area of only 455 km$^2$. The population of less than 70,000 people of incredibly diverse origins is concentrated mostly on the main island, Mahé. The country gained independence from Britain in 1976.

In the late 1960s the Seychelles shot to prominence as one of the world's most threatened island ecosystems. The international fight to save Aldabra, a Seychelles coral atoll known as the 'Galapagos of the Indian Ocean', from being turned into a military base, and the precarious status of many animal and plant species on the other islands, ensured international media attention was focused on Seychelles for some time.

Real conservation action in the country began at around the time when BirdLife International (then ICBP) bought the island of Cousin in 1968, to save one of the world's rarest birds, the Seychelles Brush-warbler. In 1969, the Seychelles passed its first comprehensive law to manage its unique biodiversity in a sustainable manner. The Act created a National Parks and Nature Conservancy Commission. It also established the basis of the network of National Parks and Nature Reserves that exists in Seychelles today. The country published its conservation strategy as a White Paper in 1971, the first such strategy in Africa.

Between 1973 and 1991, ecosystem-level protection was provided for seven areas designated as National Parks and four as Special Reserves. These include terrestrial as well as marine parks and in four cases encompass entire islands. They cover a total land area of 19,760 ha (43% of the land surface of the Seychelles), and 23,000 ha of marine areas. On paper, at least, the Seychelles has more of its national territory legally dedicated to conservation than any other country in the world. A host of other legislation protects turtles, tortoises, trees, land and sea birds and marine mammals, and environmentally destructive practices such as dynamite fishing, trawling and speargun fishing are banned.

Seychelles Fody survives on Cousin, Cousine and Fregate, all rat-free islands.

D. Hosking/FLPA

In the heady days of conservation in Seychelles in the 1970s and early 1980s, foreign scientists and experts poured into the country, and many international organisations were heavily involved. IUCN sponsored technical advisors to assist in legal and policy formulation, and WWF became involved in studies on sea turtles. BirdLife International continued its focus on threatened birds, but also expanded conservation on Cousin to other threatened fauna and flora. The Royal Society for Nature Conservation bought Aride and provided funds for the protection of the Seychelles Paradise-flycatcher's habitat on La Digue island. In 1979, the Seychelles Island Foundation, a corporate body established by Presidential Decree with international and local members as Trustees, started to manage Aldabra, and in 1984 the atoll was declared a UNESCO World Heritage Site. The Seychelles also gained a reputation as a major player in the international conservation scene through its strong stand in the International Whaling Commission. Due to the Seychelles proposal, the Indian Ocean was declared a Marine Mammal Sanctuary, and in 1979 the Seychelles launched the original proposal for what is now the UNEP Convention for the Protection, Management and Development of the Marine and Coastal Environment of the Eastern African Region.

Despite these achievements, the Seychelles ability to manage its resources has for years been severely limited, chiefly by the lack of trained local experts and scientists. Nature conservation was until recently the preserve of expatriates, and seemed very far removed from the lives of the average Seychellois. As one Seychellois journalist put it, conservation was 'lists and more lists of weird species'.

There was also very little attempt by any organisation to build the institutional capacity of the country to understand and manage its unique flora and fauna itself. There was no conservation education in schools and further training and education opportunities were few and far between. The national institution concerned with conservation was far too small and administratively weak, being a small unit in the Ministry of Agriculture and later the Ministry of National Development. The poor salaries and lack of career prospects did not attract bright young Seychellois to conservation, most preferring further studies in medicine, engineering, tourism or business management.

BirdLife International recognised these problems, intrinsic to the small, remote and rather insular Seychelles. In 1987 BirdLife sponsored a Seychellois to attend the course in conservation èducation at the International Centre for Conservation Education in the UK. Following this, an educational slide pack on Cousin was produced and promoted in schools, and a bird book specially designed for use in the Seychelles educational system was written. More than three thousand copies of this book were presented to the Ministry of Education in 1991. In 1991 also, the management of Cousin Nature Reserve, previously headed by expatriate wardens, was 'decolonised' and the management team became totally Seychellois. Mr Robbie Bresson, a staff member with almost two decades of commitment to Cousin (see *World Birdwatch 15,2:22*), is now handling all affairs to do with the daily upkeep of the island. BirdLife has also arranged for Seychellois conservation staff to attend various seminars overseas to broaden their experience. The latest to benefit was the Assistant Conservation Officer and veteran Seychellois ornithologist, Mr Victorin Laboudalon, who presented a paper on seabirds at the 5th Pan African Ornithological Congress in Burundi in 1992.

In 1991 the country's first Conservation and National Parks Service was formed, coinciding with the launch of the Seychelles Environmental Management Plan. BirdLife saw the opportunity to help build the Seychelles' own capacity for conservation. Jim and Hanna Stevenson, on secondment from BirdLife's UK partner, the Royal Society for the Protection of Birds, were contracted for three years to train National Park Rangers and other conservation staff with a view to better management of threatened birds and their habitats. In the past two years, Jim has worked with Rangers

Seychelles Blue-pigeon, endemic to the islands.

D. Hosking/FLPA


J. & E. Forder

*Smart new signs and uniforms for the wardens have boosted the image of the Conservation and National Parks Service.*

*Patrich Briocher, one of the rangers on Praslin, tends seedlings to be used in the reforestation programme.*

in the St Anne Marine Park, Curieuse National park and La Digue Veuve (Paradise-flycatcher) Reserve. By working with Ranger Trainees and putting in place permanent training procedures and methods, Jim expects to have made himself redundant at the end of his assignment. Recently the United States Government has financed a Conservation and National Parks Training Centre in the St Anne Marine Park, and Jim has already used the resources there for his programmes.

BirdLife has not completely abandoned its focus on threatened birds in the Seychelles, however, and the recovery programme for the Seychelles Magpie-robin is proving very successful (see page 2). Other agencies and donors presently involved in Seychelles conservation programmes include the Food and Agricultural Organisation (FAO), the EC, the World Bank and the French Government. The FAO has reviewed and up-dated the conservation and protected area's legislation. The new version is now virtually complete and by 1994 the country will possess state of the art conservation laws. The EC is financing a Biodiversity and National Parks Program at a cost of 425,000 ECU. This includes a review and up-date of the Seychelles Conservation Strategy and Park Management Plans. The World Bank, through the Global Environment Facility, is assisting three biodiversity projects: the rehabilitation of Aldabra, the eradication of goats from the same atoll and the protection of endangered sea turtles. The French government is heavily committed to the rehabilitation of Curieuse National Park, and IUCN is expected to provide technical expertise for the EC and French financed projects.

Overseas assistance notwithstanding, it is ultimately the people of the country itself that have to take steps to conserve their biodiversity, and the Government of Seychelles has to provide a budget and personnel to run projects and programmes. When the Conservation and National Parks Service was created in 1991, its budget was 375,000 Seychelles

J. & E. Forder

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*The unique wildlife draws many visitors to the Seychelles, bringing important revenue to the islands.*

Rupees and its staff consisted of six semi-literate Rangers and one expatriate Conservation Officer. Rangers used an old open boat for patrols, there were no vehicles for field staff, the library consisted of six books and the filing system was a pile of papers in an old cupboard.

In many ways January 1992 was the turning point for conservation in Seychelles. The government budget for the Service is now approximately two million Seychelles Rupees, and by the end of 1992, there were over 37 staff, including three graduate Seychellois in senior positions. The organisation now possesses computers, vehicles, custom-built boats, communication facilities, diving equipment and other materials. information centres, park management headquarters and a training centre have been completed. Smart uniforms, new signs in the Parks, brochures and pamphlets, a newsletter and a series of technical reports have brightened up the image of the Service. Better equipment and resources and superior salary scales coupled with a massive recruitment drive is now reaping rewards. 'The foundation for successful conservation has finally been put in place', said a visiting international expert recently. Much of this has been achieved without any external help or funding.

The change has been due to an aggressive drive within the Service to shake off the laissez-faire image and to achieve excellence. The recruitment of Seychellois staff to form a permanent core of managers has been considered vital, and even when there are better qualified expatriates available, Seychellois have been hired on a preferential basis, with training as a precondition. It was also decided that pure research by foreign scientists would no long be acceptable. The emphasis of the new Service would be on monitoring, to collect long-term data specifically for management purposes. To this end BirdLife's latest initiative in Seychelles is a programme to assist the Service to establish a biodiversity monitoring system, giving priority to threatened species.

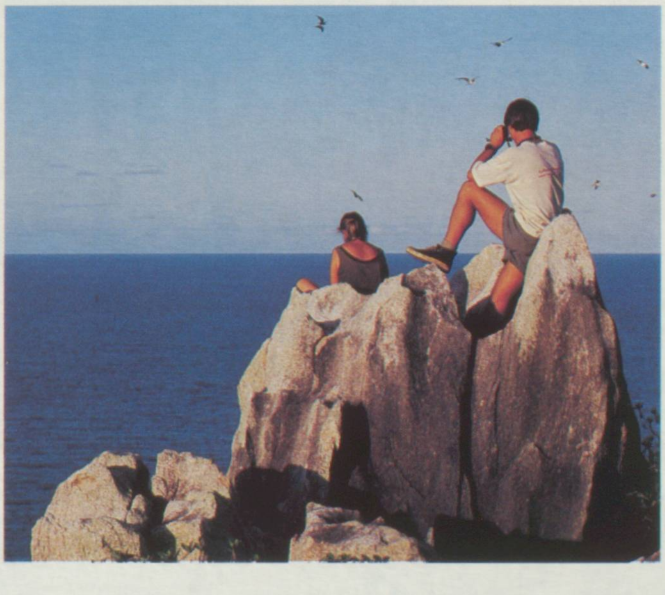
The Conservation and National Parks Service now possesses the ability to evolve into a centre of excellence. The Government of Seychelles is seriously debating the possibility of elevating the status of the Service to that of a semi-autonomous agency, to be called the Coastal and Marine Biodiversity Agency (the whole of the Seychelles can be considered as a coastal area). BirdLife International has expressed support for this proposal and will continue its efforts in reinforcing the Seychelles' ability to manage its own biodiversity.

Despite its small population and diminutive economy, the Seychelles has an enormous area of ocean and 115 islands to manage. The difficulties involved in such a task cannot be underestimated. Nevertheless, its long history in conservation and determined efforts recently to build a solid management foundation for biodiversity protection are bringing world attention back to the Seychelles.

| | | | |
|---|---|---|---|
| Seychelles Brush-warbler | *Bebrornis sechellensis* | Seychelles Paradise-flycatcher | *Tersiphone corvina* |
| Seychelles Magpie-robin | *Copsychus sechellarum* | Seychelles Blue-pigeon | *Alectroenas pulcherrima* |
| Roseate Tern | *Sterna dougallii* | | |

*Nirmal Jivan Shah, a Seychellois, is the Director of Conservation and National Parks Service, and BirdLife International's Representative in the Seychelles. Now on sabbatical leave, he has recently formed the Seychelles' first environmental consultancy organisation, called Environment Resources Oceans (ENVI.R.O).*

*Wardens on Aride counting Roseate Terns.*



J. & E. Forder

# The Calling of Cranes

K. Wothe/Bruce Coleman Ltd

*Curt Meine describes this charismatic family and the conservation issues that affect them.*

Several times each spring and fall, an unusual family conversation can be heard across the farm fields and morainal hills of south-central Wisconsin. The opening remarks come from above, as a flock of migrating Sandhill Cranes announces its arrival in the skies over the International Crane Foundation (ICF). Their calls prompt other cranes in the ICF's captive breeding facility to raise their voices in reply. As the sandhills drop in to pursue the discussion, the excitement spreads like a rumour from crane pen to crane pen. The heads of a hundred and fifty cranes lift up, long necks bend back, and the bugles cut loose.

This conversation could not occur anywhere else in the world. This is the only place on the planet where all the members of the *Gruidae* family are present. ICF, in its capacity as the world centre for the conservation of cranes and their natural habitats, houses representatives of all fifteen of the world's crane species, from the five continents where they occur (only Antarctica and South America lack cranes). These birds produce new generations of cranes for reintroduction, research, and education, and provide security against the threat of extinction.

F. Schneidermeyer/Oxford Scientific Films

*Grey-crowned Crane (above) and Black-crowned Crane are probably the most beautiful species in the group.*

*Common Cranes (opposite).*

In the ensuing uproar of crane trumpetings, the discerning human ear can make out the family's varied voices. The more 'primitive' species – the Grey- and Black-crowned Cranes from Africa – speak in shorter, flatter phrases. The Whooping, Red-crowned and Sarus Cranes, who have evolved elongated tracheas, speak in bright, stentorian tones, while the Siberian and Wattled Cranes occupy the higher registers. Somewhere in the middle, the wild Sandhill Cranes give forth their coarser call.

For a human being eaves-dropping on this crane-talk, an undercurrent of irony can be heard amid the cranes' din. Having spent the eons diversifying from their common ancestor, all the fifteen species are now brought together again by their increasing vulnerability. The discourse between wild and captive cranes is thus an echo of our own discussions about how to maintain a biologically diverse world, and how to develop a viable relationship between wildness and human civilisation.

Throughout history, we find cranes at the leading edge of such discussions. Aldo Leopold, in his textbook *Game Management* (1933), cited Kublai Khan's provision of food patches for cranes and other birds near Changanoor in the 13th century as 'the first clear record of a well-rounded system of ... management for conservation purposes'. In the 1930s, Leopold himself encountered the then-rare Sandhill Cranes in Wisconsin (not far from ICF's present site) and became deeply intrigued by this 'symbol of our untamable past'. Partly as a result of this encounter, Leopold's wildlife conservation philosophy began to expand beyond a concern for game animals and their habitats, and to embrace all members of the biological world.

The saga of the Whooping Crane – the decline to just 16 birds in the early 1940s, the discovery in 1954 of the Canadian nesting grounds of the last wild flock, the long difficult process of recovery to its current level of 150 wild birds – is one of conservation's great epics, and provides a key early example of international cooperation on behalf of endangered wildlife.

The prominence of cranes in conservation matters is due in part to the fact that, as a family, they are creatures of superlatives. They are among the most ancient of bird families: the Sandhill is generally considered to be the most ancient of the world's extant bird species. The Sarus Crane of India and Southeast Asia is, at nearly 2 metres, the tallest flying bird in the world. Cranes are long-lived: the longest recorded lifespan of an individual bird – 82 years – was a captive Siberian Crane.

While beauty defies such measures, cranes are also recognised in many cultures as being among the most striking creatures on earth. Their size, form, plumage, vocalisations, and the family's propensity for dancing, have made them special symbols wherever they occur. They appear in paintings, sculpture, ceramics and textiles, and in stories, poems and myths. Three species – the Blue, Grey-crowned, and Black-crowned Cranes – are national birds of South Africa, Uganda, and Nigeria respectively. They have symbolised luck, longevity, and fidelity in Japan, nobility in South Africa, grace and kinship with nature in Australia, and courage among native Americans.

Cranes are found in over 110 countries. East Asia, with eight species (the Red-crowned, Black-necked, Sarus, Common, Hooded, White-naped, Siberian, and Demoiselle), is the centre of crane diversity. Two species each occur in Australia (the Brolga and Sarus), North America (the Whooping and Sandhill), and Europe (the Common and, in southeastern Europe, Demoiselle Crane). Six species are permanent or part-time residents of Africa (the Blue, Wattled, Grey-crowned, Black-crowned, Common, and Demoiselle). The northern species and populations are migratory. The southern species – the Brolga, Sarus, Wattled, Blue, and Crowned Cranes and the southern subspecies of the Sandhill


*Sandhill Cranes in sunrise fog.*

Crane in Florida, Mississippi, and Cuba – are non-migratory.

Most of the cranes are wetland dwellers, although they vary in the degree to which they use other habitats. The Siberian, Whooping, Red-crowned, and Wattled Cranes are the most specialised for life in the marshes, bogs, and deltas. Other species, such as the Sandhill, Common, and Hooded Cranes, while still primarily wetland residents, also make liberal use of grain fields (especially during migration). The Blue and Demoiselle Cranes, with their shorter bills and statures, are adapted to life in the grasslands, although both favour nesting sites near wetlands.

The size, habitat needs, and migratory habits of cranes make them vulnerable to a wide range of threats. The loss and alteration of wetlands worldwide is the greatest of these, affecting breeding grounds, migration staging areas and stopover points, wintering grounds, and roosting areas, as well as the permanent homes of the non-migratory species. Wetlands are degraded through a number of processes: drainage, conversion to agriculture, dam construction, water diversion, urban expansion, pollution, over exploitation of fish and wetland vegetation, coastal shoreline development and erosion. Cranes have thus assumed yet another, newer symbolic role around the world: as 'flagship species' in the effort to protect and restore the biological diversity and ecological health of wetland ecosystems.

Even where habitats are secure, cranes face other important threats. Poisoning, both intentional and unintentional, has been reported as a cause of mortality in most species that use agricultural fields, South Africa's Blue Cranes being the most heavily affected. Although cranes are legally protected in most countries where they occur, hunting, poaching, and live trapping can pose important threats. The dwindling of India's wintering flock of Siberian Cranes, from some 200 birds in the early 1980s to just 5 individuals a decade later, is in part due to increased hunting pressures along their migration route. Once populations decline to such a low level – a situation also faced by the Whooping Crane and the Cuban and Mississippi subspecies of the Sandhill Crane – they become vulnerable to additional genetic and demographic problems, and to the effects of catastrophic events such as tropical storms.

As a result of these and other threats, seven of the fifteen crane species are considered globally threatened. Others, though still abundant, are declining. Furthermore, several subspecies and populations of cranes face greater degrees of threat than do the species as a whole.

In an effort to define better the degree of threat, assess conservation needs, and coordinate the wild and captive management of cranes, BirdLife International's Crane Specialist Group, the International Crane Foundation, and several other organisations have recently prepared a Crane Conservation Assessment and Management Plan (or CAMP). Using a new system for categorising degrees of threat, crane experts from around the world grouped the cranes into four categories: safe, vulnerable, endangered, and critical. Those groups found to be most critically threatened were the central and western populations of the Siberian Crane, the Cuban and Mississippi Sandhill Cranes, the Whooping Crane, the Ethiopian population of the Wattled Crane, the north-west African population of the Demoiselle Crane, and the Blue Crane. Results from the CAMP are now being used to develop a Crane Action Plan to address the threats to cranes worldwide.

Despite the vulnerable state of many populations, cranes are in a sense more fortunate than many other endangered forms of wildlife. Their high aesthetic and cultural value has brought them much attention from conservationists, and they are among the most intensively studied families of organisms in nature. Although there is much that we do not know about certain species (for example, the Black-necked Crane), and certain aspects of crane biology (for example, the migration routes of many populations), cranes are nonetheless 'ahead of the game'. Unlike so many groups of plants and animals, much of the information that is needed to design conservation programmes is already available.

Cranes also have the benefit of their 'own' foundation. The International Crane Foundation has, in the twenty years since its establishment, provided the focal point for a far-flung network of crane researchers and conservationists. Working with and through colleagues around the world, ICF helps to coordinate captive breeding and reintroduction programmes. This, however, is only one of many components that must go into a balanced conservation programme. ICF also organises regular crane workshops (the latest, on African cranes, was held in Botswana in August 1993), sponsors research on cranes and their wetland habitats, administers public education and professional training programmes, and assists in the design of sustainable development and habitat management projects.

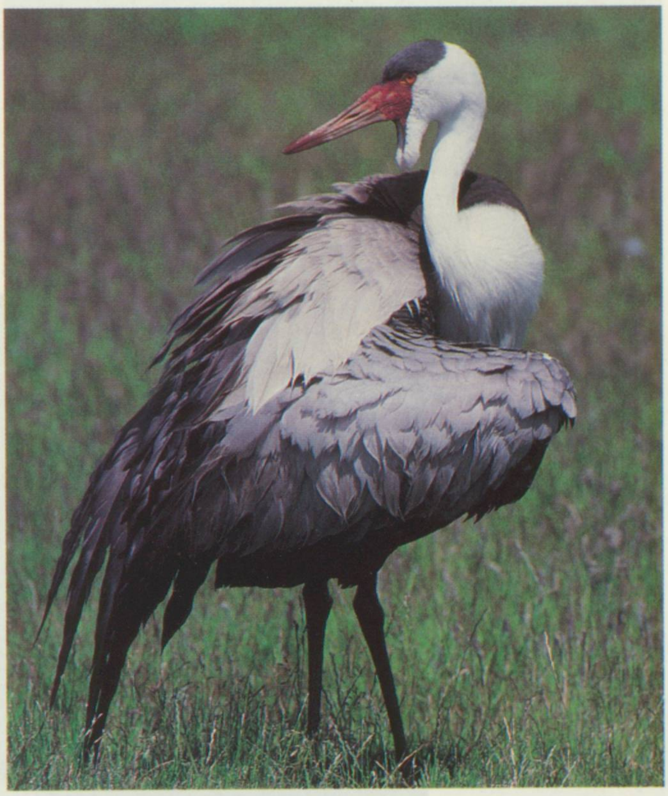
Despite the advantages that cranes possess in confronting the threats to their continued survival, the conservation of this family of birds will not be easy. The trend in many species and populations is downward. The pressure on their habitats will only increase as human populations continue to expand. And despite great effort, no self-sustaining crane population has yet been artificially re-established in the wild.

But in the face of these realities, it is salutary to listen to the Sandhill Cranes that initiate the excited clamour at ICF. Only a few decades ago, their voices were all but silenced in the state of Wisconsin. Reduced to just a few dozen remnant wild birds in the 1930s, the Sandhill Crane has now reclaimed this portion of its ancestral home, thanks to a combination of habitat restoration and effective hunting restrictions. In this year's annual crane count in Winsconsin, involving 2,500 people, more than 11,000 cranes were recorded. As the migrating Sandhill Cranes leave ICF behind, their insistent calling provides a message of hope and survival for this much-loved and celebrated family.

| | | | |
|---|---|---|---|
| Sandhill Crane | *Grus canadensis* | Blue Crane | *Grus paradisea* |
| Grey-crowned Crane | *Belearica regulorum* | Black-necked Crane | *Grus nigricollis* |
| Black-crowned Crane | *Belearica pavonina* | Common Crane | *Grus grus* |
| Whooping Crane | *Grus americana* | Hooded Crane | *Grus monacha* |
| Red-crowned Crane | *Grus japonensis* | White-naped Crane | *Grus vipio* |
| Sarus Crane | *Grus antigone* | Demoiselle Crane | *Grus virgo* |
| Siberian Crane | *Grus leucogeranus* | Brolga | *Grus rubicunda* |
| Wattled Crane | *Grus carunculatus* | | |

*Curt Meine is a consultant with the International Crane Foundation, where he is helping to prepare the IUCN Crane Action Plan.*

J. & D. Bartlett/Bruce Coleman Ltd



R. Williams/Bruce Coleman Ltd

M. Price/Bruce Coleman Ltd

*The Blue Crane (top) occurs only in open grassy habitats in the upland interior of South Africa,with a small, disjunct population in Namibia.*

*Wattled Crane (centre), a large shy species that occurs in wetlands in Africa, and is globally threatened.*

*Siberian Crane (bottom) is one of the most critically threatened species in the group. It breeds in two discrete areas in Siberia: birds from the western area winter at Bharatpur, India, those from the east migrate to China.*

RED DATA BIRD

# Lesser Florican

## *by Ravi Sankaran*

By early July the clouds of the south-west monsoon have swept over the Western Ghats and spread over peninsular, north-western and northern India, bringing greenness and water to a land that has been naked and parched through the long hot summer months. And with the onset of the monsoon, the season of the Lesser Florican begins.

The Lesser Florican is one of three bustard species resident in India. Together with the Indian Bustard and the Bengal Florican, they are the most threatened species in the group.

The Lesser Florican is a migratory species. Details of its distribution in the non-breeding season are lacking, but it is known to be dispersed over much of peninsular India. With the onset of the monsoon, the birds migrate into north-western India to breed, appearing in Gujarat, western Madjya Pradesh, north-western Maharashtra and south-eastern Rajasthan with the first heavy showers. They breed in grassland, requiring areas not grazed by livestock where the grass is allowed to grow tall during the monsoon season.


R. Sankaran

Males are territorial; each territory is 1–2 ha in size, and several territories are normally aggregated together into an exploded lek. In the non-breeding season, both male and female Lesser Floricans are cryptically coloured, but in the breeding season the males moult into a showy, predominantly black and white plumage.

Their display is even more spectacular: best described as a 'flutter-jump', the bird typically crouches, then springs vertically upwards, and with 10 to 12 rapid wing strokes rises about a metre above the surrounding grass before descending to the ground with wings held loosely. The jump is accompanied by a curious rattling sound produced by specialized feathers on the wings. When a female enters his territory, the male approaches, neck outstretched, halting and jerking his neck back on to the mantle when he gets close to her.

Males display from the onset of the rains until the end of September, often choosing elevated ground or small ridges for their performances. At the peak of the season, they can jump over 600 times a day, favoured spots becoming trampled bare of all vegetation.

The females nest outside the male's territory in a patch of long grass. Clutch-size is usually four, but may be three to six, and the incubation period is about 21 days.

Sadly this magnificent bird is seriously declining. Numbers are known to have been decreasing for many decades, but the past ten years have been particularly catastrophic. In 1989, at the end of a five-year study on the Lesser Florican by the Bombay Natural History Society (BNHS), the species's known breeding range was surveyed. In 63 grassland areas spread across most of the range, covering a total of 332 km$^2$, 45 birds were recorded, leading to a population estimate of 750. This was a drastic decrease from 1982, when a BirdLife-sponsored survey of parts of Saurashtra in Gujarat and a BNHS survey of parts of western Madhya Pradesh estimated a total of 4,500 birds. Clearly, the Lesser Florican was in serious trouble.

But why? A look at the biology of the species and its breeding habitat, and the ecological and political changes in north-western India may provide the answers.

The south-west monsoon is erratic in date of arrival, in areas where rain falls, in the amount of rain and in its distribution through the season. Thus the Lesser Florican is nomadic, congregating in areas where rainfall has been or will be adequate. Good rains are essential to breeding success, because without rain the grass does not grow sufficiently to provide the necessary cover for nesting.

Centuries ago, the grasslands in which the Lesser Florican breeds extended over several thousand square kilometres, covering all areas in north-west India that were not forested or mountainous. But today these grasslands, known as bheed or vidi, are minute islands in an ocean of cultivation, over-grazed land and urban areas. In fact, bheed is perhaps the most fragmented and patchily distributed of habitat types in India today, with patches rarely exceeding 1,000 ha and more often being less than 100 ha. These small areas, mostly owned by the government or by farmers, are generally allowed to grow long during the monsoon, and then harvested for hay.

The loss of these grasslands really began at the end of the feudal era. Until that time, landowners needed large areas of bheed to produce sufficient hay for their cattle and horses. With the change in the land act (the Land Ceiling Act) in the early 1970s, large areas of grassland reverted to government ownership, or were divided and given to a number of small agrarians. As the need for fertile land increased to meet the demands of a growing population, these grasslands were gradually destroyed. At the same time, the livestock population in the area grew, meaning that all grassland that was not specifically protected was soon over-grazed.

But habitat loss itself was not the primary factor in the large-scale decline of the Lesser Florican. In the past, the species was an extremely popular game bird, and entire male populations were decimated in a single morning's shoot during the breeding season. The widespread hunting prompted A.O Hume, one of the great fathers of Indian ornithology, to write in 1879 'Owing to the unsportsmanlike manner in which these beautiful birds are massacred during the breeding season, they are everywhere diminishing perceptibly in numbers and will, in another half century be, I fear, almost extinct'. Fortunately the threat from hunting, though still present, is much reduced, largely because of the introduction of strict regulations.

The dramatic decline of the Lesser Florican between 1982 and 1989 cannot be explained by either of these factors, however, since much of the grassland that existed in 1982 was still present in 1989, and hunting pressure was not great. The problem was almost certainly rainfall. For three years, between 1985 and 1987, north-western India was gripped by a severe drought, and the breeding success of the Lesser Florican was extremely low in most areas. Lack of rain is a very real problem for the Lesser Florican, since north-western India experiences sub-normal rainfall or droughts at least once every four years. Since 1988, however, the rains have been good, and there are indications that the population may have recovered a little.

The unreliability of the rainfall has significant implications for the conservation of the Lesser Florican. Although western Madhya Pradesh has better habitat for the species than west Gujarat, inadequate rainfall in the former might cause the birds to migrate to the latter. Even if weather conditions were favourable in the latter, breeding success would be low because of lack of suitable grassland. Rainfall patterns are such that optimal conditions can occur in pockets as small as a few hundred square kilometres, and the chances of these conditions coinciding with adequately protected grassland are slight. It is therefore necessary to protect grasslands throughout the species' breeding range, so that wherever the birds migrate in their search for optimum rainfall, they will find adequate habitat. Given the size of the species's range (over 342,000 $km^2$), this is a daunting task indeed.


R. Sankaran

*The spectacular display of the Lesser Florican includes a 'flutter-jump', in which the bird rises about a metre above the ground.*

However, an increase in the area of ungrazed grassland is not incompatible with the needs of the local people. Optimal Lesser Florican habitat is excellent for hay production, and hay is extremely useful cattle fodder. Growing hay to feed cattle is in fact a more efficient and sustainable way of using the land than allowing the cattle to free-graze. It does require, however, a change in the way cattle are kept, from free-grazing to stall-fed.

If funds are forthcoming, the Salim Ali Centre for Ornithology and Natural History will initiate a series of conservation measures for the Lesser Florican. The plan is to survey the breeding range in 1994 to re-assess the population and its trend. A workshop will then be held, involving conservationists and land-use managers, to discuss methods by which the extent of protected grasslands can be increased. As part of a much longer-term action plan, land that is currently overgrazed and unprotected will be identified, and a network of protected grasslands will be established. The goal is that in 10 years time, around a tenth of north-western India should be protected grasslands used for hay production. If this is achieved, the Lesser Florican should survive into the future.

| | | | |
|---|---|---|---|
| Lesser Florican | *Eupodotis indica* | Indian Bustard | *Ardeotis nigriceps* |
| Bengal Florican | *Eupodotis bengalensis* | | |

*Ravi Sankaran did his doctorate on the Lesser Florican with the Bombay Natural History Society. He is currently working for the Salim Ali Centre for Ornithology and Natural History in the Andaman and Nicobar Islands.*

# The Conservation Society of Sierra Leone

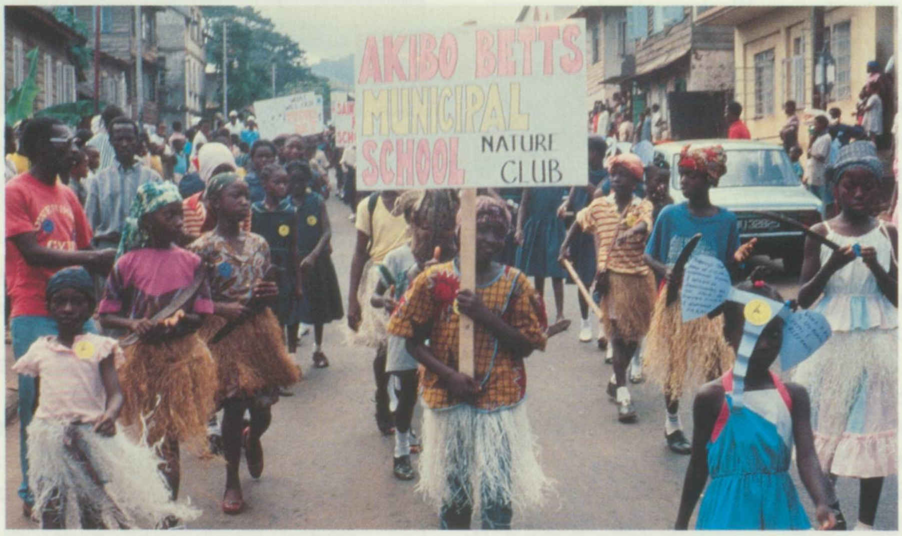
*by D. D. Siaffe*

Sierra Leone is a small republican state in West Africa with a human population of about 4.2 million. Biologically rich, the wildlife has suffered greatly in the past few decades. Once largely covered with rainforest, the remaining pockets of fragmented protected forest and nature reserves now cover a mere 6% of the country. Amongst these are 750 $km^2$ of the last remaining Guinea Rainforest (Gola Forest). The Gola Forest supports endangered and notable species including elephant and other rare mammals, 10 globally threatened species of birds and at least 13 globally threatened species of plants.

The country also has 340 km of mangrove coastline, which hosts many thousands of migrating birds and several threatened mammal species. The savanna woodland in the north supports populations of elephants, chimpanzees, wetland birds and other rare animals. Sadly, the activities of farmers, miners, logging companies, hunting and bush fires threaten the wildlife and environment throughout the country.

The Conservation Society of Sierra Leone (CSSL), founded in September 1986, was formed to promote the wise use and management of the country's natural resources through education, advice and research. The activities of the Society are varied, and expanding rapidly. CSSL is involved in the protection and management of remaining forests and nature reserves, in collaboration with the government of Sierra Leone, and has implemented a bush fire control and prevention programme in the savanna areas of the country. It also runs programmes to re-habilitate and protect mined and deforested areas, and single species projects.

One of CSSL's main aims is to raise public awareness about the importance of wildlife and environmental conservation in Sierra Leone. One of the major achievements so far has been the establishment of school nature clubs and district ornithological societies, which educate and foster concern for wildlife and the environment among young people. The Society also hosts public lectures, seminars, meetings, radio programmes and an annual national Wildlife Week celebration, and produces posters, magazines, and education resource materials for teachers and adult literacy facilitators.




K. Smith/RSPB

*One of the Wildlife Week activities organised by CSSL.*

This year's Wildlife Week was an excellent example of how the Society is working with a wide range of people and groups. Twenty seven different organisations, including some that are not primarily concerned with conservation, participated in the celebrations, which included the BirdLife International WORLD BIRDWATCH '93 event. The 1993 Wildlife Week theme, *Birds, the Environment and Us*, drew attention to the fact that birds are a part of everyday life, as well as demonstrating the role they play in ecosystems as consumers of insects and other invertebrates, pollinators of flowers and dispersers of seeds, and as the best indicators of a healthy environment, or of pollution or other misuse.

Another important message of the wildlife week was the interdependence of all human activities – agriculture, forestry, harvesting of wild resources, building, manufacturing, tourism, transportation, education and everything else upon which people's lives and the economy depend.

The Wildlife Week was celebrated in Freetown, Kenema and Kambia, and several schools and the general public participated. About 150 people took part in the WORLD BIRDWATCH '93 event, which was held at two locations, Kingtom Cemetery and Congo Bay. Birds seen included Hooded Vulture, Pin-tailed Whydah and several northern European waders.

Other events included an exhibition with information about the country's wildlife and environment, guided walks to nature reserves (in which over 200 people participated), and an Appropriate Technology Fair, demonstrating ways of using scarce resources more efficiently. The Nature Clubs put on various activities, including a march with banners carrying messages on conservation. There was also an Environmental Education seminar, in which nine NGOs participated.

While the activities of the Society are expanding, there is a substantial shortfall of funding, which has resulted in the some of the planned programmes being put off. But there is much to do in Sierra Leone and the CSSL will continue to tackle as many of the problems as they can.

Hooded Vulture *Necrosyrtes monachus* Pin-tailed Whydah *Vidua macroura*

*D. D. Siaffe is Programme Officer at CSSL.*

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# Guillermo Egli

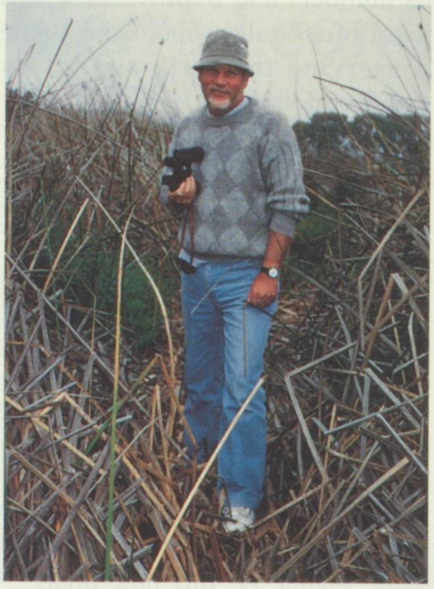
There can be few Chilean ornithologists who do not know Guillermo (Wilheln) Egli. A Swiss-Chilean with an outstanding passion for birds, Guillermo's dedication, enthusiasm and determination have been fundamental to the growth and development of the Union of Ornithologists of Chile (UNORCH). UNORCH, which represents BirdLife International in Chile, brings together professional and amateur ornithologists from around the country. Guillermo has been the Secretary General of the organisation since 1982, when the first group of ornithologists got together in Santiago, under the umbrella of BirdLife.

Guillermo has contributed greatly to the knowledge of Chilean birds. His publications on bird song broke new ground, leading to the production of the only cassette with songs of Chilean birds. This cassette has proved a valuable aid in promoting interest in birds in the country.

Interested in nature since his youth in Thun (Switzerland), Guillermo has always has a particular fascination for birds. After finishing his studies as a teacher of Natural Sciences, this fascination motivated him to migrate to Latin America. He travelled first to Colombia, but finally settled in Chile, where he got a job in the Swiss School in Santiago. Here he met Helga, his wife, and despite returning to Switzerland with the intention of settling there, memories of his time in Chile eventually made him go back. Throughout this time, his work as a teacher and ornithologist never stopped.

His innate affinity with teaching, together with his great patience and straightforward nature, have made him a role model to his young students, who are inspired by his love and interest for nature and birds and motivated to follow his vocation. His ringing project, financed by the PACS Small Grants Programme, exemplifies this: he encouraged students to participate in the project as much as possible, and many of those that did are now active ornithologists, working in conservation or research.

Records from Guillermo's travels throughout Chile have added greatly to the knowledge of the distribution and behaviour of Chilean birds. He determined the importance for birds of wetlands in the centre of the country and has provided valuable data about rare and threatened birds. Barely a single


BirdLife

weekend goes by in which he is not either off on or planning some new and exciting excursion.

In 1994 an important phase of his life comes to an end, when he retires from his job as a teacher at the Swiss School. But it gives him immense pleasure to know that he will now have more time to dedicate to his great passion: birds and UNORCH.

For Chilean ornithologists, and for those elsewhere, Guillermo Egli's great love and hard work for birds is an inspiration and an example to follow.


A. Hay/RSPB

*Dr Christoph Imboden (left) receives the RSPB Conservation Medal from RSPB Chairman Professor John Lawton.*

## Environmental awards for Director-General

Dr Christoph Imboden, BirdLife International Director-General, received two very prestigious awards recently. The RSPB Conservation Medal is awarded for services to conservation, and in Dr Imboden's case, was particularly for the development of BirdLife International into a strong, global partnership of organisations. The Gaia Award, made by the Rassegna Internazionale di Cultura Contemporanea in Sicily, is given to people or institutions that have made a significant international contribution to environmental preservation, natural or socio-cultural. Her Royal Highness Princess Maha Chakri Sirindhorn of Thailand also received the award this year.

Dr Imboden said 'Both these awards should in fact be made to BirdLife as a whole – the entire network and the dedicated staff – without whom none of the achievements for which we have been recognised would have been possible'.

## 80th birthday celebration

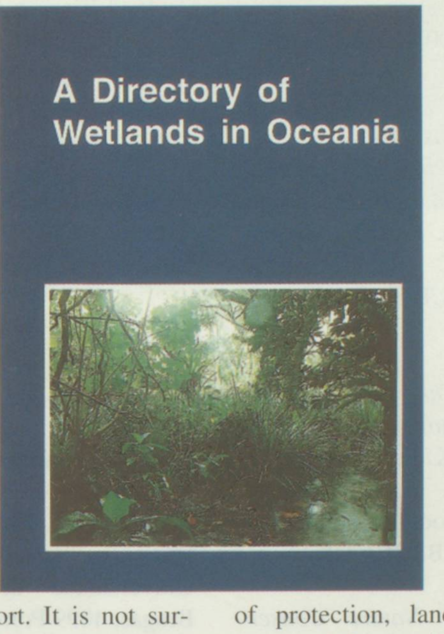
The 80th birthday of Dillon Ripley, President of BirdLife International (then ICBP) for 25 years from 1958 to 1983, was celebrated in Washington on 19 September, 1992. A special birthday dinner party took place at the S. Dillon Ripley Centre of the Smithsonian Institution (Dillon was chief executive of the Smithsonian for 21 years). The event also raised money for the S. Dillon Ripley Library Endowment, which supports the library programme at the Institution.

The dinner party was chaired by, amongst others, Anne Armstrong, former American Ambassador to the Court of St James, and Elliot Richardson, former US Attorney General, and was attended by about 250 guests from eight or nine different countries. Unfortunately, the guest of honour was at the last minute unable to attend due to illness, but he was ably represented by his three daughters, who spoke on his behalf.

# A directory of wetlands in Oceania

*edited by D. A. Scott. International Waterfowl and Wetlands Research Bureau and Asian Wetland Bureau, Slimbridge, UK and Kuala Lumpur, Malaysia, 1993. xvii + 444pp, 16 maps, £25 from IWRB + postage and packing £4.50 (UK), £10 (Europe), £12 (outside Europe) (pb).*

The continuing world-wide destruction of natural habitats and the resulting increase in the numbers of threatened species, local extirpations and even global extinctions has put the conservation of the world's biodiversity more prominently on the political agenda. In particular, forests are being recognised as important species-rich ecosystems and are receiving more conservation attention (in some parts of the world) than ever before. Wetlands, on the other hand, are often neglected, despite being very important for the diverse flora and fauna which they too shelter and support. It is not surprising, then, that wetlands are classed amongst the world's most threatened habitats.




In Oceania, where increasing populations on small islands threaten ecologically sustainable development of all natural resources, little conservation attention has been afforded to wetlands in the past. Thus the promotion of wetland conservation and their sustainable utilisation is one of the (many) objectives of the South Pacific Regional Environment Programme (SPREP) Action Plan for 1991–1995. The publication of A directory of wetlands in Oceania is the first step in the development of an effective wetland conservation strategy for the region and provides a basis for action.

Wetlands from 25 political entities are included, from Palau and the Solomon Islands in the west to Easter Island in the east, and from the Mariana and Hawaiian islands in the north to New Caledonia and French Polynesia in the south. A short chapter on Papua New Guinea is also included.

The format of the book is similar to that of earlier wetland directories, consisting of a series of national reports. Each begins with an introduction that summarises the general situation of the wetlands and provides information on the institutional and legal base for wetland conservation and research. Then follows a series of accounts of those wetlands that are known or thought to be of greatest importance from the point of view of nature conservation. The site descriptions include basic information on size, location, physical and ecological features, ownership, degree of protection, land use, noteworthy flora and fauna, threats and conservation values.

Scott recognises that the comprehensiveness of the country reports varies greatly, from the very thorough, as in the cases of American Samoa, Guam and the Northern Mariana Islands, to the very preliminary, as in the cases of the Cook Islands, Fiji, French Polynesia, New Caledonia, the Solomon Islands and Tonga. Nevertheless the compilation of these wetland data represents a very important achievement, not only in drawing together the available information, but also in providing the stimulus to complete detailed national wetland inventories in the future.

**Alison Stattersfield**

# Just Published

**The Peregrine Falcon** *by D. Ratcliffe. T & A D Poyser, London, 1993. 454pp, £25.00 (hb).* The success story of the recovery of the British and Irish Peregrine Falcon populations and their restoration in other countries where organochlorine pesticides had also been used.

**Birds in Brazil: a natural history** *by H. Sick. Princeton University Press, Princeton, New Jersey, USA, 1993. 703pp (plus plates), £70.00 (hb).* Lists every Brazilian species, with accounts for most. Problems of conservation, the composition of the avifauna in relation to geography and the history of Brazilian ornithology are also discussed.

**Nesting birds of the coastal islands: a naturalist's year on Galveston Bay** *by J. C. Dyes. University of Texas Press, Austin, Texas, USA, 1993. 160pp, $24.95 (hb).* Twenty two species of colonial wading birds, gulls and terns of the Gulf coast are observed through a one year nesting cycle, in a month-by-month account.

**Natural history of Seram, Maluku, Indonesia** *edited by I. D. Edwards, A. A. Macdonald and J. Proctor. Intercept, Andover, UK, 1993. 240pp, £42.50 (hb).* The first book to cover the findings of a Raleigh International scientific expedition. Information on a variety of aspects of Seram, including avifauna, mammals and human impact.

**The private life of James Bond** *by D. R. Contosta. Sutter House, Lititz, Philadelphia, USA, 1993. 130pp, $16.95 (hb).* The biography of naturalist James Bond (1900–1989), covering his childhood in Wales and England, his early life in the Caribbean and his lifelong association with Philadelphia's Academy of Natural Sciences.

# Just Published

**The Great Tit** *by A. Gosler. Hamlyn, London, 1993. 128pp, £9.99 (pb).* **Finches and sparrows: an identification guide** *by P. Clement, A. Harris and J. Davis. Christopher Helm, London, 1993. 500pp, £29.99 (hb).* **Waterbirds: birds of southern Africa's wetlands** *by N. Dennis and W. Tarboton. New Holland, London, 1993. 137pp, £29.99 (hb).* **Illustrated guide to the birds of southern Africa** *by I. Sinclair, P. Hockey and W. Tarboton. New Holland, London, 1993. 426pp, £19.99 (hb).* **Las aves de la provincia de Buenos Aires: distribucion y estatus** *by T. Narosky and A. G. di Giacomo. Asociacion Ornitologica del Plata, Buenos Aires, 1993. 127pp (pb).* **The birds of Chile** *by B. Araya and S. Chester. Latour, Santiago, 1993. 400pp (pb).* **Great Auk islands: a field biologist in the Arctic** *by T. Birkhead. T & A D Poyser, London, 1993. 275pp, £22.00 (hb).* **The birds of the island of Chios, Greece** *by J. Choremi, C. Dimitris and V. Spinthakis. Municipality of the city of Homeroupolis, Chios, 1993. 128pp (pb).* **A world checklist of birds** *by B. L. Monroe and C. G. Sibley. Yale University Press, New Haven, 1993. 393pp, £35.00 (hb).* **A supplement to distribution and taxonomy of birds of the world** *by C. G. Sibley and B. L. Monroe. Yale University Press, New Haven, 1993. 108pp, £19.95 (pb).* **World checklist of threatened birds** *compiled by the World Conservation Monitoring Centre. Joint Nature Conservation Committee, Peterborough, UK, 1993. 308pp, £26 (pb).* **Bird population studies** *edited by C. M. Perrins, J. D. Lebreton and G. J. M. Hirons. Oxford University Press, 1993. 683pp, £25.00 (pb).* **The birdwatcher's yearbook and diary 1994** *edited by J. E. Pemberton. Buckingham Press, Maids Moreton, UK, 1993. 320pp, £11.50 (pb) (available post free from publishers).* **Applied ecology** *by E. I. Newman. Blackwell, Oxford, 1993. 328pp, £17.50 (pb).* **Biogeography: an ecological and evolutionary approach** *by C. B. Cox and P. D. Moore. Blackwell Scientific Publications, Oxford, 1993. 326pp, £16.50 (pb).*

## DIARY DATES

**17–26 January 1994** *IUCN General Assembly.* Buenos Aires, Argentina. Further information from IUCN, Rue Mauverney 28, CH-1196 Gland, Switzerland.

**20–24 March 1994** *The Role of NGOs in Protecting the Environment* and **25 March–10 April 1994** *SPNI Annual International Seminar on Environmental Education, Conservation and Public Action.* Elat, Israel. Further information from SPNI International Conference and Seminar Coordinator, 4 Hashfela Street, Tel–Aviv 66183, Israel.

**25 April–13 May 1994** *Life Zone Ecology Course.* San José, Costa Rica. Further information from Dr Humberto Jiménez Saa, Tropical Science Center, PO Box 8-3870-1000, San José, Costa Rica.

**2–8 May 1994** *Coastal Conservation and Management of the Baltic Region.* Multi-site conference, starting and ending in Riga, Latvia. Further information from EUCC Baltic Office, Kareiviniu gt.4-7, LT-5800 Klaipeda, Lithuania.

**5–6 May 1994** *The Biogeography, Ecology and Prehistory of the Pitcairn Islands.* London, UK. Further information from Dr M. de L. Brooke, Department of Zoology, Downing Street, Cambridge CB2 3EJ, UK.

**15–20 May 1994** *Nature Conservation: the Role of Networks.* Geraldton, Western Australia. Further information from Dr D. Saunders, CSIRO Division of Wildlife and Ecology, LMB No. 4, PO Midland, Western Australia 6056.

**12–18 August 1994** *BirdLife International 21st World Conference.* Rosenheim, Germany. Further information from Bayer. Akademie für Naturschutz und Landschaftspflege (ANL), BirdLife International World Conference, Postfach 1261, D–8229 Laufen/Salzach, Germany.

**20–25 August 1994** *21st International Ornithological Conference.* Vienna, Austria. Further information from IOC Interconvention, Friedrichstrasse 7, A–1043 Vienna, Austria.

**20–26 August 1994** *6th International Congress of Ecology.* Manchester, UK. Further information from The Secretary, VI International Congress of Ecology, The Manchester Conference Centre, UMIST, PO Box 88, Manchester, M60 1QD, UK.

**26–29 September 1994** *Littoral '94 – European Coastal Zone Association for Science and Technology Second International Symposium.* Lisbon, Portugal. Further information from Associação Eurocoast-Portugal, a/c Instituto de Hidráulica e Recursos Hídrocos, Faculdade de Engenharia-Universidade do Porto, Rua dos Bragas, 4099 Porto CODEX, Portugal.

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## Shoebill

*by David C. Houston*

This huge, extraordinary species is so unique it is classified by some in a family of its own. Widely but very locally distributed through the swamps of eastern and central Africa, the Shoebill uses its heavy bill to feed on fish and other aquatic vertebrates. In most of its range, it is suffering from development and disturbance from the burgeoning human populations in the region, and it is considered to be globally threatened.

This photograph is just one from the extensive and comprehensive archives of colour transparencies covering the natural world held by the Bruce Coleman Wildlife and Travel Collection. Bruce Coleman is pleased to continue to support conservation initiatives for the world's globally threatened bird species through BirdLife International

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

### Volume 2: The Islands

Wildlife Trust of India

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Eds: Rahul Kaul and Vivek Menon

Wildlife Trust of India
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To V R Sankaran and Sarasa Sankaran from the Author R. Sankaran assisted by Rajyashree and Yamini

**Wildlife Trust of India (WTI)**
A-220 New Friends Colony
New Delhi -110065
India

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 wildlife rescue and rehabilitation.

**International Fund for Animal Welfare (IFAW)**
International Headquarters:
411 Main Street,
Yarmouth Port,
MA, 02675, USA

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.



*In collaboration with:*

**Salim Ali Centre for Ornithology and Natural History**
Anaikatty P.O.,
Coimbatore
Tamil Nadu-641108

Sálim Ali Centre for Ornithology and Natural History (SACON) is an autonomous centre of excellence aided by the Ministry of Environment and Forests, Government of India and is a registered society. SACONs objectives are primarily to study India's biological diversity so as to promote its conservation. Since 1992, SACON has been studying the avifauna of the Andaman and Nicobar Islands and advocating sustainable development and the conservation of this hot spot of endemism.

Andaman and Nicobar Environmental Team (ANET)
**Madras Crocodile Bank Trust**
Post Bag 4,
Mamallapuram,
Tamil Nadu-603104

The Madras Crocodile Bank is a trust started in 1976 with the main objectives of creating awareness about crocodiles and their role in the environment. ANET, a division of the Madras Crocodile Bank/Center for Herpetology, is studying and helping to protect the unique biodiversity of the ecologically rich and fragile Andaman and Nicobar Islands, where a quarter of the flora and fauna is endemic.

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# FOREWORD

भारत सरकार
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MINISTRY OF ENVIRONMENT & FORESTS

सत्यमेव जयते


**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 b ecame a pparent v ery 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।।*


पर्यावरण भवन, सी.जी.ओ. कॉम्पलैक्स, लोदी रोड़, नई दिल्ली-110003
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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 megapodes. 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<br>
Executive Director<br>
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 run up 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 the 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 freshwater 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 the 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 of the Earthquake and the Tsunami on the Nicobar Islands

**R. Sankaran**

**The earthquake and tsunami have changed the coastline, destroying promontories, straightening smaller indentations and joining adjacent bays**

## The Nicobar Islands

The Andaman and Nicobar islands in the Bay of Bengal are peaks of a submerged mountain range arching from Arakan Yoma in Burma in the north to Sumatra in Indonesia in the south, between latitudes 6°45' and 13°41' and longitudes 92°12' and 93°57' (Saldanha 1989, Dagar *et al.* 1991), and are a southern extension of the Arakan Yoma mountain range. The island group comprises over 300 named and unnamed islands and over 260 named and unnamed rocks (Singh 1981), with a total coastline of about 1,962 km. The entire island group covers 8,249 $km^2$, the Andaman group with over 325 islands (21 inhabited) covering 6,408 $km^2$, and the Nicobar group with more than 24 islands (12 inhabited) with an area of 1,841 $km^2$ (Figure 1).

The Nicobar Islands (Figure 1), can be divided into three distinct subgroups. To the south is the Great Nicobar group consisting of two islands larger than 100 $km^2$, nine islets smaller than five $km^2$, and a few rocks. Four islands are inhabited. The human population on Great Nicobar (6831 people) has both tribal (8%) and mainland Indians. The tribals are thinly distributed along the southern, western, and northern coasts. Fifty-five

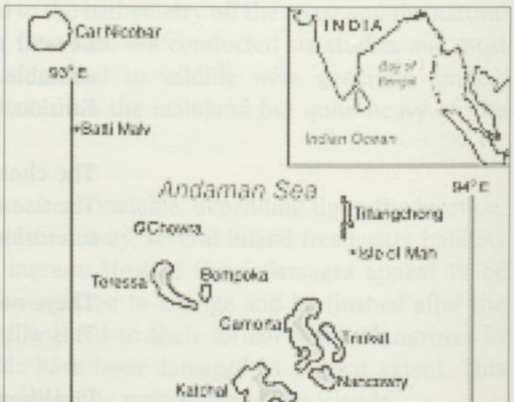


**Figure 1: The Nicobar Islands**

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percent of the mainlanders are in the township Campbell Bay midway up the east coast, and the remaining pursue agrarian livelihoods along the south-eastern coast. Little Nicobar has no mainland settlers and the tribals are distributed all around the island. Kondul and Pulo Milo are inhabited islets. Meroe, Treis, Trak, Menchal, Megapode, Kabra and Pigeon are uninhabited islets.

About 58 km north of the Great Nicobar group is the Nancowry group, which consists of three islands larger than 100 $km^2$, two of 36 and 67 $km^2$, three less than 17 $km^2$, two islets and a few rocks. Seven islands in this group are inhabited with a population of 12,464 people comprised of both tribals (64%) and mainlanders. The tribals are distributed all around the islands. Mainlanders do not own land in the Nancowry group, and about 80% are either employed by Government Agencies, Tribal Cooperative Societies or trade sectors. About 20% of mainlanders in the Nancowry group are Sri Lankan repatriates who have been settled on Katchall and who work on the 600-hectare rubber plantation there. Tillanchong and the Isle of Man are the only uninhabited islands of the group.

The northern most subgroup comprising of Batti Malv and Car Nicobar is 88 km north of the Nancowry group. Batti Malv is uninhabited and Car Nicobar has a population of over 19,000 people, 80% of whom are tribals. The mainlanders are mainly employed in Government and trade sectors.

The climate of the islands can be defined as humid, tropical coastal climate. Proximity to the equator and the sea ensures a hot, humid, and uniform climate (Saldanha 1989). The islands receive rainfall from both the southwest and northeast monsoons. Maximum precipitation is between May and December, the driest period being between January and April. The mean annual rainfall is about 3800 mm (Saldanha 1989). Temperature variations are low from a minimum of 20°C to a maximum of about 32°C (Dagar *et al.*, 1991).

## People

The Nicobar Islands were colonised by people of mongoloid origin 'sometime before the Christian era' (Singh 1978). Two distinct groups of people are present. The Nicobaris, who are essentially horticulturists, inhabit the coast of 12 islands in the Nicobars with dialectic and cultural variations between different islands and island groups (Figure 2). The Shompen are essentially an interior forest dwelling tribe and only inhabit Great Nicobar .

Between the 1600s and the mid 1800s, the Danes made several unsuccessful attempts at colonising the Nicobar Islands and in 1848, formally renounced claims of sovereignty. In 1869, the British announced the occupation of the Nicobar Islands and briefly established a penal settlement on Camorta. During World War II, the Japanese occupied the Andaman and Nicobar Islands between 1942 and 1945. With Independence, the Andaman and Nicobar Islands became a part of the Republic of India.

While most Nicobar Islands have been designated as tribal areas under the Andaman & Nicobar Islands Protection of Aboriginal Tribes Regulation (1957), there has been colonisation and a continuing inflow of mainlanders. The settlement of ex-servicemen in Great Nicobar began in 1969 and 337 families were settled for which 1499.65 hectares of forest was cleared on the south-eastern coast of Great Nicobar, each family receiving 4.45 ha (Saldanha 1989). However, the actual loss of forest was far more because of the construction of roads (the North South road is 51 km long, with settlements up to 35 km, and the East-West road is 41 km long with settlements up to 8 km). In the early 1970s, 268 Sri Lankan repatriates were settled in Katchall and necessary infrastructure was built. Over time, there was a rapid growth in the labour, fishing and trading sector. Thus, there was no inhabited island in the Nicobar Islands, which was free of mainland influences. Every island, and most tribal villages had some form of mainland activity and included powerhouses to generate electricity, schools, primary health centres, mainland fishermen or other floating mainlanders who stopped by and used resources of, traded with or worked for the Nicobaris.


**Figure 2: A Nicobari on Tillanchong, 1994**

## Vegetation

The forest type of the Nicobar Islands can be broadly classified as tropical evergreen, with minor variations from north to south depending on rainfall, type of soil and degree of salinity

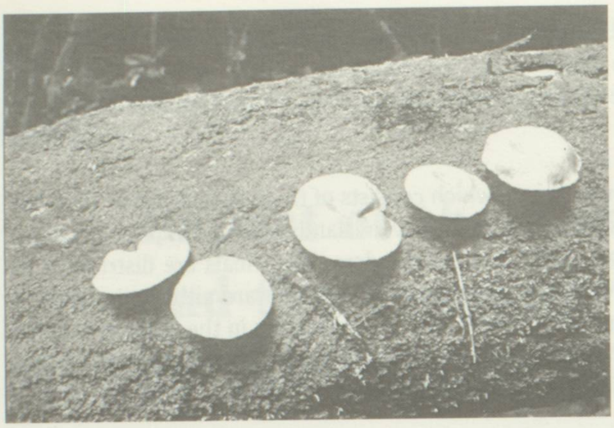


Figure 3: Fungi on Great Nicobar

Figure 4: Ayoum Bay, Great Nicobar

(Balakrishnan 1989). Since most shorelines of the Nicobar Islands face open seas, are not sheltered, and are relatively deep waters, mangroves dominated by *Rhizophora mucronata, Bruguiera gymnorhiza*, and *Heriteria littoralis*, with its associate *Nypa fruticens* were present in patches and as thin fringes on Great Nicobar, Little Nicobar and Car Nicobar, and as larger stands on Camorta, Nancowry, Trinkat and Katchall Islands.

The islands are covered with tropical evergreen forests that start from the beaches where strand formations includes *Ipomoea pescaprae*, followed by *Scaveola sericea.* In retreating coastlines, Baringtonia formations dominate. This is then followed by littoral forests, which are dominated by *Henrnandia peltata, Thespesia populnea, Manilkara littoralis, Hibiscus tiliaceus, Terminalia spp. Artocarpus spp.* and *Sterculia spp.* Stands of *Casuarina equisetifolia* also occur in some coastal areas. *Pandanus spp*. occurred in large numbers in this belt and often formed dense stands. The lowland areas which tend to get inundated during the rains, are dominated by *Syzigium spp., Myristica spp., Atalantia alabarica* and *Baccaurea sapida.* Such areas also have dense stands of naturally occurring Arecanut. In lowland and riverine areas, grasslands also occur and these are dominated by *Coix lacrym, Coelorachis glandulosa* and *Phragmites karka*.

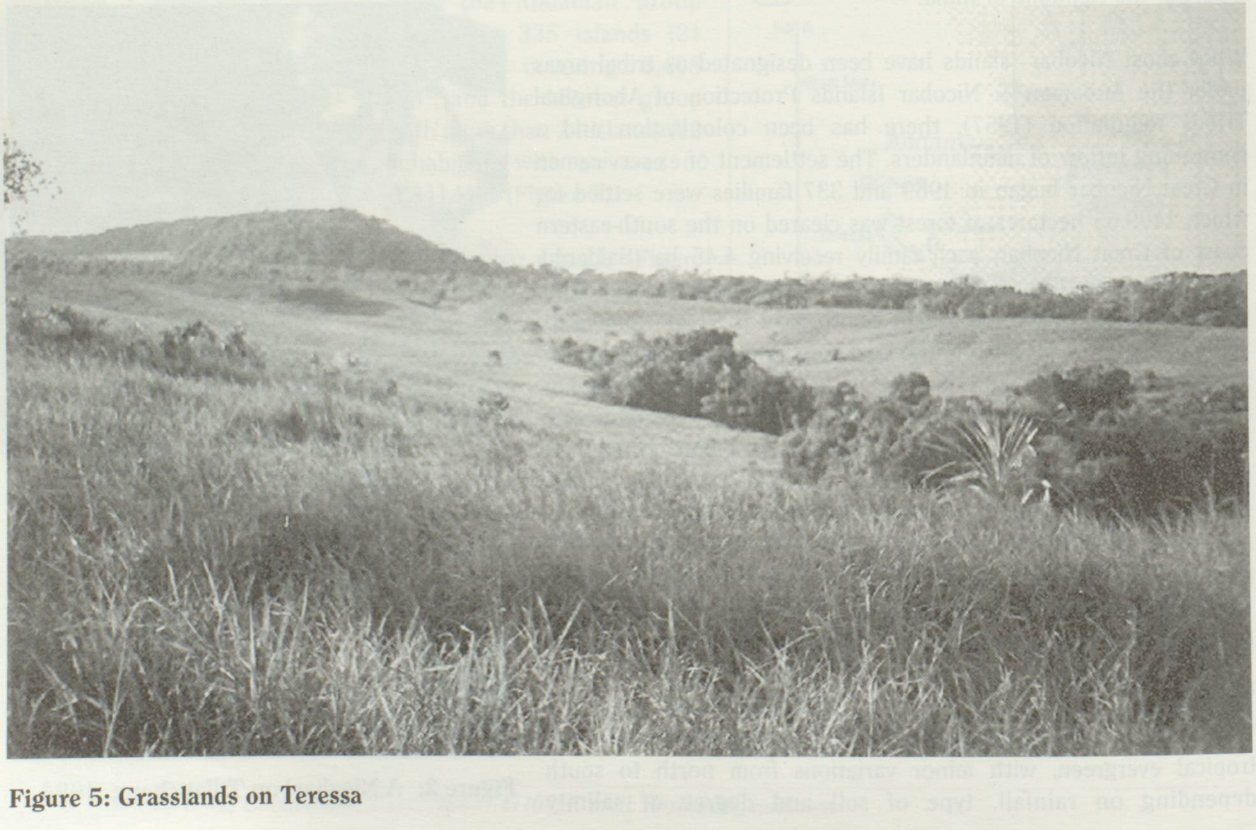


Figure 5: Grasslands on Teressa

The hills are dominated by Andaman evergreen, mixed evergreen and moist deciduous forests which have species, such as *Acronychia pedunculata, Morus macroura, Mussaenda macrophylla, Xanthophyllum vitellinum, Terminalia spp., Calophyllum soulattri, Sideroxylon longipetiolatum, Garcina xanthochymus, Pisonia excelsa* and *Mangifera sylvatica.*

The habitat characteristics of the islands vary. In the Great Nicobar group, all islands are completely forested. A small proportion of the coast of the larger islands was mangrove. In the Nancowry group of islands, the central portion of all islands, excepting Katchall and Tillanchong, are grasslands (over 60% of Trinkat and Teressa, 30-50% of Camorta and at least 20% of Nancowry and Bompoka), often extending to the coast itself (Figure 5). These grasslands are dominated by *Trema orientalis, Zizyphus oenoplia, Cajanus scarabaeides, Carex cruciata, Carex cryptostachys, Cassia mimosoides, Chrysopogon aciculatus, Cissuss spp. Desmodium heteropogon* and *Phragmites karka.* Various explanations exist for the occurrence of these grasslands, primarily that they are man made. However, there is no historic evidence that colonisers cleared forests for animal husbandry. Indeed, the existence of the endemic Nicobar Blue Breasted Quail *Coturnix chinensis trinkutensis* in these grasslands is an indication that these grasslands are so old that not only did colonisation take place, but speciation occurred as well. Within the grasslands there are patches of forest. A substantial area of the coast of Camorta, Trinkat and Nancowry was mangrove.

The vegetation of the Nicobars shows striking dissimilarities with that of the Andamans. The genera *Dipterocarpus* and *Pterocarpus,* widespread in the Andamans, are not present in the Nicobars. Genera, such as *Cyathea, Otanthera, Astronia, Cyrtandra, Stemonurus, Bentinckia* and *Rhopaoblate* present in the Nicobars are absent in the Andamans (Balakrishnan 1989).

## Endemism

Of the 5,357 species of fauna covering all major groups recorded by Rao (1989), 487 (9%) are endemic. If marine species are excluded (none of which are endemic), 13% (487 of 3,704) are endemic. Endemism is very high in some faunal groups such as birds where 39% of the 270 species and subspecies recorded from the islands are endemic (Abdulali 1964a, 1964b, 1966, 1967, 1971,1974,1978, Das 1971, Dasgupta 1976, Ripley 1982). Other vertebrates also show high degrees of endemism; 60% of 58 species of mammals, 31.94% of 83 species of reptiles and 20% of 10 species of amphibians recorded are endemic (Rao 1989). High endemism is also seen in the flora; of the 1,454 taxa of angiosperms, 221 are endemic, 60 of which are only known from type specimens and 22 only from type localities (Rao 1986, Balakrishnan 1989).

There are significant differences in the faunal profiles of these two groups, although they remain largely similar. For instance, the Blyth's Nicobar parakeet *Psitaculla caniceps* occurs on Great Nicobar, Little Nicobar, Kondul and Menchal but is absent in the Nancowry group. The Nicobar bulbul *Hypsipetes nicobariensis* is present in the Nancowry group but is absent in the Great Nicobar Group. The Nicobar megapode occurs as two distinct subspecies; *Megapodius nicobariensis nicobariensis* in the Nancowry group and *M. n. abbotti* in the Great Nicobar group. The Nicobar racket-tailed drongo occurs on Great and Little Nicobar, Katchall, and Car Nicobar, but is absent on other islands of the Nancowry group. The differences are also evident in the herpetofauna; pit vipers are common on the Nancowry group but have not been recorded from the Great Nicobar group. The endemic Nicobar crab eating macaque is present only on Great Nicobar, Little Nicobar, and Katchall.

## Protected Areas

Three islands in the Nicobar group, Tillanchong, Batti Malv and Megapod Island, all uninhabited, are wildlife sanctuaries. Great Nicobar is a Biosphere Reserve (885 km$^2$) whose core area consists of two National Parks, the Galathea National Park (110 km$^2$) and the Campbell Bay National Park (426 km$^2$).

## On Tsunamis

The term tsunami is from Japanese, meaning harbour (tsu) and wave (nami), and was coined by fishermen who returned to port to find the harbour devastated, although they had not been aware of any wave in the open water. A tsunami consists of a series of waves generated when water is rapidly displaced on a massive scale. Earthquakes, landslides, volcanic eruptions and large meteorite impacts all have the potential to generate a tsunami, which can range from unnoticeable to devastating. However, the most common cause is an undersea earthquake where the abrupt deformation of the seafloor vertically displaces the overlying water. Such large vertical movements of the earth's crust can occur at plate boundaries where denser oceanic plates slip under continental plates resulting in subduction earthquakes.

Waves are formed as the displaced water mass moves under the influence of gravity to regain its equilibrium and radiate across the ocean like ripples on a pond. A tsunami is not a sub-surface event in the deep ocean; it simply has much smaller amplitude offshore, and a very long wavelength (often hundreds of kilometres long), which is why they generally pass unnoticed at sea, forming only a passing hump in the ocean. Unlike wind-driven waves, a tsunami is a new and suddenly higher sea level, which manifests as a shelf or shelves of water. The leading edge of a tsunami resembles a breaking wave but behaves differently: the rapid rise in sea level, combined with the weight and pressure of the ocean behind it, has far greater force.

Tsunamis are phenomena which move the entire depth of the ocean (often several kilometres deep) rather than just the surface, so they contain immense energy, propagate at high speeds and can travel great transoceanic distances with little overall energy loss. A tsunami can cause damage thousands of kilometres from its origin, so there may be several hours between its creation and its impact on a coast, arriving long after the seismic wave generated by the originating event arrives. Although the total or overall loss of energy is small, the total energy is spread over a larger and larger circumference as the wave travels, so the energy per linear meter in the wave decreases as the inverse power of the distance from the source. A single tsunami event may involve a series of waves of varying heights; the set of waves is called a train. In open water, tsunamis have extremely long periods (the time for the next wave top to pass a point after the previous one), from minutes to hours, and long wavelengths of up to several hundred kilometres.

The wave travels across the ocean at speeds from 500 to 1,000 km/h. As the wave approaches land, the sea shallows and the wave no longer travels as quickly, so it begins to 'pile-up'; the wave-front becomes steeper and taller, and there is less distance between crests. On reaching landfall, the wave dissipates its tremendous force and quantity of seawater, which causes the devastation normally associated with such an event.

### History of Earthquakes and Tsunamis in the Andaman & Nicobar Islands

Earthquakes are a common feature in the Andaman-Sumatra section of the subduction zone. Mild to moderate tremors frequently occur and many more destructive earthquakes have also occurred, a few of which have also generated tsunamis. However, tsunamis are rare and those documented are, 31 October 1847 on Great Nicobar Island, 31 December 1881 on Car Nicobar Island, and 26 June 1941 in North Andamans. Other tsunamis may have affected the islands, and these could include the earthquake on the Andaman off-shore on 28 January 1679, the M 8.7 earthquakes of 1833, the M 8.5 earthquake of 1861, the earthquakes of 31 December 1881 and 26 August 1883 when Krakatoa exploded. The most recent tsunami, on a small scale, occurred in 1988, sweeping over the breakwater at Campbell bay, killing three people.

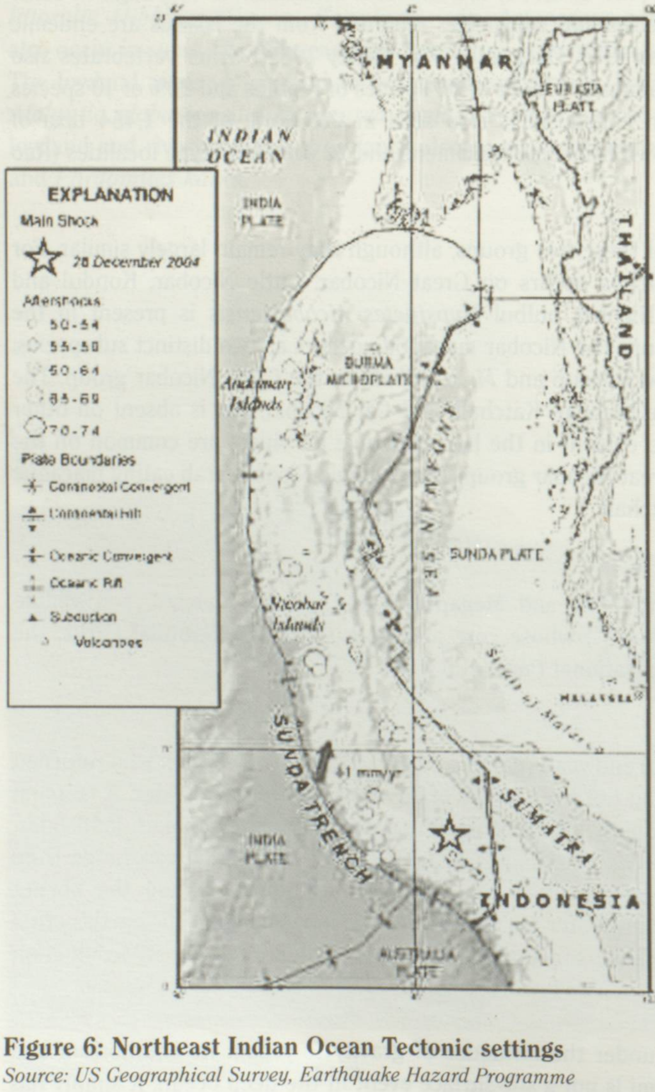



**Figure 6: Northeast Indian Ocean Tectonic settings**
*Source: US Geographical Survey, Earthquake Hazard Programme*

There appears to be little or no memory of tsunamis amongst the Nicobaris. The only one that I could ascertain was of an unusually large wave that washed a house down along the shore of Kondul Island some years ago, possibly the 1988 event (Manish Chandi *pers. comm.*). Two rocks on Little Nicobar are associated with the legend of a village washed away by the sea (Manish Chandi *pers. comm.*), and there are references to large waves in songs (Mathew Crispin *pers com.*). It is therefore certain that tsunamis of the recent past, at least over the last two or three centuries, have been small and have not caused significant damage as this would then have been both in the memories of the Nicobaris, and been reflected in the coastal vegetation. In any case, the 26th December 2004 tsunami is unprecedented in terms of its scale and reach, and cannot be compared to its smaller preceding historical events.

## The Great Earthquake of 2004

Tsunamis have been of little concern to Indians, since the Indian coast was affected by tsunamis only five times during the last 122 years (1883-2004), while in contrast, in the Pacific Ocean, the frequency of tsunamis is five per year (Sadhuram 2005). The earthquake of December 26th 2004, originated along the boundary between the Indo-Australian and Eurasian plates, which arcs over a distance of 5500 km from Myanmar to Sumatra and Java to Australia. This was the largest earthquake to have occurred in the region since historic times (Rajendran *et al.* 2005), and the fourth largest ever recorded. This boundary, forms part of the western extremity of the Pacific Rim of Fire, also known as the Ring of Fire, and is characterized by volcanoes and subduction zones, friction from which often produces large destructive earthquakes.

The earthquake of magnitude 9.15 (variably reported from M 6.8 to 9.3), had its epicentre at 3.29°N and 95.94°E off the coast of Sumatra with a focal depth of 30 km on 26th December 2004 at 06:28:50 AM (IST) (Chaddha, 2005). The earthquake occurred at the interface between the India and Burma plates (Figure 6). The India Plate is part of the great Indo-Australian Plate, which underlies the Indian Ocean and Bay of Bengal, and is drifting northeast at an average of 6 cm/year. The India Plate meets the Burma Plate (which is considered a portion of the great Eurasian Plate) at the Sunda Trench. At this point, the India Plate subducts the Burma Plate, which carries the Nicobar Islands, the Andaman Islands and northern Sumatra.

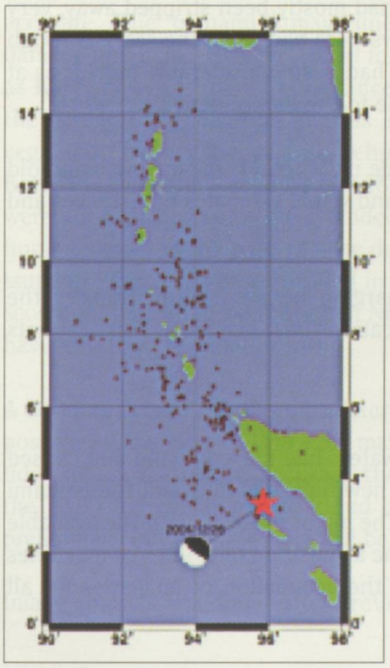



**Figure 7: Location of aftershocks greater than M5**

'The earthquake was unusually large in geographical extent. An estimated 1200 km of faultline slipped about 15 m along the subduction zone where the India Plate dives under the Burma Plate. The slip did not happen instantaneously but took place in two phases over a period of several minutes. The first phase involved the formation of a rupture about 400 km long and 100 km wide, located 30 km beneath the seabed–the longest ever rupture known to have been caused by an earthquake. The rupture proceeded at a speed of about 2 km/s or 7200 km/h, beginning off the coast of Aceh and proceeding northwesterly over a period of about 100 seconds. After a pause of about another 100 seconds, the rupture continued northwards towards the Andaman and Nicobar Islands. However, the northern rupture occurred more slowly, reducing the speed of the water displacement and so reducing the size of the tsunami that hit the northern part of the Indian Ocean. In addition to the sideways movement between the plates, the seabed is estimated to have risen by several metres, displacing an estimated 30 km$^3$ of water, triggering the tsunami waves. The waves did not originate from a point source, but radiated outwards along the entire 1,200 km length of the rupture. This greatly increased the geographical area over which the waves were observed, reaching as far as Mexico, Chile and the Arctic. The raising of the sea bed significantly reduced the capacity of the Indian Ocean, producing a permanent rise in the global sea level by an estimated 0.1 mm.' (source: Wikipedia, 2005).

Over 200 aftershocks greater than M 5 occurred off the Andaman and the Nicobar Islands and the region of the original epicentre in the hours and days that followed (Figure 7). The largest aftershock was 8.7 epicentred off the Sumatran Island of Nias. Other aftershocks up to magnitude 6.6 continued to shake the region on a daily basis. After a lull with only a few minor tremors over several months, a M 7.2 quake occurred off the shore of the Nicobar Islands on the 24th of July 2005, indicating that the region continues to be seismically volatile. This seismic activity resulted in Barren Island erupting once again. Narcondam, an extinct volcano, is also showing signs of volcanic activity.

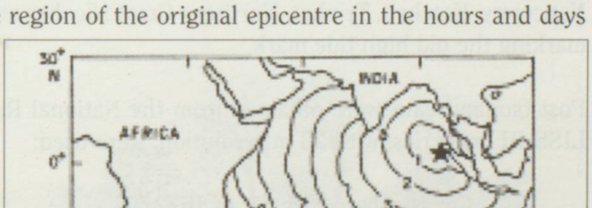



**Figure 8: Travel time of the tsunami, from the epicentre (star) in hours in the Indian Ocean.**
*Source NOAA*

The earthquake occurred on 26th December 2004 at 06: 28: 50 hrs. The tsunami that followed, was within a few minutes of the earthquake (probably within 15 minutes) at Galathea Bay, Southern Great Nicobar, reaching Port Blair at 07:25 hrs. The sea appears to have receded first, exposing the seabed for considerable distances. This can be accounted for by the nature of tsunamis, which is a series of troughs and crests often as much as 100 km apart. It appears that the trough of the tsunami wave reached the coast first, causing a phenomenon called drawdown, where the sea level dropped considerably. The drawdown was followed by the crest of the wave, which resulted in sea inundating land, also known as the run up (Figure 8). There appears to have been three waves in succession, with the second being the largest. The waters took several, hours to recede completely, leaving in its wake a devastation of unimaginable magnitude.

## Methods

### Field data

Field data was collected through March and April 2005. With the exception of Batti Malv and Meroe, all islands of the Nicobar group of islands were visited and damage visually assessed. Soon after commencement of the survey, it was apparent that in the time available, only very few sites could be covered if empirical data on nature and extent of damage was to be collected. This was compounded by the quantum of debris in littoral areas which made traversing these exceedingly time consuming. It was considered far more worthwhile to circumvent the islands by small boats, and noting visual descriptions and estimates of damage with GPS readings (Garmin 12xl) for location, thus getting an overall picture of the impact of the tsunami in coastal areas. Since the sea was calm for much of the time, the boat was more often than not well within 100 m from the shore, and as the undergrowth had mostly been stripped away, very good views often up to the hill that stopped the tsunami were to be had. Poor views were had when the sea was rough and the boat necessarily had to be diverted away from land. In areas where there had been considerable ingress as at the mouth of rivers due to large amounts of debris, it was not possible to get close to the line of damage.

The information gathered included qualitative assessments of the nature of damage i.e. whether undergrowth and old growth trees were uprooted or intact, whether vegetation was green or scorched, and visual estimates of distances and heights of run up using features to make judgements.

About 250 readings on the GPS were lost due to the memory battery discharging before I could transfer the information. While detailed notes are available against way point numbers, their locations have been lost. This accounts for the `dot-less' sections of coasts on the maps of Great and Little Nicobar.

### Imageries

The objective of the mapping was to determine the extent to which the tsunami waters had moved inland and caused damage. To achieve this, the three lines required were the old high tide line, the new high tide line, and the tsunami damage line. The maps of tsunami damage were derived from satellite imageries. The major problem with the available imageries of the Nicobar Islands is the presence of cloud cover, which precluded the acquisition of cloud-free imageries from the period during which the survey was conducted, as well as precluding the acquisition of imageries for all islands at the same time.

Landsat images from the Global Land Cover Facility at the University of Maryland (http://glcf.umiacs.umd.edu), with a resolution of 30 m were used to determine pre-tsunami status. The imageries however, particularly for Camorta, Nancowry, Katchall, Trinkat, Northern Great Nicobar and Little Nicobar, were very cloudy, resulting in inaccuracies in marking the old high tide mark.

Post tsunami data were obtained from the National Remote Sensing Agency, and the following relatively cloud-free LISS III imageries, with 23 m resolution, were used:

1. Car Nicobar: 116, 67; of 16/2/05
2. Central Nicobar: 116, 68; of 4/1/05
3. Great Nicobar: 116, 67; of 26/2/05
4. Great & Little Nicobar: 116, 69; of 28/1/05 and 28/5/05 to form one composite relatively cloud-free image of the area.

In addition to the LISS III and Landsat digital data for the rest of the Nicobar Islands, for Katchall island, JPEG images of Spot Satellite Imageries of 28th December 2004, which had a resolution of 10 m (for west Bay Katchall) and 20 m (for Katchall Island) from National University of Singapore (CRISP), and 10th July 2004 were also used.

The old and new high tide lines were determined by segregating water from land using an echo spectral spatial classifier in the Multispec remote sensing package. Psuedo training sites were derived on screen demarcating areas that were clearly water, shallow water, and terrestrial vegetation (Biehl 2005).

The line of tsunami damage was determined using Normalized Differenced Vegetation Index (NDVI) calculated from the LISS III data of the Nicobar Islands. NDVI has been used extensively in measuring changes in vegetation since it is a measure of vegetation 'greenness' between imageries. Since the tsunami either destroyed vegetation by physically uprooting them, or because of the low salt tolerance of terrestrial vegetation, were scorched by the inundation of sea water, the drop in NDVI of areas affected by the tsunami was expected to be significant. The use of NDVI provided a standardized method to determine the tsunami damage line. Visual estimation of damage from the imageries could be misleading since affected areas where the canopy continued to be green and continuous were not readily identifiable from the images.

There are limitations, significantly so on some islands, in the use of NDVI to derive the tsunami damage line. Areas with highly salt tolerant or halophylic species will show less response to salt water inundation than less tolerant assemblages. Coconut, which dominate significant parts of the coastal forests of many Nicobar Islands, were most often the only green that was seen in the scorched zone. Thus areas with tolerant species will have estimated inundation lines at shorter distances than areas with low salt tolerance where the inundation lines will be more accurate. The 'tsunami damage line' more accurately reflects damage than inundation. While the fit of the tsunami damage line using NDVI to visual interpretation is very high, as in Great Nicobar, this is not the case on islands such as Katchall where there are instances of considerable difference where the NDVI has not captured areas damaged by the tsunami. The reasons for this are probably (1) tsunami line has been derived from change in NDVI from the vegetation further inland. Due to human impact, NDVIs appear to be low on relatively densely populated islands like Katchall. Thus, the threshold of 0.18 that we used captured heavy and moderate damage, whereas lower damage areas were not captured since these tended to blend in with areas that were not affected by the tsunami but had undergone human impact in the past. (2) The data for central Nicobar is from imageries that were taken only eight days after the tsunami. This could have resulted in both wetness of the soil as well as the presence of vegetation yet to fully manifest scorching indicating no change in NDVI damage. (3) The presence of coconut, which do not undergo scorching, could have also have resulted in this.

A far more accurate line can be determined by comparing the change in NDVI using two sets of imageries both pre and post for all the islands. While for many of the maps, the tsunami damage line, the new high tide line and the old high tide line are reasonably accurate, there are others, where these are obviously erroneous due to problems with using the NDVI as well as due to cloud cover. These errors have not been corrected. These maps can be considered as preliminary outputs and they will be improved upon as the study progresses.

Image analysis was done using ArcView, Image Analyst, Multispec, and Idrisi.

**Near Indira Point, Great Nicobar**

# Impact of the tsunami

## Some observations on the overall patterns of the tsunami

A few overall patterns were evident from the kind of destruction that has taken place in the Nicobar Islands and this appears to be uniform throughout the islands. Some of these observations are listed below:

- The bathymetry of the near-shore waters appears to have played a critical role in the run up levels (Figure 9). Wide shelves of shallow waters resulted in much higher waves, than in areas where the near-shore water was deep. Coasts adjacent to wide shelves that were 30 m or less suffered the worst damage.

- The broad shallow shelf off the west coast magnified the power of the tsunami, and it was on this board that some of the worst damage occurred.

- Nothing stopped the tsunami other than high ground. This varied according to the height of the waves, which ranged between two and about 12 metres. The more commonly encountered run up height was between four and eight metres. Very rarely was the run up greater than 12 m, and at no place was the run up estimated to be over 18 metres. Variations in run up levels were evident with significant differences occurring a couple of 100 metres apart, this probably having to do with the depth of near-shore waters.

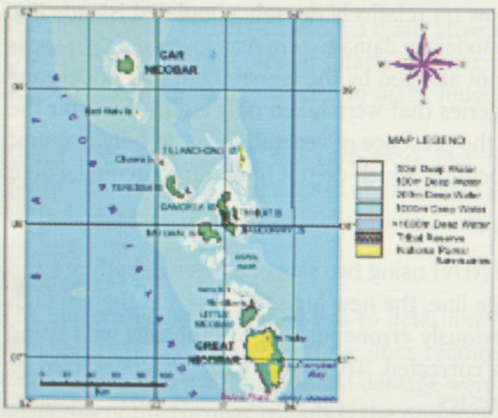



**Figure 9: Bathymetry of the sea around the Nicobar Islands**

- The level of damage was worst at sea level. Thus the tsunami ran up creeks and rivers, and through littoral forests destroying all on the banks and the adjoining flatlands. Mangroves were the worst affected of all habitats, followed by littoral forests. Habitations that were near creeks or adjacent to or behind mangroves suffered the most causalities.

- The damage was amplified several times as uprooted trees acted as battering rams destroying other vegetation and structures before them.

- It often appeared that the receding waves caused as much, if not more damage than the oncoming ones.

- The majority of the vegetation in the littoral forests is not salt resistant. Since the waters took some time to recede, the vegetation between the sea and the tsunami line, had been scorched, and the vegetation was largely leafless. This band was clearly demarcated as a brown band fringing the islands.

- Due to the subduction, the pneumatophores of the mangroves were perennially submerged, making them leafless, and possibly killing them.

- Structures built by humans were invariably razed to the ground.

The tsunami has completely destroyed or significantly damaged all vegetation that existed in the coastal area between the beach and the hill, up to a height of 10-12 m asl, and at a few places higher still, this depending on the run ups.

The earthquake and tsunami has changed the coastline, destroying promontories, straightening smaller indentations, and joining adjacent bays. Receding coastlines, and deep sheltered bays that resulted in the formation of vegetation stands like mangroves or *Barringtonia,* have been straightened out or the bays significantly widened. In some cases, bays have merged, with the promontories in between fragmented into islets. Coastlines have receded towards the hills, at places by several hundred metres, often resulting in very little or no land between the hills or high ground and the sea. Several new islands have been broken off the main islands.

The worst affected of habitats were those at sea level, The mouths of creeks and rivers, and up to the hills they originate from were completely denuded of vegetation. Thus mangroves, Nypa formations, riverine vegetation along nallahs and tidal creeks were the worst affected where over 90% of these have been physically uprooted, and in many areas there is no sign that mangroves and their associates were present.

**Figure 10: Significant damage to coastal vegetation on Great Nicobar**

Equally badly affected were the freshwater wetlands and marshes that occurred at several places in the coastal areas of the islands. Apart from turning these freshwater bodies saline or brackish, some of these are now part of the sea. In some cases this may be temporary, as beach formation and subsequent rains may flush them out. The vast majority, however, have probably turned perennially saline since the sinking of the islands has resulted in many being well below sea level, and the wave action opened up channels that allow sea water to enter during high tides.

Littoral forests have been variably damaged. No strand vegetation and less than a dozen Barringtonia have survived the tsunami. The damage by uprooting of trees was enormous, and undergrowth and middle stories were far more likely to get stripped completely than old growth trees. A considerable number of the latter exist, often forming continuous canopies of leafless branches (Figure 10). In the belt that was affected by the tsunami, over 90% of the vegetation has been scorched due to salt stress and is devoid of leaves. Very few trees showed signs of new leaf emerging. Trees that were giving out fresh leaves were likely to be *Ficus spp.,* though other species also were noted as sprouting fresh leaves. In most affected coastlines, the only green was that of coconuts.

Hills have been affected at the bases till run up heights, and in the badly affected areas, the vegetation has been completely stripped to bare ground. In these coasts, the demarcation between the tsunami line and the no impact zone was stark, with the tsunami affected areas scorched brown or devoid of vegetation and the hills above, luxuriant evergreen forests.

Very broadly, four levels of damage could be assigned, these often merging into the other (Table 1). Areas with massive damage were assigned as Category 1. These were typically areas where all the undergrowth and middle stories had been completely stripped, and the vast majority of the old growth trees had been uprooted, leaving huge gaps with bare ground or pile ups of the debris of uprooted vegetation. The very few trees that remained were typically scorched brown.

Areas with heavy damage were assigned as Category 2. These too were typically areas where all the undergrowth and middle stories had been completely stripped away, but there was a greater proportion of old growth trees standing, often with the leafless branches of the canopy showing continuity. Here too, there was typically little or no green vegetation, though some of the trees were sprouting fresh leaves.

**Table 1: Qualitative assessment of damage to different parts of the Nicobar Islands**

| Island | Damage level 1 | Damage level 2 | Damage level 3 | Damage level 4 |
|---|---|---|---|---|
| Great Nicobar | Galathea Bay | `47' - Light hous | Kochindon | East coast |
| | Pulo Bha – Hingl | Pulo Bhabi | East Coast | |
| | Inponchi | Kochindon | | |
| | Alexandra | Kopenheat | | |
| | Dagmar | Pulokunji | | |
| | Pulo Kunji | Pulo Bed | | |
| | Pulo Bed | Retokeil | | |
| | Renhong | East coast | | |
| | Ganges Harbour | Ganges Harbour | | |
| Megapod | Whole island | | | |
| Kondul | South Point (subr | Middle Point | North Point | West & north coast |
| Menchal | | | Western coast | East Coast |
| Little Nicobar | Pulo Panja | Northeast coast | South East Coast | |
| | Laon Lo Reyeh | Southeast Coast | | |
| | North West Coas | Southwest coast | | |
| | | Northwest coast | | |
| Pilo Milo | Whole Island | | | |
| Treis | Whole Island | | | |
| Trax | Whole Island | | | |
| Meroe | West coast? | | | East coast |
| Cabra | | | | Whole Island? |
| Pigeon | | | | Whole Island? |
| Nancowry | | North coast | North coast | North coast |
| | | West coast | West coast | West coast |
| | | East coast | East coast | |
| Camorta | Rumyuk | Bandarkhadi | South Coast | South coast |
| | Ol Hinpun | Dering Harbour | Bandarkhadi | |
| | Pil Pilo | Ol Hinpun | East coast | |
| | Takaroach | West Coast | | |
| | East coast | Kakana | | |
| | | East Coast | | |
| Trinket | West coast | West coast | West coast | |
| | North coast | East coast | East coast | |
| | | North coast | | |
| Katchall | East Bay | Southeast coast | South Bay | Southeast coast |
| | Northwest coast | Northwest coast | Southeast coast | |
| | West Bay | | | |
| Teressa | North coast | East coast | East coast | East coast |
| | West coast | North coast | | |
| | South coast | Enam | | |
| Bompoka | Southwest coast | East coast | Northwest coast | Northwest coast |
| | South coast | Northeast coast | West coast | |
| | | West coast | | |
| Chaura | West coast | West coast | Raiheon | |
| | East coast | East coast | Kwaitasuk | |
| Tillanchong | | Matai Takaru | Cheela | Cheela |
| | | Rehnpap | Lakamuang | Rest of island |
| | | Sadagaal | Matai Takaru | |
| | | Lanai | Rest of island | |
| Isle of Man | | | | Whole Island |
| Paira Rock | | | | Whole Island |
| Car Nicobar | Coastal villages | Rest of the island | | |
| Batti Malv | | | | |

Nb: See text for details on damage levels

Areas with moderate damage were assigned as Category 3. These were typically areas where some of the undergrowth and the middle stories and much of the old growth trees remained intact, though these too were salt scorched and there was little or no green vegetation.

Areas with mild damage were assigned as Category 4. These were typically areas where much of the ground cover or undergrowth as well as middle layers and old growth trees remained. Though these areas too were scorched, considerable proportions of the vegetation remained green.

### Nypa and Pandanus Palms

Two palms, Nypa and Pandanus (Figure 11), present in the islands are important to the Nicobaris since the former is the used for thatch on Great Nicobar, Kondul, Little Nicobar, Pilo Milo, Nancowry, Camorta, Trinket and Katchall, and the latter is an important source of food. These resources have more or less been wiped out, and Table 2 gives locations of sites where these are still surviving. While all types of pandanus have been listed, only some types are eaten. Planting of these species will be required, and sourcing seed/planting material from the plants listed below should ensure that the potential genetic uniqueness is not tampered with. In the list below, that of Nypa is comprehensive. The list of Pandanus is only indicative, and several sites that are present have not been noted down.

### Debris

Throughout the coasts there were huge piles of debris from the forests and habitations that had been razed to the ground, as well as stretches of coast where there was very little debris, indicative of receding tides having washed much of the debris out to sea. Hundreds if not thousands of cubic metres of timber, both trees as well as

**Figure 11: Nypa Palm (left) and Pandanus (right)**

**Table 2: Locations of resources important to Nicobaris: Pandanus and Nypa Palms**

| **Pandanus** | |
|---|---|
| *Camorta* | *Great Nicobar settlement area* |
| $8^{0}$ 03.556' $93^{0}$ 29.001' | $6^{0}$ 54.378' $93^{0}$ 54.571' |
| *Nancowry* | $6^{0}$ 53.647' $93^{0}$ 53.723' |
| $7^{0}$ 56.032' $93^{0}$ 32.736' | $6^{0}$ 53.217' $93^{0}$ 53.796' |
| *Tillanchong* | $6^{0}$ 51.627' $93^{0}$ 53.520' |
| $8^{0}$ 26.365' $93^{0}$ 37.641' | $6^{0}$ 51.488' $93^{0}$ 53.568' |
| $8^{0}$27.020' $93^{0}$36.986' | $6^{0}$ 52.015' $93^{0}$ 53.558' |
| *Katchall* | |
| $7^{0}$ 57.622' $93^{0}$ 24.830' | |
| $7^{0}$ 57.745' $93^{0}$ 24.730' | |
| *Little Nicobar* | |
| Pulo Ulon | |
| Nb: List of Pandanus locations not exhaustive | |

| **Nypa**<br>Location | |
|---|---|
| *Camorta* | *Trinket* |
| $8^{0}$ 04.472' $93^{0}$ 30.775' | $08^{0}$ 02.880' $93^{0}$ 35.067' |
| $8^{0}$ 02.362' $93^{0}$ 33.002' | $08^{0}$ 03.365' $93^{0}$ 34.656' |
| *Nancowry* | $08^{0}$ 06.027' $93^{0}$ 35.373' |
| $08^{0}$ 01.277' $93^{0}$ 32.804' | *Tillanchong* |
| $07^{0}$ 59.621' $93^{0}$ 33.100' | Cheela |
| $08^{0}$ 00.247' $93^{0}$ 32.726' | Matai Takaru |
| $08^{0}$ 01.489' $93^{0}$ 32.890' | Lanai? |
| $07^{0}$ 59.915' $93^{0}$ 30.744' | *Great Nicobar* |
| $07^{0}$ 56.982' $93^{0}$ 32.645' | Re Tukeinyal? |
| $08^{0}$ 01.495' $93^{0}$ 33.760' | Laful |
| $08^{0}$ 01.392' $93^{0}$ 32.690' | Near Laxman Beach |

coconut palms were present on the shores (Figure 12). In this devastated landscape, devoid of vegetation, these functioned as the only check against soil erosion by acting as small check dams.

**Figure 12: Debris from a badly damaged plantation**

## Fauna

Almost all the species present in the Nicobar islands are distributed in suitable habitats throughout the islands. However, almost all species were seen at higher densities, significantly so as in the case of the Nicobar megapode, in the littoral forests along the coast. Thus, the loss of coastal habitat would have resulted in declines in populations of all species. The species and faunal groups that have been affected the worst are listed below.

### *Nicobar megapode*

The Nicobar megapode, a mound building megapode endemic to the Nicobar Islands, occurs as two subspecies. *Megapodius nicobariensis nicobariensis* occurs in the Nancowry subgroup of islands, while *M. n. abbotti* occurs in the Great Nicobar group of islands. The Nicobar megapode was distributed throughout the islands in forests that are not subjected to inundation. The greatest concentrations, however, were in littoral forests due to the propensity for megapodes to build incubation mounds close to the beach (Figure 13) and over 80% of incubation mounds were built within 60 m of the high tide line (Sankaran 1995, Sivakumar 1999).

**Figure 13: Incubation mound of the Nicobar megapode on Bompoka island. Water reached the base of this mound but did not damage it. This mound is an exception. Mounds were just swept away elsewhere.**

Nesting as they did in littoral forests, the Nicobar megapode was amongst the worst affected species. Over 850 incubation mounds on Great Nicobar, Little Nicobar and adjoining islands, and over 300 incubation mounds on islands of the Nancowry subgroup have been lost to the tsunami. The denuding of vegetation of the coastal area implies that the preferred nesting habitat, littoral forests, has serious implications on the nesting capabilities in future. The megapodes however, are in no danger of extinction. Birds were seen, heard or their mounds sighted on most islands; these are listed in Table 3.

**Table 3: Sightings of Nicobar Megapode**

| Location | Remarks |
|---|---|
| Kopenheat, Great Nicobar | A pair foraging just above the tsunami line, in hills. |
| Chingeh, Great Nicobar | At least 2-3 birds heard calling from forest beyond tsunami line, in hills |
| Pulo Ulon, Little Nicobar | Type `B' Incubation newly constructed; birds heard |
| Km 18, NS Rd, Camorta | Active type A / B mound in inland forest. Birds heard. |
| Kapila, Trinkat Island | One pair seen foraging. |
| Above Hun Kun, Trinkat I | Single bird seen. |
| Near Safed Balu, Teressa | Two active incubation mounds |
| North west coast of Bompoka | Four active incubation mounds seen close to each other, birds heard calling, one pair seen. |
| Tillanchong | Active A type mound |
| Cheela, Tillanchong | 2 active A type mounds, one very large > 1.5 m high. |
| Northeastern coast Tillanchong | Active A type mound |
| Tillanchong | 2-3 pairs heard |

***Coral Reefs and sea grasses***

Incidental observations were made on coral reefs both from the boat as well as by snorkeling at a few places. By and large, the visibility off the west coast was very poor, due to suspended particulate matter, this being the worst off shores where there had been heavy damage. While coral reefs had been battered, as evidenced from direct observations as well as considerable coral rubble (Figure 14), including whole boulder corals on the shore, the damage may not be as extensive as one feared, since there were several places around the islands, where coral reefs, including plates, staghorns and boulders, were in good health. Often, as off Tillanchong, there were significant differences in damage levels within a few metres, differences that were not easily attributable to either coastal features or bathymetry. Table 4 gives the location and remarks on the corals observed during the survey. Unfortunately no surveys of the past status of corals or post tsunami damage assessments were made, and this needs to be done as a priority. Fish catches during this survey, using a trawling line, seemed to be normal. Sea grass beds were not surveyed but one patch, near Champin on Nancowry (08°01.277' 93°32.804') was intact.

**Table 4: Location and remarks on corals observed during the survey**

| Location | Remarks | Location | Remarks |
|---|---|---|---|
| *Camorta* | | *Tillanchong* | |
| 8$^0$01.828’ 93$^0$31.61 | Coral one patch seen intact | 8$^0$25.547’ 93$^0$37.504’ | Coral intact |
| 8$^0$00.186’, 93$^0$30.43 | Coral intact | 8$^0$26.187’ 93$^0$37.651’ | Coral intact earlier. This point on coral damage quite heavy. |
| 8$^0$00.823’ 93$^0$29.16 | Only remnant boulder corals. | 8$^0$26.581’ 93$^0$37.617’ | Coral damaged but coming up |
| 8$^0$12.683’ 93$^0$29.32 | Coral dead. No staghorn and plates seen | 8$^0$27.641’ 93$^0$37.521’ | Heavy coral damage |
| *Nancowry* | | 8$^0$28.141’ 93$^0$38.100’ | Heavy coral damage |
| 8$^0$01.392’ 93$^0$32.69 | No coral only rubble | 8$^0$31.676’ 93$^0$37.506’ | Coral intact and damaged |
| 8$^0$01.247’ 93$^0$32.72 | Coral mostly broken | 8$^0$30.388’ 93$^0$37.442’ | Coral in excellent condition |
| 8$^0$01.75’ 93$^0$32.184 | Coral live | *Little Nicobar* | |
| 8$^0$00.293’ 93$^0$ 31.64 | Coral appears live | Near Makachua | Corals present, mostly boulder |
| 8$^0$00.192’ 93$^0$ 31.49 | Coral rubble. | Pulo Ulun | Coral intact |
| | | *Great Nicobar* | |
| | | Ganges Harbour to Murray Pt. | Coral, little or no damage |

***Turtles***

Four species of turtles, the leatherback, green sea, olive ridley and the hawksbill turtle, nest in the Nicobar Islands, particularly on Great and Little Nicobar. The tsunami seriously damaged beaches, and the breeding season of 2004-05 was mostly a write off. However, new beaches were being formed, some of which were much larger than those that they have replaced. Numerous signs of turtles nesting were observed. It is likely that the tsunami would not have had a major impact on the turtles that nest in the Nicobar Islands. Leatherback, olive ridley, green sea and hawksbill turtle nesting signs were observed at the Light House, Great Nicobar (18 leatherback, 10 hawksbill, one olive ridley, one green sea and two unidentified tracks), and at 17-18 leatherback tracks at Muhincohn, Little Nicobar. The formation of large new beaches will probably result in new nesting beaches for species such as the leather back turtle. Old beaches at the mouths of the Galathea, Alexandra and Dugmar have disappeared, and it is probable that these too will build up in the future.

**Figure 14: The damage to coral was evidenced by the considerable amounts of coral rubble on the shore. At several places however, the reefs were intact and healthy**

**Figure 15: Robber crab, possibly the worst affected species**

***Robber Crab***

Of all species on the islands, the robber crab was possibly the worst affected, since it almost exclusively inhabits a very narrow (less than 100 m) strip of forest adjacent to the sea. Signs of robber crab were seen on Menchal and on Tillanchong, indicating that extinction has not yet taken place (Figure 15).

## Impact on People

People have been very badly affected in the Nicobar group of islands with 3513 now known to be be dead or missing (A & N Administration, June 2005). The damage to plantations, homes and other infrastructure has been enormous. Brief accounts of the island-wise impacts are listed below.

*Great Nicobar*

The worst affected coastline was the southern and western coasts, which was inhabited by the Nicobaris.

At the Wildlife Camp at '41', seven of the eight people there died. The bridge spanning the Galathea has been destroyed. Four Shompen were known to live upstream of the Galathea, and they are thought to have been killed. At Chingeh, 38 people died and there are now 91 survivors. Extensive plantations of coconut and arecanut have been completely destroyed, and not a single house or other building, excepting for the Department of Lighthouse and Lightship's building, remains. At the Lighthouse at Indira Point, 17 people died. There were no survivors and the infrastructure was irreparably damaged.

Of the nearly 300 people who inhabited the west-coast of Great Nicobar, 199 people have been killed (plus c. 12 at Pilo Bed who have been counted under Kondul). Only nine people walked out of the west coast of Great Nicobar alive. The 55 other survivors were people who were elsewhere on December 26th, a majority of whom are children from a school in Car Nicobar. The villages and plantations that existed on this coast have been completely erased, with a few clumps of coconut at Pilo Bhabi, Kochin Down and Kopenheat bearing testimony to what was. No infrastructure exists on the west coast, and there was no sign that villages once existed there.

Two small hamlets on the north coast of Great Nicobar have also been destroyed.

The largest population, mainly mainlander settlers, was on the east coast of Great Nicobar. As the force of the tsunami was less here, the number of casualties was less. Seventeen people died at (or belonged to and died elsewhere) Campbell Bay. The coastal area of the town has been permanently inundated to over 75- 80 m at places. The worst affected community is the fisherfolk, as their homes have mostly been inundated (Figure 17).

Considerable infrastructure, particularly government offices (e.g. Forest Department, see Figure 18), has been rendered uninhabitable. In the settlement area, 10 people at Vijay Nagar, six at Joginder Nagar and one at Shastri Nagar died. There were over 4500 survivors. Most of the paddy lands have been inundated with sea water, and many continue to now be part of the intertidal zone. There was loss to plantations, housing and infrastructure. Schools and hospitals and other government establishments, and roads, bridges and culverts have by and large been destroyed.

Freshwater wells have been damaged, many of these are likely to revive once flushed out. Fresh water continues to be available in the hills where such streams and springs existed in the past.

**Figure 16: A tragedy of humongous proportions. Human remains on Pilo Milo.** *Courtesy M Chandi*

**Figure 17: Submerged fishermen's colony, Campbell Bay, Great Nicobar.** *Courtesy M Chandi*

**Figure 18: Divisional Forest Office, Campbell Bay, Great Nicobar.** *Courtesy M Chandi*

*Kondul*

Thirty-seven people died at Kondul (this includes 10-15 people who died at Rekoret and Pulo Bed on Great Nicobar). The infrastructure was badly damaged, and none of the buildings excepting the police barracks hospital, which was on high ground, escaped damage, the majority irreparably so. The jetty, passenger hall, food supply godown, generator room, school and all houses have been destroyed. The plantations at South Point are inundated and were dying out. At the Middle Point and North Point, some of the plantation has survived; those on the shore were dying out. There are now 176 survivors.

The freshwater wells have been damaged, but adequate freshwater was present on the hill slope behind Middle Point.

*Little Nicobar*

The village with the largest population, Pulo Panja on the north-eastern coast, also had the greatest casualities, with 24 people having been killed, including those that were staying at Olenchi, School Point, and Elaye (Figure 19). There were 95 survivors. There are no standing buildings or houses on this coast.

Seventeen people were recorded to have been killed on the south-eastern coast (4-5 of whom actually died elsewhere), and there were 127 survivors. While all housing and other infrastructure has been completely damaged, excepting one incomplete machan house at Pulo Ulon, the plantations have not been as badly affected as on other coasts. The arecanut plantations on the coast were dying out due to salt stress as were the coconut which now stood in the sea. The coconuts that were inland were by and large intact, as were pandanus plantations.

The southwestern coast was badly damaged, and at least 13 (plus two counted under Pulo Ulon) were killed in the villages of Kiyang, Bahua and at Muhincohn. There were 34 survivors. The plantations have been very badly damaged, with possibly less than 5% of the original having survived the tsunami. All the houses and other infrastructure have been destroyed.

**Figure 19: At Elaye, the tsunami swept through the habitation area and stopped at the hill beyond it, perennially flooding low lying areas**

Freshwater wells have been damaged, with the exception of that at Kiyang which miraculously was sparkling and sweet, despite having been flooded by the tsunami. At all villages, fresh water was available in the nearby hills, and in very few cases nearly a kilometre or more away.

*Pulo Milo and the North Western coast of Little Nicobar*

Pulo Milo and the north western coast of Little Nicobar, comprising the villages of Patatifiem, Infok, Anula, Inhuieteh, Makachua, Minlan, and Kongueph were very badly damaged. No plantations barring a few coconut palms remain. 127 people died and there were 125 survivors. There was no infrastructure left, none of the houses remain, and the region is by and large not immediately habitable for larger populations. Fresh water wells have been damaged. A fresh water spring was reported to be active near the lighthouse at Pulo Milo.

*Relief Camp*

All the survivors of Great Nicobar, Little Nicobar, Kondul and Pilo Milo were in relief camps at Campbell Bay, Great Nicobar.

*Nancowry*

Nancowry was inhabited by 927 people in seven villages and their hamlets prior to the tsunami. Because of the reduced force of the tsunami on this island and the presence of hills very close to the villages, only two people were killed, one each at Champin and Hitui. The infrastructure, however has been either totally destroyed, or badly damaged. All the survivors of Nancowry are in relief camps at sites above their respective villages. These are likely to become the sites of permanent settlements.

*Camorta*

At Camorta township, of a total population of 1717, only one person was killed while attempting to retrieve his television between waves. The town itself has got off very lightly since it was situated on a hill, and most of the infrastructure remains. In the Nicobari villages on the south coast, namely Munak, Ramjaw and Payhua all of 190 inhabitants survived, while at Alkhayak, three of 39 died. Due to submergence of the coastal area, these people have lost a significant portion of their plantations and their villages are uninhabitable.

On the western coast, Changua lost 3 of 87 people and Mala Tapu nine of 40. At Bandarkhadi, 21 of 45 people were killed, as the village was situated amidst mangroves and virtually surrounded by water. Only a small proportion of the plantations have survived and the village is now uninhabitable. Similarly Dering, too lost 98 of 215 people, as it too was situated within mangroves. At Pilpilo and including adjacent hamlets as well as the village of Ol Hinpun, 99 people died out of 414. Some of the plantations at Ol Hinpun have survived, but almost none at all at Pilpilo. At Kakana, despite being near mangroves the causalities were less, and 41 of 406 people died. Most of the plantations have been destroyed. All 48 people survived at Chota Enaka, while 11 of 26 people lost their lives at Bada Enaka. Damage to infrastructure and plantations has been extensive.

All the survivors of the tsunami are at sites above their old villages, with the exception of Ol Hinpun, which has merged with Pilpilo.

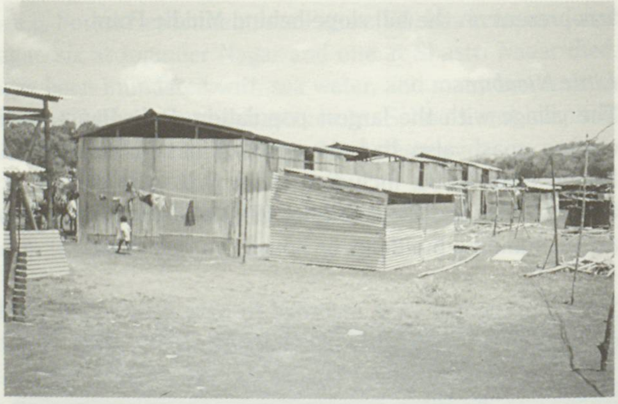


**Figure 20: Relief camps at Camorta**

*Trinkat*

Trinkat was badly affected, and at the main village Ookchuaka and its hamlets, 79 of 270 people died (two people who were visiting Pilo Milo for Christmas died there). At Takasem to the north of the island, 10 of 162 people died. The infrastructure has been completely destroyed, the plantations very badly damaged and the only fresh water available now is from the well at Kapila.

The survivors of Trinkat are in camps on Camorta. The people of Ookchuaka are at Vikas Nagar, the centre of Camorta, where water is scarce, while those from Takasem have returned to their parent villages Bada Enaka or Chota Enaka.

*Katchall*

Katchall was amongst the worst affected of the islands, and in terms of the number of people killed by the tsunami, it ranked the highest, with 1551 dead or missing out of a population of 5312 (A&N Administration, June 2005). Virtually the entire populations of West Bay Katchall (over 500 people) and Jansin were killed as were large numbers near the jetty. All survivors are at camps at Mildera, among the rubber plantations and since it was on high ground, it remained unscathed. The people of Upper Katchall, are in a relief camp above their village. The infrastructure of Katchall, other than that at Mildera, has been completely wiped out. This includes the majority of the plantations, excepting that at Upper Katchall, as well. Freshwater is plentiful on Katchall.

*Teressa*

Mortality on Teressa was amongst the lowest in the Nicobar Islands and only 51 people died of 2003 people. These include seven at Bengali, four at Alurong, 18 at Enam, 20 at Luxi and two at Kalassi. A significant portion of the plantations and a small proportion of the infrastructure of the east coast of Teressa has survived. No infrastructure or plantation, other than a small stand of coconuts at Enam, survived on the west, north or south coast. Fresh water is plentiful on Teressa.

*Bompoka*

The inhabited areas of Bompoka were badly ravaged, and 10 of 58 people died despite high ground being very close to the village. The infrastructure has all been destroyed and the plantations have been wiped out, excepting those in the north western corner, and a few elsewhere on the island. There is plenty of freshwater on the island. The survivors now live in a relief camp on Chaura.

*Chaura*

For such a small island, the Chaurans have had a miraculous escape, and only 58 people of 1287 were killed. While the infrastructure and plantations have been severely damaged, about half the houses of Kuitasuk village have survived (Figure 21). Several thousand coconut trees have also withstood the onslaught. The water situation continues to be same as it was pre-tsunami on Chaura and all the rain water harvesting water tanks have survived. The people of Chaura are now in relief camps on Teressa and are desperate to get back to their island.

*Car Nicobar*

Of the 22008 people who inhabited Car Nicobar, 854 people were either killed or missing, a majority of who were tribals. The considerable infrastructure that had been developed over the years has been very severely damaged, particularly in the Nicobari villages. The headquarters of the district has remained unscathed, while the Air Force base has been devastated. Some villages, such as Tapoiming have been untouched. Most people now in live in relief camps some distance from the shore.

**Figure 21: Considering the size of Chaura, it was a miracle that homes survived. Almost half the homes at Kuitasuk are habitable. The other villages on Chaura have been wiped out.**

## Post Earthquake Reconstruction and Rehabilitation in the Nicobar Islands

The earthquake and the tsunami of December 26th, 2004 has caused a huge loss of human life and property, and of species of flora and fauna that formed the coastal ecosystems of the Nicobar Islands. This note is based upon an assessment of the Nicobar group of islands that examined ecological change and its impact on the sociological and cultural dynamics of the islands. It recognises that:

- Ecological security of the islands is paramount to the long-term well being of the Nicobaris. Ecological constraints have to be recognised and should govern all planning.
- Modernisation is required, but will need to blend with the cultural values of the islands. The sociological and cultural heritage will need to be nurtured through the transition phase.
- The greatest challenge is the manner in which rehabilitation takes place, and the kind and extent of reconstruction that needs to be undertaken. This has far reaching consequences to the ecological security and the sociological and cultural values of the Nicobar Islands.
- Reconstruction and developmental investments will need to be limited by a proper perspective of what was, of what is required, and wish lists. Investments will need to be confined to what the people and the ecology can cope with.
- Immigration has been an area of prime concern pre-tsunami. It is imperative that all reconstruction and development activity exclusively utilises only Nicobaris and settlers of the Nicobar islands for work, both skilled and unskilled, to develop work ethos and skills as well as to exclude migrant labour.
- Above all else, excessive fund allocations and consequently its utilisation in intemperate construction is the greatest threat to the healing of the Nicobar Islands.

This note identifies rehabilitation and reconstruction requirements while ensuring that no harm ensues from the good that is being done. It is based on a consensus arising out of detailed discussions on post-tsunami development among various segments of the Nicobari society. This note is structured in two parts. The first deals with the broad issues that concern all islands. The second deals with island, people and village specific issues.

### Broad Issues

- **Ecological Concerns**
  - Coastal areas have undergone severe damage and are ecologically highly unstable.
  - Erosion, leading to further loss of land is the principal ecological concern and the single greatest threat.
  - To the extent possible, there is a need to allow 'nature to take its course' to enable vegetation to colonise and regenerate leading to stabilisation of coastal regions. This will take time.
  - Erosion will be accelerated by anthropogenic activities; potential impacts of reconstruction will have to be within a framework of least impact.
  - The choice of construction material is critical. The use of concrete can only lead to sand mining, legal or otherwise. This will accelerate erosion, leading to further loss of coastal land.
  - There needs to be a five year moratorium on (a) the use of concrete, thus pre-empting any possibility of legal or illicit sand mining in the Nicobar Islands, and (b) building structures the equivalent of which did not exist pre-tsunami.

- **Housing**

  Apart from government buildings, over 7500 residential houses need to be reconstructed in the Nicobar Islands. There are three major issues concerning this:
  - Architecture and construction material
  - Who will construct
  - How much needs to be constructed

- **Infrastructure**

  Infrastructure that facilitates transportation, communication, health care, education and administration needs to be repaired or rebuilt. The major concerns would include:
  - Prioritisation of requirements
  - Extent of infrastructure development

- **Livelihood**

  Livelihoods of a majority have been seriously disrupted, or rendered defunct. A major area of concern would be:
  - To develop and modernise the copra and arecanut economy
  - To develop alternates that would augment livelihoods and yet not be a paradigm shift.

- **Housing**

*Rebuilding Tuhets*

- The Nicobaris live in joint families, variably called the *Tuhet* in Car Nicobar, *Ye Kanaal* in Chaura, *Chanang Oovyaw* in Terressa, *Che Nyi* in the Nancowry Islands, and *Oochuvo* in Kondul. Typically, a *Tuhet* consists of an ancestral house from which the extended family originated, and other houses affiliated to it, which were built as it expanded and as plantations were partitioned. Each house usually has more than one family living in it. Several families often use a single kitchen.
- The houses in the *Tuhets* were typically large *machan* houses made of wood with wooden or bamboo flooring and roofs of Nypa leaves or thatch grass, and walls that doubled as windows. Kitchens were either within the *machan* house or were a separate structure.
- The temporary houses that have already been constructed for the affected families of the Nicobar Islands, and the permanent houses that are planned, however, follow the nuclear family model, a system alien to the cultural heritage of the Nicobaris. The major repercussions are:
  - Imposition of alien culture through architecture and construction materials (Figure 22)
  - Alienation within families due to the imposition of nuclear family systems by way of architecture
  - Disintegration of social structure, as joint families are fragmented
  - Problems associated with divisions of property

*Architecture and design*

- The basic design is that of a rectangular machan house with a single large hall measuring about 80 $m^3$, elevated to about 2 m in height with wood or bamboo flooring and corrugated galvanized iron sheeting for roofs. The kitchen will be included in the same hall, as was practiced in many houses or as a separate machan/ground house as was the practice by others. Since the onus of construction will rest solely on the inhabitants of the house there will be considerable freedom to the Nicobaris to decide dimensions and design as per their requirements.

*How many houses?*

- Apart from the immense sociological advantages that reconstruction of the *Tuhet* has for the Nicobaris, the other most tangible benefit is in the number of houses that will need to be constructed. The nuclear family concept, the basis on which the temporary and permanent housing is proposed, grossly inflates the number of houses that were actually there prior to the tsunami.
- An example from Chaura Island illustrates the difference (also see section on *Rebuilding Tuhets* on this page). As against the 343 houses that have been or will need to be constructed under the nuclear family, in reality only 231 houses need to be constructed as this was the number of houses that were lost to the tsunami.

*Medium of construction*

- The single most important aspect of the reconstruction in the Nicobar Islands is the medium of construction. The shoreline has been very badly damaged and there has been a physical loss of between 15 m to over 200 m of the shore. Further, the vegetation that prevented erosion by holding the soil and sand together has been severely depleted. Therefore, using concrete as a construction medium at this juncture is exceedingly dangerous, since the immense quantum of sand that is required will result in further losses of the shore through accelerated erosion.

**Figure 22: Nicobaris prefer thatch to tin roofs**

- The alternate to concrete is timber. A typical Nicobar house was made of timber, and was elegant as well as well airy, hygienic and relatively free of pests. Since these structures housed more than one family, they were usually large, and a machan house that measures about 800 sq ft will be a reasonable approximation of the lifestyle that the Nicobaris had.

*Who will construct*

- Apart from being in consonance with the life and culture of the Nicobaris, a major advantage will be the elimination of the immigrant labour force that follows any construction boom that involves the use of concrete. This has been a serious problem in the Nicobar Islands, and with the resource base significantly reduced, immigration can only exacerbate problems.

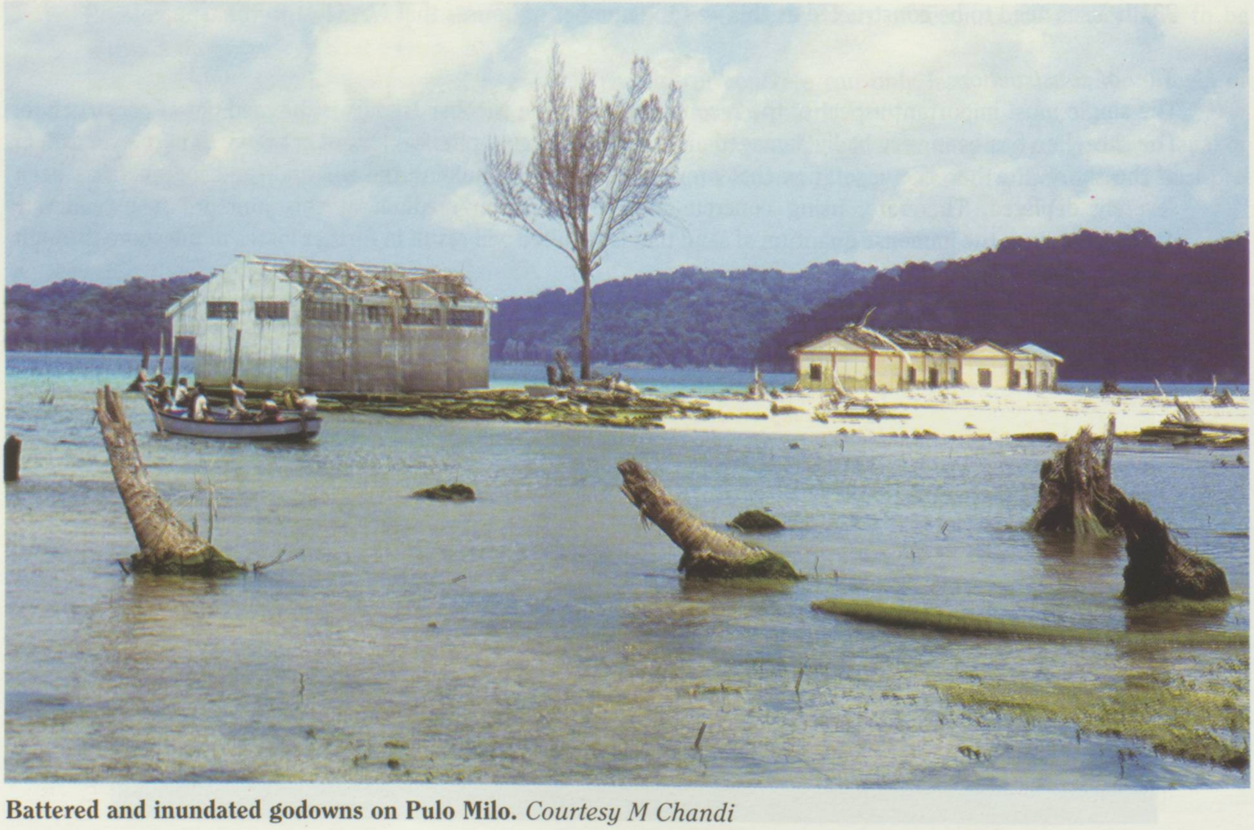
- **Infrastructure**

Reconstruction and development must be constrained by construction using concrete only where absolutely essential. The Nicobaris must build their own infrastructure.

Prior to the tsunami, considerable infrastructure had been developed in the Nicobar Islands, ensuring adequate connectivity to major population centres, which had near adequate infrastructure such as medical and educational facilities. A fairly comprehensive network of these facilities resulted in adequate coverage to most outlying areas. The Nicobar Islands compared favourably on most accounts with more 'developed' areas of the country. The common problem of inefficiency and a lack of accountability plague these islands as well.

Post-tsunami, there have been widespread notions that these islands suffered from a lack of infrastructure, and therefore there is now pressure to develop infrastructure far beyond the needs and indeed the carrying capacity of the islands. Reconstruction and developmental investments will need to be limited by a proper perspective of what was, of what the people require, and what the ecology can cope with. It must be recognised that intemperate reconstruction and infrastructure development, simply because the funds are available is the greatest threat to the healing of the Nicobar Islands.

The priority for the reconstruction and development of the Nicobar Islands would be: (a) creation of housing, (b) improvement of efficiency of sea transport systems, (c) repair and renovation of roads and jetties, (d) recreating health care and educational systems, (e) modernisation of communication networks, (f) providing electricity to villages.



**Battered and inundated godowns on Pulo Milo.** *Courtesy M Chandi*

*Specifically:*

- Efficiency in the sea based transportation systems that exist will need to be significantly improved. At present, the number of passenger vessels appears to be adequate for servicing the Nicobar Islands provided frequency of voyages is improved upon. This was clearly evidenced in the excellent manner in which people and materials were transported to and from the islands in the relief phase, post tsunami.
- Jetties existed in all major ports of call, the size being commensurate with the passenger traffic and hydrography of the approach to the island. Calls to significantly expand the size of these jetties and to build new ones in areas that are sparsely inhabited is a typical case of intemperate development activity. The immense quantity of sand required to implement such schemes could only accelerate erosion.
- Road connectivity is required to link habitations and are currently unavoidable on most islands. However roads fragment landscapes and fragmentation is a primary cause for habitat degradation. Roads also permit easy access, thereby accelerating degradation due to anthropogenic pressures. Construction of roads should be restricted to the repair of existing roads, and new roads developed only to locations where populations exist.
- The proposed north-south road along the west coast of Great Nicobar Island, is typically an intemperate developmental proposal, since people no longer inhabit that area and are unlikely to do so in the foreseeable future. The road can only accelerate environmental degradation in an already ravaged landscape. So also is the construction of helipads another case of intemperate investment, especially as its requirement and use is limited in comparison to existing modes of evacuation and transportation. It will also mean the degradation of vital habitat in most places.
- Sea walls are another example of intemperate investment. The construction of sea walls requires immense quantities of sand from coastlines that it proposes to protect, and thus forms a vicious cycle of increased erosion due to sand mining requiring more sea walls.
- Modernisation of communication facilities is imperative. While basic coverage in important population centres exists, a more comprehensive network of cellular telephones would provide effective access of information to the larger populace.
- There was an excellent network of health care coverage in the Nicobar Islands. This will need to be reconstructed to the extent that was. Optimal utilisation of Medical Service Ship, M.V. Shompen is an excellent method of providing quality medical attention to the more remote areas.
- Primary and secondary education was available to the majority of Nicobaris. The system however suffered from a shameful lack of accountability. Adequate residential facilities for those children studying in distant areas need to be made available, such as Nicobari student hostels for students of the Secondary and Higher secondary levels studying far from home. Distance education needs to be developed to provide contemporary and quality of education.
- Currently the provision of electricity is largely diesel generator based. Renewable resources such as solar energy, especially in outlying areas should be explored. Solar lanterns that have been supplied to inmates of relief camps are appropriate, and needs to be expanded for future habitations.
- For the foreseeable future, there is a need for a strong governmental intervention to establish trade in the Nicobar islands and to ensure that the exploitative systems that were in place are far more equitable. The Andaman & Nicobar Islands Integrated Development Corporation (ANIIDCO), and the Central Co-operative Society (CCS) have been effective in the supply of essential commodities to the islands. A larger role, including the purchase and export of copra, arecanut, sea foods and other products needs to be developed.

- **Livelihoods**

  *Coconut and Arecanut*:

  - Copra and arecanut are the corner stone of the economy of the Nicobar Islands, and also have significant cultural values. There is a need to immediately begin replanting lost plantations. Modernisation will include:
    - The quality of copra processed to be improved with modern drying and processing technology.
    - Development of bio-fuels from coconut waste to generate power to form self sustaining loops to dry copra.
    - Extraction of coir and coco pith to enhance revenues.

  *Subsistence allowance:*

  - Until the coconut economy is re-established, which will take eight to ten years, abject poverty faces many Nicobaris, as livelihoods of the majority have been seriously disrupted, or rendered defunct. There is therefore a genuine need to provide food rations freely. However, this is also where the great danger, that of developing a 'dole culture', exists. Subsistence allowances will need to be given on a case by case basis, till new plantations start fruiting. For the majority of the Nicobaris and settlers, the primary source of income will have to be wage for labour.

*Wage for labour:*

- The workforce for the re-construction of the Nicobar Islands must be drawn purely from the tribals and settlers, thus financially empowering people. A policy of build-it-yourself for wages will need to be established. Restricting the flow of outside skilled and unskilled labour will not only lead to the development of such skills toward self-development and governance in the Nicobar Islands, but will also ensure that the inhabitants do not depend purely or entirely on handouts.

*Fisheries:*

- In the past the majority of fisheries activity was for subsistence, though small quantities were marketed within the islands. There is scope to develop this economic activity as an alternate source of employment. The area of focus would be:
  - Providing boats and fishing gear
  - Line fishing specifically for shark and groupers, both of which demand premium prices in the international market.
  - The regular stationing and plying of vessels with on-board cold rooms to both collect and transport catches.
  - The development and marketing of Nicobari sun-dried fish, which is a premium product.

*Aquaculture:*

Inundated paddy lands on Great Nicobar Island and elsewhere in the Andaman group of Islands, has tremendous potential for development as aquaculture of prawn and mud crabs. This would need to be done organically, and with safeguards that ensure that areas other than that inundated by the sea cannot be converted to aquaculture.

*Handicrafts:*

- There is a potential, albeit small, to develop handicrafts to augment livelihoods.
- Participatory governance and administration is key to developing skills and sustainable livelihoods. It is imperative that such opportunities are explored to incorporate indigenous systems of governance and jurisprudence rather than imposing mainland systems which may not be applicable. This could erode excellent existing tenets of governance that are practised at the village/community level amongst the indigenous islanders.

## Specific Issues

- *Repatriation and rehabilitation:* Almost all Nicobaris are in relief camps, since their houses and villages have been washed away. Two categories of displaced people are evident. Those who have been displaced but continue to reside some distance from their erstwhile village on their islands and those that have been displaced/evacuated from their islands and who live in relief camps on another island.
  - While the evacuation was essential in the immediate aftermath, the establishment of temporary relief camps on other islands was a mistake. It needs to be recognised that almost all land in the islands are 'owned' and that land for plantation is simply not there for an islander from one island on another.
  - The priority will be to ensure that displaced people are repatriated to their original islands and to sites as close to their original villages as possible.

## Island and Village-specific Issues

- Most localities are inhabitable as fresh water and other resources are available to recommence lives. By provisioning basic resources such as boats, food rations and construction material, there is a great potential for the Nicobaris and settlers to rebuild their lives. The following is an island-wise account of displacements that need to be rectified.

*Great Nicobar Island*

- Chingeh village: There are 91 survivors of 28 families from Chingeh, who are currently in a relief camp at the Agriculture Department farm near Campbell Bay, Great Nicobar. The erstwhile Chingeh area was completely swept away by the tsunami, and there is no plantation left. However, there is adequate fresh water, and locations near the old village where a new village can be established. Chingeh can be easily repatriated.
- The west Coast of Great Nicobar comprised over 10 villages and hamlets (Pulo Bha, Hingloi, Pulo Pakka, Kokeon, Inponchi, Pulo Bhabi, Kochin Down, Kopenheat, Pulo Kunji, Pulo Bed and Rekoret). Only 65 people survived, the majority of whom are school going children who were studying in Car Nicobar. There are barely 10 adults in the group. They will have to adjust themselves with the people of Chingeh, Kondul or Little Nicobar in the short term before trying to re-establish themselves on the West Coast.

*Kondul Island*

- There are 176 survivors comprising 40 families from Kondul Island and two small hamlets from the north western coast of Great Nicobar. Only small portions of Kondul are inhabitable, and the people of Kondul intend settling on the Northern coast of Great Nicobar, in the area between Sodom Bay and Re Maun, which is part of their traditional plantation and resource gathering area.

*Pulo Milo Island*

- 125 people of 35 families have survived from Pulo Milo and hamlets from the opposite shore of Little Nicobar. Pulo Milo is not inhabitable, and the villagers plan to live at Makachua on Little Nicobar, where they traditionally had land and plantations.

*Trinkat Island*

- Ookchooaka (Trinkat) village: Amongst the worst affected villages in the Nancowry group of Islands, the survivors are now camped at km 16 on Camorta Island. The old village area, lying as it did behind a mangrove is uninhabitable. As of now, about 6 families own land between Kapila and Lahoum, and there is one well that is functional at Kapila. These families can be repatriated immediately. The remaining will need to be rehabilitated to the northern hill region of Trinkat Island, for which infrastructure, including wells will need to be created.
- Takasem (Safed Balu) Village, was also very badly affected and is for the most uninhabitable. The people however, originate from the Tuhets of Bada Inaka, where they now choose to reside. They can re-develop plantations at Safed Balu, but live at Bada Inaka.

*Chaura Island*

- The 1300 odd people of Chaura are now in temporary shelters on Teressa. There is no future for the Chaurans on Teressa since the limits on the resources of Teressa are acute, and there is no spare land to share with the Chaurans,; whatever is left is required by Teressans to recoup. Chaura is however, habitable. The major resource crunch was freshwater on this island. The rain water harvesting tanks that had been created are intact, and as far as water is concerned, they have exactly the same amount of resource as they had pre-tsunami (Figure 23). A sizeable number of plantations have also survived making the repatriation of Chaurans to Chaura, possible. This needs to be done, since there is very little scope for them to develop livelihoods on Teressa.

**Figure 23: The three rain water harvesting tanks on Chaura are intact**

- **Traditional rights on Tillangchong Island**

*Status*

Tillangchong Island was declared as a Wildlife Sanctuary, under the Wildlife (Protection) Act, 1972 in 1985 *vide* the order No: CS/WS/30Nol-1 1985.

*Traditional rights*

The coconut, arecanut and pandanus plantations on Tillanchong are natural, and these and all else is owned by '*Kumeta*'(or the spirit or *Shaitan*) who permits the Nicobaris to collect coconut and other forest produce for a brief period annually in safety, provided the Nicoabaris adhere to customary practices on the island. The '*Kumeta*' originally gave the ownership of the collection rights of Tillanchong to Shri Lawa who founded Nyi Takaru of Trinkat Island. Shri Lawa was followed by a son, then Jom Kang, then Halakka (who died in the tsunami of 2004) and now the head of Nyi Takaru is Shri Jonathon.

In the past, due to hardships faced by Kakana village, Nyi Takaru to Nyi Samyue of Kakana village permitted collection of produce from Tillanchong. This was ratified by the then Deputy Commissioner in 1950 (No Camp 15, dated 4.11.1950, Camp on board I.N.S. Avenger). The practice ever since has been that every even year (2000, 2002, 2004 etc) is the turn of Nyi Takaru of Trinkat Island, and every odd year (2001,2003,2005 etc) is the turn of Nyi Samyue of Kakana village.

Nyi Takaru has further given rights to Nyi Mumala founded by Smt Tara-ala sister of Shri Lawa, and whose present day head of family is Joseph Moin, and the understanding reached between them appears to be that the turn of Trinket Island, will be alternated between Nyi Takaru and Nyi Mumala. Nyi Mumala collected produce from Tillanchong in 2004, hence 2006 will be the turn of Nyi Takaru.

Nyi Samyue has split about five years ago, and the original head of family Shri Samson Prakash has formed Nyi Malge (Milleren), and therefore the current head of family of Nyi Samue is Shri Koshish Salindoh.

The traditional rights to collect the produce of Tillanchong rest with:

1. Nyi Takaru of Trinket Village whose head of family is Shri Jonathon
2. Nyi Samyue of Kakana Village whose head of family is Shri Koshish Selandoh
3. Nyi Mumala of Trinket Village whose head of family is Joseph Moin
4. The rights of Nyi Mileren of Kakana Village whose head of family is Samson Prakash are to be verified.

## Monitoring tsunami affected areas in the Andaman and Nicobar Islands with a view to develop and implement site specific restoration measures

## Introduction

The subduction of the Indian plate under the Burma plate and the resultant mega earthquake and tsunami of December 26, 2004 destroyed large areas of coastal and mangrove forest in the Andaman & Nicobar Islands. It also resulted in a tilt in the land, with the southernmost Nicobar Islands having sunk by about 1.6 m and the northernmost Andaman Islands having risen by about 1.2 metres. The impact on the inhabitants of the islands has been immense; almost 10% of the inhabitants of the Nicobar Islands lost their lives, and the majority of the survivors were rendered homeless with complete loss of livelihoods. The impact of the tsunami and the change in land position to coastal ecosystems have been:

1. The physical uprooting of coastal forests and mangroves by the tsunami
2. The scorching of littoral vegetation due to salt stress from sea water inundation
3. The dying out of mangroves due to perennial submergence of the pneumatophores
4. Sea water inundation of inland fresh water bodies, and the destruction of marshes and creeks
5. The physical destruction of coral reefs by the tsunami waters
6. The dying out of coral as reef flats were exposed to the atmosphere

**Figure 24: Agamid on Great Nicobar.** *Courtesy M Chandi*

The ecological concerns arising from these are:

- The tsunami was stopped only by high ground. All vegetation up to between five and 10 m asl in coastal areas of the Nicobar Island has been stripped or killed leaving behind large gaps and bare soil, and a large quantum of debris of the fallen vegetation. Due to the sinking of the islands by nearly two metres, between 5 m and over 200 m of the shoreline has been lost to the sea. The tsunami has stripped and/or damaged coastal forests to considerable distances inland. Seawater ingress along existing and new channels has resulted in inundation of considerable coastal areas that includes areas under cultivation and horticulture.
- Ecosystems are currently unstable and the geography of the land has been altered. Most issues will need to be considered in relation to the altered distribution and availability of resources.
- Soil erosion in the affected belt is the primary ecological threat that needs to be safeguarded against, since retention of land is now of paramount

importance. Stabilising affected coastal ecosystems would need to follow ecologically sound and safe methods. Natural regeneration is the safest and most effective way to stabilise the affected belt.

- Regeneration, natural or otherwise, takes time. The primary ecological requirement would be to minimise human intervention to allow for natural processes to stabilise and heal affected coastal ecosystems.
- Activities that have the potential to accelerate erosion need to be prohibited. This would primarily be sand quarrying from beaches for construction. The main ecological constraint is that the use of concrete must be at the barest minimum. Reconstruction will therefore have to be primarily timber based.
- It is preferable to source timber from outside the islands, since (a) extraction of the quantum of timber required from the forests of the Nicobar Islands is untenable since this can only compound the ecological degradation that has taken place, and (b) extraction of trees uprooted by the tsunami is unsound since, in the absence of vegetation, these are the only barricades against soil erosion.
- Mangroves and coral reefs, critical to the development of fisheries in the Nicobar Islands, have been affected. Mangroves have been completely decimated, while damage to reefs has been variable. There will be a need to keep limitations arising from these in mind while developing fisheries as alternate livelihoods in the islands.

**Restoration**

A major post tsunami objective must be to try and restore, as far as possible, the pre-tsunami state of affairs. This would necessarily involve the rebuilding of homes, infrastructure and livelihoods in a manner that is consistent with the cultural values of the islands and that recognises and adheres to the ecological constraints that are often unique to island systems, more so now with the severe depletion of resources post tsunami. This would also involve the restoration of habitats that have been damaged by the tsunami.

The planting of trees in the affected areas has been widely recommended as a post tsunami programme to restore the ecological values of the affected areas. It is also widely believed, that vegetation cover, in particular mangroves, have reduced the impact of the tsunami inland. This is not the case in the Nicobar Islands, where all vegetation and infrastructure was severely damaged by the waves till it reached ground that was higher than the run up level. It is likely that no protective measure, natural or otherwise, can stop or perhaps even reduce the impact of a tsunami, particularly when close to the epicenter. Coastal belts and mangroves are of tremendous and invaluable importance and these need to be restored where lost and protected where they exist.

The knowledge base and experience required to restore habitats after such a mega event does not exist. Human intervention without this knowledge will aggravate situations rather than ameliorate them. For instance, amongst the negative aspects of extensive planting of trees are that this will predetermine the nature of forests that will be formed which is likely to be a poor replacement to the diversity that is likely to result when 'nature takes its own course'. Moreover, hundreds of people digging pits to plant saplings, and cutting poles to protect them will be a major problem, coupled with the encroachment and general deforestation that goes hand-in-glove with such an operation. However, there will be instances where site-specific intervention will be required, and these could include preventing erosion, controlling weeds, enhancing the re-colonisation process, and overcoming the constraints that limit regeneration and restoration.

The following will need to be recognized:

- Allowing nature to take its course is the best way to allow habitats to restore themselves, and species to colonize areas. Leaving areas alone should be the preferred management option.
- Each and every island is biologically unique, often with species or subspecies endemic or restricted to it. Seed material must be collected from within the island or from within the subgroup.
- No exotics to be planted. This will need to be monitored by a panel of experts, who should also determine selection of species, sites and patterns of planting.
- *Casuarina equisetifolia* is not an exotic to the Nicobar Islands, and stands of naturally occurring casuarina were present at several locations. Casuarina, however is not a replacement for littoral and evergreen forests, and it is extremely unlikely that other species will come up in areas planted with it, thus having negative impacts on a wide range of species. The casuarina in the Nicobar Islands shows markedly superior phenotypic characters, that include thinner branches and greater girth as well as faster growth rates, and as such is important as a gene pool with silviculture applications (Jayaraj, R.S.C. *pers comm.*.). Hence, planting of casuarina must be restricted only to those sites that are part of human habitations, and where large stands occurred earlier.
- Pandanus and Nypa, resources that are very important to the Nicobaris, will need to be planted where they occurred earlier and in other suitable habitats..


**Figure 25: The Great Nicobar subgroup of Islands**

**Figure 26: Damage on Great Nicobar Island**

## Monitoring

The post tsunami effort represents a unique challenge and opportunity, which requires a continuous inflow of information to make the right decisions and choices. Thus, it is imperative that a long-term monitoring programme of the tsunami affected areas be initiated in the Andaman and Nicobar Islands with a view to develop and implement site specific restoration measures and to collect baseline data so as to better understand how ecosystems respond to such mega events.

Seven focal areas have been identified for specific requirement based intervention and long-term monitoring. Organisations already involved, or likely to be, are:

| | |
|---|---|
| 1. Littoral Forests | SACON-fauna; flora - CEMDE, SACON [Nicobar Islands, Little Andaman] |
| 2. Herpetofauna | WII/ANET [Nicobar Islands] |
| 3. Mangroves | FERAL, CEMDE [Andaman & Nicobar Islands] |
| 4. Coral reefs | FERAL, NCF [Andaman & Nicobar Islands] |
| 5. Turtles/Beaches | ANET/CES, IISC [Nicobar islands] |
| 6. People | TISS/ANET [Nicobar Islands] |
| 7. Planting Nypa and pandanus to develop resources for Nicobaris | ANET |

### Goals

To monitor regeneration and colonisation in tsunami affected areas, to devise and implement site specific strategies to encourage and hasten regeneration where necessary.

### Objectives

1. To prepare detailed pre-tsunami vegetation profiles and resource distribution through the use of satellite imageries, existing data and local knowledge
2. To establish permanent quadrats and transects to assess vegetation regeneration in sample sites and to monitor the regeneration processes that have begun
3. To monitor the species of fauna that inhabit coastal ecosystems, focusing on the Nicobar megapode, robber crab, turtles and crocodiles
4. To develop appropriate strategies to restore damaged habitats and implement immediate habitats that are *prima facie* problematic, such as sites with considerable erosion
5. To plant nypa and pandanus at appropriate sites so as to develop required resources for the Nicobaris
6. To monitor colonisation of both sites with and without restoration activities
7. To aid regeneration through targeted restoration activities, including planting and control of invasives that are constraints to regeneration

## Description of Damage

### Great Nicobar

Great Nicobar Island is the southernmost island of the Nicobar group of islands and lies just 127 km north-northwest of Sumatra in Indonesia. With an area of 1045.10 km$^2$, it is the largest island of the Nicobar group. Topographically, the central and northern areas of Great Nicobar are hilly with increasing flat coastal areas in the southern and western portions of the islands (Figure 25). Mt. Thullier at 670 m in the northeast of the island, is the second tallest peak in the A & N Islands. There are several rivers that originate from the hills, which include the Galathea in the south, the Alexandra, the Dagmar, and Renhong in the west and Jubilee in the north, with several smaller streams descending to the sea. Lying less than 150 km to the north of the epicentre of the earthquake, Great Nicobar was very badly affected by the tsunami (Figure 27).

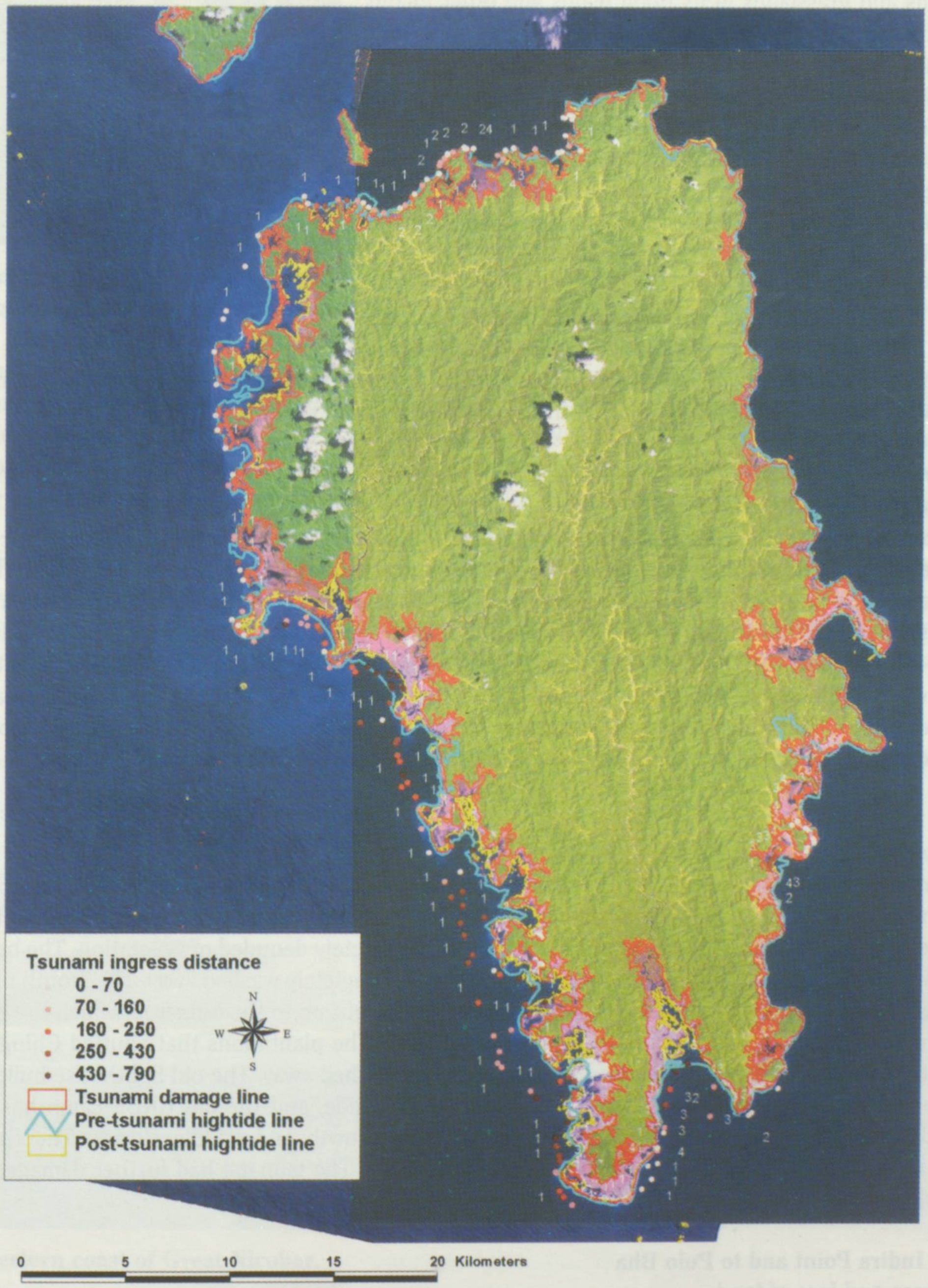



**Figure 27: LISS 3 imagery of Great Nicobar Island on 26/2/05 showing areas damaged by the tsunami.** *Map by N. Pelkey and V. Srinivas, FERAL*

## Southern Great Nicobar

The southern portion of Great Nicobar mainly comprised the Galathea river and the large flat lands between the two ridges that descend from the central portion of the island through to south. The southern tip of the island was separated from the Galathea Bay by the west-flanking ridge, and the tip itself was a large flatland, with higher ground further and hills advancing inland. The entire Galathea Bay had diverse habitats and the extensive beach along the eastern portion of the bay was the most important area for nesting leatherback turtles in the Andaman and Nicobar Islands (Bhaskar 1993, Andrews *et al.* 2002, Andrew and Shanker 2002). Beaches were also present along the shore all the way to the southern tip, and these were very important nesting beaches for green sea, olive ridley, and hawksbill turtles, with well over 200 nestings taking place through the year (Bhaskar 1993). The Galathea river itself and the marshlands and grasslands in its flood plains and other inland wetlands at the southern tip were also amongst the most important habitat for saltwater crocodiles in the Nicobar Islands. The littoral forests of southern Great Nicobar were amongst the most important habitats of the Nicobar megapode in the islands. There were over 35 active incubation mounds in the stretch of coastal forest between the Landslide (km 47) and Indira Point (km 51) (Sivakumar 1999). The littoral forests that abutted the shore quite possibly had the highest densities of robber crabs in the islands.

**Figure 28: Due to intolerance to salt water most vegetation in the impact zone was scorched, and possibly killed.**

Four parts of the southern coast were inhabited. The wildlife camp at the mouth of the Galathea (km 41), Chingenh (km 43) a Nicobari village also in the Galathea bay, a small APWD camp at km 46, and the lighthouse personnel who inhabited Indira Point. There were about 150 people who lived on the southern coast of Great Nicobar.

### Galathea Bay

*Run up, ingress and loss of land*

The sea adjacent to the Galathea bay had a depth of under 30 m to a distance of between 1.5 km at the narrowest and 8.5 km at the widest. This resulted in some of the highest run ups seen in the Nicobar Islands, with wave heights varying between 6-7 m and over 10-12 m above sea level (asl). Since the land of the Galathea Bay was a large flat area, the tsunami had damaged all land up to the hill, which was like an inverted 'V', within which the Galathea flowed. The ingress has been the most in the island with water having gone up to where the Galathea descends to the plains, a distance of over 6.5 kilometres. Along the eastern and western shore of the bay, the flat coastal area was less, and ingress has been till the hill which varied between a few meters, where the hill ended in the sea and about 400 m. Loss of land has been immense, with the shore line having receded by between 50 m and over 1.5 km at the mouth of the Galathea.

*Extent of damage*

There was very heavy damage from the hill that starts from 35 km up to the hill and landslide at km 46 (GREF camp). The undergrowth and middle storeys were completely stripped and most of the old growth trees had been uprooted. Flat land which extends from the hill range and the shore was completely denuded of vegetation. The beach, which ran along the shore up to the mouth of the Galathea River, had been completely washed away. The mouth of Galathea bore the brunt of the tsunami and all vegetation had been swept away, right up to the hills from which the river descended into the plains. The Galathea Bridge had also been washed away. The plantations that abutted Chingeh village with coconut and fairly extensive stands of arecanut were completely washed away. The old lighthouse building is the only standing structure left. The entire stretch of shore upto the landslide, and the old GREF camp has similarly been washed out to the hill, with few standing trees and no undergrowth and middle stories. The GREF camp has disappeared, in which place a large brackish pool of water remains. The tsunami had further damaged the landslide, and more rock and soil had slipped.

### Landslide to Indira Point and to Pulo Bha

*Run up, ingress and loss of land*

The sea adjacent to this stretch of coast had a depth of under 30 m to a distance of between three km at the narrowest and five km at the widest. This resulted in high run ups, with wave heights varying between five and seven metres; this could not be ascertained, as the hill slopes were some distance inland. The ingress here ranged between 700 m and about 1.75 km. Loss of land here varied between zero at the cliff face and at the landslide at 47km, and about 40-50 m, and perhaps even more at certain places.

*Extent of damage*

This area was very heavily damaged from the shore all the way up to the hill. The belt about 15-200 m from the shore bore the brunt of the force and all the undergrowth and middle storeys were completely stripped with most of the old growth trees uprooted. The number of standing trees increased as one moved inland and at the base of the hill, with a majority of trees and middle storeys being upright. The wetlands had all been significantly enlarged and had turned brackish. Further, new channels were formed between the shore and the wetlands, which permitted seawater to enter during high tides. The lighthouse was standing in the sea 15 m from shore. Beyond the lighthouse, the high ground of the Air Force land, about 150 m to the interior, appeared intact. The coastal area between this high ground and the sea was also very badly damaged. North of Indira Point, the hill range swings towards the shore and here the vegetation had been stripped to about six to nine metres asl. Throughout this section of the coast, wide and large beaches were being formed.

## The Western Coast

The western coast had three major patches of mangrove at Pulo Bha, Kokeon and Inponchi. Several rivers and streams, including the Alexandra, the Dagmar, at whose inter-tidal zones mangroves occurred as well, and Renhong are present in the north section of the western coast. The beaches at the mouths of the Alexandra and Dagmar rivers were important turtle nesting beaches where large numbers of the leather-back turtles would nest. The rivers and mangroves were important habitats for the saltwater crocodile, and the mudflats in the bays that were fringed with mangrove were important to wintering waders including crab plovers and oyster catchers. The small Megapod Island at the mouth of the Kokeon Bay, which was mostly vegetated with coconut, had a small population of the Nicobar megapode. The littoral forests had populations of megapodes, and there were probably atleast 90-100 incubation mounds on the western coast.

Several Nicobari villages and hamlets were situated along this stretch of the coast: Pulo Baha, Inhingloi, Pulo Pakka, Kokeon, Inponchi, Pulobhabi, Koe, Koshindoun and Kopenheat. Further north, the coast was very thinly inhabited , with just three hamlets, Pulo Kunji, Pulo Bed and Rekoret. Since Nicobaris inhabited this area, the coast was marked with plantations of coconut, which occurred as a mosaic with littoral forests. As the northern section was more thinly inhabited, the coastal forests were relatively pristine (Figure 29). At least 300 people lived on the western coast.

### Pulo Bha to Kopenheat

*Run up, ingress and loss of land*

The sea adjacent to this stretch of coast was shallow and wide, with a depth of under 30 m to a distance of between 4.5 km at the narrowest and nine km at the widest. In some areas, as in the Kokeon Bay, the water was very shallow,

**Figure 29: Western coast of Great Nicobar.**

**Figure 30: The mouth of the Alexandra River, where all vegetation had been flattened**

less than seven metres up to a distance of 3.75 km. This resulted in high runs ups, with wave heights over six or seven metres. The tsunami had reached the hill slopes and damaged land from between 50 m where hill slopes were close to the shore and over two kilometres inland. The shorelines had receded by between 40 and 50m or less to over 1.5 km where mangrove swamps dominated inter tidal zones, as at Kokeon Bay and Pulo Bha Bay. Pulo Bhabi was characterised by a fairly large area of flat land. Most of this land has disappeared underwater.

*Extent of damage*

This section of the coast was also subjected to very heavy damage, the tsunami waters having swept its way right up to the hill range, which was considerably inshore. The worst affected areas were those bays on which there were mangroves, and virtually no mangrove or Nypa palm remained. Bare soil of the high ground beyond the mangrove was visible in many places, particularly at Inponchi. The coastal area had been stripped of vegetation, though several old growth trees, and in patches, continuous canopy remained. The entire area was scorched brown and very little green was visible. Where the coastal belt was narrow, as between Hingloi and Pulo Pakka, all the vegetation had been stripped of the land and only an occasional tree remained standing. Upto Pulo Bhabi, there were no coconut or plantations and at Pulo Bhabi, less than 50 coconut palms survived. Since Kochindon was in the north facing portion of the bay, this area was marginally less affected, with several hundred coconut palms still standing. However, the majority was standing in the water or would be inundated during high tide due to the subsidence of the island. The entire stretch was scorched brown to a height of about six m asl.

## Alexandra River to North Western tip of Great Nicobar

*Run up, ingress and loss of land*

The sea adjacent to this stretch of coast, was shallow and wide, with a depth of under 30 m to a distance of between five km at the narrowest and nine km at the widest. At some places, the sea was even shallower, with shelves less than 20 m deep occurring about two km from the mouths of Renhong River. This resulted in very high runs ups, with wave heights varying between 6 and 10 m. The land here was wide and flat, with several creeks and rivers ending in the sea, with large flat lands including low lying areas, some possibly at or below sea level, often extending behind small hillocks on the shore. The ingress here ranged from over three to 3.5 km at Dagmar and Alexandra Rivers, over 1.75 km at Pulo Kunji and Pulobed, to over a kilometre at Ayoam Bay. Ingress had been over two kilometres at Renhong and Rekoret. Loss of land has been considerable, with the shore line having receded from 50 m or less where the flat coastal land was narrow between hill and sea, and over one kilometre at the mouths of the rivers (Figure 30).

*Extent of damage*

The north western coast of Great Nicobar was also subjected to massive damage, and the mouths of Alexandra and Dagmar rivers were completely washed away till the hills, barring one small hillock that divides the two. The flat land behind the hillock was also washed out. No vegetation stands in this bay since the mangroves, Nypa formations and riverine forests have all been washed out. The large turtle-nesting beach has disappeared, and there was very little sign of new beach build up. Likewise, the tsunami completely washed out the bays in which Pulo Kunji and Pulobed villages were, as was Ayoam bay. The undergrowth and middle storeys were completely stripped away, while a large number of old growth trees continue to stand, often with continuous canopy. Much of the shore line was subject to inundation during high tides, and the promontories which divided the bays were also severely damaged, and in many cases with water now passing through them. Several new islands have broken of from Great Nicobar in this stretch; essentially these were promontories or hillocks on the shore that have now got cut off (such as between Pulobed and Ayoam bay and Rekoret). The mouth and up to the hills of both Re Anose and Renhong rivers has also been very severely damaged.

## Northern Great Nicobar

The northern coastline of Great Nicobar was characterised by narrow coastal forests with the hills reaching the shore and with the Re Tukeinyal (Jubilee river) river and the Ganges Harbour, both of which were dominated by mangroves. Since the flatland forest between the sea and the hill was not much, the megapodes found in these forest were few in number, and there were probably less than 30-50 incubation mounds in the littoral forests. There were no beaches and hence not important for turtles. Re Tukeinyal (Jubilee River) was important for crocodiles and was also used to source the Nypa palm leaves for thatch, by the Nicobaris of the region . The eastern extremity of the northern shores was made up of rocks and cliff faces, on which the edible-nest swiftlet *Collocalia fuciphaga* nests.

The northern coastline had a few plantations of coconut, and a couple of hamlets were present here. This was a region that was increasingly being converted to plantation in the recent past.

*Run up, ingress and loss of land*

The St Georges Channel, a deep water channel, separates Great Nicobar from Little Nicobar to the north. Pryce Channel, which separates Great Nicobar from Kondul is shallow, about 20 m deep and less than a kilometre wide at Kondul at the western portion and about 3.75 km at its widest at the Ganges harbour in the east. The height of the waves here varied between five and eight metres asl. The flat coastal land occurred as a narrow belt along the northern coastline, with the hills descending to the shore at many places with shallow bays in between, these being deep only at Ganges Harbour and Re Tukeinyal (Jubilee River). Hence sea water ingress has not been much, since the high ground stopped the waves, and varied between zero (where hills or rocks ended in the sea) to over 2.75 km at Re Tukeinyal. Likewise, loss of land has been low, with the shoreline having receded less than 50 m, and often not at all. Loss of land has been the greatest at Ganges Harbour, where the mangroves have been swept away and their habitats now submerged.

*Extent of damage*

The Northern coast of Great Nicobar has also been subjected to fairly heavy damage. Since the majority of the coast has hills ending almost in the sea, with very little coastal flatlands, there has not been much depth in damage for the most; deeper damage has been there only in the bays.

The north western tip has been cut off with a large rocky crag breaking the waves at sea. The first bay had two or three nallahs with the result that this was heavily damaged, with only 69 coconut palms now standing in the sea. Sodom bay/Kui-jaii to Re Maun, a new settlement by people from Kondul Island, occupied the little flatland and has been likewise damaged. The undergrowth and middle canopy were stripped, and the hill slopes at the further end were visible from the shore. The damage to the next bay was not so extensive and some vegetation was still left standing, though this had been burnt by the salt water. The next bay had been washed clear of vegetation up to the hill, leaving about 50+ coconut palms at the shoreline along the nallah. A few salt-scorched casuarina still stand in the bay. The vegetation within the deep bay where Re Tukeinyal (Jubilee River) empties was fully washed out till the hill, over 500 m deep. The sand spit on which mounds were was completely washed out, leaving a few standing trees in the western portion. The mangroves were still standing, but were leafless and presumably dead, as a result of the pneumatophores having been completely submerged. The next bay was washed out to the nearest hill. The next big bay with a nallah had plenty of standing vegetation, which included undergrowth of cane and pandanus, were salt scorched but with a little green showing through. The mangroves that fringed Ganges harbour had been completely stripped, and the hills which ended in the sea had been mostly denuded of vegetation to a height of 6-7 m asl. Several spurs of the hills end in the Ganges harbour; the vegetation at the base of these had been washed away. At the eastern tip of Ganges harbour, a separate island had been cut away from Great Nicobar. The damage by the tsunami continued from the eastern tip of

**Figure 31: Due to the subduction, the coastal areas submerged taking with it plantations like these. Due to salt resistance, the coconuts were the only green on most coasts, but were dying out in places.**

the Ganges harbour till Murray Point, with the narrow littoral forests scorched brown. Standing mangrove trees in the bays were leafless and apparently dead.

**Murray Point to Laxman Beach**

The northern half of the east coast was an important area for the Nicobar megapode with over 100 incubation mounds. Populations of crocodile were present at mangroves at Laful and even along some of the rivers that occurred in the settlement area. The northern section was the most pristine coastal area of Great Nicobar, since this shore was inhabited only by the Shompen with one wildlife camp at Navy Dera.

*Run up, ingress and loss of land*

The waters off the eastern coast were deeper. At Trinkat Bay, the sea was more than 50 m deep just a kilometre off shore, and shallow waters continued to occur as a narrow belt, less than a kilometre wide all the way to Laxman Beach. The run up levels were less here and ranged between 2 and 4 m asl at the most, often less. The majority of this coast was characterised by a narrow flat coastal belt. Like other parts, the ingress has been till the hill and varied in distance from not at all (where hill or rock ended in the sea) to less than 200 m; this depended on how much flat land there was before high ground began. The deepest ingress had occurred at Laful, a little over 600 m, and at Jhau Nallah, where the waters reached a little over 2 km inland. Loss of land has by and large remained under 50 m, often none where hills or rocks ended in the sea.

*Extent of damage*

The cliff at Murray point appeared to have undergone damage with landslides and rockslips. Trinkat bay was also very heavily damaged, and the coastal forest has disappeared with no beach left. The hill appears to now end in the sea, with a little flat land and beach at the centre of the bay, where a few Nypa palm still stand. Ihaov where a few Shompen lived on the north-facing shore of the southern arm of Trinkat Bay, was a little sheltered and has therefore suffered lower levels of damage. A few coconut palms still stand. The damage perceptibly diminishes from this point onwards and Shan Bay to Laful and Navy Dera; the latter had most of the old growth trees still standing, with undergrowth and middle storeys. Though this stretch of the coast was scorched brown, there was plenty of green showing through. The mouth of Laful nallah was damaged, but most of the mangrove and Nypa were still standing, though these were by and

**Figure 32: Submerged paddy lands with spider webs on the debris.** *Courtesy M Chandi*

large leafless. The Nypa was sprouting fresh leaves. Like the rest of the coast, Navy Dera too had plenty of standing old growth trees, middle storeys and undergrowth, with plenty of green showing through the brown vegetation. This was the case with Jhau Nallah and all the way to Laxman Beach, where there was considerable sea water ingress, in places to over a 100 m, but the vegetation was standing and some of this was green.

**Campbell Bay to 35 km**

The eastern coast of Great Nicobar was characterized by narrow flat coastal forests followed by steep hills, with the hills often descending to the sea itself. The littoral and coastal areas were pristine till slightly north of Campbell Bay, and the southern half of the eastern coast had been settled with mainlanders and most of the coastal areas upto the hills had been converted to agricultural lands. The southern portion of the east-coast was the most populated area of the island. It housed the township of Campbell Bay, the littoral forests and all other natural vegetation, particularly in the flatlands. The south of Campbell Bay had, by and large, been converted into agricultural lands and homesteads. This conversion of land had extended to some distance on the hill as well. The south eastern coast of Great Nicobar was also the most ecologically damaged area of the island.

*Run up, ingress and loss of land*

The narrow shallow water shelf continued down the coast from Campbell bay to 35 km where the waters were deeper than 50 m from between 3.5 and 5.5 km off shore. Very shallow waters, less than 30 m occurred as a very narrow belt less than one to 1.5 km from the shore. The height at which the tsunami waters reached was between 6-7m asl at most, and for the most part probably 3-4 m. Like other parts, the ingress has been till the hill. Much of the flat coastal land was under paddy cultivation (Figure 32) and it is likely that in the imagery, some of this has been included in the tsunami affected zone. At Campbell Bay, at Mugger Nallah, the tsunami has penetrated to over three kilometers deep. Elsewhere along this coast, it has damaged flat coastal land to between none, where the hills descended to the sea, to about 2.25 km.

**Figure 33: A couple of trees standing dead in the sea is all that remains of Megapod Island.**
*Courtesy M Chandi*

*Extent of damage*

While the force of the tsunami was considerably less than on the west coast, salt water ingress at Campbell Bay, as elsewhere, has been up to the high ground. This has damaged much of the houses and buildings in the coastal area, though a significant portion of them continue to stand. There has been considerable saltwater ingress into the town, and during spring tide the water surges well past the road at places, inundating low lying places further inland. From the southern tip of Campbell Bay, where the coast is hilly (3-10 km), there has been further erosion, and the road has now been completely cut off. From 12 km on the NS road, there has been considerable inundation. Here, as elsewhere in the islands, the flat coastal forests occur as a series of high and low grounds parallel to the sea. The low ground was inundated with seawater, while the high ground, mostly comprising coconut, was more or less intact. Homesteads had been broken and the bridge over the nallahs had been broken as well. Coastal vegetation had mostly been damaged, but some pandanus still stood. The next bay had the settlements of 16-19 km. Here the salt water ingress was upto the road and had completely submerged the mangrove behind, leaving a 100 m wide strip of coconut plantation between. From km 20, the damage significantly reduced and the damage at most places had not crossed the road, leaving a narrow patch of littoral forest between the road and the sea intact. Ingress had occurred only in patches, and sea water now inundated only low land. From km 21 onwards, the coastal forest widens to 40 m east of road. The 21 km bridge was broken, and while the tsunami had reached the hill, low lying areas on both sides of the road remained inundated. From km 22, the hill was close to the road, and there was not much damage inland. The pandanus on the coast was more or less intact and inundation was apparent only in the series of low grounds further inland. There was not much damage seaward of the road 24 km onwards, and the plantations were more or less intact, and there was relatively less damage to houses. Upto km 27 and beyond, the damage was relatively less, and the houses too escaped significant damage. From km 30 onwards, the inundation was significantly more, with the hospital, buildings of the agricultural department etc, all inundated, since these were situated on low ground behind the hill. The tsunami waters have gone on behind the hill, isolating it as if it were an island, though land connectivity apparently continues to exist. Likewise, the settlement area at km 35 also witnessed damage, and the hill of 35 km has also been isolated. In the inhabited regions of the settlement where the tsunami waves reached and where inundation during the change of tides continue to occur, land that was used to cultivate paddy and horticultural crops has been considerably damaged.

## Megapod Island

Megapod Island lay in the Kokeon Bay (Nanjappa bay) along the southwestern coast of Great Nicobar. It was a small flat islet, about 0.13km$^2$ in area, with very little raised ground. During low tide, it was possible to wade across to the island. Over the years, Megapod Island had been completely overrun by coconut. This was actively aided by Nicobaris since the crop depredation by Nicobar crab eating macaque seriously undermined plantations of coconut on adjoining parts of Great Nicobar. However, typical to other plantation areas in the region, the coconut was mixed with remnant forests, with a few old growth trees still present and coastal areas fringed with, amongst others, *Barringtonia*. There was a small population of the Nicobar megapode on the island, and atleast two incubation mounds were known to exist.

*Extent of damage*

Megapod Island has been completely submerged, and only two standing dead trees, now mark its erstwhile location (Figure 33).

**Kondul**

Lying in the western portion of St Georges Channel that divides Little Nicobar from Great Nicobar, Kondul is a small, hilly island with a little flatland to the southeast, on which the village of Kondul existed. This flatland and a little of the beginning of the slopes were mostly inhabited or with plantations of coconut, arecanut and pandanus. The hill itself was densely vegetated, and it is likely that the species composition was similar to that of Little and Great Nicobar Islands. To the southwest, west, north, and northeast the hill ended in the sea; this region was characterised by rocky coast and small cliffs with shallow bays in between, and were home to the caves that were populated by edible-nest swifttlet *Collocalia fuciphaga*. The flatland area of Kondul was densely populated with Nicobaris, and a few mainlanders who manned the governmental establishments there, which included a school, PHC, food supply godown, police barracks, jetty, and generators for electricity.

Lying as it did between Great and Little Nicobar, Kondul was an important island ecologically since it possessed subsets of the fauna and flora of the other larger islands. It also had a small population of the Nicobar megapode and two known incubation mounds.

*Run up, ingress and loss of land*

Bounded as it is by the St. Georges and Pryce Channels, Kondul has deep waters to the north, east and west, with shallow waters only occurring in the south, which was partly sheltered by Great Nicobar. The height at which the tsunami waters reached was between 5-6 m asl at the most. Like other parts, the ingress has been till the hill. Since

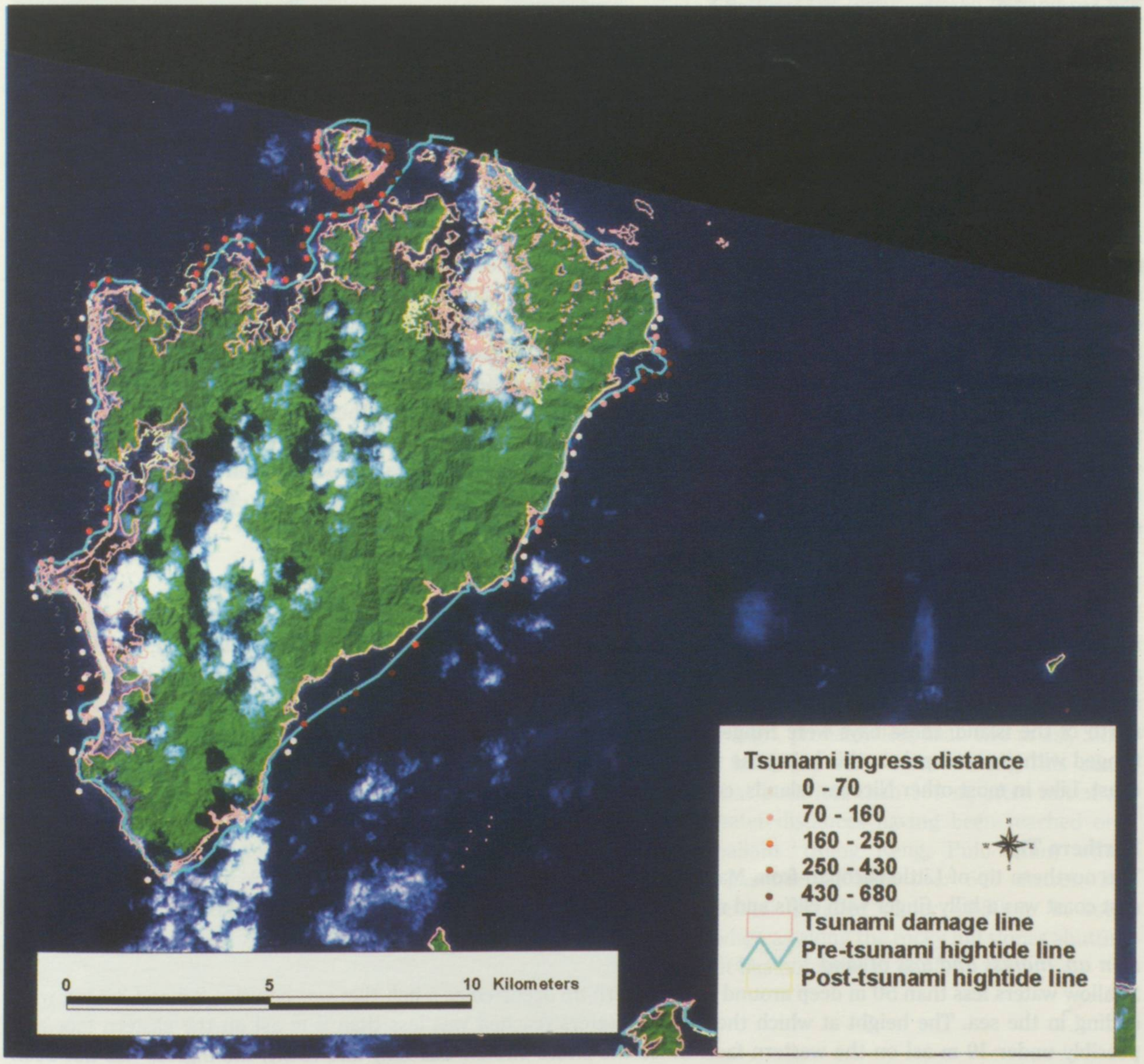



**Figure 34: LISS 3 imagery of Little Nicobar Island on 28/1/05 and 28/5/05 showing areas damaged by the tsunami. The northern tip is not shown.** *Map by N. Pelkey and V. Srinivas, FERAL*

**Figure 35: Pulo Panja was badly damaged since it lay on a promontory between the creek and the sea**

the flat coastal land was very narrow on Kondul, the tsunami has damaged land to a distance of not more than 75 m inland. Loss of land has varied between none, where cliffs ended in the sea, and 75 m at South and Middle Point.

*Extent of damage*

At the South Point, the majority of the coconut as well as other trees are still standing. However, due to the submergence of the island there has been considerable inundation, and almost all the flatland area is now inundated during high tide. Most of the coconut were green but were showing signs of dying out. The other trees there were scorched brown. At Middle Point, the land is higher and while all the houses had been damaged, and destroyed, the food godown and passenger hall had only been partially damaged. Kondul jetty had undergone severe damage. Some of the coconuts were still standing live. At north point, which was still higher, the damage was less, and the police barracks and medical building was intact, though water had reached here as well. Since the rest of Kondul was rocky with cliffs ending in the sea, the damage has been minimal. However, damage has occurred in the very narrow bays that exist and there have been run ups along nallahs that descend from the hill to the sea. The smaller caves have disappeared due to rock fall while the two large swiftlet caves were still intact.

## Little Nicobar

Lying north of Kondul, Little Nicobar with an area of 159.1 $km^2$ is the fourth largest island in the Nicobar group of islands. Topographically, the entire island is hilly with a narrow flatland coastal belt around the island, which widens along the west coast. There are no major rivers, but several smaller streams and rivulets originate from the hills of the island and descend to the sea. The coastline is not marked with major indentations and the only deep bays lie in the north of the island; these bays were fringed with mangrove. The majority of the coast of Little Nicobar Island was fringed with coconut palms, this being the most along the eastern and southern coast and least in the southwestern coast. Like in most other Nicobar Islands, coconut occurred as a mosaic with forest.

### Northern Tip

The northern tip of Little Nicobar, from Makachua on the west to Sombrero Point and back to School Point on the east coast was a hilly finger with cliffs and rocky coasts, interspersed with small, narrow flat coastal areas.

*Run up, ingress and loss of land*

Shallow waters less than 50 m deep around the northern tip occurred as a belt that was between 2.5 and 3.3 km wide ending in the sea. The height at which the tsunami waters reached was less than 5 m asl on the eastern face and possibly under 10 m asl on the western face. Since the entire stretch was hilly and rocky, the ingress has not been much, and there has been a vertical loss of land rather than a horizontal one. Similarly, loss of land has been low and only the very small bays and beaches, some of which were exposed during low tide, have been lost.

*Extent of damage*

Since the entire tip was hilly and did not have much littoral forests, or flat coastlands, the damage here has been minimal.

**Northeastern Coast**

The northeastern coast of Little Nicobar was typically fairly narrow coastal flatlands climbing into the central hill slopes. Since the biggest village of Little Nicobar, Pulo Panja, was located here, the coastal forests were dominated by coconut, with a mosaic of arecanut and littoral forests. There were two small nallahs in this stretch of the coast, at Pulo Panja and at Olenchi, where some mangroves and Nypa and other intertidal species were to be found. The eastern tip of Little Nicobar was rocky and had a swiftlet cave. The Nicobar Megapode was present on this coast, but the majority of the incubation mounds were present in the northern section of the northeastern coast.

*Run up, ingress and loss of land*

The sea adjoining the northeastern coast was less than 50 m deep to a distance of about 3.5 km. The height at which the tsunami waters reached was less than five m asl. The flat land between hill and sea was fairly narrow, and ingress has ranged from very little to about 300 m at Pulo Panja to over a kilometre at Olenchi. The shore line has receded less than 40-50 m at most places, with greater losses of land in the intertidal areas at the nallah at Olenchi and at Pulo Panja (Figure 35).

*Extent of damage*

There were three major points of damage. School Point to Elaye, where the wider flat lands between hill and sea has largely been submerged with sea water ingress during high tides. The majority of the trees and undergrowth continues to stand, but had undergone scorching and were mostly brown with some green showing here and there. A few coconut palms had survived. Pulo Panja has had the worst damage in this section of the coast, since a nallah ran from the sea to behind the village. All housing and most buildings were washed away, and the majority of the trees were also uprooted. From Pulo Panja to Olenchi, the entire coastal area, up to the hill, had been scorched brown, but as this coast was east facing, the force of the tsunami was less, and many old growth trees and undergrowth and middle storeys were still standing. Some trees were sprouting fresh leaves. The damage was more at Olenchi due to the presence of the nallah there, and fairly heavy damage had occurred to the mangroves, though many of these were still standing.

**South Eastern Coast**

The southeastern coast was a long stretch of narrow coastal forest with the hill beginning just behind the shore, and at places was the shore itself. The shoreline was more or less even, and other than at Reng Reng, at the eastern end there were no deep indentations. There were several small villages and hamlets on this coast, Pulo Patia, Howain, Pulobahaun, Pulo Peya, Pulo Ulon, and Bivaye. The littoral forests were mostly a mixture of coconut which was mainly a narrow strip abutting the beach, arecanut and pandanus to the interior, with other trees and undergrowth forming the rest of the vegetation. There were several small fresh water streams that descended from the hills and emptied into the sea. The Nicobar megapode was found throughout this coast, but were at lower densities since the littoral forests were narrow.

*Run up, ingress and loss of land*

Since this coast abutted the St. Georges Channel, the waters here were deep, over 70 m as close as one kilometre from the shore, the only shallow area being at Reng Reng. Consequently, the waves were not very high, probably less than five m asl. Since the flat land was very narrow along this coast, ingress has been less than 100 m, often not at all, with greater distances having been reached only along nallahs, (Reng Reng, Pulo Ulon) where ingress has been a little over 600 metres. The shoreline has receded under 40-50 m in some places, whereas along the rocky hill slopes abutting the sea it has not receded at all.

**Figure 36: Tavithe, West Coast, Little Nicobar**

*Extent of damage*

The southeastern coast of Little Nicobar was amongst the least damaged of coastlines in the Great Nicobar Group of islands, as this was sheltered by Great Nicobar and was east facing as well. Moreover, the channel off this coast was deep, with the result that run ups were less. Here too the tsunami had been stopped only by high ground, and the entire stretch had been scorched brown. However, as the majority of the coastal forests had coconut and Pandanus, both of which are salt resistant, there was a lot of green in this shore line. Wherever there were nallahs, as at Pulo Ulon, Olenchi, Pulobahaun, the waters have rushed deep inland. While the coconut that were on shore, and subject to considerable inundation by sea water, were dying out, the coconut on higher ground further inland were intact.

**South Western Coast**

The southwestern coast can be divided into three sections. The southern most portion had the village of Kiang and was followed by the Kiang beach, which was the most important beach on Little Nicobar as large numbers of leatherback turtles nested here (Bhaskar 1993). North of this were the twin bays of Tavithe and Muhincohn/Tauhiyol, which were long beaches with a fairly broad flatland littoral forest abutting it, which had the highest density of Nicobar megapodes on Little Nicobar Island. There were at least 20 or more incubation mounds in this region. This was followed by the receding Pahua Bay and then continued as narrow coastal forest all the way till the northwestern tip of Little Nicobar. The long beach at Tauhiyol was an important leatherback turtle nesting beach as well. Large creeks, Ra Hoah, and Ra Annuii along Tauhiyol beach and a larger creek Rireyeh, adjacent to Pahua were major freshwater habitats, with healthy populations of breeding crocodiles.The entire stretch was thinly populated with small villages only at Kiang, Tauhiyol and at Pahua. Coconut and other plantations too were more or less restricted to the areas near the habitations.

*Run up, ingress and loss of land*

The waters off the southwestern coast were shallow, less than 50 m deep to a distance of over seven km. Consequently, the waves were higher, and ranged between five and eight metres asl. Fairly extensive flat coastal land occurred at places, the widest being at Tauhiyol, where ingress has been over 1.5 km. Elsewhere, ingress has been less than 250 m to very little. Loss of land along this coast was, by and large, under 50 - 60 m.

*Extent of damage*

The southwestern coast has been the worst affected on Little Nicobar. The entire littoral forests and coconut plantations at Kiang have been swept away till about 5-6 m asl on the hill, leaving behind a small patch of coconut near where the well was, whose water was still fresh. Two freshwater springs are still present just above the tsunami line. The Kiang Beach was still present and appeared to be building up. The rock at the tip of Kiang Beach (Muhimoh) was intact as was the cliff adjoining it, though they had sunk significantly. Earlier it was just about possible to traverse this stretch of coast on foot; now it is not possible. The entire Thavithe and Tauhiyol bays had also undergone very heavy damage (Figure 36). While a significant number of old growth trees were still standing, the undergrowth and plantations had been completely stripped away. Water had rushed up the three nallahs that were there and had caused damage to the interior, leaving large gaps in the vegetation. Small nullahs, such as Re Peking, and Re Muhincohn, have been washed away along the coast. The entire coastal vegetation had been scorched, but several trees, primarily *Ficus spp.* were giving out fresh leaves. Most of the plantation had been stripped, and less than a 100 coconut palms remained. The next bay, where the village of Pahua was, had also been badly damaged, with the vegetation scorched brown till the hill with several standing trees and most of the undergrowth and middle canopy trees uprooted. Three small patches of coconut, one of nine, the other of about 25, and the third of about 10 were all that remained of the plantations of Pahua. The flatland behind the rocks in the seas, Pinaii and Mange-tera-ye, was also badly damaged, with most of the coastal forest having been swept away to about 5-6 m asl. Further north, the damage was even greater with the forest having been stripped to over 7 m asl leaving behind very few trees.

**North Western Coast**

The northwestern coast, from Patatifiem till Makachua, had both littoral forests towards Patatifiem and the coast was fringed with mangroves and their associates at creek mouths after Akupa, as this was a deep bay. Megapodes were found throughout this forest but at lower densities. Some of the beaches had sea turtles nesting on them. The mangrove creek, Laon Lo Reyeh, in the northern section opposite Pulo Milo, was the largest stretch of mangrove in Little Nicobar, and had healthy populations of crocodiles.

*Run up, ingress and loss of land*

The waters abutting northwestern coast were very shallow, less than 20 m to a distance of about 3.5 to four km. Consequently, the tsunami waves were high, and reached between seven and 12 m asl, possibly more at places The coast was marked with deep indentations with nallahs and fresh and saltwater swamps, with the result that this coast saw some of the deepest penetrations by the tsunami, which damaged habitats along the innumerable valleys that open out into the bays, and along which nallahs flow. At places damage occurred as far as over three kilometres inland. Loss of land has also been the most here, and the coastline has receded from less than 50 m to over several hundred metres.

*Extent of damage*

This was the worst affected coast of Little Nicobar with virtually all vegetation stripped clean to a height of over 7-8 m asl, leaving behind very few standing trees, which had been scorched brown. Since there were three deeply indented bays, each with nallahs and tidal creeks, the penetration by the tsunami inland was deep. The bay between Infok and Akupa had been considerably widened and deepened and there was no sign of the villages, and less than 50 scattered coconut palms, the majority of them in the sea, were the only remnants of the plantations that had existed here. There were a few patches of standing old growth trees, with some of the middle storey trees still standing. The tsunami had stripped away most of the vegetation into the valleys along which the nallah flowed. The next bay, between Akupa and Anuleh was also very badly affected as there was an intertidal zone to the interior of the island along Komat creek, where the vegetation was stripped up to the hill and along the valleys, possibly to over 10 m asl. The mangrove creek with swamp, the Laon Lo Reyeh that existed between Anula and Makachua, opposite Pulo Milo, was completely stripped, and barring very few mangrove trees, there was no sign that luxuriant mangroves once existed here. There were a few hillocks on the shore with flatland to the interior, and the tsunami had swept the vegetation behind them clean, leaving them isolated, and with one bay visible through to the next. In the entire bay and its arm the hills now end in the sea, with very little or no flat coastal area. That flat land that existed was stripped bare of vegetation. The damage continued along the shoreline of Makachua, with the vegetation stripped bare to over 7 m asl. There were patches of old growth trees as well as middle canopy trees, but the majority were destroyed. A few coconut palms were still standing, and at one place north of erstwhile Makachua, there was a stand of 75 to 100 coconuts trees that were more or less intact.

### Pulo Milo

With an area of 1.3 $km^2$, Pulo Milo was the smallest inhabited island in the Nicobar Group of Islands. Being densely populated with Nicobaris and few mainlanders who manned the various governmental establishments there, much of the flat land to the southeast, east and northeast of the island was inhabited and was under coconut, banana and arecanut plantations, which extended up the hill slopes as well. The southern, western and northern portions had very little flat coastal forest as the three hillocks which formed the island ended almost at the sea. These coasts, as well as the hillocks themselves, had natural habitats, which were degraded and interspersed with small stands of coconut and banana plantations. The Nicobar Megapode was believed to have become extinct here in the past.

*Run up, ingress and loss of land*

The waters abutting Pulo Milo were very shallow, less than 20 - 30 m to a distance of about 3.5 to four km. Consequently, the tsunami waves were very high, and reached over 10-12 m asl. The belt of flat land around the hillocks that were there on Pulo Milo was narrow, and ingress has been till the hill and along its slopes.

*Extent of damage*

Pulo Milo was very badly damaged, and the vegetation of the entire flatland off the coast had been swept away, a damage that extended to over 6-8 m along the hill slopes. The tsunami had cut across the island through the low valleys of the hillocks at two places. The only vegetation left of Pulo Milo was on the hills. Pulo Milo is now uninhabitable.

### Treis

Treis with an area of 0.5 $km^2$, was a very small uninhabited island that consisted of a hillock to the east that ended in the sea, and a small flat land to the south, west and northwest. The hillock had natural vegetation, while the flat land was mostly coconut and banana interspersed with natural vegetation. The seas around Treis are shallow, less than 30 m deep to a distance of about 4.5 km. Treis had a small population of the Nicobar megapode, and the robber crab; its importance however lay in the fact that hundreds if not thousands of pied imperial pigeon *Ducula bicolor* nested on the island.

*Extent of damage*

The waves here probably were over 6-7 m high, and swept away all vegetation of the flat land and along the lower portion of the hill slopes. A small patch of less than 150 coconut palms remained at the southwestern corner, and several bananas were sprouting. The rest of the island had been denuded of vegetation.

**Trak**

With an area of 0.2 km$^2$, Trak is a very small uninhabited island that consisted of a small hillock to the east, that ended in the sea and a small flat land to the west. The hillock had natural vegetation, while the flat land was mostly a mixture of natural vegetation, coconut and banana. The seas around Trak are shallow, less than 30 m deep to a distance of about 4.5 km. Trak also had a small population of the Nicobar megapode, and the robber crab; its importance however lay in the fact that hundreds of pied imperial pigeon nested on the island.

*Extent of damage*

The waves here probably were over 6-7 m high, and washed away all vegetation to the flat land and along the lower portion of the hill slopes. A small patch of less than 100 coconut palms remained along the west-facing slope of the hillock. The rest of the island had been denuded of vegetation.

**Menchal**

Menchal is a small island 1.5 km$^2$ in extent, which is uninhabited. It is mostly a low hill with a small flat coastal area in the western corner, while the coastline of the rest of the island is mainly hilly and rocky. Menchal is densely vegetated with coconut and banana owned by the islanders of Little Nicobar, with small patches of natural vegetation, where bamboo is amongst the dominant species. There is an excellent freshwater spring on the island. Species of importance include a small population of the Nicobar megapode and the robber crab.

*Run up, ingress and loss of land*

The sea around Menchall is not very shallow, under 50 m to a distance of about 3.5 to 4.5 km, with patches of deeper water closer to the shore. The wave does not appear to have been very high here possibly just three to four metres, and ingress in the flatland area did not appear to be under 100 m. Loss of land appeared to be low with possibly 20-30 m only having been cut off.

*Extent of damage*

Menchal had got off lightly, and the damage to the island was amongst the least seen in the Nicobar Islands. The flatland area has undergone some loss of trees, including coconut, as have some of the very small bays in the hilly portion of the coastline. The rest of the island was undamaged.

**Meroe**

The western most of the Great Nicobar subgroup of islands, Meroe is a small uninhabited island, 2 km$^2$ in area. The sea abutting Meroe is not very shallow, under 50 m deep to a distance of less than two kilometres. The southern and eastern portions of the island is a low hill, with the eastern sea face being cliffs. Approximately at the centre of the island was a large inland salt-water body that was subterraneously connected to the sea. The entire island was very densely vegetated with coconut belonging to the Nicobaris of Little Nicobar, Pulo Milo and Kondul. The little natural habitat that existed was interspersed with coconut. Meroe had small populations of the Nicobar Megapode and the robber crab, as well as the only known colony of tropic birds *Phaethon spp.* in the islands.

*Extent of damage*

Meroe was not visited, but reports are that the western and northern areas have been very badly damaged, with the tsunami having reached the central water body.

**Camorta**

With an area of 188.2 km$^2$, Camorta is the biggest island in the Nancowry group of islands. It is a long, bean like island with deep indentations and bays, with the result that the majority of the mangroves present in the Nicobar Islands fringed the shores of Camorta. The island itself consists more or less of a single low hill ridge running north to south, with its ridges, undulations and valleys descending to the sea. There is very little flat coastal forest on Camorta; more often than not, the low hills end in the sea. The tallest peak at 210 m is in the south western corner, which descends to Swell Point that flanks the western opening to Nancowry harbour. The rest of the island is low mostly under 50 m high, with peaks of 108 m and 105 m occurring in the central and north central parts of the island. The majority of the central portion of the island is grasslands, which account for about 39% of the vegetation of the island. Forests occur as patches interspersed with grasslands, and are reminiscent of the shola-grassland mosaic of the Western Ghats of India. The largest patches of forest occur in the south-western corner and central parts of the island, the latter being the most extensive contiguous forest on Camorta.


**Figure 37: Camorta, Nancowry, Trinkat and Katchall islands**

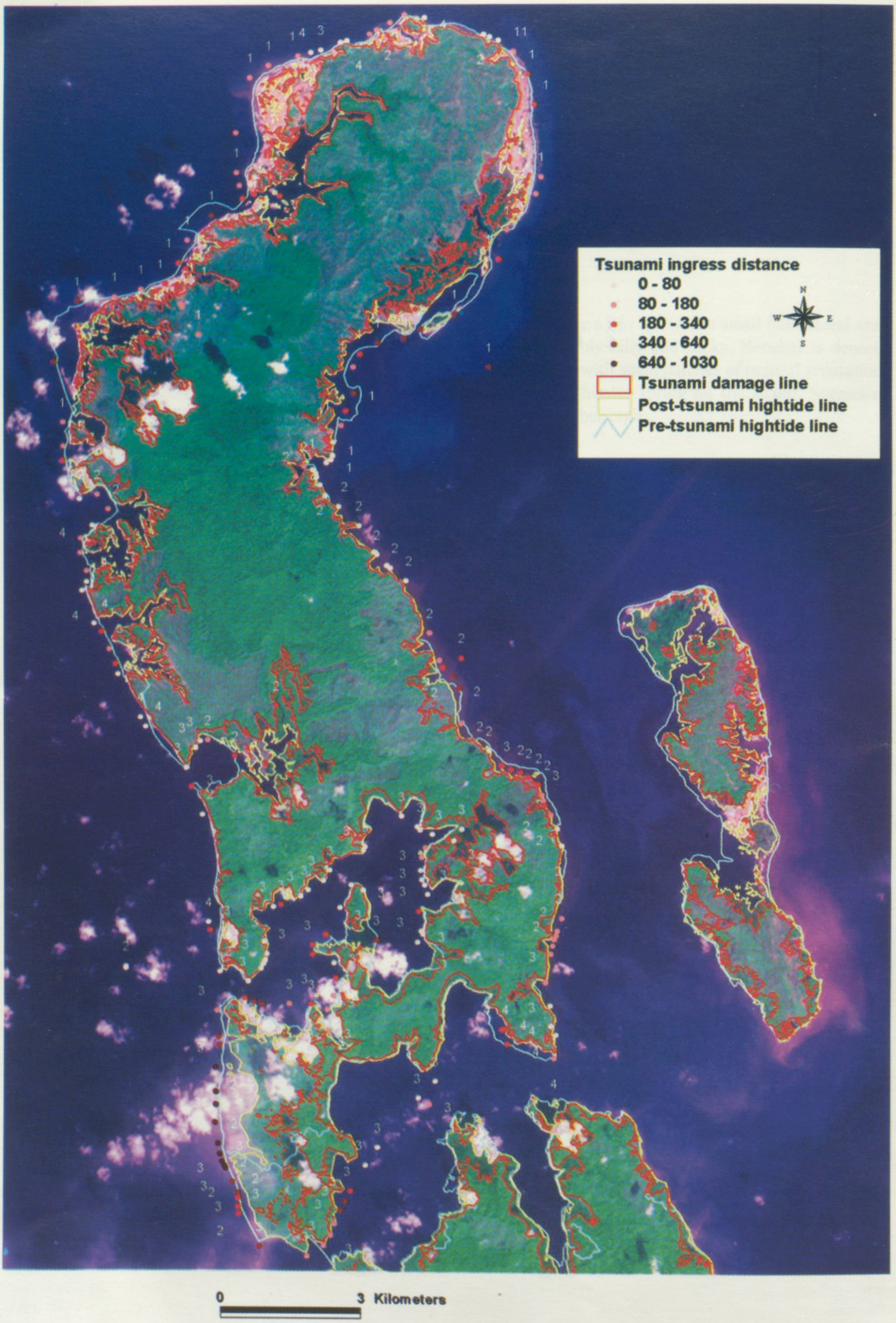



**Figure 38: LISS 3 imagery of Camorta and Trinket Islands on 04/01/05 and 28/5/05 showing areas damaged by the tsunami.** *Map by N. Pelkey and V. Srinivas, FERAL*

**Southern Coast**

The southern coast of Camorta is sheltered by Nancowry and the protected channel between the two islands forms Nancowry Harbour, one of the best natural harbours in the Andaman & Nicobar Islands. The southern coast is comprised of two large shallow bays and several smaller indentations, which were fringed with mangroves not wider than 100 m. The flat land between sea and hill was very little or not at all; flat lands that did occur had small Nicobari hamlets on them. The promontory to the east was by and large occupied by the township of Camorta (or Kinlaha). The entire southern portion of the island was fairly intensely used by man, the coastal area and to some distance on the hill slopes having several plantations of coconut and arecanut, and the forests were fairly heavily used by both Nicobaris and mainlanders from the township of Camorta. Between the larger bays and Swell Point, the coast was hilly and rocky with very small sandy bays in between. This section of the coast had several habitations, Camorta town being the largest, followed by Monac and Ramjau and Payuha, which were small Nicobar villages. The hills above Swell Point at the southwestern corner had small populations of the Nicobar megpode.

*Run up, ingress and loss of land*

The sea adjacent to the Southern Coast, though shallow, less than 30 m deep, was protected by Nancowry island, barely 450 m away at the south western corner and 750 m at the south eastern corner. Thus the tsunami has occurred more as a very powerful swell, that has been under 5 m high, and more probably not more than 2-3 metres asl. Here too as elsewhere, the tsunami has stopped only at the hill, which was very close to or on the high water mark, and hence ingress on to land has been very little. Due to the very narrow flat coastal land available, loss of land has also been little with the major loss having occurred at Camorta Jetty where the high tide mark has made inroads into the island by about 50-60 metres. At other sites this was probably between no loss of land at all and less than 20 m.

*Extent of damage*

The fringing mangroves of the entire southern coast, mostly less than 100 m deep were leafless and appeared dead. The forests and plantations above the high tide mark were intact and green. Some vegetation had been uprooted, particularly in the very small flat coastal land that was present, but this damage was not extensive. That the power of tsunami was low on this coast was also evident by the fact that many of the houses at Monac and Ramjau were damaged but still standing, and some were even intact. The damage at Payuha and Mohul was more, with the entire villages having been washed out. The vegetation, including coconut and arecanut plantations were more or less intact, with only those trees that were now standing in the sea showing signs of dying out. In the several small bays between rocky outcrops and cliffs that marked the coast after Payuha, there was dead or dying coconut on shore, which were intact further in. Other dead trees were also visible, but the vegetation was more or less intact above a height of 1.5 m asl. The villages and small hamlets (single houses) that occurred in the western most portion of the southern coast, including Alu Khayak, had been totally washed out, with dead and dying coconut and arecanut to a height of 3-4 m asl. The south western corner, also largely rocky with small bays and flat land, was devoid of trees, but with fresh vegetation coming up on the ground. Wherever there were nallahs descending to the sea, these and the adjacent shores had suffered greater damage.

**Western Coast (Swell Point to north of Pil Pilo)**

The western coast of Camorta is the longest shore of the island. The southern section of the coast is marked by long stretches of rocky and hilly shores interspersed with a few shallow indentations, some of which were inhabited. The most prominent geographical feature is Bandarkhadi (Expedition and Grand Harbours), which is a very deep narrow mouthed bay that extends nearly six kilometres into the island, almost to the east coast, and with its arms extending almost to the southern coast from which it is seperated by a narrow neck barely 300-400 m wide. The entire bay was fringed with mangroves, interspersed with coconut, arecanut and banana plantations where there was flat land between mangrove and hill and at places on the hills. The coast continued as a rocky and hilly shore till the next big bay Dering, which was a smaller version of Bandarkhadi, and with a larger mouth. The village of Dering was here, and the majority of the more sheltered inlets of the bay were dense stands of mangrove. The coast continued north mostly as a long mud and stone embankment 20 or more metres high till it reached the next deep bay at Rumyuk. Rumyuk had two main nallahs and some mangroves, but the majority of the flat land and up the hill slopes were densely vegetated with coconut. The coast continues north with little or no flat land between grass covered hills and sea. The next big bay, Ol Hinpun (Alimpong), also had several nallahs and some mangroves but the shores were densely vegetated with coconut. Soon after Ol Hinpun, the flat coastal land widens and becomes a wide beach at Pil Pilo, which further north had the nallahs of Thanange, and still further north Moreak, which was a deep indentation into the island. All the bays and available coastal flat land in the western coast of Camorta was densely vegetated with coconut, with very little natural habitat interspersed in between. Like other Nicobari plantations, a fair number of trees and other species of vegetation were to be encountered in these plantations as well. There were a number of small hamlets and villages on the western coast. On the southern section was the village of Changuah and other very small hamlets; in Bandarkhadi was the village of Pullaw and a few other hamlets. Dering harbour had the village of Dering (Ol Loe) which was densely populated with 215 people. Ol Hinpun was a small hamlet with three to four houses, and until recently was the only village on Camorta where the old animist religion was practised. Pil Pilo was a very large and old village with a population of 414 people. In addition to the main villages, there were several smaller hamlets with one or two houses and small houses in the coconut plantations. Due to preponderance of coconut on the coast, the population of Nicobar megpode was low, and the main concentrations were at Rumyuk and Ol Hinpun. Crocodiles were found in the bays and inlets.

**Swell Point to Dering Harbour**

*Run up, ingress and loss of land*

The deep water Revello channel separates the west coast of Camorta from Katchall. The near shore waters of the southern section of the western coast were deep, with depths greater 50 m between 750 m and one kilometre from Swell Point to between Bandarkhadi and Dering. After this, the shallow shelf widens with the waters less than 50 m deep to a distance of 3.75 km at Dering Harbour. At Changuah the run up appears to have been between four and six metres. At Bandarkhadi, the run up appears to have been less, possibly only about two to three metres (at Havike, Bandarkhadi it was two metres). At Dering, the run ups appear to have been more with heights of the wave ranging between four and six metres, and less at places. Ingress distances as much as three km, took place where nallahs, fringed with mangrove, ran deep into the island as at Bandarkhadi, Dering, and Rumyuk. Loss of land has been quite acute at places, where between 10-20 m to well over a 100 m of shore has been lost. Where hills or rocks ended in the sea, there has been no loss of land.

*Extent of damage*

The southern section of the west coast was mostly hill and rock that ended in the sea, with deep valleys along which nallahs flowed. These were all washed out completely with very few trees left behind. Coconuts that were present on this coast had been uprooted, those that were standing on or close to the shore were dying out while those further inland were still green. There was no trace of both Changuah and Massala Tapu.

Within Bandarkhadi, the waves were smaller and the vegetation was more or less intact above 1.5 m asl. The damage was variable, with mangroves and shore vegetation having been uprooted at places and intact at others, this extending to the very end of the several dozen inlets that open into the bay. The mangroves, which for the most formed a belt 30-50 m deep along the shore were leafless and appeared to have died. There were several patches of coconut behind the mangroves where the palms on shore were dying out and those further inland were green and intact. Some new islands have been formed as the mangroves, which connected these sites to the main island were washed out. At many places, where hills ended at the sea without fringing vegetation, the vegetation was by and large intact almost up to sea level. The three villages on the shore of Bandarkhadi, Chanol, Kafang and Bula were all washed out, with few coconut standing.

**Relief material at Camorta jetty**

The rocky coast between Bandarkhadi and Dering was damaged mainly along the two nallahs that descend between rock faces to the sea. Some pandanus and coconut still survive here.

The spit of high ground that was Dering between the sea and the mangroves to the south and east, was very badly damaged. All houses and infrastructure had been washed away, and the plantations very badly damaged, as large numbers of trees have been uprooted and with coconut dying out as the ground they were on was inundated by the sea. The extensive mangrove area abutting Dering was also very badly damaged, with great many trees having been uprooted and broken off. The majority, however, were still standing, but these were leafless and appeared to be dead. The tsunami had reached the hill behind the mangrove to 3-4 m and in some places stripped it bare but at most others there was scorched vegetation up to the tsunami line. There was not much sign of greening in this stretch. Wave mark here to 10-15 ft high though some debris above as well at places. At the entrance of Dering harbour, there were two small patches of live green coconut and one small patch of Nypa.

**Dering Harbour to Pil Pilo**

*Run up, ingress and loss of land*

The shallow shelf, which at Dering Harbour was less than 50 m deep to a distance of 3.75 km widens and becomes even shallower to less than 30 m deep at a distance of four to six km at Pil Pilo. At Rumyuk, the near shore water was very shallow, less than 20 m to a distance of nearly 2.5 km. Consequently the waves were much higher, probably between nine and 12 metres. At Alimpong and Pil Pilo the heights of the waves were probably between five and six metres. (GPS altitude readings at two points above Pil Pilo indicate that the water reached points 17.27 m asl; accuracy not known). Ingress has throughout been up till the hills or high ground, and ranged between zero to several 100 metres deep. Loss of land has been quite acute at places, where between 10-20 m and well over a 100 m of shore has been lost. Where hills or rocks ended in the sea, there has been no loss of land.

*Extent of damage*

The low mud and rock cliff face north of Dering Harbour, had not under gone much damage, and the well established colony of bluetailed bee-eaters *Merops philippinus* continued to nest in the burrows there. There was very little flat coastal land and damage appeared to be minimal. The rock at the mouth of Rumyuk nallah marked the start of very heavy devastation, where the destruction has been near total up to the hill slopes and along the several valleys that open into the area, with all vegetation stripped and debris piled up to over 10 m asl. All the valleys had been inundated, and there was standing water, apparently deep at places. There were a few hundred standing coconut, but the majority of the plantation had been flattened. The second inlet into Rumyuk had been similarly damaged and inundated, with the vegetation destroyed from the flatland and the hill slopes stripped to a height of of six to seven metres. Coconuts that were inundated were dying out, and those that were on higher ground particularly along the northern shores of the bay were still green of inlet then rocky coast to sea with grass on top. North of Rumyuk the coast, the coast was hilly and rocky, and the bits of flat land present between sea and hill in small bays had coconut on them, which were largely intact.

Ol Hinpun bay had also been subjected to very heavy damage, with the vegetation having been razed on the flat land and along the hill slopes to about three to four metres asl. There was extensive inundation in the flatlands, and the coconut were dead or dying out. Inundation ran like fingers up the various valleys that opened out into this area. The coconut appeared intact further inland wherever there was high ground. There was some beach formation in the small bays between low high grounds after the northern tip of the Ol Hinpun bay, where the coconut inland was intact, while those on the shore and the sea were dying out. In the deeper indentations, the damage was up to the hill slope less than 75 m inland. Series of low high grounds with fringing beaches in between. Coast mostly coconut. The nallah, before Pil Pilo, was also very badly damaged, and there was no trace of the mangroves that fringed it. Coconut continued to fringe the damage line.

The broad flat land on which the village of Pil Pilo existed had undergone very heavy damage. Apart from a stand of coconut at the southern portion of Pil Pilo, the whole beach had been washed out till hill slope to a height of three to five metres asl, where grassland or forest fringed the damage line. Apart from the veterinary building and the concrete floor of some buildings, there was no sign that Pil Pilo existed. A few coconut palms survived, and some dead/leafless standing trees were also present.

The two nallahs that were present north of Pil Pilo, Thanange and Moreak had been significantly widened and considerably deepened with heavy damage along shores of the valley that opened into them. Trees and other vegetation were intact on top of the low hills that fringed these nallahs, but vegetation had been stripped to between four and six metres asl. The flatland between the two nallahs had also been stripped of vegetation, and the two nallahs have joined

Nicobar group 75 kg
Camorta 15
Kondul - 40
C'bay - 10-12
Car Nicobar - 2-3 kg

1977-85 - 100-120

86-88 - 100-110 + [Baratang]
Mayabunder-diglipur - 30 kg
Wandoor - 40 kg.

Neil - 5 kg.
Havelock - 15-20 kg.
Hut bay - 10-15 kg

w.B.S. 4-5 urs.

1997 - 450-500 kg.
96 -

| | 1997 | 1996 |
| --- | --- | --- |
| Full cup | 20,000 | 30-35 |
| medium | 15 | 20-22 |
| Rest | 4-7,000/- | 10-12,000 |

1996

Indian
Karnabaha - Edible-nest swiftlet
25 kg.

Havelock - Pmarine Store Next to Jetty.
'~~Kumar~~'
Rangat - Old Power house.

4147=00

inland with a small hillock separating them at the mouth. A small line of beach was being formed. At Moreak nallah, there was a small patch of mangrove in the eastern corner that was dead and battered. The flatland north of Moreak, once an extensive coconut plantation, had been stripped of vegetation up till the grass covered hills, leaving behind very few standing trees.

**Northern Coast**

The Northern coast of Camorta is narrow and consists of rocks and cliffs ending in the sea. A few small nallahs descend from the tops of the hills, which were mostly grasslands with a few small patches of forest, including casuarina, fringing the nallahs and the grasslands. A few scattered coconut palms were also present along this coast

*Extent of damage*

The damage on the northern coast has been restricted to along nallahs that descend to the sea through the cliffs, and to the small beaches that were present at the mouths of these nallahs. These were by and large thinly vegetated, with grasslands being the dominant vegetation type. The trees and coconut palms that were along the nallahs has mostly been swept away to a height of about six metres asl. Heavy rock fall was present only at one place in the entire stretch.

## Eastern Coast

The cliffs on the northern coast opened out into a fairly wide flat land at the northeastern corner that extended all the way south to Kakana. This strip of flat coastal land, between 200 and 800 metres wide, was an extensive coconut stand interspersed with patches of littoral forests, which extended along the valleys and into the hills. Abutting and above the forests were extensive grasslands that extended as a mosaic with patches of forest and scrub till Pil Pilo. At Kakana, a major inlet separated the coast from the hills, and this was fringed with mangroves, with the high ground being densely vegetated with coconut and interspersed with forest and natural vegetation. The promontory opposite Kakana was vegetated by a large patch of old growth casuarina trees. South of Kakana, the island was indented into several bays and inlets, which was fringed with mangrove, all the way south to Camorta. There was virtually no flat coastal land between the mangroves and the hills behind them, with high tides reaching the base of the hills. The forests started above the mangrove along the slopes of the hills, beyond which the vegetation was a mosaic of forest and grasslands, with a few coconut and banana plantations in the southern half of this coast. There were several villages, hamlets and lone houses on this coast; Takaroach, Nyikalang, Ol Mentaitit and Oal Heat were small habitations in coconut plantations north of Kakana, which was a large village inhabited by 406 people. The mangrove area south of Kakana, had one or two lone houses like at Meho, and two small villages, Chota Enaka and Bada Enaka, with 48 and 26 people respectively, inhabiting them. Megapodes were found mainly in the promontory east of Kakana and along the littoral forests till Takaroach.

*Run up, ingress and loss of land*

The sea adjacent to the east coast of Camorta is shallow, with depths less than 50 m to a distance of between six and 13.5 km from the shore. The southern portion of the east coast is protected by Trinket Island, which lies a little over two kilometres away, and the two islands are separated by the shallow, less than 20 m deep, Beresford Channel. In the northern section of this coast, the run up levels have been between six and eight metres, whereas in the southern portion, the run up has been two to four metres asl. Like elsewhere, the ingress has been up till the hills, which was widest at Kakana, where sea water reached up to 1.5 kilometres inland. Loss of land has also occurred here, which has been maximum at Kakana where the shoreline has receded by over 50 metres, and because of the nallah, land had also been submerged inland.

*Extent of damage*

All the vegetation between Takaroach and Ol Mentaitit has been swept away, leaving behind barely a dozen scattered standing leafless trees, up to about six to nine metres asl, above which there was a fringe of forest, coconut and other palms, above which was grassland. At places the trees had been completely cleared and the grassland now fringed the damage zone. Dense standing trees, with contiguous leafless branches were present from Ol Mentaitit southwards, with standing coconut, dying out where inundated and green to the interior. The coconut plantations in this stretch of the coast have undergone very heavy damage. The tip of the casuarina vegetated promontory opposite Kakana has been cut off and now forms a separate island. Some scorched trees are showing signs of greening, as was the case with several trees beyond the inlet and inland. Kakana village areas had been completely devastated, with only the damaged school building, now partly in the sea, standing. At the southern tip of Kakana, over 100 metres of land had been submerged. Some mangroves were still standing in this area, but were leafless and appeared dead. South of Kakana, the coastline featured low hills whose valleys formed deep inlets that were fringed with mangrove. By and large, the mangroves had all been swept away, leaving behind a few scattered stands or individual trees that were all leafless. The hills that ended just behind the mangroves, extending into each and every nallah and inlet, had all been swept of their vegetation to between two and three metres asl. The tsunami damage area was fringed by trees and bigger patches of forest, and at several places the trees had all been swept away and grassland now fringed the damage zone. At places 100 to 150 m wide swathes of mangove that once existed had all been swept away. Piles of mangrove and other debris lined the shores. The village at Meho had been washed away, as were Bada Inaka and Chota Inaka, along with all the mangroves, and the plantations have been heavily damaged to about two to three metres asl. The last bay in the southeastern coast had a small patch of Nypa that had survived the tsunami.

**Trinkat**

Trinkat Island was a small, narrow, inhabited island that was 36.3 $km^2$ in area, which consisted of two low predominantly grass covered hills in the south and in the north, the highest points of which were 20 and 29 m asl respectively. Grasslands account for nearly 59% of the vegetation of Trinkat. The southern, eastern and northern seashores were mostly beaches, while the western shore, sheltered as it was by Camorta, was predominantly mangrove. The southern and northern hills were connected to each other by a sandbank, Tapiang, that was mostly vegetated by coconut to the east and by mangroves to the west. Between these mangroves and the northern hill lay the village of Ookchuaka on the western coast. The northern extremity extended as a wide sandbank, Takasem or Safed Balu, around the second large patch of mangrove that fringed the northern hill. This sandbank was also mostly vegetated with coconut. The shores of the southern hill was a narrow flatland on the western front, and both the southern hill and the northern hill had narrow flat coastal land on the eastern sea face. Apart from Takasem (162 people), Tapiang and Ookchuaka (270 people), a few isolated settlements at Kapila, Kurawak and Lahoum were present on the western front. The majority of the vegetation of the island was grassland and mangrove, forests occurring in patches, and often as a fringe above the mangroves. Most of the available flat coastal lands were coconut plantations, with very little natural habitats. The Nicobar megapode was present in small numbers on the island, and a few turtles nested on the beaches of the eastern shore.

*Run up, ingress and loss of land*

The seas around Trinkat are shallow, with depths under 20 m to a distance of about two kilometres, and under 50 m to a distance of six or more kilometres off the eastern coast, and under 20 m deep to the west which is the Beresford Channel. Run up levels varied between three and four metres which appears to have been the case at most places, to about seven to eight metres at some places like at Ookchuaka. Ingress was till the hills at all places on the island, which by and large did not exceed 75 to 100 metres since available flat land was very little. Loss of land has been acute at Ookchuaka and at Takasem, where the shore line has receded by at least 100 metres at places.

*Extent of damage*

The southern tip of Trinkat had not under gone much damage, and the small beach there continued to have coconut beyond which the hills were grass covered, the major damage having occurred along the nallah which descended here from the hills. The lighthouse here was intact. From the southern tip till Tapiang, the eastern coast was a long beach whose shore is a series of undulations as the spurs of the hill descended to the shore. Damage was largely restricted to the coconut on the shore which was dying out, while those further inland were intact. Pools of water had been left behind by the tsunami in the low ground between beach and hills, Wherever there were nallahs, damage was significantly more, and these had been widened, and the vegetation swept away clear to the low grass hills beyond. Damage here varied between three and six metres asl, with forests above the damage zone, which was fringed with grassland further inland. Tapiang beach had undergone very heavy damage, with the coconut on the shore dying out and very few standing inland, west of which was the very heavily damaged mangrove. Less than 200 live coconut palms were left in the entire Tapiang area, remnants of the few thousand trees that existed in the past. The beach had been considerably thinned, with the result that the sandbank which joins the southern with the northern hill, though intact, is much narrower now. There were several dead standing trees on high ground inside the mangrove at the fringe of the southern hill, which further north was completely flattened out and not a single mangrove tree was left standing. On the high ground as well, all the vegetation has been flattened out, and there were very few standing trees through to Ookchooka village and to about six to seven metres on the slopes of the northern hill. Above the damaged zone was a mixed habitat of coconut, other trees and vegetation and scrub.

The flat coastal land between the northern hill and the sea was also devoid of vegetation. At the Hun Kun, which is a sea water inlet deep into Trinket that fills up several valleys, most vegetation was stripped till the hill slopes which were damaged to 3 to six metres, above which there was grassland. The mouth of the Hun Kun nallah was closed by beach formation. Kumeta nallah was considerably wider, and the vegetation stripped along the hill slopes. Above the damage line, the hills along the coast had natural forests on top with grasslands further inland. After the Kumeta nallah, the coast was a series of small spurs and valleys with beach seawards. In the sea facing valleys there were salt water pools, with the sea water crossing the sand bank and entering the pools during high tide. In the valleys, nallah descended from the grasslands to the pools. There was very little flat coastal land left, and this was mostly devoid of vegetation. Above the damage line was forests. There were virtually no coconuts left till just before Taskasem, where a few small

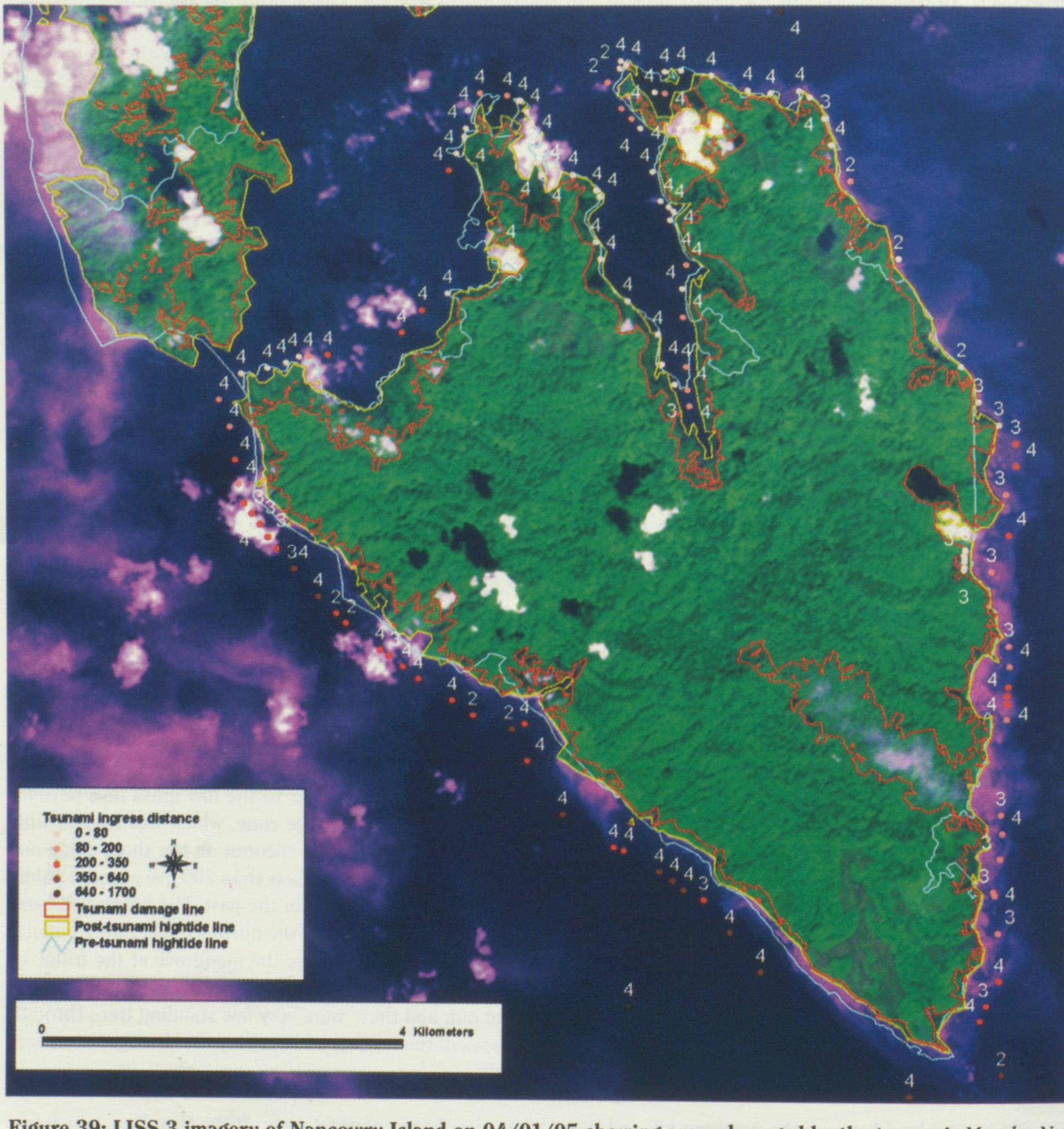



**Figure 39: LISS 3 imagery of Nancowry Island on 04/01/05 showing areas damaged by the tsunami.** *Map by N. Pelkey and V. Srinivas, FERAL*

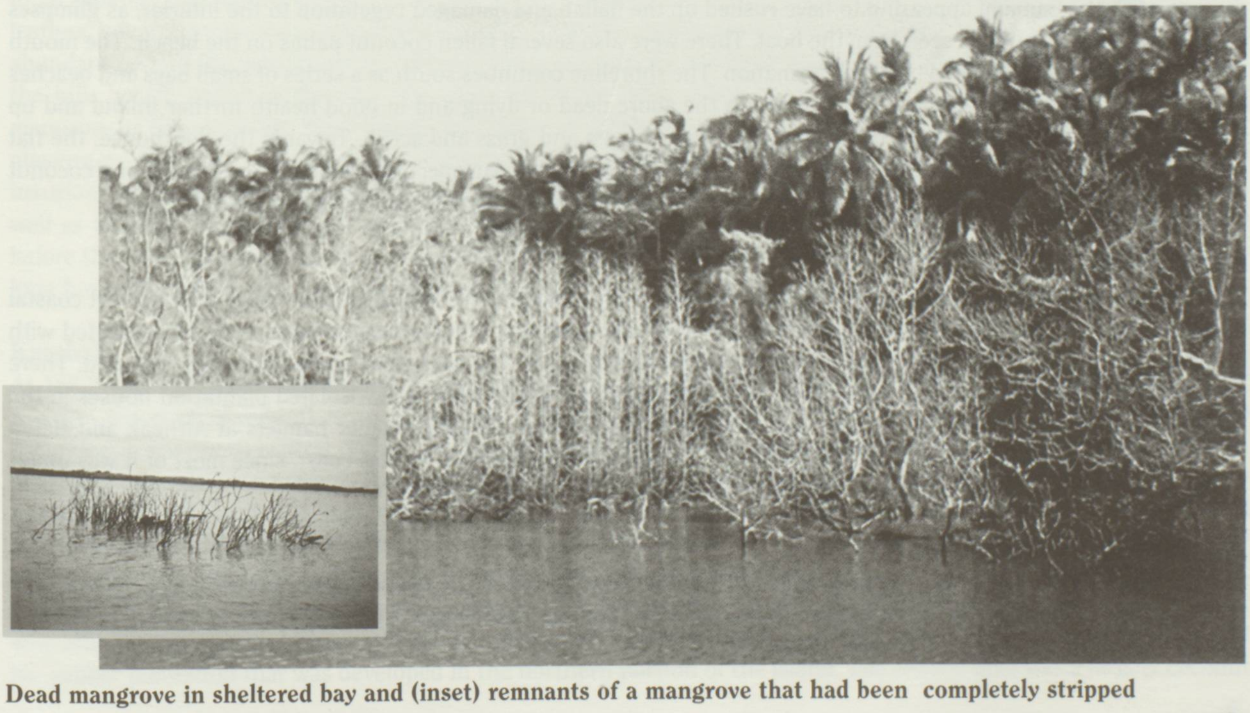
stands of coconut survived on the coast, and this stretch of the coast was also marked with fresh water nallahs descending from the grassland to the beach. The fairly wide flat land between the hills and the sea, which was mostly coconut plantation towards the sea and littoral forests inland, was all gone.

The beach of Takasem or Safed Balu continued to be connected to the northern hill, but the mangrove that it fringed was flattened out from west to east coast. The fringing sand was less than 75 m wide and had some coconut standing with probably 1000-1500 coconut palms still surviving. Like elsewhere, the coconuts on the shore were dead or dying and those further inland on high ground were green. At Takasem, many of the standing trees were still green, but the majority of the casuarina at the northwestern tip were now standing in the sea and were dead. Some of those on high ground were still live. No houses or structures now remained.

The mangroves within Oal were devastated. Those fringing the Takasem beach to the north had undergone less damage, and were standing leafless. Those that fringed the hill to the south were devastated, and broken mangroves marked the various inlets and valleys that marked that shore. At places, the devastation extended up the hill slopes. This devastation continued clear till the eastern coast where the narrow sandbridge that connects Takasem to the northern hill tenuously remains. At the mouth of the Oal a small island had been cut away from Trinket.

The damage continued down the eastern coast, where mangroves fringing the hill were smashed and the damage continued some distance up the slopes, above which there was a fringe of forest and grasslands beyond. The shore was littered with debris, mostly of mangrove, and a few standing leafless mangroves were all that remained.

Ookchuaka village had been severely damaged, as the waves had come in from both sides, from the east over the Tapiang beach, and from the west, from the Beresford Channel. Other than the power house just inaugurated and badly damaged, and the housing for teachers on the hill top, there was no sign that a village existed here. There were a few stands of standing dead mangrove that fringed the northern and southern hills, but by and large all the mangrove had been stripped clean all the way to Tapiang beach. A few trees were standing which were all scorched brown. The damage extended up to the hill to a height of two to three metres. At Kapila, which was at the north western tip of the southern hill, the mangroves had all been stripped away. Further south at Kinyal, there was a small mangrove patch standing dead, and some standing coconut, and dead fallen trees on shore. The heavy mangrove damage continued southwards. There were patches of mangrove that still stood, but these were leafless and dead. At Kuruak, few coconut palms and other dead trees marked the narrow shoreline. At Lahoum the damage extended inland along the nallah, but there were a large number of coconut that had survived the tsunami, as well as a small stand of Nypa. Along the creek, all trees were smashed to the hill. The mangrove between Lahoum and Luana was damaged but standing, leafless, and at Luana the low grassy hills reached the shore, with a few standing fringe trees, including live coconut. Dead and broken mangrove, and green and dying coconut on the shore marked the coast till Fulaj. Towards the southern tip the coast was rocky and here the damage was minimal, with a few coconut standing and casuarina above the damage line.



**Dead mangrove in sheltered bay and (inset) remnants of a mangrove that had been completely stripped**

**Nancowry**

The island after which the central Nicobar Islands takes its name, Nancowry was 66.9 $km^2$ in extent. The island itself consists more of a central hilly region, with its ridges, undulations and valleys descending to the sea. There is very little flat coastal forest on Nancowry; more often than not the low hills end in the sea. The tallest peak, in the north central portion of the island is only 118 m high. Other peaks include one which is 115 m in the north-western corner, facing Swell Point on Camorta, and flanks the western opening to Nancowry harbour. The island slopes down southward, where the peaks are under 100 m high. The rest of the island is low, mostly under 100 m high. The majority of the island is forested, with grasslands accounting for 29% of the vegetation, which occur as patches interspersed with forests, and are reminiscent of the shola-grassland mosaic of the Western Ghats of India. The northern coast is deeply indented, and sheltered by Camorta to the north, and vegetated with a fringe of mangroves. The eastern and western coasts are hills descending to the sea, with narrow flat coastal land.

**The Western Coast**

The west coast of Nancowry faces the open sea with Katchall Island about 7.5 km away. The entire coastline was hilly and rocky with narrow beaches and flat coastal land between hill and sea, with the tips of hills and rocks ending in the sea at several places. The west coast had very shallow indentations, with very few places where boats could be beached and that too only during fair weather. The hills were a mosaic of forest and grassland, and the flat coastal land was mostly coconut. The northern half of the west coast had more flat land than the southern half, and the only large flat coastal area was along the nallahs at Hindrah. Several smaller nallahs flowed down from the hills and onto the shore. South of Hindrah, the coast was narrow and towards the southern tip, cliffs ended on the beach. There was very little habitation on the west coast, with one or two isolated houses in plantations, and a small hamlet at Hindrah. A few megapodes were present at Hindrah, and turtle nested on the beaches there occasionally.

*Run up, ingress and loss of land*

The Revello Channel which borders the west coast of Nancowry was deep here, with shallow waters less than 50 m deep only up to a distance of 600 metres, with deeper water greater than 200 m beyond 2.25 kilometres. Run ups appeared to be low; this could not be ascertained since breakers on the shore forced us to move the boat some distance away from the sea. Here too, it was clear that the tsunami had stopped only when it reached the hill. Loss of land also could not be ascertained, but the loss elsewhere appears to be that the coast has receded by over 10 metres.

*Extent of damage*

Tapui is the first beach after the rocks that guard Nancowry gate, and the coconut appeared more or less intact on this shore. The coast continues south as a series of very small beaches with rocky outcrops separating them. Most of these bays had small stands of coconut, which appeared to be intact inland and were dying out on the shore, as receding shorelines had resulted in the palms now standing at the high tide mark. The run up did not appear to be high since the forests and other vegetation along nallahs that opened onto most of these small beaches were mostly green. At a couple of places there were rock falls as a result of the earthquake. Hindrah appeared to have had significantly more damage, with the tsunami appearing to have rushed up the nallah and damaged vegetation to the interior, as glimpses of scorched forests could be seen from the boat. There were also several fallen coconut palms on the beach. The mouth of the nallah had been blocked by beach formation. The shoreline continues south as a series of small bays and beaches amidst rocky and hilly outcrops, with coconut on the shore dead or dying and in good health further inland and up the slopes. The vegetation on the hills varying between forests and grass and scrub. Towards the lighthouse, the flat coastal land became narrower still, and there was not much discernible damage, other than the dead and dying coconut on the small patches of beaches. The hilltop was mostly grassland and then casuarina before the lighthouse.

**Eastern Coast**

The eastern coast of Nancowry is more indented than the west coast and has several shallow bays, with the flat coastal land between sea and hill being separated by rocky and hilly outcrops. The flat coastal lands were all vegetated with coconut plantations and natural vegetation was sparse on this coast. The hills were however, densely forested. There were very few nallahs along this coast; these were typically small. Apart from a few isolated plantation houses in the southern half of the east coast, the only big villages were at Tapong, and the smaller hamlets at Altheak and Baloo Basti; these had a total population of 321 people. There were few megapodes on this coast, since most of it was under coconut plantations. A few incubation mounds were present near the lighthouse.

*Run up, ingress and loss of land*

The sea abutting the east coast of Nancowry was shallow, and was less than 30 m deep between 1.5 and 7.5 km from the shore. The waves on the east coast were between three and six metres high. The inundation had been till the hill, and the shoreline had receded by over 10 metres.

*Extent of damage*

The cove just below the lighthouse had been badly damaged with undergrowth and middle storeys stripped, coastal trees scorched and the coconut dying out. The hill had been washed out to about six metres asl. Subsequent to this covers the next damage in the few coves was less, with some dead trees, and vegetation intact from about three metres upward. The undergrowth and trees appear intact. Though scorching had taken place, there were plenty of green leaves and the damage was not extensive. Coconut, though damaged, had fared better than in most places. While those on the shore were showing signs of dying out, a majority were green. The only patch of mangrove on this coast, just before Tapong, was leafless. Damage at Tapong appeared to be largely focused on the houses and other infrastcructure, and only damaged RCC buildings were evident, with all Nicobari houses washed away. Altheak was the most damaged part of this coast, and the shore had been fully stripped till the hill. The remaining coastline to the northeastern tip was very narrow. A few leafless trees were standing but the majority had toppled over. The few coconut that were present on this shore had both dead and living palms.

**Northern Coast**

The northern coast of Nancowry is sheltered by Camorta and consists of hills that end virtually at the sea, with a very narrow strip of coastal land between the sea and the hill. The coast has a shallow bay to the east, an inlet that goes deep into the island in the centre and a wider narrower bay to the west. Dense mangroves, interspersed with points where hill and rocks reach the sea, fringed the northern coast of the island. The inhabited area, the twin villages of Champin and Malacca with a pre-tsunami population of 381 people, was present here. The other large habitation was at Hitui and Lapat, which was inhabited by 222 people. Smaller hamlets and isolated plantation houses were also present at the heads of nallahs in the mangroves, as well as in the small coves that marked the western end of the north coast. There were probably very small populations of megapodes on this coast.

*Run up, ingress and loss of land*

Run up heights on the northern coast were not very high and were between three and four metres, with the waves stopping only at the hill. Loss of land has been fairly acute, considering that the flat coastal land was very narrow, and was at least 30 to 40 metres at places.

*Extent of damage*

The eastern corner of the northern shore had a couple of small bays with coconut and a small patch of mangrove, which, while standing, was leafless. The coconut were by and large intact inland and dead or dying on the shore and there was a small stand of Nypa as well. Malacca and Champin had been badly damaged and were inundated. However, a few buildings as well as Nicobari houses were standing, indicative that the force of the tsunami was less here. Coconuts were live inland and dying out on the shore and on inundated ground. A small patch of Nypa was present near Champin Jetty, which was also badly damaged.

In the big bay the mangroves were all dead and leafless, the only green seen in the mangrove was a tiny clump of 15 to 20 saplings that had taken root on an exposed mound of earth. While the majority of the mangroves were standing, leafless, heavy damage was visible at places, particularly where nallahs were present. The coconut plantations that were abundant behind the mangroves and up the hill slopes were by and large intact, and at most places, the vegetation on the hills, which ended in the sea, was intact up to sea level. A few patches of Nypa were present in between the mangrove at the shoreline. Hitui village had come off lightly since most of the houses were well above sea level. The playground that was just behind the mangrove was inundated, and this was the only place in the islands where a luxuriant stand of Nypa was present. The coast towards Nancowry Gate continued to have mangroves, dense stands as well as thinner fringing stands, which had been damaged lightly and were all standing leafless. In the small coves before the Gate, there were small plantations of coconut which were alive while the arecanut plantation were dead. The lone house at Ketoola was only marginally damaged.

## Katchall

At 188.2 $km^2$ Katchall is the second largest island in the Nancowry sub-group of islands, and the third largest in the Nicobar group of islands. It is an island that is mostly composed of low hills, with the highest peak (201 m asl) occurring in the south central region, and the hills extend to the south eastern and eastern ends, where peaks of 174 m asl and 159 m asl are present. The coast of the island can be divided into four main bays: West Bay that had mostly mangrove; South Bay, forest and coconut plantation; East Bay, a major mainlander settlement area with coconut and arecanut plantation; and North Bay, mostly coconut plantations. The rest of the coast of the island was a low escarpment, with little flat land between it and the sea. Unlike the other islands in the Nancowry subgroup of islands, Katchall had no grasslands and was wholly forested. Due to the large number of people inhabiting Katchall, the habitat was, after Car nicobar and Chaua, the most degraded in the Nicobar group of islands, this being largely due to the 589 ha. rubber plantation that was developed in the northern portion of the island. The coastal area was a largely coconut

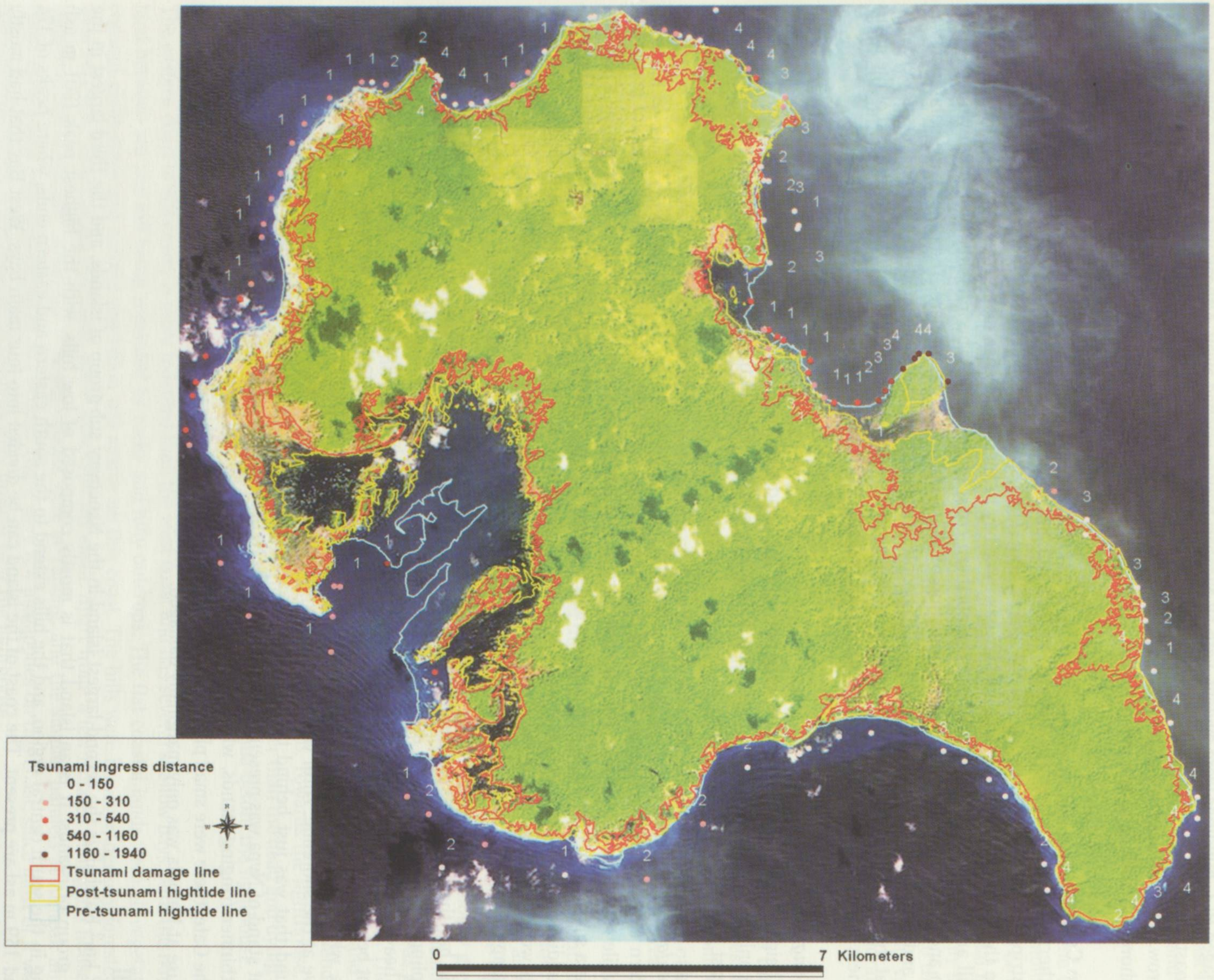



**Figure 40: LISS 3 imagery of Katchall Island on 04/01/05 showing areas damaged by the tsunami.**
*Map by N. Pelkey and V. Srinivas, FERAL*

and arecanut plantation. While the faunal characteristics of Katchall were that of others in the Nancowry sub-group, two affinities shared with the Great Nicobar subgroup of islands were the crab-eating macaque and the racket-tailed drongo, both of which were not present on the other Nancowry islands.

Katchall was a densely populated island, with both tribals and mainlander populations, who inhabited 35 villages and hamlets (TISS 2005). The mainlanders can be further segregated into two distinct groupings, those from mainland India, and the 48 Sri Lankan repatriate families who were settled on the island between 1974 and 1976. The number of mainlanders on Katchall has been a contentious issue due to the presence of a large number of 'illegals' who occupied the east bay area of the island. While the 2001 census places the population at 5312 (about 2500 tribals) other estimates place it at 8512 (TISS 2005), and this difference of 3200 people (or fraction of it) was likely to be that of the illegal mainlanders. In terms of numbers of people killed by the tsunami, Katchall ranked the highest, with 1551 dead or missing (A&N Administration, June 2005).

**East Coast - Cape Albany to Kapanga**

The southeastern corner of the east coast of Katchall was predominantly hilly, with a narrow shore line that was under coconut plantations. The narrow shore line widened further north and ended as a low escarpment, the flat land between the escarpment and the hills to the interior being predominantly coconut. Several small nallahs descend to the seashore. There were several small habitations on this stretch of coast, the biggest being Upper Katchall. The entire stretch was mostly dense coconut plantations, with fragments of littoral forests at places. The northern half of the east coast consists of large bays. The first was separated from the East Bay, the largest on this coast, by the hillock at Atkuna. East Bay and up to Kapanga was a densely populated area as this formed the administrative seat of the island and was built up with a mixture of government housing and offices, shops and residences of mainlanders, as well as a few Nicobari villages and their plantations. Megapodes occurred in small numbers in the southern portion of this coast, the rest being mostly under human habitation and plantations.

*Run up, ingress and loss of land*

The Revello Channel adjoins the east coast of Katchall and depths of this coast range from less than 50 m deep to a distance of about 900 m at the southern portion, to over three kilometres in the northern portion. Run up has likewise been variable, and throughout the coast the waves had stopped only at the hills. The wave height on this coast has probably varied between three and nine metres. The distance to which the waves travelled varied according to the flat land that was available. This was the least in the southern portion where run ups have been less than 100 m to over two kilometres in the East Bay area as the tsunami devastated the vegetation behind the Atkuna Hillock. Loss of land has also been the most in the East Bay where over 100 m of land has been lost at places.

*Extent of damage*

At Cape Albany, where cliffs descend to the sea, the damage was minimal. Damage was considerably higher in the shallow bays, and narrow beaches with flat lands that occurred subsequently. Once the escarpment started, damage was limited to the small shoreline and the nallahs that were present, while the plantations and mixed forests that were present inland were more or less intact. Like elsewhere, the coconuts that were on the shore were dying out. Wherever there had been habitation, the damage was considerably high with all the houses having been destroyed. This was true of Upper Katchall, where the damage had been right up to the hill, and the only sign that the village once existed was a couple of very badly damaged RCC buildings. Several coconut palms remained. The bay between Upper Katchall and Atkuna had been subjected to very heavy damage, and all vegetation and houses had been destroyed to the hill slopes further inland. Coconut palms were intact on the southern shore of this bay. The northern tip of the bay was also more or less intact as the shore line was very narrow, and to which the damage was restricted. At Atkuna, the coconut and mixed forest on the slopes were intact, while there was some damage on the shore, which included coconut dying out. The southern shore of East Bay was a series of small bays, where damage to vegetation was patchy. Very heavy damage started at the beach area of East Bay, where the shore vegetation was smashed, and the extensive to complete stripping extended to the hill inland. There were some standing trees mostly dead, though some were spouting fresh leaves. Damage was more at the nallahs. At approximately the centre of the bay, a small hillock on shore had provided some protection, and trees, coconuts and pandanus were present. The next half of the east bay, was likewise very heavily damaged. The only signs that this had been a fairly densely inhabited marine area, were the damaged power house buildings and debris of concrete rubble. There were standing dead trees, and some coconut to the south which were live, but by and large the entire bay had been stripped, and damage extended at places to over 10 metres on the hill slope. The damage continued all the way upto Kapanga, though the intensity was somewhat less, with small stands of coconut and other trees present, and greater damage occurring along the nallahs. At places, there was standing coconut on shore, while the interior had been smashed to the hill, with not much damage on the slopes.

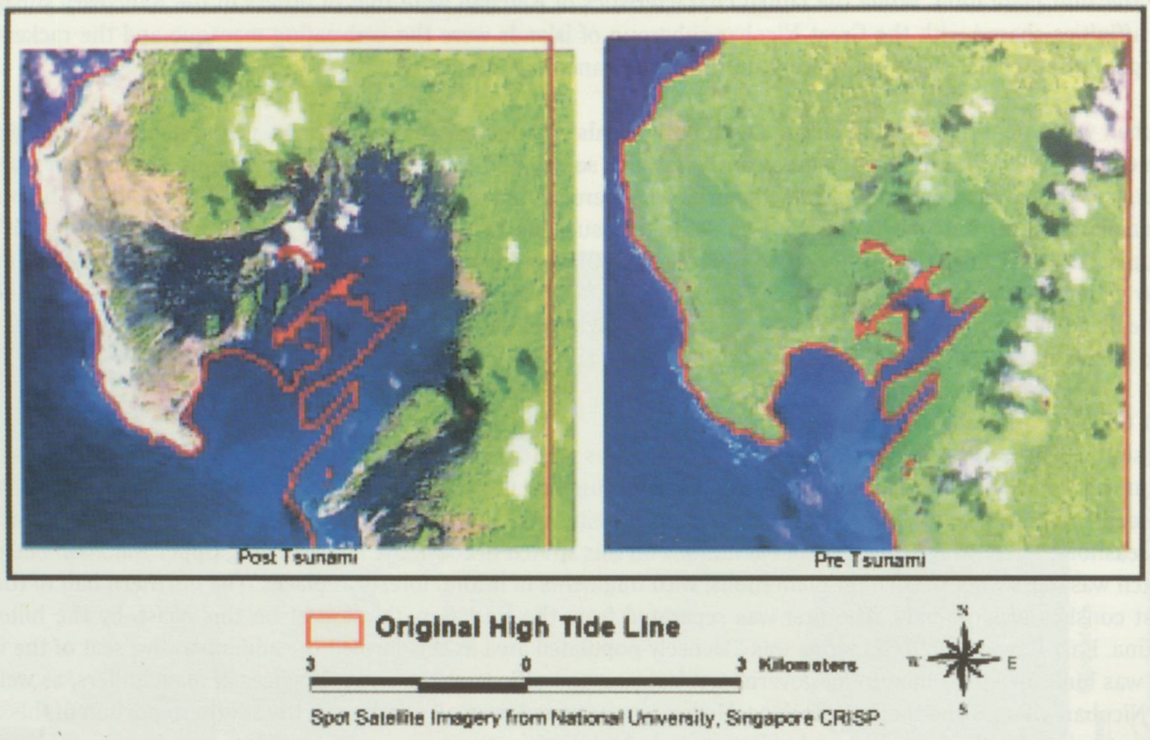



**Figure 41: Changes in coastline, West Bay Katchall**

**North and West Coast - Kapanga to West Bay**

The northern portion of this section was mostly low hills ending in the sea, with narrow bays between rocks, hillsides and cliffs ending in the sea, with several small nallahs descending through them. Wherever flat coastal land was available, or the slopes of the hill were gentle, these were mostly under coconut, with natural vegetation occurring in patches. After North Bay, the flat coastal area between hill and sea widened and was bounded by a beach that ran all the way along the coast till west bay, the area being mostly under coconut plantations. The beach ended at the south western corner of West Bay, within which was extensive and dense mangroves. Three major villages Jhula, Jansin and West bay Katchall, and several smaller hamlets occurred along this coast. Small populations of megapode were present at Jhula.

*Run up, ingress and loss of land*

The sea abutting this coast was shallow, with depths less than 50 m to a distance of between 3.5 and 7.5 km from the shore. This section of the coast has had some of the highest run ups, mostly between six and 7.5 m asl, and over nine metres at places. Here too, the depth to which the waters have reached was up to the hill, which ranged from very little to over two kilometres, and in the mangrove area of West Bay to over three kilometres deep. Loss of land also was acute at West Bay, and at places it is likely that over a hundred metres of land is lost. In the mangrove swamps it is likely that over a kilometre of land is lost.

*Extent of damage*

The northern portion of this stretch of coast, which was a series of cliffs, hill sides and rocks with narrow beaches and bays in between, was variably affected. At points, the vegetation had been swept clear to a height of over six metres, but in the majority of the smaller beaches, the coconut was mostly intact at the base of the hill and along the slopes, on top of which the forest was intact. Wherever there was a nallah, the damage was considerably more, and deeper inland. There were standing trees, mostly green, but the ground and middle storeys had been swept away. In some bays, the entire vegetation had been swept away till the hill. Much more extensive damage started from where the flat coastal area widened, where there were a few standing trees, mostly brown, with coconut on the high ground but the majority of the vegetation having been swept away. The level of damage greatly increased at the erstwhile village of Jhansin, where there was no sign that habitation existed and the majority of the plantation had been stripped, leaving behind a few coconut palms. Very few standing trees remain of the patch of forest that was present after Jhansin, with most trees gone. Of those that remained, most were scorched, and the undergrowth had been stripped to the hill slope. Barely 75 to a 100 coconut palms were present. There was a wide beach that was formed all the way to West bay Katchall but behind the beach, the destruction was very heavy till the hill slopes. At West bay, there was not much vegetation left standing inland, as the extensive mangroves had been swept away and barely 30-40 coconut palms remained in the whole area. There were a few standing trees on the high ground. These mostly occurred as a thin strip along the shore and then the vegetation was swept clear till the hill, leaving a fringe at the base, or as small scorched clumps on high ground between the beach and the mangrove area. Only one concrete structure was still standing. In the distance, there was a scorched line along the base of the hills. Separate islands have broken off the main island.

### Southern Coast -Ponda to Cape Albany

The mangrove of West Bay gives way to a large flat land, the largest in the Nancowry sub group of islands that extends between hill and sea till the south eastern corner of the island. This large flat land was mostly forest to the interior and a coconut-forest mosaic towards the shore that was in recent years being increasingly converted to plantations. There were a few nallahs in the area and several small habitations, mostly lone houses within plantations. This was the only area in Katchall where a sizeable population of megapodes existed.

*Run up, ingress and loss of land*

The sea abutting the southern coast of Katchall was less than a 100 m deep to a distance of between three and six kilometres. It was not possible to determine run up levels since the flatland was wide and cut off marks on the hills to the interior were not visible from the boat. Loss of land appears to have been less acute at most places excepting along the mangroves of West Bay. It is likely that for the most part, the shore has retreated by less than 50 metres.

*Extent of damage*

In the Ponda of West Bay, all coconuts had been broken off and green vegetation was visible on the high ground extending to the hill in the distance. Along the shore dead trees were standing, with the undergrowth stripped and several large gaps where the bare ground had been exposed, as well as patches where leafless branches formed a contiguous canopy. Between Ponda and South Bay, there were continuous coconut plantations on shore, which were mostly green, beyond which was a belt of scorched trees. This stretch of the shore had not been so badly damaged, excepting in patches where the damage had been heavy. Wherever there was a nallah, the damage had been more, as was the case where habitations had been. The majority of trees however were still standing, and a little inland much of the undergrowth and the middle storeys were also present, though mostly scorched brown. In the Dahila area of South Bay, the damage was even less, with only the outer line of trees brown, while to the interior there were considerable number of live and green trees, though the undergrowth had been stripped, at many places. Here too damage had been the most along nallahs, and there were large gaps where habitations once occurred.

### Bompoka

Bompoka, an inhabited island with an area of 13.3 $km^2$, is the second smallest island in the Nancowry sub group. Bompoka is mostly hilly, with the tallest peak in the central portion of the island at 209 m asl. The hills descend to the shore where there is a very narrow flat coastal area between the hill and the sea. Bompoka was mostly forested, with less than 25% of the hills being grassland, concentrated in the southern part of the island. The coast was fringed with a narrow belt of coconut, with forests and other vegetation occurring just behind it and to the shore at places. The majority of the flatland occurred in the southern and western portions of the island, while the flatland in the northern and eastern coast of the island was restricted to several small narrow bays between outcrops of rocks and hill that ended in the sea. There was one small village on Bompoka, Poahat on the eastern coast, which had a population of 58 people. Bompoka had a large population of the Nicobar megapode, robber crab, and an important edible-nest swiftlet cave.

*Run up, ingress and loss of land*

The under 50 m deep shelf around Bompoka ranged from 500-600 m from the shore in the north western portion, to about 1.5 km in the south western portion. The shallow shelf at the south western corner extends to Teressa, which lies to the west of Bompoka about 4.5 km away. The sea was less than 50 m deep to a distance of three kilometres on the eastern coast, and less than 30 m deep to a distance of of 1.5 km on the northern coast of the island. Run up levels have been variable and this island has amongst the highest anywhere in the Nicobar Islands, perhaps as high as 16 to 18 metres in the south western corner of the island. However in the northwestern corner, run up has been less than three metres. As in other islands, the distance over land that the wave had traveled was determined by the start of high ground. Loss of land also has occurred, possibly up to 50 m or more at places.

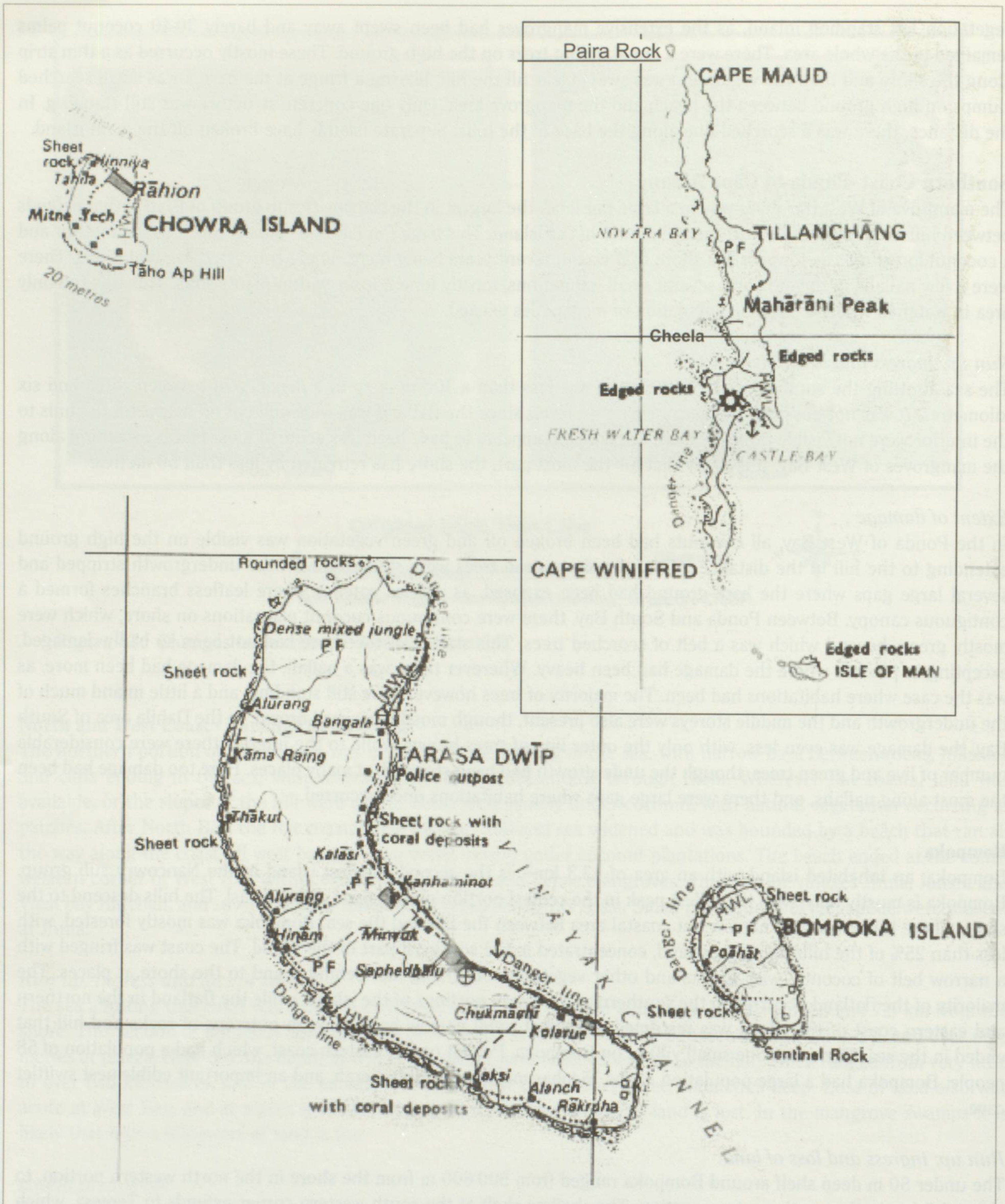



**Figure 42: Bompoka, Teressa and Tillanchong islands**

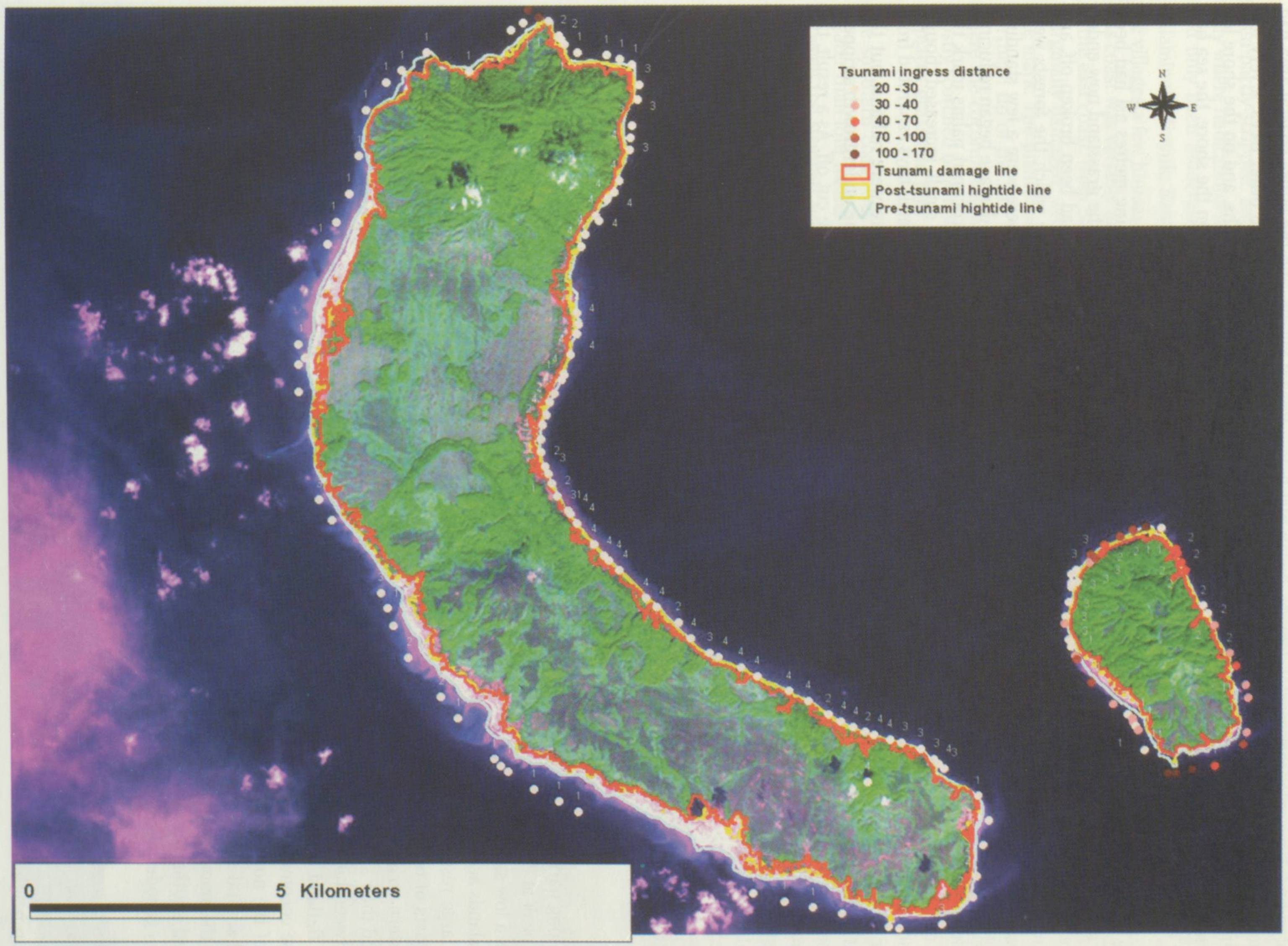



**Figure 43: LISS 3 imagery of Terressa and Bompoka Islands on 04/01/05 showing areas damaged by the tsunami.**
*Map by N. Pelkey and V. Srinivas, FERAL*

*Extent of damage*

The survey commenced at 8° 15.380' E, 93° 13.246' N, just north of Poahat village. and continued in an anti clockwise direction. The damage initially was not much, though there were fallen trees on shore, and there was vegetation within 10-20 m of the high tide mark with undergrowth that was both green as well as scorched brown. Along nallahs, the damage was variable but along these too the damage was not extensive. The flat land between sea and hill was 'high ground', and hence dense vegetation existed from about 30-40 m inland. Some of the undergrowth was stripped but was partly standing. Very extensive coastal damage, began just before Poahat village, and the entire coastal area had been flattened to between six and nine metres asl. There were very few standing coconuts and other trees, a very few of the remainder green, while the rest scorched brown. Deeper penetration inland along nallahs, and on the shore led to beach formation throughout. At the white bellied swiftlet cave that was just behind a rock on the shore, the sea had reached the cave mouth, causing some rock fall. No birds were seen.

The damage increased substantially after this point, and all vegetation to a height of over nine metres asl had been stripped. At several places the intervening forests or fringing trees had been swept away and the grassland now ended on the shore, where the run up was not discernible. At the Lighthouse tip (a small island) had been broken off, and here the damage was significantly more with run up levels reaching 17 to 18 metres, above which the forests were intact. As was the case earlier, along nallahs there was considerably more damage inland. There were a few standing trees throughout, some of which were green. Towards the latter part of the southern coast, the damage began reducing, and vegetation had been stripped about six metres asl. Along with standing trees, surviving coconut palms mark the shore, dead or dying on the shore and live inland. The number of standing trees, both big and small, increased though many were scorched while others were still green. The east coast was marked with a series of small bays separated from one another by rocks or the spurs of hills. There was damage to the interior wherever there were nallahs, but the coconut that remained were mostly green. Several trees had survived but were scorched and the undergrowth stripped. There was heavy shore damage at the north eastern tip, with considerable amount of shoreline cut off. As a result, the coconuts, most of which were dying out, were standing in the sea. The damage somewhat reduced along the northern coast, with standing coconut in sea and inland; those in the sea were dying out, while many green trees and coconut were present inland but the undergrowth was mostly stripped. The damage significantly reduced in the north western corner; here too because of loss of land there were many coconut in the sea which were dying out, but further inland much of the vegetation was intact. That the waves did not have much force or height here was also evident from the fact that there were active megapode mounds just above the high tide mark, and the damage was restricted to the high tide mark.

## Teressa

Teressa is a long narrow, bean shaped island with an area of 101.4 $km^2$. The northern portion of the island is hilly with the highest peak at 273 m asl. The central portion is also hilly, with the highest peak at 112 m asl. Between these two hills there is a low saddle below 50 to 75 m asl, which was predominantly grasslands, as was the southern half of the island. Grasslands account for nearly 61% of the area and dominate the vegetation to the interior of the island. Forests are by and large restricted to the northern and central hills, along nallahs and in patches along the coastline. The southern coasts of the islands were a series of narrow bays with little flat coastal land divided by hills ending in the sea. The eastern coast was a fairly wide flat coast land between hill and sea, with the northern portion of it breaking in to hills and their spurs ending in the sea sheltering very small bays. The northern coast had both long beaches with flat land between hill and sea, as well as fairly large bays. The western coast was a long beach from north to south, with a wide flatland between hill and sea. The entire flat coastal forest, which rarely exceeded 250 to 300 metres, was mostly dense coconut plantations from the base of the hill or high ground to the shore. Forests occurred only along the slopes of the northern and southern coasts as patches amongst the coconut plantations. Teressa had seven big villages and several smaller hamlets that were inhabited by 1093 people. The island itself was fast reaching carrying capacity, as the amount of available land for coconut plantations was very little. Megapodes were found mainly in the northern and southern coast, which had the highest densities, and in northeastern area of the island. There were reports of megapodes also being present in the patches of forest that were present to the interior of the island.

*Run up, ingress and loss of land*

Depths of less than 50 m were present as a fairly wide belt around Teressa, and was widest off the northwestern coast where it was nearly six kilometres wide, and least off parts of the north eastern coast where it was less than 600 m wide. Run up heights have been variable. On the east coast, run up has been low with the waves being 2.5 to three metres high. On the southern, western and northern coasts wave heights were upto six metres high. Ingress, like elsewhere, was up to the hills. There has been loss of land throughout, and between 50 and 100 metres of land has been lost around the island.

*Extent of damage*

The survey commenced at the Jetty (Bengali Village) on the east coast, and proceeded around the island in a clockwise direction. The jetty at Bengali Village was completely submerged, and about 50-60 metres of shore had been inundated. The Hanuman temple was at the high tide mark, and there were big gaps where habitation used to be. There were plenty of coconut palms to the interior and up to the shore, which at places were more or less intact, while those on the shore and in the sea were dead or dying. The entire coast was mostly coconut, and stands of trees were present in patches. These were scorched, but showing signs of leaf emergence, and the coconuts were live. The undergrowth had been partly stripped, and some trees and coconuts had been toppled. Large gaps and severe damage had taken place only where habitations used to be present, or along the several nallahs that flow to the sea. In between, the plantations had only been moderately damaged, and the majority of palms were still standing. The villages of Bengali, Kalassi, Kalaminot, Minyuk, Safed Balu, Chukmaji had been very severely damaged and no houses remained. However, in all the villages a few houses that were 150 - 200 metres or more to the interior, were intact. The plantations that abounded this coast was variably damaged, with maximum damage along the nallahs and around habitations. Towards the north of the east coast, from Safed Balu to Chukmaji and beyond, the land abutting the sea was high ground and hence only marginally damaged, with intact houses of both RCC and Nicobari houses seen as close as 50 to 60 m from the high tide mark. The plantations and patches of forests that occur here were also intact. Heavy damage started towards the northern tip of the east coast of the island, which is a series of small beaches between spurs of the hills behind, and where the coconut began giving way to natural vegetation. The vegetation had been thinned but trees were standing, mostly scorched brown with some showing green. The undergrowth was stripped to about three to four metres asl, and at places grassland now fringed the shore.

The southern coast was very badly damaged, and the coastal forest was stripped clean to the grassy hills inland to greater than four metres asl. Though there were several standing scorched trees, these were largely present as a fringe between the stripped zone and the hills, which had gaps at several places through which the grasslands were visible. The majority of the coconut had disappeared, but small stands still persisted amidst the stands of scorched and heavily damaged forests that also were present. Like elsewhere, damage was more acute along the nallahs that descended to the coastal area from the hills. There was beach formation throughout.

The damage was greater in the west coast of Teressa where the entire coastal vegetation from north of Luxi to south of Alurong had been stripped clean to the hills to about four metres asl. Very few trees, and few coconut palms remained. Pre-tsunami, this largely consisted of coconut plantations. It was only at Enam, about half way up the western coast, that a fairly dense stand of coconut was present on the shore. Forests continued to exist on the slope and to the interior, and at several places grasslands now abutted the stripped zone. The only area along the west coast where coastal vegetation was more or less intact was in the small stretch of high ground area between Enam and Kamaranj. At Alurong, the hospital on the slope was intact and was the only sign that habitation once occurred on the west coast.

This level of damage continued to the northern end of the west coast and along the northern coast, where the coastal land was narrower with one large bay, Alek, and a series of smaller bays and coves. Here too the majority of vegetation had been stripped between sea and hill, to a height of over four metres asl, above which there was either fringing forests or grasslands. Several trees, mostly scorched brown, and small stands of coconut were present, with only one small bay where the plantation forest mosaic was less damaged. The only bits that were not damaged were the rocks that ended at the sea which divided the coast into small coves.

**On the southern coast of Teressa, the tsunami had swept away coastal forests up to the grasslands inland**

This heavy damage continued to the north eastern tip but reduced significantly on the east coast, which till Bengali was a series of plantations of coconut and arecanut and patches of degraded forest. Though the undergrowth had been stripped, in the patches of forest the trees were green as well as scorched brown. The coconut was green inland, while those on the shore were dead or dying, and relative to the west coast, the damage was not extensive, excepting along the nallahs where the damage was somewhat more. The arecanut, however was worse affected than the coconut and were mostly dead.

## Chaura

Chaura is the smallest inhabited island of the Nancowry group of Islands, and is 8.2 $km^2$ in area. It consists of a single 'Table Hill' that is 104 m asl at the southern end of the island, to the north of which the rest of the island extends as a flatland. The entire island was mostly comprised of coconut plantations, with degraded small patches of forest and other vegetation. There was a small grassland in the centre of the island about 20 hectares in extent. A narrow fringe of coastal vegetation often separated the beach from the plantations inland. Chaura was densely populated, with 1287 people inhabiting the five villages, Raiheon, Kuitasuk, Chongamong, Alheat, and Ta-eela, which were present as a continuous stretch on the eastern coast of the island. Chaura had a scarcity of drinking water. During the summer months drinking water was primarily sourced from three tanks that harvested rainwater. There were three edible-nest swiftlet caves on the lone hill of Chaura. Megapodes were probably present in the past, but are now extinct.

*Run up, ingress and loss of land*

The sea around Chaura was shallow, with depths under 20 m to a distance of 1.5 to three kilometres from the shore. The wave run up height has been between 4.5 and six metres to the south and probably to the west as well, and probably under four metres on the eastern coast. The tsunami has reached all but the central portion of the island, which includes the grassland there. At the southern part of the island, the tsunami appears to have crossed from one end of the island to the other. The shoreline of Chaura has receded by between 20 and 50 metres.

*Extent of damage*

The southern hill, which ends in the sea as a cliff with sparse vegetation, had been damaged to about six metres asl. At the commencement of the flat land on the eastern coast, a stand of coconut was present, subsequent to which was a nallah. It appeared that the tsunami had crossed the island at this point, as there was a very large gap to the intrior. Upto the jetty from this point onwards, scorched trees marked the shore, while there was coconut to the interior. A significant proportion of the plantations at Raiheon was still standing, but most of the habitations had been destroyed. The water tank, however was intact, under which one of the fabled houdis (canoes) of Chaura was present, miraculously intact. Kuitasuk had been spared, and at least 40% of the houses including the school were intact or only partially damaged. The plantations and coastal vegetation was moderately damaged. This damage extended up to the beginning of Chongamong village, where two or three houses were intact, after which the coastal damage was near total, with only the water tanks at Alheat and Ta-eela intact, and a few coconut and other trees standing. This heavy damage continued around the northern tip and extended down the west coast, where there were huge gaps to the interior, and patches of coconut, trees and scrub on the shore, often as a narrow fringe. Part of the west coast was a low rocky embankment, with patches of small trees on the coast and coconut to the interior, with heavily damaged areas to the interior. Very heavy damage continued till the southwestern corner of the island, where huge gaps in the vegetation were the most striking feature. A dense stand of coconut inland with the shore line badly smashed extends to the southern hill, which ends as cliff faces to the sea. Here the sparse vegetation on it had been stripped and there were one or two rock falls.

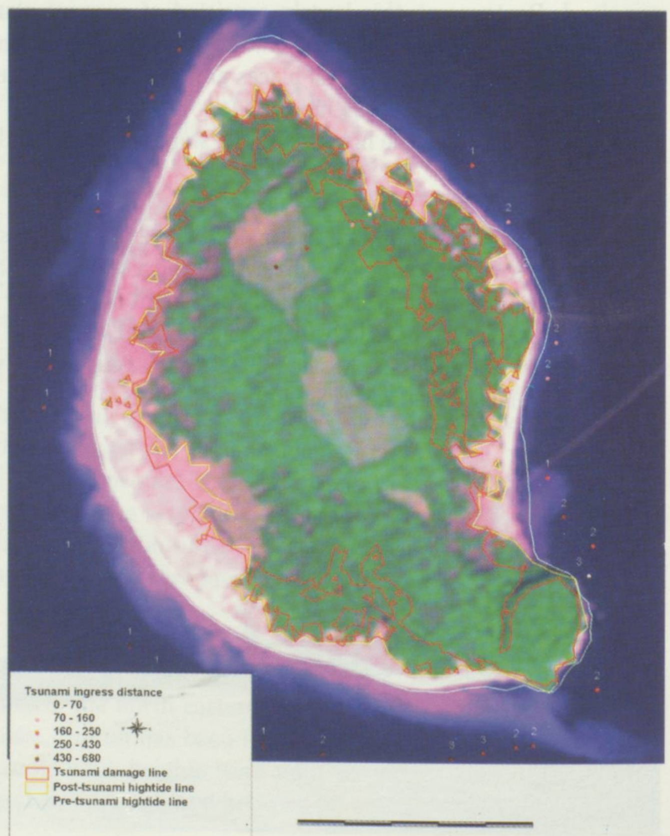



**Figure 44: LISS 3 imagery of Teressa and Bompoka Islands on 04/01/05 showing areas damaged by the tsunami.** *Map by N. Pelkey and V. Srinivasan, FERAL*

**Tillanchong**

Tillanchong, along with the Isle of Man to the south of it and Paira Rock to the north, are the only uninhabited islands in the Nancowry sub group of islands. The island is 16.82 $km^2$ in extent and consists of three long narrow ridges that run north to south, which are connected to each other by flat land. The entire island is hilly and the highest point at 323 m asl is situated mid-way. The majority of the shoreline is cliffs or rocky, with very small beaches within the indentations, that are either formed of sand and pebbles. There were two creeks and one inland water body on Tillanchong. The entire island is forested, with stands of casuarina above some of the cliffs, and mangrove and Nypa formations in areas inundated by the creeks. There are several small coconut plantations, which belong to '*Kumeta*' (or the spirit or *Shaitan*) who permits the Nicobaris to collect coconut and other forest produce for a brief period annually (see details on page 34 in this report). Tillanchong Island was declared as a Wildlife Sanctuary, under the Wildlife (Protection) Act, 1972 in 1985 vide the order No: CS/WS/30Nol-1 1985. Tillanchong is an important island biologically since it has healthy populations of various species of flora and fauna that are endemic to the Nicobar Islands, including the Nicobar megapode, the Nicobar bulbul, various species of pit vipers as well as other species such as the robber crab and the dugong. There are also excellent coral reefs around the island. There was a police Look Out Post established there in the early 1980s which was subsequently abandoned due to the prevalence of malaria and poisonous snakes and inaccessibility during most of the year. In 2002, a Police Look-Out Post as well as a Wildlife Camp was once again established and was subsequently withdrawn for the above reasons. The infrastructure has now been washed out by the tsunami.

*Run up, ingress and loss of land*

The shallow shelf of the sea around Tillanchong is narrower off the west coast. It is about 1.5 kilometres here while it is about 4.5 kilometres wide in the east coast. The sea abutting this shallow shelf is very deep, over 3000 metres on the east coast and over 100 meters on the west coast. The run up has not been very high and has mostly been between 1.5 and two metres, which at a few places have been three to 4.5 metres. Ingress has also not been much, since there was very little flat coastal land. Wherever there was flat coastal land with creeks, the ingress has been more to about 200 metres or more. Loss of land has occurred, this to the tune of 20 metres at Cheela, and less elsewhere.

*Extent of damage*

At Ranok, in the south western corner of the island, the beach is now submerged by high tide, and the small stand of about 20 coconut palms were present along the nallah. Thus was also true of the next small bay where the small stand of coconuts along nallah still exists though there was slight damage along the nallah. The rest of the island till the southern tip is cliffs ending to the sea where a damage was either not discernible or very little. The southern part of the eastern coast is primarily hill and rocks to the shore or sea, with small stretches of very narrow stony beaches that were less than five metres wide. There were eight coconut palms and no discernible damage. At Tanusha, a small small bay with 5-6 coconuts and pandanus palms, the damage was minor, though the waves may have crossed the embankment and flooded the flat land behind. Sadagaal had been damaged but not much. A rock had broken off and there was a small land slide here. The embankment at Sadagaal had been breached on the southern corner and the tsunami had crossed over into the wetland there. The bank now is probably just above the high tide mark and the tsunami had crossed over into the wetland there. As the hills became gentler towards Lakamaun, there was damage though minor. The Lakamoun beach and flatland had been affected, particularly along the nallah, but on the shore the coconut loss was not much and the *Barringtonia* formation intact. The small mangrove patch was also intact and green. The rest of the coast till the northern tip was mostly steep hillsides, rocks and cliffs ending in the sea, with several very narrow bays and indents, many of which had nallahs descending from hill to shore. There was some shore line damage, more so at the nallah, but overall the damage was negligible. At one point towards the northern end there was a rock fall. From the northern tip down the coast to Matai Takaru on the west coast, the shoreline was mostly steep hillsides, rocks and cliffs ending in the sea, with very narrow bays and indents, many of which had nallahs descending from hill to shore. There was some shore line damage, more so at the nallahs, but overall the damage was negligible. Matai Takaru had undergone fairly heavy damage, with the northern end having been swept to over three metres asl. Less than 25% of the coconut remained, and there was heavy damage along the nallah, though some Nypa had survived. The police camp and the wildlife camp had been swept away. Rehnpap, the next bay, had also been badly damaged along the nallah and along the slopes, though many green trees were still present. At Sadaagal, there was heavy damage to pandanus and less than 25% of the coconut remained. The fresh water pool had turned salt. Regnagning was not very badly affected and about 25-40 coconut palms still remained. At Lanai the damage was much more, with over 80% having been lost, and there was some interior damage as well. But the vegetation, mostly pandanus was still green. At Cheela, about 50% of the coconut has been lost, primarily due to loss of land. Inland the damage was not much and an enormous active megapode mound about 50 to 60 metres from the high tide mark was also indicative that the tsunami was mild here.

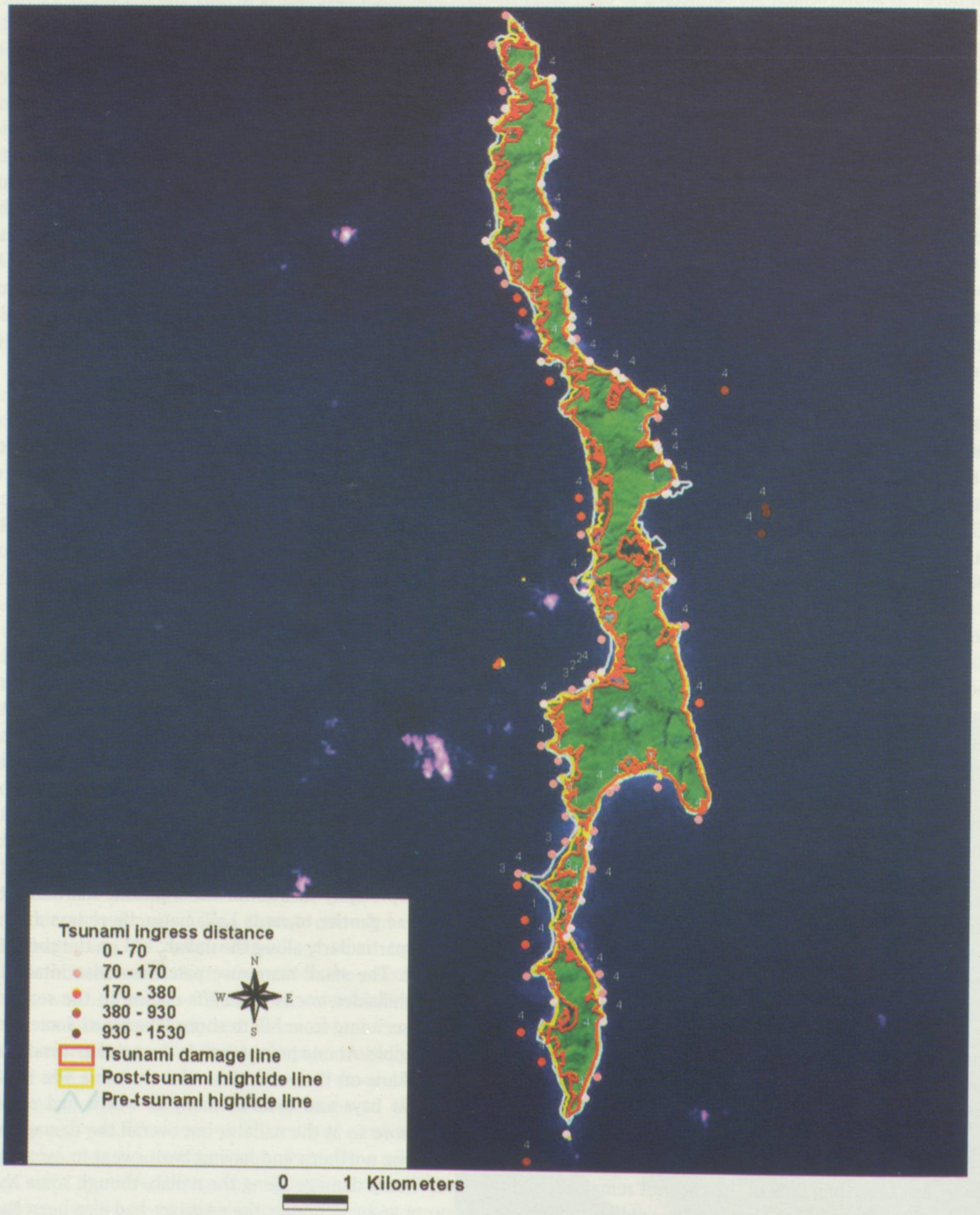



**Figure 45: LISS 3 imagery of Tillanchong Island on 04/01/05 showing areas damaged by the tsunami.**
*Map by N. Pelkey and V. Srinivas, FERAL*

### Paira Rock and Isle of Man

These small islets rise steeply out of the sea, with virtually no flat coastal land, and are vegetated on the slopes and the top. There was very little to no damage to the two.

## Car Nicobar

The district headquarters, and the most populous island in the Nicobar Islands, Car Nicobar covers an area of 126.9 km$^2$. The island is low and flat, with the highest point at 72 m at the centre. The only major nallahs in the island were in the north, near Sawai, and in the south, near Kimios, the latter having a fairly extensive mangrove swamp as well. The coastal area of the island was mostly coconut and other horticultural gardens, natural vegetation being degraded and distributed in patches. Some original forests remain only towards the centre of the island. There were at least 15 large villages on the island that were populated by 18008 tribals and about 4000 non-tribals. Car Nicobar also had a serious illegal immigrant problem, and it is believed by some that the non-tribal population was actually much higher. Car Nicobar's wildlife values include the presence of an endemic sub-species of the Nicobar shikra.

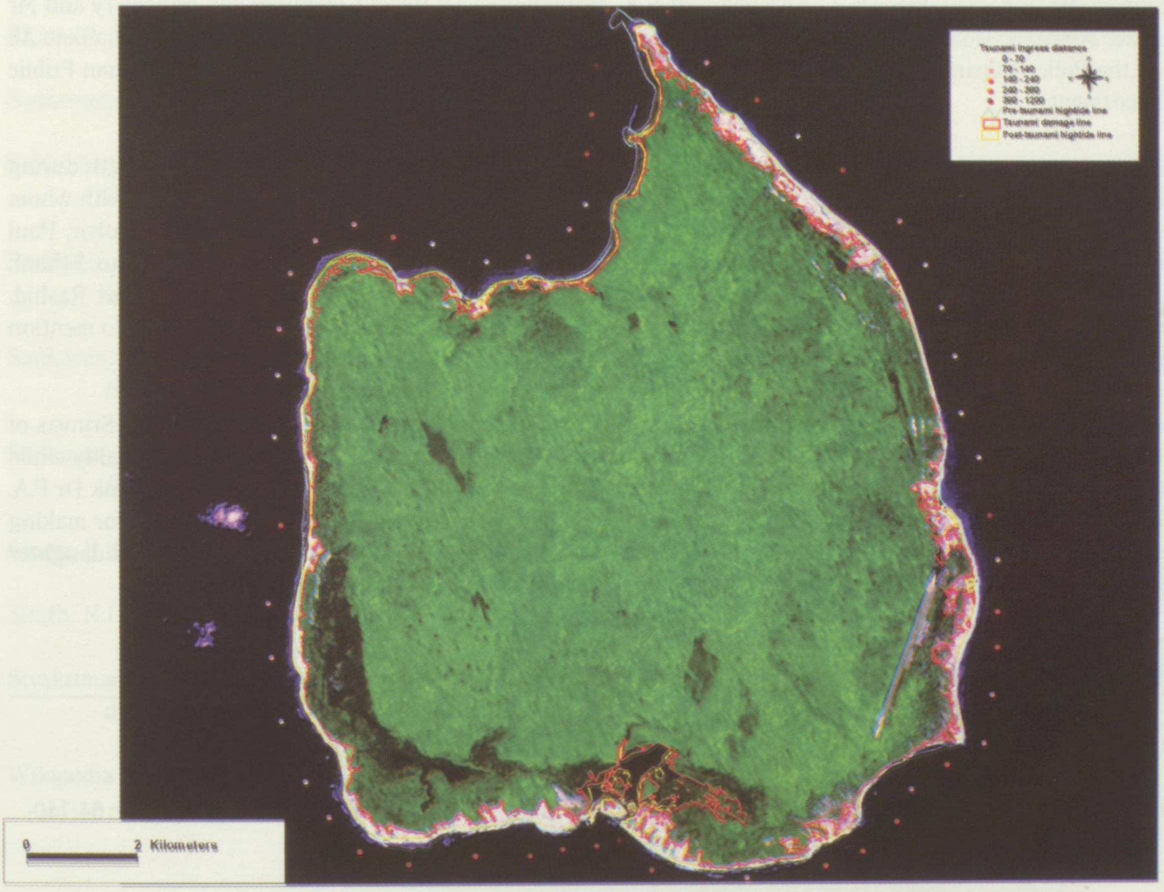



**Figure 46: LISS 3 imagery of Tillanchong Island on 04/01/05 showing areas damaged by the tsunami.** *Map by N. Pelkey and V. Srinivas, FERAL*

Car Nicobar was cursorily surveyed, essentially by driving along the road that encircles the island, which often passed well away from the tsunami zone. The information collected was not GPS based. The habitation areas of Car Nicobar was very badly affected, and most villages that were close to or on the shore were completely flattened by waves that were six metres high or less. There has also been damage due to the earthquake, as evidenced by damaged and fallen houses away from the tsunami affected areas. While there has been considerable damage to the plantations of coconut thousands of palms have survived in the tsunami affected zone, as have patches of other vegetation.

### Batti Malv

With an area of 2.1 km$^2$, Batti Malv is a small uninhabited island south of Car Nicobar. The island is said to be flat, on a low escarpment that rises out of the sea. The island is vegetated by scrub and small trees, and there are said to be a few coconuts as well. Batti Malv's biological importance lies in the fact that it is the only known island in the Andaman and Nicobar islands where the Nicobar pigeon *Caloenas nicobarica* nests. The island was not surveyed, but it is likely that the damage has been minimal.

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# Ecological Impact Assessment in the Andaman Islands and Observations in the Nicobar Islands

**Harry V. Andrews[1] and Allen Vaughan[2]**

**Almost all coastal habitats in all the 23 islands have been affected to a great extent**

The 26th December 2004 M 9.0 earthquake that occurred off-shore northwest of Sumatra is the severest known in this region. The largest tsunami caused by the quake affected the coasts of Thailand, Indonesia, India, Sri Lanka, Maldives and Somalia. The quake and the tsunami also caused major devastation in the Andaman and Nicobar archipelago. The quake caused the subsidence of the Nicobar Islands and a portion of South Andaman Island, besides the upheaval, by an average of 1 m, of Little Andaman Island, northwestern South Andaman, entire Middle and North Andaman Islands including Landfall Island. This also led to the extensive upheaval of reef flats along the west coast of South, Middle and North Andaman Islands and along the east coast of North and Middle Andaman Islands.

The subsidence of the Nicobars and South Andaman Island by almost 1 m caused high tides reaching inland and flooding of lowland flat lands including agricultural lands, human habitation, mangroves and littoral forests. This has also led to drying up of mangroves along creeks and in marshes due to flooding and submergence during low tide. The upheaval and the tsunami caused the drying of front-line mangroves along creeks, in marshes and littoral forests on some small islands. The substratum from the bottom of most creeks has been swept out into bays causing large extensive mud flats and in some bays closing of the mouth of creeks and covering coral reefs.

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Since the Nicobars are very close to and north of Sumatra, almost all coastal habitats in all the 23 islands have been affected to a great extent. Beaches and coastal habitats have been swept away. On some islands, the wave, at a height of 30 m, reached as far as 1.5 km inland uprooting all vegetation including 30 m tall trees besides sweeping away large beaches and flooding agricultural land and destroying most human habitation.

Mud volcanoes in Baratang, Middle and North Andaman Islands were active for two weeks after the tsunami. Several new vents emerged around old existing mud volcanoes and long, 15- 30 cm wide, cracks were also observed around these. Barren Island volcano is active and is still rumbling, smoking and several new smoking ground vents have developed including a large vent on one side of the volcano.

## The Bay Islands

The Andaman and Nicobars form the largest archipelago in the Bay of Bengal, consisting of 306 islands, 206 rocks and rocky outcrops. This island chain is situated latitudinally between 6°45' N and 13°41' N and longitudinally between 92°12' E and 93°57' E. The total geographical area is 8,249 $km^2$ with a coastline of 1,962 km; the Andaman group is 6,408 $km^2$ and the Nicobar Group is 1,841 $km^2$. This long archipelago is separated from mainland India by almost 1,000 km. (Figure 1).

The Great Andaman group of islands comprises North, Middle and South Andaman Islands with Baratang Island situated between Middle and South Andaman Islands. The Ritchie's Archipelago is located east of Middle Andaman and the Labyrinth group of islands is situated southwest of South Andamans. Rutland Island lies southeast of South Andaman and Little Andaman Island, across the Duncan Passage, is 55 km south of South Andaman Island (Figure 2).

The 10° Channel, 160 km wide with strong currents and heavy tidal flows, separates the Nicobar Islands from the Andamans. The Nicobar group has 23 islands in three distinct clusters of which 12 are inhabited by small villages, hamlets and seasonal camps. The Northern Group consists of Car Nicobar and Batti Malv and the central or the Nancowry group, consists of Tillanchong, Chowra, Teressa, Bompoka, Trinket, Kamorta, Katchal and Nancowry. The southern group consists of Little and Great Nicobar Islands, together with Pigeon, Megapode, Kondul, Pulomilo, Menchal, Treis, Trak and Meroe Islands (Figure 3). Table1 details the location and area profiles.

The Rakhine (Arakan) Yomas, which merges into the Himalayas, is considered to form the corridor along which the continental Southeast Asia and Great Andamans form as a range (Rodolfo, 1969). The Mentaweri Island to the south and south west of Sumatra is presumed to be a southern extension of the Nicobars (Rodolfo, 1969; Weeks *et al.*, 1967). Kumar and Bhatia (1999) have reported these islands to be highly seismic with magnitude ranging between 7. 5 and 8. 5.

The southwest monsoon lasts between April and September, contributing much of the annual precipitation; the northeast monsoon is experienced during October- November and in some years into December. Average annual rainfall is 3200 mm in the South Andaman Island and 3800 mm in the Nicobars.

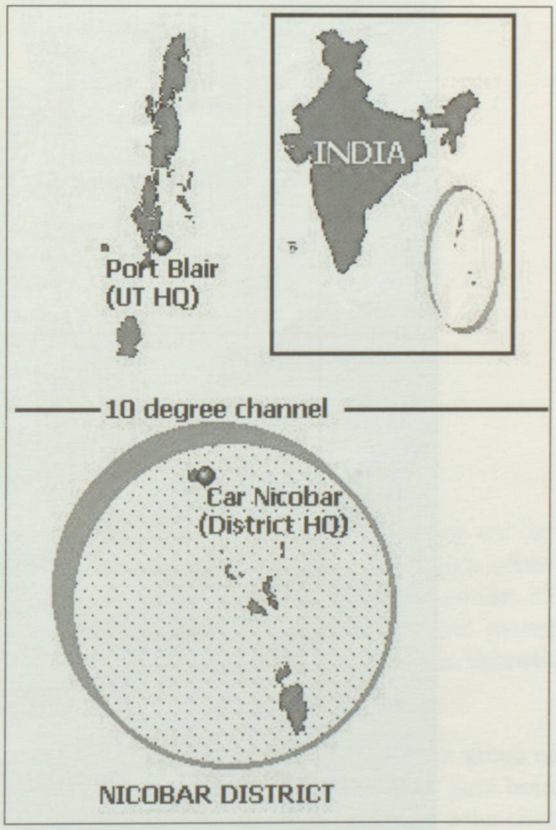


**Figure 1: The Andaman and Nicobar Islands**

The topography of the Andaman and Nicobar Islands is a distinct eco-region forming one of the 12 biogeographical zones of India. Rodger & Panwar (1988) in their biogeographic classification of India have classified these islands as 10A/B. The general topography of the large islands is hilly and undulating and small outlying islands are flat. The elevation in the Andamans is 0 to 732 m and Great Nicobar Island has Mount Thullier, 670 m, as the highest peak. The landscape for larger islands emerges from sea grass beds, coral reef or rocky outcrops, to beaches, littoral forest, Andaman slope forests, hilltops, into valley forests and streams. The topography of all large islands in the Andamans, Little Andaman, Little Nicobar and Great Nicobar Islands, is mostly interlaced with perennial and seasonal freshwater streams and in some areas a matrix of mangrove creeks extending into marshes. Little Andaman Island has ecosystems that do not occur anywhere else in the Andamans or the Nicobars, mainly extensive fresh and saline water marshes and peat bogs (Mahadevan & Easterson. 1983; Andrews, 1999; 2000). The mangroves occupy 11% of the land area (IIRS, 2003) and are protected. In the Andaman Islands mangroves cover an area of 929 $km^2$ and in the Nicobar the extent is 37 $km^2$ (Balakrishnan, 1989). Grasslands are unique to the central group of Nicobars and occur on low hillsides of Teressa, Bompoka, Nancowry and Camorta and in the central part of Trinkat. Lowland grasslands are restricted to Great Nicobar Island, mainly on riverbanks.

**Figure 2: Map of the Andaman Islands showing the location of Duncan Passage**

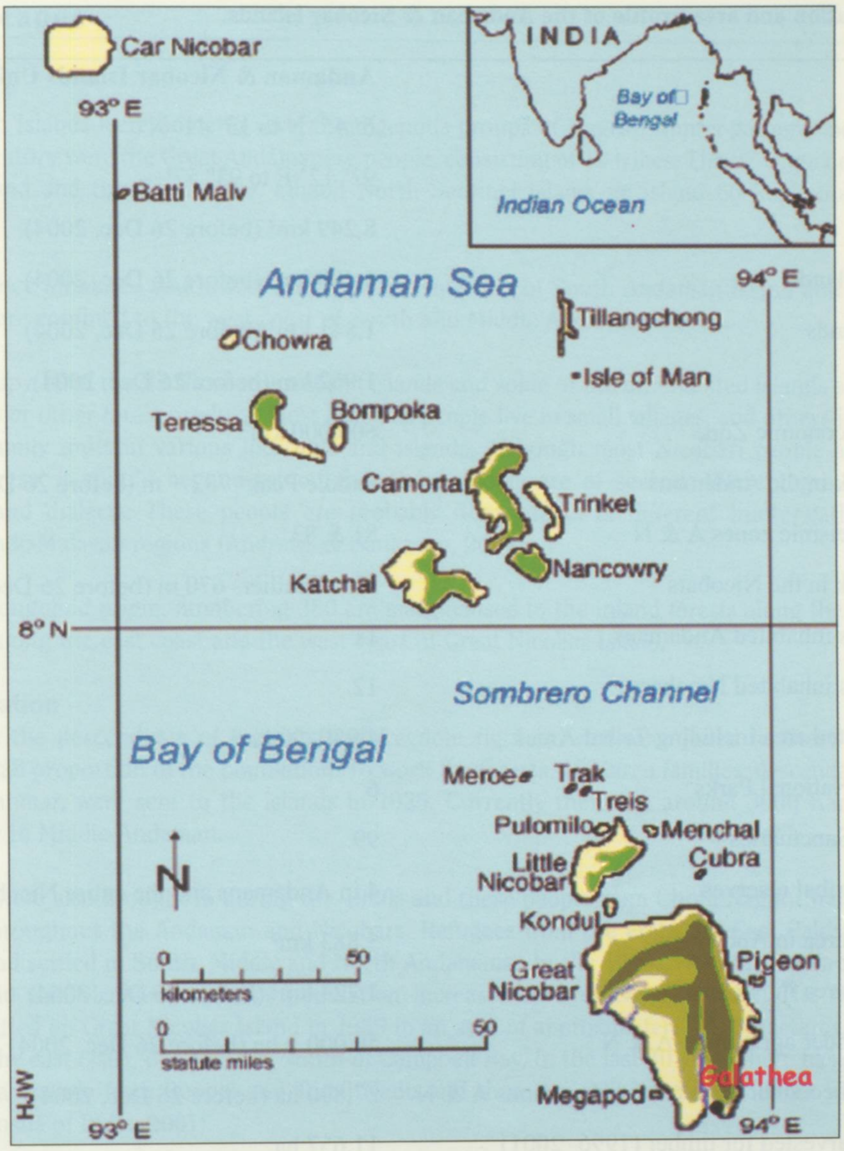


**Figure 3: Map of the Nicobar Islands**

Forest types represented outside tidal influence include evergreen, semi-evergreen and deciduous. The flora and the history of early botanical explorations of these islands was first described by Parkinson (1923), a classic which is now outdated. Currently 40 plant species are extremely localised and not known from more than one locality; besides 85 species are recorded as rare, endangered and threatened. Previously a total of 34 exclusive mangrove species among 17 genera and 13 families was recorded for the Andaman and Nicobars (Dagar *et. al.*, 1991). More recently, Debnath (2004) reported 58 species from both island groups.

The only primate, the Nicobar crab eating macaque (*Macaca fascicularis umbrasa*) occurs in the southern group of the Nicobar Islands. Miller, (1902) was the first to list most of the mammals; since then, over 60 species have been reported for both island groups and these include several species of shrews that are endemic, rats and a palm civet (*Paguma larvata tytleri*). Others include 32 species of bats in the Andaman and Nicobars (Chakraborty, 1978; Das, 1997; 1998; Aul, 2003; Aul & Vijayakumar, 2003). Invertebrate groups include spiders (62 species); the butterfly diversity of 298 species and 236 subspecies in 116 genera have been reported (Khatri, 1997; 1998; Devy, *et. al.*, 1994; Rao & Dev Roy, 1985). Among the avifauna, 40% of the 244 species and subspecies of birds are endemic (Sankaran, 1993; 1995; 1996).

Table 1: **Location and area profile of the Andaman & Nicobar islands.**

| Name | Andaman & Nicobar Islands Union Territory |
|---|---|
| Latitude | 6° 45' N to 13° 41' N |
| Longitude | 92° 12' E to 93° 57' |
| Total area | 8,249 km² (before 26 Dec, 2004) |
| Andaman Islands | 6,408 km² (before 26 Dec, 2004) |
| Nicobar Islands | 1,841 km² (before 26 Dec, 2004) |
| Coastline | 1,962 km (before 26 Dec, 2004) |
| Exclusive Economic Zone | 600,000 km² |
| Highest peak in the Andamans | Saddle Peak- 732 + m (before 26 Dec, 2004) |
| Transition seismic zones A & N | 81 & 83 |
| Highest peak in the Nicobars | Mt. Thullier- 670 m (before 26 Dec, 2004) |
| Total islands inhabited Andamans | 11 |
| Total islands inhabited Nicobars | 12 |
| Total Protected area including Tribal Areas | 4,989. 90 km² |
| Total no of National Parks | 6 |
| Total no of Sanctuaries | 99 |
| Total no of tribal reserves | 4 in Andamans and the entire Nicobars |
| Total forest area in Andamans | 5,883 km² |
| Total forest area in Nicobars | 1,723 km² (before 26 Dec, 2004) |
| Total area under agriculture A & N | 50,000 + ha (before 26 Dec, 2004) |
| Total area of coconut & areca nut plantations A & N | 27,890 ha (before 26 Dec, 2004) |
| Total area harvested for timber (1996- 2001) | 11,657 ha |

*Source: A & N. Dept. E & F, 2002.*

The reptile and amphibian fauna comprises over 125 species and is diverse with an assemblage of several species of frogs and toads. The mega species in the Andamans include the king cobra (*Ophiophagus hannah*) and the Andaman cobra (*Naja sagittifera*), water monitor lizard (*Varanus salvator*), and the saltwater crocodile (*Crocodylus porosus*).

Four species of marine turtles, leatherback turtles (*Dermochelys coriacea*), hawksbill turtle (*Eretmochelys imbricata*), green sea turtle (*Chelonia mydas*) and the olive ridley turtle (*Lepidochelys olivacea*) nest and feed around both island groups. Das (1999b) has discussed the biogeography of the herpetofauna for these islands and Andrews (2001) has discussed the various impacts and threats. However, systematic status of most species is still unknown, even for some of the mega species.

Reefs of the Andaman and Nicobars are not only significant for the Indian Ocean region but are also globally significant and are comparable to the 'Coral Triangle' around Philippines, Indonesia and Papua New Guinea, the world's centre for coral diversity (Vousden, 2000; Turner *et. al.*, 2001; Venkataraman, *et. al.*, 2003). Surveys have resulted in 198 species of scleractinian corals within 58 genera at 13 different sites sampled in the Andamans of which 11 are new records for India (Turner *et al.*, 2001). The total area of reef flat was estimated to be 259 km$^2$, providing a total area of shallow reef of 520 km$^2$ around North Andaman alone and species numbers ranged from 44 to 89 at different sites. However, this has changed since the 26th December quake due to the upheaval of most of South, Middle and North Andamans. Considering the areas and extent of coral reefs sampled by various authors and agencies, it is clear that the extent of reefs in both island groups is far from known.

## Human landscapes

### Indigenous groups

The entire Andaman Islands were home to several indigenous groups of Negrito hunter-gatherer people. The largest groups in the last century were the Great Andamanese people, consisting of 12 tribes. The 97 Onge people, who inhabit Little Andaman Island and the Sentinelese, inhabit North Sentinel Island, an island 60 $km^2$ south west of South Andaman Island.

The Jarawas, who once inhabited south west coast and the interiors of South Andaman Island and who had resisted contact until 1974, are confined to the west coast of South and Middle Andaman Islands.

The Nicobarese occupy 12 of the 23 Nicobar groups of islands and some of the uninhabited islands are visited only for harvesting coconuts or other forest produce. Most Nicobari people live in small villages, and others in smaller hamlets and in individual family units in various locations and islands. Although most Nicobari people are referred to, in general, as 'Nicobarese' it should be understood that these people are of several different groups with different customs, cultures and dialects. These people are probably descendents of different hunter-gatherer tribes from Myanmar and the Indo-Malayan regions (Andrews & Sankaran, 2002).

The Shompen, of Mongoloid origin, numbering 380 are marginalised to the inland forests along the three major river systems, and areas along the east coast and the west coast of Great Nicobar Island.

### The settled population

Initial settlers were the descendants of convicts and freedom fighters who were jailed in these islands and they constitute a very small proportion of the population. To work the forests, 45 Karen families, descendants of the several Karen tribes in Myanmar, were sent to the islands in 1925. Currently there are around 3000 Karens concentrated around Mayabunder in Middle Andaman.

The Ranchi people were also brought in during the 1920s and these people from Chota Nagpur have settled on most inhabited islands throughout the Andaman and Nicobars. Refugees from the erstwhile East Pakistan were brought here in the 1950s and settled in South, Middle and North Andamans. In the 1960s, 300 Sri Lanka repatriates settled on Katchal Island in the Nicobars, and this population increased to over two thousand. The first groups of ex-servicemen were settled on Great Nicobar Island in 1969 in an area of approximately 1,500 hectares, cleared for these 337 families along the east coast, up to 35 km, south of Campbell Bay. In the last 30 years there has been immigration from mainland India, mainly from Bengal and Tamil Nadu and there are 503 inhabited villages in the Andaman & Nicobar Islands (Census of India, 2001).

## Methods

Observations and rapid assessments of the coastal habitats that include beaches, reef flats, littoral forests, mangroves, creeks and inland marshes and wetland areas were conducted by ground surveys. Areas and islands were assessed with a local inboard, dugout canoe (dungi). Mangrove creek surveys were conducted in an inflatable boat fitted with a 15 HP outboard engine. Random night surveys were conducted in crocodile habitats and methods employed were as previously discussed by Andrews & Whitaker (1994a) and Andrews (1999). Reef flats were observed from onshore and offshore and some shallow reefs were assessed by snorkeling. Mega species such as the saltwater crocodile, marine turtles and the endangered Andaman teal were used as indicator species. In Great Nicobar Island surveys were conducted by ground and helicopter surveys and central Nicobars by boat and on ground. Some areas of South Andaman Island were surveyed over land.

To estimate the height of islands and reef upheaval and subsidence, reef flats were observed during high and low tides and were estimated by the old watermarks and barnacle lines. The height of water levels reaching creek banks was also recorded during high and low tides. To compare and derive at conclusions, tide charts, satellite imageries, topographical and marine maps were used.

In impacted areas, regeneration rates were assessed by taking 1$m^2$ plots for mangroves and counting seedlings 24- 30 cm stem height; in coastal littoral forest 5 $m^2$ plots were counted for plants with a stem height of 3- 4 m. Interviews were conducted with fishermen, lobster divers, crabbers and people working and settled in different areas along the coast, to assess impacts on habitats and livelihoods.

## Results

### North Andaman islands

*Western coast*

The effects of the earthquake resulted in the upheaval of the islands and reef flats, leaving the reef flats on the south eastern, the western and northern sides of North Reef Island exposed and dead to an estimated extent of 4.5 $km^2$ (Figures 4 and 5). The reef tops are chalky white, dead giant clams several species of eels, sea snakes, several species of starfish, brittle fish and sea cucumbers was observed. Deeper reefs were observed on the south eastern, the western and northern sides of North Reef. These reefs are intact; no quantification could be carried out due to the strong currents in the area.

The reef flats on the western, southern and eastern side of Latouche Island are also exposed. However, reefs 3-5 m deep along the exposed reefs was observed on the western side of this island. Eight green sea turtles (*Chelonia mydas*) and three hawksbill turtles (*Eretmochelys imbricata*) were sighted among these reefs. The other reef flats on the western coast that were exposed and dead are around Kwangtung Island and the estimated extent is 0.5 $km^2$ . The estimated area of reef flats exposed on the northern, eastern and southern sides of Snark Island is 0.3 $km^2$ and the upheaval of this island is almost 2 m. Reefs 2-3 m deep on the eastern side of Snark were observed to be intact. Other islands, where reef flats are exposed, include Jub Jub, Boojam Rock, Point, Paget, Reef, White Cliff and West Islands. Reefs, 2-4 m deep, were observed on the eastern and southern sides of West Island. The reef between Point and Paget islands is completely covered by sand. The estimated area of reef flats exposed on the eastern side of Point Island is 2 $km^2$ and the southern and western side is approximately 2.5 $km^2$ . The reef flats to an extent of 1 $km^2$ , along the south western side of Paget Island are exposed. The exposed reef flats along northeastern side, the northern, eastern and the southern sides of West Island, are estimated to be 4.5 $km^2$.

In the north, the reef flats along the southern, western and northern sides of Landfall Island and on the northern, eastern and southern sides of East Island are exposed and estimated extent is approximately 3 $km^2$. The estimated height of Landfall Island reef flats exposed during low tide range from 0.7-1m and the estimated extent of reef flat exposed is over 6 $km^2$.

**Figure 4: Exposed reef flats on the south eastern side of North Reef Island. The island on the far left hand side is Latouche Island.** *Courtesy Pankaj Sekhsaria*

**Figure 5: Exposed reef flats on the south western side of North Reef Island.** *Courtesy Pankaj Sekhsaria*

*Eastern coast*

The reef flats around Pocock, Excelsior, Trilby, Delgarno Islands, and east coast of Smith Island and on the eastern and southern sides of Ross Island are exposed. Reef flats south between Dundas Point to Louise Bay and further to Cadell Point and east of Sound Island are also exposed. However, these are minimal as there were no extensive reef flats or coral beds along these islands or on the eastern side of Andaman.

*Beaches, coastal forests and inland wetlands*

The beaches on north western and eastern sides of North Reef Island have minimal changes, but the beach on the south eastern side has built up. Due to islands and reef flats upheaval marine turtles do not have access to these beaches for nesting and this was evident as no tracks or nests were found. Two plastrons of green sea turtle (*Chelonia mydas*) was found on the west coast and no evidences were available to conclude the cause of death. However, 22 sightings of *Chelonia mydas* around the island, off shore and among deeper reefs, were recorded.

The inland freshwater marsh on the south eastern side of North Reef Island has changed again. During 1995, the sea broke into the marsh and changed the freshwater marsh ecosystem. After the 2004 tsunami, there has been beach build up and due to the upheaval of the island there is no seawater entering this marsh. This marsh is almost dry except for a small pool where a flock of over 20 Andaman teal (*Anas gibberifrons alborgularis*) was sighted. The northern fresh water marsh is completely dry and there was no fresh water anywhere on the island, though these marshes will fill up during the monsoons. There has been no great impact on the coastal forest except for a few trees like *Manilkara littoralis* and *Pandanus tectorius* on the southeastern side and on the northern sides and a few casuarina trees along the western coast of this island. North Reef Island is one of the last strong hold, in Middle Andamans, for the Andaman teal (*Anas gibberifrons alborgularis*). The lesser whistling teal (*Dendrocygna javanica*) and cotton teals (*Nettapus coromandelianus*) also share this habitat (Andrews & Whitaker, 1994; Andrews & Sankaran, 2002). Roosts of Nicobar pigeon (*Caloenas nicobarica*) and two very large Blyth's flying fox (*Pteropus melanotus tyleri*) were observed on this island. Several monitor lizards (*Varanus salvator andamanensis*) were sighted on this island, besides fresh tracks of a 2 m *Crocodylus porosus* on the beach along the east coast.

Beaches on the eastern and southern sides of Snark Island have changed very little. Six green sea turtle nests and tracks and nest of a hawksbill turtle (*Eretmochelys imbricata*) were recorded from this island. Due to the upheaval of reef flats turtles do not have access to the beaches on the eastern and western sides of Point, Paget, Reef, West, Landfall and East Islands. There is no impact on littoral forests of these islands.

All the bays in the western and eastern coast have huge mud flat formations. Thus navigation, during low tide, into creeks has become difficult and entry into some of the creeks from bays impossible. The smaller creeks draining into larger creeks are drying up and in the large ones the high tide water reaches 0. 75-1 m below the mangrove strands. This is currently causing drying up of the front and back line mangrove strands, besides whole strands, 20- 50 m lengths, sliding into the creeks (Figures 6 and 7). The substratum from the bottom of the creeks has been swept away into the bays, leaving sandy bottoms with hardly any fish or other creek fauna.

Night surveys in mangrove creeks was conducted in Coffrie, Casuarina, Coldstream Bays and Parangara and Balm's creeks; direct sighting of crocodiles (*Crocodylus porosus*) were recorded in the creeks. *C. porosus* of different size classes, 0.5-3 m long, were sighted, indicating breeding and that habitat conditions are intact.

There has been very little impact on coastal forest and is of no long term significance. Areas where impacts were observed are Pembroke, Coffrie, Casuarina, Beale, Hudson, Cold stream, Duncan, Bluff Point, Elizabeth and Pine Bays along the west coast of North Andaman Island. The impact was restricted to a few fallen *Manilkara littoralis* trees and *Pandanus tectorius.* The same was recorded for Cadell, Minerva, Aerial, Lamia, Taraliat and Mangrove Bays on the eastern coast. Minor impacts were also observed on islands of East, Pocock, Excelsior, Trilby, Smith, Ross and Sound islands and these impacts are of no major concern. Four minor landslides were observed on the eastern side of Saddle Peak and these too are of no major significance.

### Middle Andaman islands

*West coast*

The reef flats from Foul Bay, southern tip of Middle Andaman Island, and up to Rocky Point are exposed and dead including the reef flats west, south and south east of Flat Island. Further north from Hump and Tuft Islands between Mask, Anderson Islands towards Austin Strait around Bennett, Boudeville, Surat, Entrance, Sea Serpent and Snake islands the reef flats are exposed during the low tide. The estimated extent of exposed reef flats in this area is approximately 2 $km^2$. This has made navigation through these passages difficult and complicated during low tide. The entrance to Austin Strait from the western side becomes very shallow less than 50 cm deep and surrounded by dead reef flats.

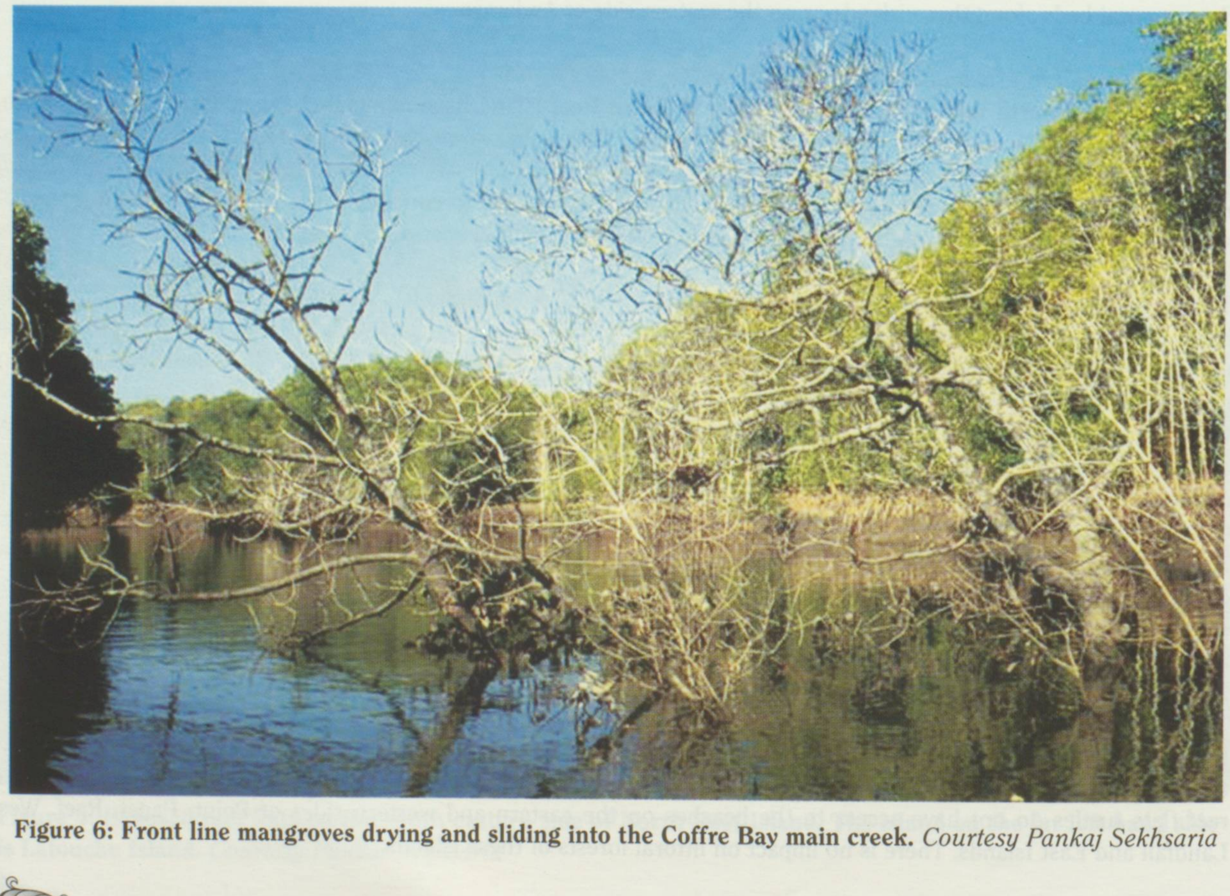

**Figure 6: Front line mangroves drying and sliding into the Coffre Bay main creek.** *Courtesy Pankaj Sekhsaria*

**Figure 7: Uplifted side creek draining into main Coffre Bay Creek, North Andaman Island.**
*Courtesy Pankaj Sekhsaria*

The reef flats around South Reef Island are also exposed and dead to an extent of 1.5 $km^2$. The estimated reef flats exposed along the west coast of Interview Island, from Nancy Point to the northern tip, is roughly around 24 $km^2$ and on the northern and north eastern side the exposed reef flats is around 3 $km^2$. The most common species were *Acropora sp.* intermittent with species of branching corals ranging from 1- 10 $m^2$ in area (Figure 8).

**Figure 8: Exposed reef flats off west coast of Interview Island.** *Courtesy Pankaj Sekhsaria*

*Eastern coast*
The reef flats between Phoenix Point and Reef Point are exposed and dead besides the reefs on the north eastern, northern and north western sides of Long, Guitar and North Passage Islands.

*Beaches, coastal forests and inland wetlands*
Very minor changes have occurred to beach along the western and eastern coasts. Since most beaches have been partially swept away, high tides now reach the forest line. However these beaches are reforming. These beaches include Foul Bay, Tanmaguta, Adita and Robert Bay on the South Western side and Cape Vestal, Paikat Bay, Woteng and Cuthbert Bay on the eastern side. Turtles were nesting up to April 2005, at Paikat Bay, Woteng and Cuthbert Bay. Turtles were nesting upto April 2005 at Paikat Bay, Woteng and Cuthbert Bay. Some of the island beaches too have been swept away partially and were observed on Flat, Hump and Tuft.

ANET monitored turtle nesting trends at Cuthbert Bay and after the tsunami, six *Chelonia mydas* were encountered and two nested. Of the 94 *Lepidochelys olivacea* encountered, 65 nested and one *Dermochelys coriacea* encountered also nested. Nesting on this beach ceased by 27th April. The beaches on the south west coast and northeastern side of Interview Island have become inaccessible for turtles to nest, due to reef flat upheaval. The status of these beaches can be only concluded after this year's monsoon. The sea grass bed on the north of Interview Island at Brasse Point has been swept away, though small tufts of 3-4 cms high have already regenerated. Moreover, over 10 *Chelonia mydas* and three *Eretmochelys imbricata* of different size classes were sighted in this bay.

As in North Andaman Island, along the west coast and on Interview Island, the smaller mangrove creeks are drying up and in the large ones the high tide waters remain 0.7-1.0 m below root levels and the effects are as mentioned for North Andamans. The high tide water in the mangrove creeks in Porlob Jig and Homfray's Strait on the eastern coast was found entering the forest edge. Mangroves were also flooded by low tide, causing drying of the front line mangrove trees.

Hardly any impact on coastal forests was observed for Middle Andamans. Seven minor landslides were observed on the southeastern and two on southwestern side of Interview Island and these are of no concern.

## Ritchie's Archipelago islands and Barren Island

No noticeable impacts were observed around Ritchie's Archipelago. Resort owners, divers and sail boat people from Havelock reported that the reefs around Havelock and Neil Islands were in good condition and not impacted. Regular sightings of dugongs south of Havelock Island was also reported. Our observations around South Button found intact reefs. Eight *Chelonia mydas* and three *Lepidochelys olivacea* nests were counted on Middle Button Island. Eleven and six nests of the above species were also observed on Inglis Island, respectively. A roost of over 1000 individuals of the Blyth's flying fox, (Pteropus melanotus tyleri), the largest in the Andamans was observed on Outram Island in a mangrove creek on the southwestern end of the island. This roost last observed in 1998 has made a comeback after the tsunami (Andrews, 2000; Aul, 2002). *Varanus salvator* was sighted on Middle Button, Henry Lawrence and on Inglis Islands. Very minor impacts on coastal forests and mangroves were observed on Outram, John Lawrence and Henry Lawrence Islands. Such impacts of few fallen littoral and mangrove trees can also be observed after cyclones and hence are of no significance.

Barren Island volcano is smoking, spewing sulphur and rumbling. A huge side vent has developed on the southeastern side towards the bottom, besides several other small ground vents (Figure 9). There is an upheaval of the Island by at least 1.5 m. The reefs off shore are still pristine and there were no visible impacts and three Blyth's flying fox (*Pteropus melanotus tyleri*) roosts were recorded. Aul (2002) reported two roosts. Several landslides, of no significance, were observed around the island.

## South Andaman Island

*West coast*
Areas from Port Mouat (west coast of South Andaman Island), Perseus Point to Constance Bay have been submerged to an average depth of 0.9-1m. Coastal mangroves and the mangroves inside Port Mouat have also been submerged to the extent of 10-50 $m^2$ causing them to dry. This is mainly the front line mangrove strands and there is no major damage to coastal or inland forest. The beaches between Perseus Point and Florence Point submerge during the high tide.

The coral reef flats from Palmer Point north of Constance Bay and along Sandy Point and north of Cape Barwell to Port Campbell and south and north east of Petrie Island are all dead as they have been exposed to an average height of 0.75-1 m above the low tide line. The estimated extent of reef flats upheaval between Palmer Point and Cape Barwell

**Figure 9: Barren Island volcano, side and ground vents smoking**

is well over 5 $km^2$ and the extent between Cape Barwell and Petrie Island is over 3 $km^2$. The coastal habitats, mangroves and littoral forest in these areas have not been affected at all except for the drying of the front line mangroves at the entrance of Partam Jig creek in Port Campbell. Mangroves have dried up to an extent of 60 $m^2$ and this is insignificant as the mangrove regeneration is very extensive in this creek. The reef flats along Bluff and Spike Islands are also dead and have emerged, 0.75-1 m, above the low tide mark.

*East Coast*

Some of the creeks in Baratang were surveyed and here the high tide water goes way up to the forest edge. During low tide, the front-line mangrove strands remain submerged and this is causing drying up of the first to the fourth strands of mangrove trees, averaging from lengths of 25-50 m stretches, besides shifting of some strands into the creek in some areas. Currently this is of no major concern as this effect has been noticed during some years after minor cyclones during the monsoonal periods. The Putatang Jig mangrove creek and a creek south of it, on the north east of South Andaman Island, were surveyed and the same impacts were observed as in Baratang Island.

The Port Meadows and Shoal Bay areas were surveyed over a period of three days and there are large areas of mangroves drying up and large tracts 20- 70 m length of mangrove strands shifting into the creeks and these trees have dried up. Compared to the extent of mangroves, regeneration in these areas may seem minor. Since the amount of dried mangrove trees are huge, it requires an assessment by the concerned department for the actual quantity as these can be utilized There is minimal loss of coastal forest south of Shoal Bay to Port Blair and this is of no major concern. The Madhuban Beach was surveyed and old and fresh tracks and nests of two species of turtles, *Chelonia mydas* and *Lepidochelys olivacea*, were recorded. However, these nests will not survive as they are flooded during high tides. No major loss of littoral forest was observed in this area.

The beaches on Twins, Rutland, Cinque's and South Brother Islands have been partially swept away to enabling the high tide reach the forest line. The sand bar along the south western side of North Cinque is swept away and currently there is a deep channel, creating a smaller island, south of North Cinque Island (Figure 10).

**Figure 10: Southern area of North Cinque Island that has separated**

**Figure 11: Beach build up on South Cinque Island, South Andamans**

There is however major beach build up on the western coast of South Cinque Island (Figure 11). Very minor impacts on coastal forests were observed on all these islands, including Boat, Hobday, Redskin and Tarmugli Islands. On Twins and Cinque Islands littoral species of stem height 1-4 m have dried up due to flooding by tsunami wave. This was observed for all these outlying islands, besides a few fallen *Manilkara littoralis* trees and *Pandanus tectorius*.

### Little Andaman Island

All areas along the west coast and east coast were surveyed intensively over a period of six days. Habitats surveyed included littoral forests, beaches, reef flats, mangrove creeks and inland fresh and saline water marshes (Figure 2).

Small tracts of littoral forests at the mouths of Dugong creek on the north eastern side, Egu Belong creek in the north and from west coast starting from Bumila creek, Ekiti Bay, the mouth of Jackson creek and right up to South Bay have been impacted but not significantly and is of no major concern. Vegetation impacted, not to any great extent were, *Manilkara littoralis, Pandanus tectorius* and mangroves *Rhizophora apiculata, R. mucronata, Avicennia officinalis, marina* and *Sonneratia caseolaris*. The major loss of littoral forest, mostly *Manilkara littoralis* trees and *Pandanus tectorius*, are along south eastern side and along Hut Bay up to Butler Bay areas. These areas are the most affected areas in Little Andaman Island (Figure 12).

**Figure 12: Impact at the mouth of Jackson Creek in Little Andaman Island**

**Figure 13: Upheaval of reef flats west coast Little Andaman Island**

**Figure 14: New beach formation north of Jackson Creek in Little Andaman Island**

The reef flats starting from Jackson Creek south to Api Island and the reef flats from West bay south to South Bay has risen to an average height of 1 m above the low tide mark. These reefs are dead and the estimated extent is roughly around 5 $km^2$ (Figure 13).

The three major sea turtle nesting beaches, West and South Bay on the west coast and Butler Bay on the eastern coast have all been affected. Four species of sea turtles including the leatherback sea turtle nest here. These beaches have been washed away partially and now submerge during the high tide. No evidence of turtles nesting on these beaches was found. But observations and indications are that these beaches are reforming and will come back to their original landscape after this year's monsoon. Two other new beaches have currently formed after the tsunami, one starting at the northern mouth side of Jackson Creek for a length of 5 km, where turtle tracks and nests of three species of marine turtles, *Chelonia mydas* (four nests), *Lepidochelys olivacea* (three nests) and *Dermochelys coriacea* (two nests) were recorded (Figure 14). Another 2 km long beach has formed and is situated 4 km south of Jackson Creek, four *Chelonia mydas* and two *Lepidochelys olivacea* nests were recorded from here (Figure 15).

**Figure 15: New beach formation south of Jackson Creek in Little Andaman Island**

Inland marshes were surveyed and the largest tract of fresh water marsh between Jackson Creek and south to Api Island Point have dried. Tracks of crocodiles, teals, and monitor lizards were found on these dry mud flats (Figure 16). As reported previously Little Andaman is the last strong hold for the Andaman teals (*Anas gibberifrons alborgularis*) where annually thousands can be observed including lesser whistling teals (*Dendrocygna javanica*) during and after the monsoons (Andrews, 1999; Andrews, 2000; Andrews & Sankaran, 2002). The other marshes surveyed are the two marshes running parallel to the north of the Jackson Creek, one just off the beach inland after a narrow strip of littoral forest, 5-10 m wide. This fresh water marsh has become saline as the southern side of the marsh, at the mouth of Jackson Creek, breached during the tsunami, with another breach about 1.5 km north (Figure 17). Crocodiles (*C. porosus*), monitor lizards (*Varanus salvator andamanensis*), Andaman teals (*Anas gibberifrons alborgularis*), egrets (*Egretta garzetta* and *Ardea alba modesta*) and grey herons (*Ardea cinerea rectirostris*) were observed. The second marsh, parallel to the first, which had peat bogs and floating vegetation, is completely dry (Figure 18). These marshes are currently affected due to the draining caused by the upheaval of the whole island and the tsunami wave flooding these marshes at a height of 10-15 m. However, these marshes are expected to rejuvenate once the monsoons starts.

**Figure 16: Marsh south of Jackson Creek, Little Andaman Island**

**Figure 17: Marsh north of Jackson Creek, Little Andaman Island**

**Figure 18: Inner marsh north of Jackson Creek, Little Andaman island**

**Figure 19: Erosion of front line mangroves in Jackson Creek**

The mangrove creeks were surveyed and first impressions were that the high tide waters do not reach above the mangroves and most of the small creeks draining into the main creek are dry. The bank of the creek remains on an average, 1 m above the normal high tide level and this is causing front line strands of mangrove trees to dry up and caving or shifting into the creek. Over time all the front line and the back line strands will dry. (Figure 19). Direct sightings of *Crocodylus porosus* in all size classes (0.3-3 m), were recorded in Dugong, Bumila and Jackson Creeks, including the creek in West Bay. Several indirect evidences, mainly through tracks on beaches and on dry marsh beds were seen. The status of *C. porosus* has been previously discussed (Andrews, 1999). The Blyth's flying fox (*Pteropus melanotus tyleri*) roosts were recorded in all the creeks, three in Dugong Creek, four in Bumila Creek and two roosts in Jackson Creek. This is significant as Aul (2002) reported only one roost from Dugong Creek and none from the other creeks.

## Great Nicobar Island and areas in the central and northern Nicobars

The entire coastal areas and habitats have been completely affected and destroyed impacting all coastal flora and fauna and affecting some of the mega species. In the Galathea area and the entire South Bay, tsunami waves of 30 m height had gone inland for almost 1.5 km (Figures 20 and 21). This has destroyed all the beaches, mangroves and the entire coastal habitat of the South Bay, including the areas around the lighthouse at 51 km.

**Figure 20: The Galathea NP turtle nesting beach swept away in Great Nicobar Island**

**Figure 21: The extent of devastation in Galathea NP**

**Figure 22: Extent of impact on mangroves at Galathea NP**

**Figure 23: Impact and sand build up at 44 km, south east coast of Great Nicobar**

Currently 4 to 10 m high debris consist of fallen trees, plastics, timber and other materials from the sea that drift on to the land area at each high tide (Figures 22 and 23). The high tide line reaches the slope forests and existing mangrove species and other coastal flora are drying up. The same effect was observed for the west coast of Great Nicobar and islands in the central group and on Car Nicobar Island.

The most affected are the sea turtle beaches along the east coast of Great Nicobar, mainly the Galathea beach and along the west coast of Great Nicobar up to the areas along the Alexandra and Dagmar Rivers (Figures 24 and 25). Beaches along Little Nicobar and Katchal Islands and areas that were once prime sea turtle nesting beaches have been washed away. Currently two beaches are forming in Great Nicobar Island in South Bay one at 43 km and at 45.5 km, where hawksbill and olive ridley sea turtles were observed nesting. However, these nests will be destroyed as these beaches flood during high tide.

With all coastal habitats destroyed, the nesting and feeding habitats of the South Nicobar megapode (*Megapodius freycinet abbotti*) have almost disappeared on Great Nicobar Island. However, this species was observed within inland forests along the east coast of Great Nicobar Island and has been previously observed to nest, feed and inhabit inland forests. It will therefore make a comeback and can be considered safe.

Other species observed along fragmented and flooded coastal habitats in Great Nicobar Island were monitor lizards (*Varanus salvator nicobarienensis*), crab eating macaques (*Macaca fasicularis*) and the southern Nicobar tree shrew (*Tupaia nicobarica Zelebor*). Observations indicate that these species have not been greatly affected, although coastal habitats have been affected to a very great extent. These species are safe and considering that they inhabit inland forests there is no threat to them due to the tsunami. The only species that must have been most affected is the giant robber crab (*Brigus latro*) that inhabits only the coastal habitat along the east coast of Great Nicobar Island, the area that was impacted the most. *Brigus latro* lives in tree hollows and below fallen trunks and feeds on coastal nuts and fruits, dead fish and others that wash ashore. As this species cannot swim, there is a likelihood of extinction of this

**Figure 24: South west coast of Great Nicobar Island**


**Figure 25: West coast Great Nicobar Island**

species in Great Nicobar Island. Evidence of this species has been reported on Menchal Island, North of Great Nicobar Island (Chandi, 2005 *Unpubl.*). However further intensive field surveys are required to assess the status of this species. The giant robber crab also occurs on Meroe and Menchal islands in South Bay in Little Andaman and South Sentinel Islands (Davis & Altevogt, 1976; Andrews & Sankaran, 2002).

Areas were also surveyed by land and interviews were conducted with the Nicobari people in the central group of the Nicobars. Observations are that all coastal habitats are now under water with high tide reaching slope forests and inland wetlands. This is currently killing mangroves, mainly along Nancowrie and Kamorta Islands, which used to have the most extensive mangrove tracts in the entire Nicobars. The other two species that have been impacted to very great extent and commonly used by the Nicobari and Shompen people are *Pandanus nicobarensis* and *Nypa fruticans*. Pandanus fruits are the staple diet for many of the Nicobarese and the Shompen people and *Nypa fruticans* is commonly used for traditional roofing. The loss of huge tracts of Pandanus and *Nypa fruticans* was also observed on Great Nicobar Island and the last two remaining strands of *Nypa fruticans* was observed inside the Galathea River (Figure 26). The subsidence of the islands is also impacting inland flora and freshwater sources to a very great extent on islands like Nancowrie, Kamorta, Trinket and Katchal. Moreover, all natural materials used by the Nicobarese people for house construction, boat building and food are currently non existent and this poses a very major problem for these people who have been living in these coastal areas for hundreds of years

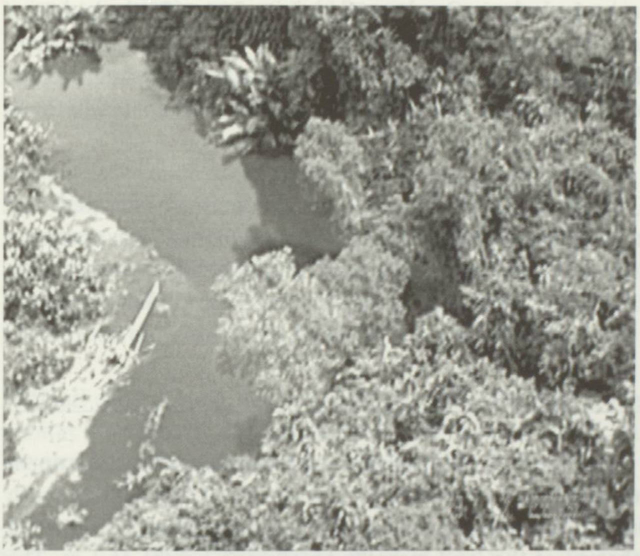

**Figure 26: The Galathea River and the remaining two strands of *Nypa fruticans***

One notable observation was the finding of a pet Malayan box turtle (*Cuora amboinensis*) on Nancowry Islands (Andrews, *pers. observ.*). Further investigations revealed that this species is on Kamorta and few other islands in the central Nicobars (Ravi Sankaran, *pers com.*). Although occurring in northeast India and in South East Asia, this species was previously reported only from Little and Great Nicobar Islands.

Of major concern in the Nicobar Islands and mainly on Great Nicobar Island are domestic animals that have become feral. These include pigs, goats, cows, dogs, cats and chickens, all of which were observed in January 2005 on Great Nicobar Island and their presence will have major ecological consequences. Most of the cows are from the settled areas along the north-south road and are now seen grazing inside forest areas and this is going to have major impacts on forest regeneration. Goats are from both areas, settled and from Chingenh village that was in South Bay at 43 km. The impacts of goats on island ecosystems and forests have been previously discussed by several authors. Pigs, as observed from 1993, will interbreed with the wild counterparts and predate on sea turtle nests. Dogs too predate on sea turtles and their nests, beside preying on wild pigs and monitor lizards (*Varanus salvator nicobarienensis*). The impacts of domestic pigs and feral dogs on sea turtles and their nests have been previously discussed by several authors (Bhaskar, 1993; Andrews, 2000; Andrews *et. al.*, 2001; Andrews & Sankaran 2002). Cats will impact ground and nesting birds, the South Nicobar megapode (Megapodius freycinetabbotti), lizards, snakes and the Southern Nicobar tree shrew (*Tupaia nicobarica zelebor*).

Small dogs, goats and chickens will be hunted down by monitor lizards (*Varanus salvator nicobarienensis*) and by reticulated pythons (*Python reticulates*), but not sufficiently enough to have any impacts on these feral domestics.

### Some livelihood observations

Fishermen, crabbers and lobsters divers were encountered on the western and eastern coast of Andaman Islands, including Little Andaman Island. Several groups of fishermen, from Diglipur, using large nets along the west coast of North Andaman Island reported that their catch rate was the same as the pre tsunami and a ten day catch effort was valued at Rs. 150,000- 200,000. Fishermen from Mayabunder using hook and line for different species of groupers also reported that their catch rate was good. Grouper fishermen were also encountered on the west coast of Little Andaman Island. Grouper fishermen go to deep reef areas and these groupers are mainly exported at very high costs while the same fish hardly has any market value in the islands. Lobster divers were encountered on the west coast of Middle and

North Andaman Islands and they too reported good catch rate and it was possible for one diver to earn Rs. 1000- Rs. 2000 per week. Shark fishermen were encountered on West Island, North Andaman. They revealed that shark are very hard to come by and catch rate and size class have reduced tremendously, compared to 10 years ago. This is evident from ANET's study in the Andaman (Jeyaraj & Andrews, 2004, *In press*) Currently very few fishermen are involved in shark fishing as it is not feasible any more. These fishermen on West Island were setting nets north of Landfall Island almost close to Coco Islands.

Lobster divers were encountered along the west coast of Middle Andaman Island and they reported good catch rates and that on an average each person earned Rs. 1,500- 2000 per week. Of major importance, are their reports of most areas being depleted and size of lobsters caught being very small. This is mainly because the lobster habitats are destroyed and disturbed due to up turning of rocks, boulders and breaking away at corals while collecting lobsters. Fertile lobsters are caught during the egg laying season which also accounts for the smaller size classes; females with eggs fetch a much higher price. Reduction in lobster sizes was evident from personal observations at Mayabunder, from were middle-men transport the catch to Port Blair.

Crabbers encountered on the west coast of Middle and North Andaman islands and along the west coast of Little Andaman Island, too reported good catch rates. In fact, their catch effort and catch rate is reported to have increased tremendously. This is mainly due to the high tide waters not reaching above the mangrove roots and this has made it easier for them to catch crabs right off the edges of the creeks. In Jackson Creek, on the west coast of Little Andaman Island, 11 boats were encountered in a single day and these were mostly crabbers and the rest were grouper fishermen. Most of them were from South Andaman and a few from Little Andaman. It was also learnt that a crabber earned Rs. 1,500/week on an average. They also reported that the size of crabs caught currently was smaller as compared to those caught five years ago.

While 90-95% of the crabs are exported out of the islands, almost 100% of the lobsters and groupers are exported. The report alongwith various species including banned species are exported out of the islands and further from mainland India to nearby overseas countries. Currently observations show that the catch effort and catch rate has increased after the 2004 tsunami.

## Synopsis of findings

The entire reef flats, starting from north of Constance Bay on the western side of South Andaman Island, further north along Middle and North Andaman Islands and along the eastern coast from the north up to Shoal Bay area in south Andaman Island are dead due to exposure, during low tide (0.75-1 m high). This is the same for all major out-lying islands around these areas and is a clear proof of the upheaval of the land mass by an average height of 1 m. The exposed reef flats, in time, will become extensive beaches and the littoral forests will extend further out, increasing the land area.

The mangrove creeks along the same areas have been affected due to the high tide waters not reaching the roots of mangrove trees, the water level staying 0.75-1 m below the normal level in the creeks. This is causing root shock and eventually drying of first to third rows of mangrove trees and shifting of strands into the creeks. These same creeks have been swept of their bottom substratum, leaving sandy bottoms affecting fish and other creek fauna.

The mangroves on the eastern side of Middle Andamans, from Rongat Bay, east of Long Island and from north of Baratang Island and in Shoal Bay area are also getting submerged during high and low tides. This is also causing drying of mangrove trees and shifting of strands into the creeks. This is because the roots cannot breathe as they are not exposed when roots have to be normally exposed for at least six to eight hours a day.

The impacts on mangroves in areas of Rongat Bay, west of Long Island, east Middle Strait Island, Baratang Island, Shoal Bay, around southern South Andaman Island and along the west coast to Port Mouat, is a clear indicator of the subsidence of the land mass of this portion of the island by 0.75-1 m.

However the front line drying and caving into the creek is of a major advantage as the tsunami has swept the entire substratum from the creek leaving only sand, affecting the creek fauna. The caving in of trees and mud will reduce the depth of the creek and high tide waters will start to reach into the mangroves and the monsoonal inflow will keep the creek mouth open and also help beach build up.

The entire coastal areas and habitats have been completely affected and destroyed impacting all coastal flora and fauna and affecting some of the mega species. In the Galathea area and the entire South Bay, the wave, at a height of 30 m, had gone inland for almost 1.5 km. This has destroyed all the beaches, mangroves and the entire coastal habitat of the South Bay, including the areas around the lighthouse for a stretch at 51 km. Currently debris (4 to 10 m high), consisting of fallen trees, plastics, timber and other materials from the sea, drift on to the land area at each high tide. The high tide line reaches the slope forests and existing mangrove species and other coastal flora are drying up. The same effect was observed for the west coast of Great Nicobar Island and islands in the central group and on Car Nicobar Island.

Observations in the Nicobars are that all coastal habitats are now under water with high tide reaching slope forests and inland wetlands. This is currently killing mangroves, mainly along Nancowry and Camorta Islands. The other two species that has been impacted to very great extent are *Pandanus nicobarensis* and *Nypa fruticans*. Loss of huge tracts of *Pandanus nicobarensis* and *Nypa fruticans* was also observed on Great Nicobar Island. The subsidence of the islands is also impacting inland fauna, flora and freshwater sources to a very great extent on islands like Nancowrie, Kamorta, Trinket and Katchal Islands.
Loss of all tracts of Pandanus in the Nicobar group of islands will, to a great extent, affect the dietary habits of some Nicobarese people and all the Shompen people. The loss of mangroves and associated food resources wil also have an effect. In addition, the loss of *Nypa fruticans* used commonly by both communities, for roofing of their traditional habitations, will not be available for many years to come.

In the Nicobar Islands and mainly on Great Nicobar Island domestic animals have become feral. These include pigs, goats, cattle, dogs, cats and chickens.

Mega species such as marine turtles were sighted off shore all around the islands, including mating pairs and tracks and nests on various beaches and islands. Crocodiles (*Crocodylus porosus*), monitor lizards (*Varanus salvator nicobarienensis*), the crab eating macaque (*Macaca fasicularis*), the southern Nicobar tree shrew (*Tupaia nicobarica zelebor*) and Andaman teal (*Anas gibberifrons alborgularis*) were seen in the areas surveyed. The large flying fox (*Pteropus melanotus tyleri*) roosts were observed in the Andamans and in several mangrove creeks in Little Andaman Island. Currently there are no major impacts to the habitats and ecosystems of most of these species.

With all coastal habitats destroyed, the South Nicobar megapode (*Megapodius freycinet abbotti*) nesting and feeding habitat have almost disappeared on Great Nicobar Island. However, this species was sighted inside inland forest along the southeastern coast of Great Nicobar Island.

**Baratang Mud volcano at Jarawa Creek active two weeks after the tsunami.** *Courtesy A&N FD*

No major impacts were observed on coastal forests in the Andamans, there is scope for quick regeneration in impacted areas on the main and small islands. Regeneration rates observed for mangroves resulted in an average of 12 seedlings in 1 $m^2$ plots (Range 6- 25) of 24- 30 cm stem height. This rate of regeneration is promising in coastal littoral forest on large and small islands 5 $m^2$ plots, eight plants of 3- 4 species, with a stem height of 4 m.

Livelihood of most Andaman fishermen, crab catchers and lobster divers are intact, except for some fishermen from Port Blair area and fishermen from Hut Bay in Little Andaman Island. These groups of people are the worst affected, as their boats and equipment have been wrecked.

Mesh size gill nets and banned mesh sizes are still being used. This not only has a long-term impact on marine turtles and dugongs but on other commercially viable fish and other marine fauna. These nets also trap small fingerlings of other species which are discarded. As recently as April 2005 a small dugong was entangled and killed in a net, west off Tarmugli Island off south west of South Andaman Island.

Shark fishermen revealed that most large shark species are very rare and catch rate and size class has reduced tremendously, compared to 10 years ago. One species that was last encountered during 1993- 1994 was the tiger shark and is today non-existent around the Andamans.
Lobster divers encountered in the Andamans have reported that most lobster habitats are depleted and size of lobsters caught currently is very small.

Crabbers from North, South and Little Andaman islands reported that the size of crabs caught currently are small when compared to five years ago, although the catch rate has increased.

## Recommendations and conclusion

1. Currently no major management or conservation effort is required for the Andaman and Nicobar Islands. Planting and restoration programmes are currently not required and it must be remembered that mangroves, and casuarina plantations do not protect anything from a tsunami. There is also no need for creating wind-breakers as there are other native littoral species (other than casuarina) that can be used to reduce erosion along coast.
2. The sea turtle beaches that have been affected will re-form after this year's monsoons and other new beaches will also build up in the next two to three years and this will require monitoring as marine turtles will find new nesting beaches.
3. Some effort can go into removal of dry mangrove trees from Shoal Bay and Middle Strait areas and from Baratang Island for utilization as fuel wood, construction and fencing. These areas are logistically accessible and workable.
4. There is an urgent need to survey and assess the reefs around the Andaman and Nicobar Islands and as of now we are still unaware of the extent and diversity. Previous studies and surveys are only from very few sites in the Andamans. Considering the estimated extent these studies and surveys have become anecdotal and in no way represents the diversity of the coral reefs of these islands.
5. There is also an urgent need for surveys of sea grass beds to quantify impacts and extent; the last survey was conducted by SACON in 1995.
6. There is a need to conduct extensive amphibians studies in the central Nicobar group as most inland freshwater marshes and streams are inundated by saltwater.
7. Further land surveys are required with the aid of GPS for ground truthing and GIS to derive the actual extent of beach and reef flat loss, besides remapping the entire Andaman and Nicobar Islands and its topography.
8. Monitoring of the natural mangrove regeneration and the inland wetland habitats are required for at least the next three years to conclude on their status and permanent changes that will occur.
9. There is an urgent need to review fisheries practices around the islands.
   a. Fishing zones- fishing should be restricted to only 5 km offshore from the high tide line of all islands.
   b. Trawler nets should be fitted with turtle excluder device (TEDs).
   c. Review crab, lobster and reef fishes harvest. A seasonal ban must be imposed for long-term sustainability and the welfare of the island's fishing communities. This 3-4 months non harvesting season, , should be during the breeding seasons of crabs, lobsters and grouper species. This is very easy to regulate and enforce, as all these marine products are sent out of the islands as air cargo. The various airline carriers can be advised and instructed not to carry these produce during the non-harvesting season.
10. It should also be understood that a lot of the areas currently being chosen by the Nicobari people may be temporary and the process of movement and rehabilitation by these people may take as long as two to three years. Therefore, they should be given the right to choose and decide. Any outside influence or decisions may be detrimental for

these people in the long run. ANET's on going studies and surveys show that these areas and places are chosen because of water availability, higher ground and easy accessibility to the sea. All these areas are also outside National Parks and sanctuaries.

11. There is a need, in the Nicobars, for extensive planting of the fast growing *Pandanus nicobarensis*. As for *Nypa fruticans*, seeds and seedling can be collected from the Andamans and this species has been very successfully propagated from seeds at ANET base. However planting of these species can be taken up only after the 2005-2006 monsoon seasons. This will require intensive surveys and assessments of islands to identify planting areas. The Nicobarese people have to be also consulted for their opinions and recommendations.
12. A plan of action needs to be urgently formulated and immediately implemented for removal of domestic pigs, goats, cows, dogs, cats and chickens that have become feral, in the Nicobar Islands and mainly on Great Nicobar Island. Cows, goats and pig can be caught and given to settlers and to the Nicobarese people. The Nicoabarese people and the settlers can be given this responsibility as an income generation option.

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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