



## **Indian Ocean – South-East Asian Marine Turtle Memorandum of Understanding**

# **Assessment of the impact of the December 2004 tsunami on marine turtles and their habitats in the Indian Ocean and South-East Asia**

**Compiled by:**

**Mark Hamann, Colin Limpus, George Hughes, Jeanne  
Mortimer, and Nicolas Pilcher**

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## Contributing authors

The assessments of tsunami impacts were written and prepared by the following country contributors. They have been edited and formatted for consistency with only minor changes to the writer's styles. In some cases information was added by the editors to incorporate additional information about the topic or include other references. For some countries reports were not received, and information was summarized by the editors based on extensive literature searches, and experience of in-country workers.

### Compilers

#### Mark Hamann

Research Fellow  
James Cook University  
TESAG, JCU, QLD 4811, Australia  
mark.hamann@jcu.edu.au  
www.jcu.edu.au

#### George Hughes

4 Thorngate Road, Hayfields,  
Pietermaritzburg 3201, South Africa  
george.hughes@tiscali.co.za

#### Colin J. Limpus

Senior Principal Conservation Officer,  
Queensland Environmental Protection Agency  
P.O. Box 15155, City East (Brisbane), Qld 4002,  
Australia  
col.limpus@epa.qld.gov.au  
www.epa.qld.gov.au

#### Jeanne Mortimer

Consultant  
c/o P.O. Box 445, Victoria, Mahe, Seychelles  
mortimer@ufl.edu

#### Nicolas Pilcher

Executive Director, Marine Research Foundation  
136 Lorong Pokok Seraya 2, Taman Khidmat,  
88450 Kota Kinabalu, Sabah, Malaysia  
pilcher@tm.net.my

### Country contributors

#### Bangladesh

M. Zahirul Islam  
Wildlife Biodiversity Mgt. Specialist  
Coastal & Wetland Biodiversity Management  
Project  
Department of Environment  
Alam Mansion Baharchara, New Circuit House  
Road,  
Cox's Bazar 4700, Bangladesh  
marinelife\_al@yahoo.com

#### Comoros

Abdallah Fatouma  
Director, Department of Environment  
BP 860, Moroni, Comores  
alfa@comorestelecom.km  
fatouma\_ay@yahoo.fr

#### French Territories of Indian Ocean

Stephane CICCIONE  
Manager  
CEDTM (Sea turtles survey and discovery centre)  
BP 40, 97436 Saint Leu France  
stephane.ciccione@tortuemarine-reunion.org

#### India

BC Choudhury  
Senior Reader  
Endangered Species Management Dept.,  
Wildlife Institute of India,  
Chandrabani, Dehradun  
Uttanchal 248001, India  
bcc@wii.gov.in  
http://www.wii.org

#### India

Jack Frazier  
Research Associate -  
Smithsonian National Zoological Park  
Conservation & Research Center  
1500 Remount Rd. Front Royal, VA 22630, USA  
kurma@shentel.net

#### Indonesia

Wandia Adnyana  
Turtle Campaign Leader WWF Indonesia  
Jalan Tukad Saba 19 Denpasar, Bali, Indonesia  
wadnyana@wwf.or.id  
www.wwf.or.id

#### Kenya

Gladys Okemwa  
Research Scientist, KMFRI Chairperson,  
KESCOM Research Subcommittee  
KMFRI, P.O Box 81651  
Mombasa Kenya 80100  
gokemwa2002@yahoo.com

#### Maldives

Hussein Zahir  
Senior Research Officer  
Marine Research Centre  
H. Whiteaves, Moon light higon, 20-05  
Republic of Maldives  
hzahir@mrc.gov.mv  
[www.mrc.gov.mv](http://www.mrc.gov.mv)

#### Mozambique

Cristina Maria Madureira Louro  
Mozambique Marine Turtle Working Group  
Secretariat and CTV Ecosystems and Biodiversity  
Assistant  
Grupo de Trabalho de Tartarugas Marinhas de  
Moçambique.  
Avenida Amílcar Cabral No 183 floor 1  
Centro Terra Viva. Bairro da Coop. Rua D. No 27.  
Maputo.  
c\_louro@ctv.org.mz

**Pakistan**

Dr. Fehmida Firdous  
Project Officer  
Sindh Wild Life Department, Maulana Din  
Mohammad  
Wafai Road Karachi  
fehmidafirdous01@yahoo.com  
sindhwildlife.com.pk

**Seychelles**

Randolph. C. Bijoux  
Marine Ranger  
Conservation Section, Nature Conservation Division  
Ministry of Environment and Natural Resources  
Botanical Gardens Mont Fleuri, Mahe, Seychelles  
r.bijoux@env.gov.sc  
www.pps.gov.sc

**Somalia**

Rudy v.d Elst  
ORI Scientist  
P O Box 10712, Marine Parade, 4056  
KwaZulu-Natal, South African

**South Africa**

Dr Ronel Nel  
Zoology Department  
Nelson Mandela Metropolitan University  
P.O. Box 77000, Port Elizabeth  
South Africa, 6031  
Ronel.Nel@nmmu.ac.za

**Sri Lanka**

Thushan Kapurusinghe  
Project Leader Turtle Conservation Project  
(TCP) – Sri Lanka  
72/4, Galle Road, Walana, Panadura, Sri Lanka  
turtle@slt.net.lk  
www.tcpsrilanka.org

**Tanzania, United Republic of**

Catharine Muir  
Coordinator, Seasense  
P O Box 105044, Dar Es Salaam  
seasense@cats-net.com  
www.seasense.org

**Thailand**

Maitree Duangsawasdi  
Director general  
Department of Marine and Coastal Resources  
92 Phahonyothin Rd.7 , Phrayathai,  
Bangkok 10400  
maitree@dmcr.go.th  
www.dmcr.go.th

**Yemen**

Mohammed Saad  
Marine Sciences & Resources Research Station,  
Khore Maksar, P.O.B. 1231 Tawahi Aden,  
Republic of Yemen

## Preface

The IOSEA Marine Turtle Memorandum of Understanding ([www.ioseaturtles.org](http://www.ioseaturtles.org)) puts in place a framework through which States of the Indian Ocean and South-East Asia region, as well as other concerned States, can work together to conserve and replenish depleted marine turtle populations for which they share responsibility. A seven-member Advisory Committee has been appointed by the Signatory States to provide advice in relation to the implementation of the IOSEA MoU's associated Conservation and Management Plan.

During the Third Meeting of the Signatory States in March 2005, concern was raised about the impacts of the December 2004 tsunami on turtle populations and habitats. Accordingly, the Meeting requested that the Advisory Committee provide an assessment of the tsunami's impacts on turtles and turtle habitats.

To undertake the assessment, marine turtle experts in each of the countries in the IOSEA region (including non-Signatory States) were contacted and asked to complete a short survey regarding the tsunami in their country. Completed surveys were then edited for content, by the compilers, and in some cases additional information was added. This report provides the results of that survey.

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## Synthesis of impacts on marine turtles and their habitats

### *Sumatra – Andaman earthquake*

On December 26 2004 at 00:58:53UTC an undersea earthquake occurred in the Indian Ocean just north of Simeulue Island in Sumatra (3.16°N, 95.854°E). The earthquake was 9.16 in magnitude making it the second most powerful earthquake ever recorded by a seismograph (Hanson 2005). The earthquake lasted for close to 10 minutes and caused the whole planet to vibrate by a couple of centimetres and triggered earthquakes as far away as Alaska (Hanson 2005; West et al. 2005). The earthquake caused a large tsunami that spread across the Indian Ocean with devastating consequences for people in many nations.

### *December 2004 tsunami - overview*

The tsunami caused by the Sumatra – Andaman earthquake spread across the Indian ocean from Malaysia to South Africa. From the epicenter, the tsunami traveled at between 500 and 1000km/h over deep waters, taking approximately 16 hours to reach the furthest location in the Indian Ocean - Struisbaai in South Africa (Figure 1). Because the orientation of the fault line was north/south, most of the tsunami's energy was dispersed in an east/west direction. An estimated 275 000 people were killed as the tsunami crossed the coast in 15 of the 21 affected countries; making it one of the deadliest disasters in recorded history. Aside from the loss of lives, the tsunami, had severe impacts on infrastructure, placed increased pressure on social-economic and health aspects of many coastal peoples and communities, affected tourism, business and fisheries, affected access to drinking water and impacted coastal zone ecology (UNEP 2005). The aim of this synthesis is to provide an overview of the impacts of the December 2004 tsunami on marine turtles and their habitats, giving priority to the completion of an assessment of the conservation status of leatherback turtles in the Indian Ocean – South East Asian region.

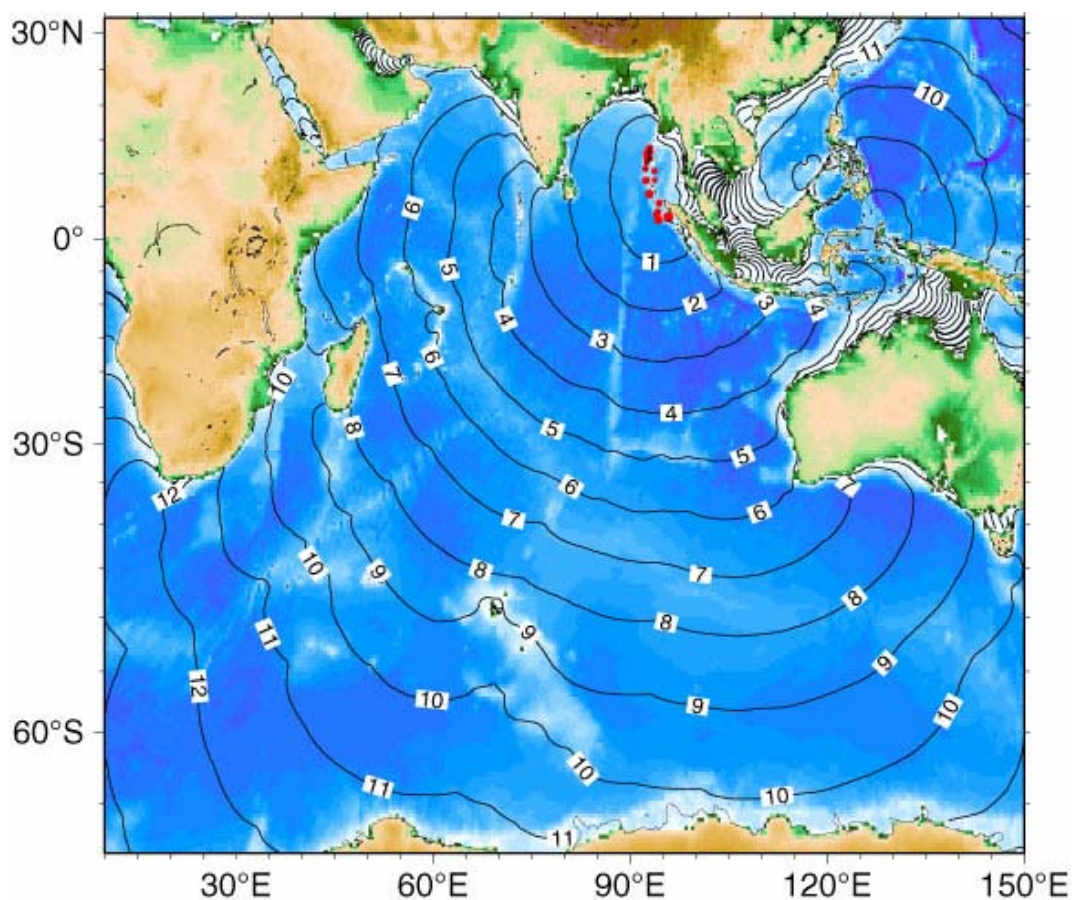


Figure 1. Graphic representation of the time frames involved with the December 2004 tsunami's movement across the Indian Ocean (the dots west of Thailand and Sumatra indicate epicenters of the main earthquake and the aftershocks).

*December 2004 tsunami; synthesis of impacts to marine turtles and their habitats*

The tsunami reports submitted by the incountry contributors (see section 2 of this chapter) indicate that the tsunami generated by the Sumatra-Andaman earthquake in December 2004 impacted 22 of the 44 nations in the Indian Ocean and Southeast Asian region (Table 1). Of these 22 countries the tsunami caused localised damage to marine turtle habitats in 11 countries ranging from minor to severe. While most of the nations affected had minor damage to coastal environments, infrastructure, social well being and marine ecosystems (Table 1), severe impacts occurred to coastal communities of Indonesia, Malaysia, Thailand, India, Sri Lanka and Maldives. The most severe impacts to marine turtle habitats and marine turtle conservation projects were found in Thailand, India and Sri Lanka.

*Damage to marine turtle nesting beaches*

The countries in which the tsunami had the most severe impact on marine turtle nesting areas are Thailand, Sri Lanka and India (in particular the Andaman and Nicobar Islands). In these countries the tsunami occurred during the nesting season and would have destroyed most clutches incubating at the time, and may have affected the laying and/or incubation of clutches laid later in the season because of increased erosion, beach debris and increased salinity of the sands. Medium term impacts (1-3 years) to the nesting beaches are difficult to assess, because in all locations a complete nesting season following the tsunami has not been completed. It is likely that the tsunami has caused localised alterations to beaches that impact nesting success, nest site choice and sex ratios over the medium term. It is unlikely that these impacts are severe enough, or on a wide enough scale to impact populations in the longer term. Longer term impacts (10+ years) are more difficult to predict because in the countries that were most affected there are few long term monitoring data on nesting turtles. However, longer term impacts should be considered in light of the species longevity, periodic reproduction and the fact that the Indian Ocean and Southeast Asian region has encountered moderate and large scale tsunamis in the past (e.g. the tsunami generated by Krakatoa in 1883, the Andaman Island earthquake tsunamis of 1881 and 1941 and the Papua New Guinea tsunami of 1998 (Iida et al. 1967; Ewing and Press 1955; George 2003).

- Assuming that the green, hawksbill and leatherback nesting rookeries that exist today in western Java and southern Sumatra (Indonesia) existed in the late 1800s, the tsunami caused by the Krakatoa explosion would almost certainly have caused them significant damage. That there are still marine turtle rookeries in this area, suggests that turtle populations were, at the time, resilient enough to survive any local impacts.
- Although few records are available, the Andaman and Nicobar Islands, and the coast of countries within the Bay of Bengal would have been impacted by the earthquake generated tsunamis that occurred in the region in 1881 and 1941.
- The West Sepik region of Papua New Guinea was hit by a tsunami in 1998, which caused considerable impacts to the coastal zone in an important leatherback turtle nesting area; there are no accounts of any remaining after effects on the nesting leatherback turtle population.

There were minor impacts to nesting beaches of green, hawksbill and olive ridley turtles in Bangladesh, Kenya, Maldives, Comores, Seychelles, and the UK Territories (BIOC). In each case the damage was restricted to particular beaches and only small numbers of clutches were affected. No longer term impacts to marine turtle populations in these nations are suspected. In two of the worst affected countries (Indonesia and Malaysia), in terms of physical damage and loss of lives, the impact on marine turtles was negligible given that the affected areas did not coincide with important marine turtle nesting habitats.

*Damage to marine turtle habitats*

The tsunami has impacted several offshore and coastal ecosystems in 11 countries. While the “terrestrial” components are relatively easy to survey the “marine” ecosystems have not yet been thoroughly examined. In several countries Rapid Assessments have been done of coral reef and seagrass areas, and the general findings are mixed. Most affected nations reported that the coral reefs and seagrass areas have been impacted to varying degrees. However, even in areas that have had significant damage to coral reefs such as Thailand (13% of coral reefs along the Indian Ocean Coast impacted) it is not certain whether the damage is severe enough to have even a local impact on marine turtles. Likewise with the damage to seagrass pastures, in most cases only shallow water areas were monitored, and marine turtle populations have endured localised loss of seagrass in other areas of the world (e.g. Shoalwater Bay – Australia; Limpus et al. 2005). In each of the countries affected there are few data on foraging populations of marine turtles, without this data it is difficult to

assess what impacts the tsunami, and the subsequent changes to the marine habitat, had on marine turtle populations. However, it is likely that there would have been short to medium term, localised impacts to foraging marine turtles in Indonesia, Thailand, India, Maldives and Sri Lanka.

*Marine turtle conservation projects*

Three countries suffered significant damage to their marine turtle conservation projects, including the loss of lives of some of their conservation staff. In India's Andaman-Nicobar Islands, Sri Lanka and Thailand long term research projects were placed in jeopardy as the tsunami destroyed research infrastructure, research equipment was lost or destroyed and the local communities with which they worked suffered immense social, economic and personal losses. These were communities in which turtle projects had worked side by side for many years to protect sea turtles. Thankfully strong community bonds remain and shared adversity has brought communities and turtle project staff together and may offer new opportunities. In each of the locations impacted turtle project staff have been heavily involved in rebuilding communities and generating financial support to assist in the process. For example in Thailand and Sri Lanka marine turtle NGO groups have played an integral role in kick starting education for children, redevelopment of local business such as fisheries and tourism, and getting projects up and going for the 2005/2006 marine turtle nesting season. It is with the continuation of these extremely important community-based programs that we will learn more about the longer term impacts of the tsunami on coastal habitats, marine turtle populations and on the coastal communities themselves.

Table 1. Nations of the Indian Ocean and South East Asian region, and summary of the impacts of the December 2004 tsunami.

<b>Country</b>	<b>Affected</b>	<b>Impact (H/M/L/Nil) to coastal zones, infrastructure and social welfare</b>	<b>Impact to marine turtles &amp; their habitats</b>
Australia	Yes	Nil	Nil
Bangladesh	Yes	Low	Low
Bahrain	No	-	-
Brunei Darussalam	No	-	-
Cambodia	No	-	-
China	No	-	-
Comoros	Yes	Low	Nil to Low
Djibouti	No	-	-
Egypt	No	-	-
Eritrea	No	-	-
French Territories	Yes	Nil	Nil
India	Yes	High	High for 2004/05 nesting season & unknown long term impacts
Indonesia	Yes	High	Low – but unknown if any impacts occurred to low density turtle rookeries in north Sumatra.
Iraq	No	-	-
Islamic Republic of Iran	Yes	Nil	Nil
Japan	No	-	-
Jordan	No	-	-
Kenya	Yes	Medium	Low & long term impacts have not been assessed
Korea (Republic of)	No	-	-
Kuwait	No	-	-
Madagascar	Yes	Low	Nil
Malaysia	Yes	High	Low
Maldives	Yes	High	Low & long term impacts have not been assessed
Mauritius	Yes	Nil	Nil
Mozambique	No	-	-
Myanmar	Yes	Low	Nil
Oman	Yes	Nil	Nil
Pakistan	Yes	Nil	Nil
Papua New Guinea	No	-	-
Philippines	No	-	-
Qatar	No	-	-
Saudi Arabia	No	-	-
Seychelles	Yes	Medium	Few long term impacts suspected
Singapore	No	-	-
Somalia	Yes	Low	Unknown
Sri Lanka	Yes	High	High for 2004/05 nesting season & unknown long term impacts
Sudan	No	-	-
Thailand	Yes	High	High for 2004/05 nesting season & unknown long term impacts
Timor Leste	No	-	-
Tanzania, United Rep. of	Yes	Low	Nil
United Arab Emirates	No	-	-
United Kingdom Territories	Yes	Medium	Low & short term
Viet Nam	No	-	-
Yemen	Yes	Low	Unknown

## December 2004 tsunami; country reports

### Indonesia

The tsunami had a severe impact on the northern coast of Sumatra (Acheh Province) and some of the smaller islands along the north-west coast of Sumatra. The tsunami had devastating impacts on the city of Banda Acheh; causing substantial loss of lives, buildings, and other coastal infrastructure. Aside from the devastation the tsunami had on built up areas, in Acheh and North Sumatra, a UNEP assessment estimated that 25,000 hectares (ha) of mangroves, some 32,000 ha of previously existing coral reefs, and 120 ha of seagrass beds have been damaged. The economic loss associated with this environmental damage is valued at \$118.2 million, \$332.4 million and \$2.3 million, respectively (UNEP 2005).

The tsunami is believed to have had very little impact on nesting turtles in Indonesia. Although there are several very low density (or unknown density) nesting sites along the southern coast of Sumatra for green, hawksbill, leatherback and olive ridley turtles the tsunami occurred well outside the main nesting season for the area (nesting distribution data from IMAPS <http://www.ioseaturtles.org/imaps.php>). Long term impacts of the tsunami on nesting marine turtles in Indonesia have not been estimated. Similarly there could be localized impacts to foraging turtles in northern Sumatra, however, there have been no studies looking at marine turtle abundance in the foraging areas in this region.

### Malaysia

The tsunami impacted the west coast of Peninsula Malaysia. The northern states and islands were worst affected, such as Kedah (in particular Langkawi), Penang, Perlis, Perak, and Selangor. Impacts included the loss of lives and or livelihoods, destruction of fishing boats, fisheries infrastructure and housing. Although there are nesting areas for green and hawksbill turtles along the western coast of Malaysia there are not believed to have been any short or long term impacts to marine turtles, especially since the tsunami occurred at the opposite time of the year to the turtle nesting season (Kamarruddin Ibrahim Pers. Comm.).

### Thailand (Indian Ocean coast)

Prepared by Maitree Duangsawadi, with input from Mark Hamann and Monica Aureggi

The tsunami hit the Indian Ocean coast of Thailand at around 1000 local time on December 24 resulting in widespread destruction of many coastal areas. It caused the high loss of lives in many of the tourist areas, substantial destruction to tourism infrastructure, business, roads, coastal ecosystems and severely affected the social, economic and health of local people. Many of these impacts have been well documented in the general media, popular literature and scientific press.

The United Nations Environment Program's Asian Tsunami Disaster Task Force conducted a rapid assessment of Thailand's marine and coastal environment shortly after the tsunami (UNEP 2005). The taskforce assessed the condition of coral reefs, seagrass pastures, mangroves and marine wildlife. The taskforce's key findings for Thailand were; 13% of the coral reefs (of the 324 reefs within the affected provinces) were significantly impacted, 3.5% (70% of seagrass pastures in Indian Ocean Thailand were assessed) were impacted by siltation and sand sedimentation, with 1.5% suffering total habitat loss and 0.2% of mangroves were impacted and these mangroves were mostly in Phang Nga province which was the hardest hit of the coastal provinces (UNEP 2005).

With regard to the impact of the tsunami on marine turtles, their habitats and conservation infrastructure, the tsunami severely impacted all marine turtle research projects along the Indian Ocean coast. Naucrates, which had established research infrastructure and a successful conservation project at Phra Throng Beach (Phang Nga province) over the last eight years suffered severe damage; the lives of two young research volunteers were lost and the museum, volunteer huts,

instruments, turtle tank and other research equipment was all destroyed (see <http://www.naucrates.org> for more details). At Tap Lamu (Phang Nga province) the Thai Navy's marine turtle conservation centre has suffered severe damage and approximately 2000 turtles that were being headstarted for release escaped. The Phuket Marine and Coastal Resource Development and Research Institute lost research infrastructure and reported the loss of 18 breeding olive ridley turtles. Finally the Marine Turtle Conservation Project in Ranong Province suffered major structural damage and the loss of research equipment.



The tsunami wave crashing ashore on the turtle nesting beach at Pha Throng Island. Photo courtesy Naucrates collection.



Damage to the Naucrates turtle project tanks after the tsunami. Photo by Emma Dilkes

The tsunami occurred in the middle of the nesting season for each of the species of marine turtles that nest along the Indian Ocean Coast. Many of the marine turtle nesting beaches were substantially altered with regard to erosion of the beach and dunes, deposition of debris such as building materials, trees, drift wood and rubbish. Given the more immediate concerns about loss of lives, and the need to re-build social, health, economic and education facilities there were few studies on the short term impacts of the tsunami on marine turtle nesting. However, an unpublished report by Asst. Prof. Kumthorn Thirakhupt of Chulalongkorn University speculates that leatherback turtle eggs that were laid a week after the tsunami at Thai Muang Beach (Phang Nga province) did not hatch because saltwater inundation of the dune system had elevated salinity levels by 12 to 25 times baseline. It is likely that saltwater inundation would have ceased the development of all eggs that had been laid prior to the tsunami occurring. The number of affected clutches is not known, but is likely to be less than a 100 for all species combined. It is interesting to note that while leatherback turtle nests were not found along the Andaman coast for a few years, after the tsunami more nests were laid along the coast, but still in a limited number (less than 15 nests per season). In the area close to Phra Thong Island, according to local fishermen's observations, the number of jellyfish has increased a lot after the tsunami.

Long term impacts on turtle nesting are unlikely because it appears that most of the nesting beaches remain in good condition, and there has not been significant sand loss. Sandy nesting beaches at Phra Thong Island (15 km) changed after the tsunami. It is evident that the beach profile has changed. In particular, the wave action created different lagoon areas (freshwater mixed with sea water) which are now located behind the beaches. In some areas of the beach these have reduced in the available space for turtle nesting. It is not known whether the impacts to coastal vegetation will have any affect on the incubation of turtle nests. Assessment of the longer term impacts will depend in part on the ability of conservation groups to develop the necessary infrastructure and local support. Naucrates staff began monitoring the turtle beaches in January 2006 and are planning a detailed post tsunami evaluation of the status of the marine turtle nesting and foraging populations in the area. In addition they are coordinating local assessments of mangrove ecosystems and coral reefs. Furthermore Naucrates have coordinated efforts to help rebuild the education facilities that were destroyed, and assist in the socio-economic repatriation of coastal villages (see <http://www.naucrates.org> for more details).

## Myanmar

Reports indicate that while the tsunami did impact the coast of Myanmar, its force was greatly reduced due to coastline topography (along the southern and delta coast) and the presence of numerous rocky islands and headlands. Local scale impacts to communities have been assessed, and significant impacts to the livelihoods of around 5000 to 7000 people have been directly affected. No quantitative assessments of the impacts to the natural environment have been conducted. It is not known whether the tsunami affected marine turtle nesting or foraging populations in Myanmar.

## Bangladesh

Prepared by M. Zahirul Islam

The tsunami did not affect the Bangladesh coast like the other countries in the adjacent area. Only some small tidal abnormalities were identified by the people of St. Martin Island. They observed an extreme low tide exposing all sub tidal areas and trapping marine fishes and then the waters returned quite suddenly thereafter. No coastal zone or infrastructure damage has been reported. There are likely to have been no impact of nesting turtle beaches or foraging areas.

## Sri Lanka

Prepared by Thushan Kapurusinghe

### *Nesting beaches*

The tsunami hit the coast of Sri Lanka around 0815 to 0915 local time on December 24 resulting in widespread destruction of many coastal areas. It caused the high loss of lives in many of the tourist areas, substantial destruction to tourism infrastructure, business, roads, coastal ecosystems and severely affected the social, economic and health of local people. Many of these impacts have been well documented in the general media, popular literature and scientific press. The tsunami hit Sri Lanka at low tide in the low season for marine turtle nesting, however there were still incubating nests at most of the nesting beaches, and turtles coming ashore. The short term impacts to the nesting beaches were the inundation of incubating clutches, the deposition of rubble and other washed up debris, many beaches suffered large scale sand erosion, and destruction of beach vegetation. In the longer term beach width has been reduced in some areas, and this together with the destruction of beach vegetation will increase the beach erosion in future monsoon seasons (due to low resistance). In addition, as beach vegetation is not available for turtle nesting in some areas, there may be an impact on sex ratios as turtles often utilise beach vegetation while nesting.

### *Foraging areas*

With regard to the foraging areas, coral reefs were covered with sand and debris which may have impacts on feeding turtles. However, surveys have shown that mangroves and coral reefs acted as protective barriers prevent more severe coastal damage (Daoudouh-Guebas et al. 2005). Daoudouh-Guebas et al. (2005) assessed the tsunami damage in Sri Lanka and the role that mangrove communities played in forming a barrier to prevent damage. The level of damage to the coastal zone was worse in areas that had mangroves cleared, or where mangrove forests had been infused with non-mangrove species. Similarly, Fernando et al. (2005) have found that the damage caused by the tsunami was more severe, and water traveled further inland in areas with no coral reef protection. Moreover, Fernando et al. (2005) report that illegal collection of corals for souvenirs or for use in house paint has exacerbated the effect of the tsunami in some locations in western Sri Lanka.

### *Marine turtle hatcheries*

Most of the commercially operated turtle hatcheries suffered severe damage. Marine turtles that were kept in captive by the turtle hatcheries were washed away and some of them were later found dead. Eggs being incubated by the hatcheries were inundated with salt water and as a consequence most probably died. Some of the juvenile turtles and hatchlings that were housed by the facilities were found in inland water bodies such as wells and small tanks and released to the sea. Because the tsunami destroyed most of the illegal turtle hatcheries, it was the best opportunity for the Department of Wildlife Conservation to initiate a mechanism to regulate the activities of these hatcheries.

Unfortunately DWC was unable to take an action and therefore the hatchery owners were able to rebuild their hatcheries on a larger scale than they were before the tsunami.

#### *Marine turtle infrastructure and projects*

The Turtle Conservation Project (TCP) lost the lives of turtle nest protectors in Kosgoda. In addition, TCP lost the beach hut (beach operations centre), sales outlet with sales items, research equipment, educational materials, office equipment and other items. TCP run turtle hatcheries were destroyed and they lost research and conservation property and equipment. In addition, activities of the Department of Wildlife Conservation were disturbed in Yala and Bundala National Parks; the beach hut used by the Bundala turtle programme was destroyed and research equipment was lost or destroyed. This beach hut has since been re-built for DWC by TCP. One main hurdle to overcome in the re-development is getting permission from the Coast Conservation Department for turtle conservation constructions such as research centers, marine turtle hospitals, as long as they continue to enforce a '100 metre no built zone' rule. A long term impact of the tsunami will be the risk of employing nest protectors, research officers, local and foreign volunteers on the beaches. There is no tsunami warning system available in the country and communication facilities are not at satisfactory level to inform the beach staff for immediate evacuation.

#### *Other implications of the tsunami*

Following the tsunami, in which thousands of lives were lost and people were swept out to sea, there was a growing local paranoia about eating fish that may have fed on humans. The result of this was a reported increase in the number of marine turtles being deliberately caught and sold in the markets as meat (Sri Lanka victims of tsunami – news article 3 Feb 2005, BBC news UK).

## India

Prepared by BC Choudhury (Andaman-Nicobar Archipelago) and Mark Hamann (Mainland India)

#### *Mainland coast*

The mainland coast of India was impacted by the December tsunami, however, it was not reported to have significant impacts on marine turtle nesting beaches or conservation facilities/projects. The worst affected area was the state of Tamil Nadu, and the States of Pondicherry, Andhra Pradesh and Kerala were affected to a lesser extent. The marine turtle hatchery sites and project facilities along the east coast of mainland India were spared significant damage. The tsunami began hitting around 1645 with waves estimated at between 1.3metres at Kochi and 2.4 metres at Vishakapatam (quoted from email Abe, ERI, University of Tokyo posted on tsunami-Japan on January 27, 2005). The impacts of the tsunami on coastal communities on mainland India was large, particularly in the state of Tamil Nadu. In Tamil Nadu there was substantial loss of lives; buildings, infrastructure, fishing boats and ports were destroyed and the social, health, economic and education well being of the people were severely hampered (Yeh 2005). It is likely, similar to other areas that were significantly impacted that coastal fisheries and the fishing industry will suffer large losses that could have economic affects that last for many years. It has been estimated that 2200km<sup>2</sup> (including approximately 11 000ha of cropped lands) of coastal land was affected with saltwater inundation of coastal lands ranging from 300 metres to 3km inland.

#### *Andaman and Nicobar Islands*

The Andaman and Nicobar Islands is a significant location for nesting marine turtles especially the leatherback turtle (*Dermochelys coriacea*) in the Indian Ocean. There are currently four nesting beaches known for the Andaman Islands (all on Little Andaman Island); specifically there is high density nesting on the South and West Bay beaches and low density nesting on two beaches on the north west coast (Figure 2; Andrews et al. 2002). There are 17 confirmed nesting locations in the Nicobar group; five along both the west and east coast of Great Nicobar Island, five beaches on the western shore of Little Nicobar Island, west coast of Teressa Island and the west bay of Katchal Island (Figures 3 and 4; Andrews et al. 2002).

Important nesting beaches identified in the Little Nicobar Islands were mainly on the west coast including Pulo Kiyang, Pulo Baha, and beaches on Kiyang and Akupa hamlets (Figure 4). The Great Nicobar Islands contained two important nesting sites, one on the West Coast (beaches at the mouth of Alexandra and Dogma rivers) and other on the South east coast (Galathea bay) (Figure 4). Other Islands where the species has been observed to nest include, Teressa and Katchal (West bay) in the

Central Nicobar Islands (Figure 3). In the Nicobar Islands, peak nesting of this species occurs from December to April.

The Nicobar group of islands were among the worst hit in the Indian region. The tsunami created giant waves as high as 12 metres that caused a heavy damage to the coastal habitats in the Andaman and Nicobar Islands. The plate movements have lead to subsidence of land in Nicobar Islands and vertical uplifting in parts of the Andaman Islands (Ramachandran et al. 2005). Over the entire Andaman and Nicobar region estimates of inland seawater intrusion by tsunami waves ranged between 50 and 2000m, depending on the topographic conditions of the individual island (Ramanamurthy et al. 2005). Moreover, Ramachandran et al. (2005) used spatial and aspatial data and estimated that in four islands in the Nicobar group (Camorta, Katchal, Nancowry and Trinkat) that the extent of damage ranged from 51 to 100% for mangrove ecosystems and 41 to 100% for coral reef ecosystems (see Figure 5 for an example from Katchal).

The tsunami caused significant damage to nesting sites in the Andaman and Nicobar Islands. Important nesting beaches in the Great Nicobar and Little Nicobar Islands have been heavily damaged and are currently inundated (Manish Chandy & Ravi Sankaran, *Unpub. Report*). In particular the beaches along the West Coast

(Figure 4: [http://www.disasterscharter.org/disasters/CALLID\\_077a\\_e.html](http://www.disasterscharter.org/disasters/CALLID_077a_e.html)),

including submergence at Casuarina Bay (Alexandra and Dogma River mouth area) and the beaches on the Southeast coast such as Galathea Bay

(Figure 4: [http://www.disasterscharter.org/disasters/CALLID\\_077a\\_e.html](http://www.disasterscharter.org/disasters/CALLID_077a_e.html) )

were severely impacted and are still at least partially submerged (Manish Chandy & Ravi Sankaran, *Unpub. Report*). Similar damage to the nesting sites has been reported from the West Coast of Little Nicobar and Little Andaman Island (Andrews, pers. comm.). Nesting beaches on the West Coast of Katchal Island, although only a low density nesting site, were among the worst affected areas (Figures 4 and 5: [http://www.spotimage.fr/html/167\\_240\\_241\\_781.php](http://www.spotimage.fr/html/167_240_241_781.php)) by the tsunami. Because the tsunami occurred during the peak breeding season of the leatherbacks in the Andaman and Nicobar Islands the impacts to leatherback turtle nests that had already been laid for the season would have been severe; with mortality of those clutches approaching 100%. In addition, it is unknown what affects the tsunami, and its effect on beach elevation, beach submergence and beach debris, had on females that attempted to nest for the remainder of the season. A clearer picture of the longer term impacts of the tsunami will emerge over the next few years as nesting leatherback turtle and beach surveys can be completed.

Interestingly, there have been reports of new beach formation in the Islands of Great Nicobar, Katchal and Little Andaman (Manish Chandy, *Unpub. Report*). At certain sites (e.g. Little Andaman), nesting beaches were found to be inaccessible for turtles due to the uplifting of the Coral reef (Andrews, pers. comm.). Recent attempts to assess the marine turtle populations at some of these new beaches have been impeded due to complete breakdown of logistics in the Islands (Ravi Sankaran, pers. comm., Vijayakumar & Choudhury, *Unpub. Report*). There is an urgent need to map these new beaches and monitor the usage of these sites by the leatherbacks in the ensuing leatherback nesting season.

#### *Aftershocks*

Following the main shock there were approximately 400 aftershocks which were mostly centered in the Andaman and Nicobar Archipelago. These aftershocks ranged in severity from less than 3 up to 7.5 on the Richter scale, probably adding to localised affects of the tsunami event, by further impacting building structure, uplifting of beaches and stability of the coral reef ecosystems.

#### *Previous tsunamis in the Indian region*

Any long term impacts of the 2004 tsunami must be considered in the context that the Andaman-Nicobar Archipelago and the coastlines of India and Sri Lanka have been affected by tsunamis in the past (Ewing 1967; Pararas-Carayannis 2004). Some of those recorded include:

- An 1881 earthquake beneath Car Nicobar caused a 1m tsunami to hit the coast of India adjacent to Chennai.

- In 1883 the explosion of Krakatoa in Indonesia caused 2m tsunamis to hit the coast of Chennai (India).
- In 1941 an 8.1 Richter scale earthquake occurred in the Andaman Islands, this earthquake caused a destructive tsunami that impacted the middle and south Andaman Islands and caused major damage and loss of lives at many coastal villages in the Andaman Islands, Sri Lanka, Bangladesh and India.
- Similarly, another major earthquake in the Andaman-Nicobar Archipelago in 1945 (Richter scale 7.8) caused major damage along the coasts of India, Pakistan, Oman and Sri Lanka.

It is possible that these previous tsunamis have had similar impacts to the coastal zone as the December 2004 tsunami. Hence, marine turtle populations have managed to persist despite these periodic alterations to their nesting environments.

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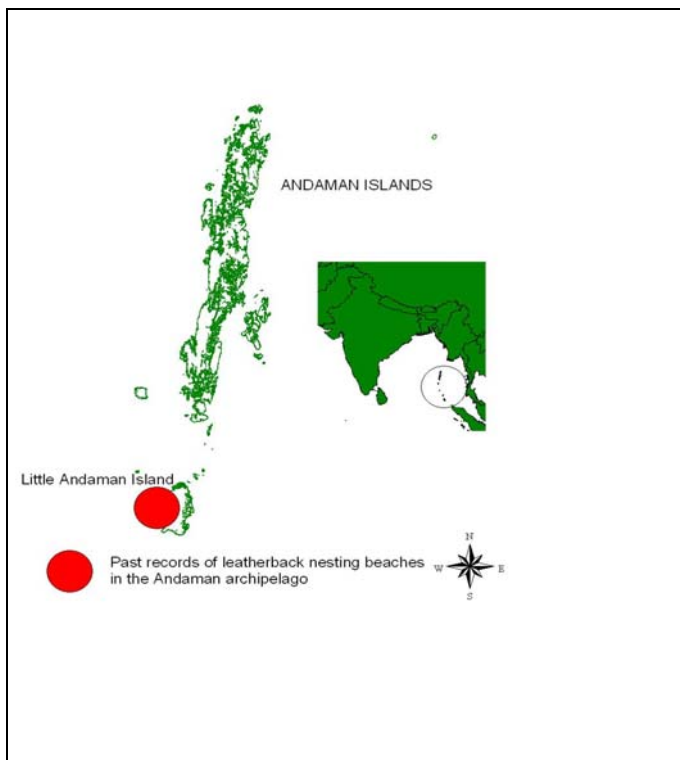


Figure 2. Main nesting areas for leatherback turtles in the Andaman Islands.

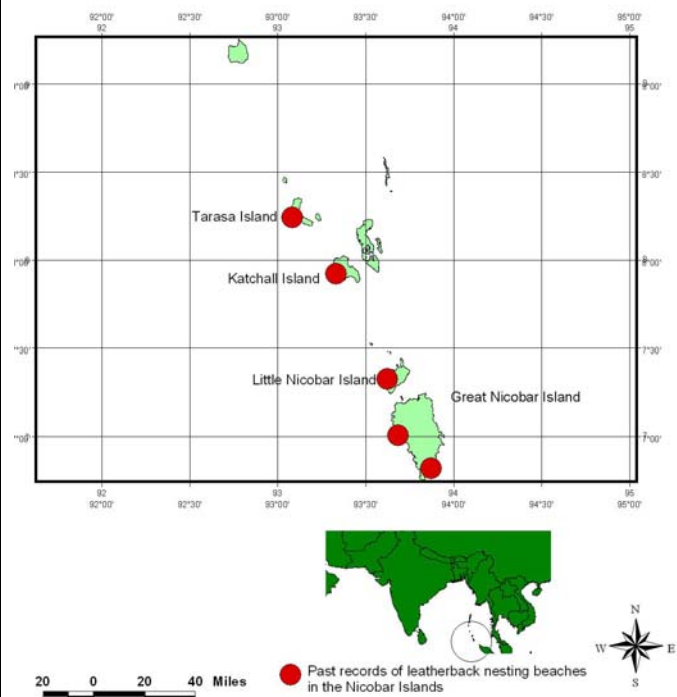


Figure 3. The main islands of the Nicobar Group; showing important nesting locations for leatherback turtles

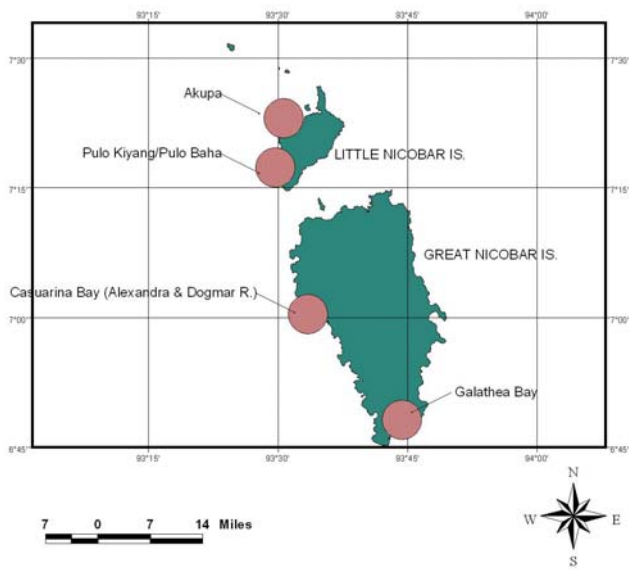


Figure 4. Little Nicobar and Great Nicobar; showing important nesting locations for leatherback turtles

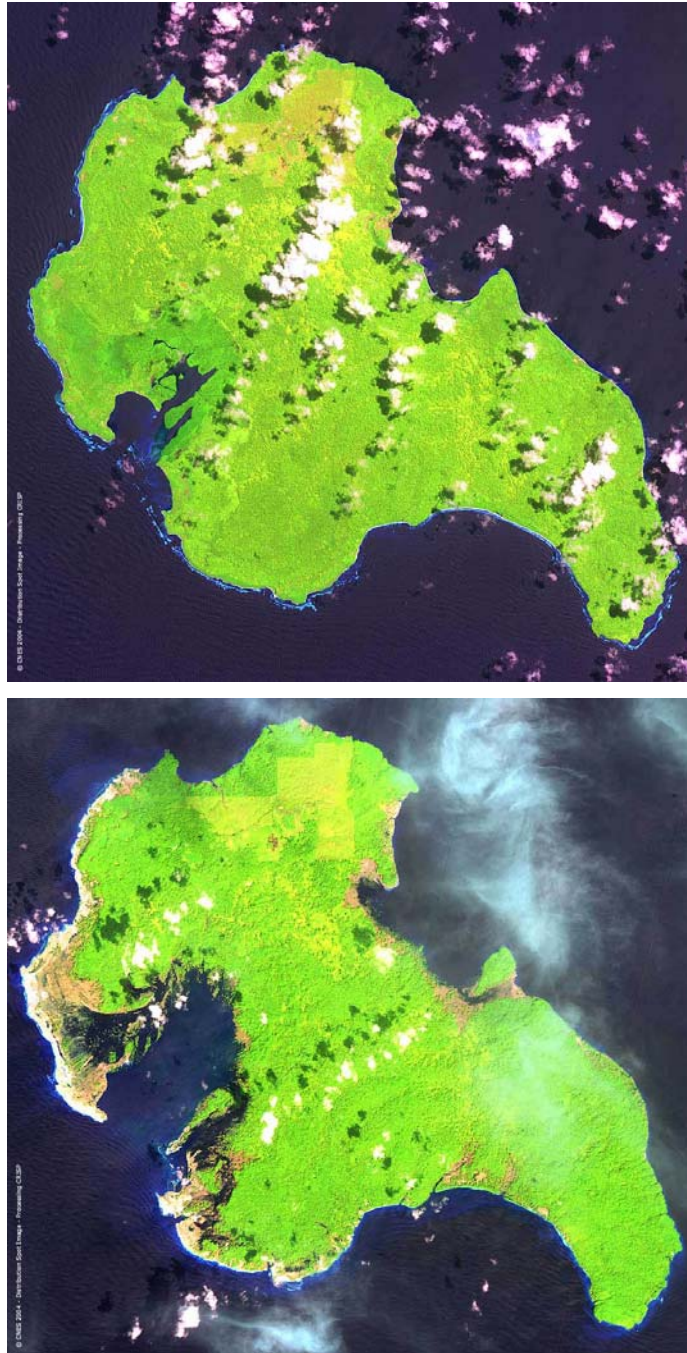


Figure 5. Pre- and post-tsunami satellite images of the Katchal Is. in the central Nicobar. The West coast where the species have been observed to nest in the past has been largely disturbed by the tsunami waves. But, new beaches appear to have been formed due to uplifting.

## Maldives

*Prepared by Hussein Zahir*

Turtles nest all near around in the Maldives, and December is a good time of the year in some locations. The tsunami hit at approximately 0920 at low tide. There is no specific assessment on the impact of tsunami on the marine turtles in the Maldives. However, because leatherback turtles do not nest in the Maldives it would not have had any impact on leatherback turtles. Some of the good nesting beaches for green turtles were reported to have been temporarily eroded and obviously flooded by the waves, however, it has been reported that nesting has resumed in these beaches. The long term impact of tsunami on marine turtles is unknown.

An assessment of the damage to Maldivian Coral reefs and baitfish populations from the Indian Ocean Tsunami was carried out using rapid assessment protocols to assess the damage to the reefs. The overall finding was that there is little physical damage to the reefs and the impact from the sedimentation for the tsunami was variable throughout the area assessed. There is little evidence of immediate impact to the baitfish populations and it's too early to say much about the biological and ecological impacts of the tsunami. Overall Maldivian reefs are recovering from 1998 bleaching and the possible effect of sedimentation. Recruitment of corals and recovery of the reefs is a concern (Commonwealth of Australia 2005).

## Comoros

*Prepared by Abdallah Fatouma*

Comoros was impacted by the Tsunami of December 2004. The tsunami caused a quick retreat of sea water from the coastline, and in certain areas this was followed by strong waves. The tsunami occurred six months after the nesting season of the green turtle (the only nesting species in Comores), hence impacts to nesting turtles was negligible. There was also little damage other than slight beach erosion so longer term impacts on nesting turtles are thought to be low. No impacts were noted to any of the marine turtle foraging areas – such as seagrass habitats or coral reefs, conservation infrastructure or marine turtles (Intergovernmental Oceanographic Commission 2005).

## Mauritius

There were no impacts to Mauritius as a result of the tsunami (Mangar Vijay pers. comm.).

## Seychelles

*Prepared by Jude Bijoux*

Seychelles was impacted by the Tsunami of December 2004. The Seychelles are approximately 4500km away from the earthquake epicenter and the tsunami hit the Seychelles approximately 6 hours after the earthquake. The first wave arrived at 1125 and was 1.2 metres above the predicted tide of 0.4 m. The second wave occurred just after 1300 and was 1.7 metres above normal low tide of 0.3 m. The third wave occurred just after 1700 and was 1.2 metres above normal high tide of 1.1 metres. The tsunami occurred at the peak of, and nearing the end of, the hawksbill (*Eretmochelys imbricata*) nesting season. Green turtles nest all year around and leatherback turtles do not nest in the Seychelles hence the tsunami would have had no impact on leatherback turtles in Seychelles.

### *Impacts to nesting beaches*

The short term impacts on marine turtle nesting at both the Inner Granitic Islands and the Outer Coralline Islands are:

- Inner Granitic Islands
  - Only 1 nest (probably hawksbill turtle) was reported to have been damaged on the island of Curieuse in the Seychelles inner islands. Apart from that though, there were nesting sites that were eroded to certain degree, but the erosion was not as severe as to damage turtle nests.
- Outer Coralline Islands
  - The Seychelles outer coralline islands appear to have been relatively untouched by the tsunami.

The impact of the tsunami on nesting marine turtles in the Seychelles was also assessed by Obura and Abdulla (2005). Aside from the impacts listed above they state that; Bird Island which monitors all their turtle nests reported "large tides" but no apparent damage to any of the nests (Margaret Norah). Aride Island monitors all their nests and reported two nests destroyed by the tsunami (Dylan Evans). Within the Marine Parks, no apparent damage was reported on the beaches of Ste. Anne Island (Jude Bijoux), but at Curieuse nests were lost in the vicinity of Anse Cimitiere but not in the vicinity of the most important nesting beach Grand Anse (Alain Cedras). At Curieuse, erosion at Grande Anse is the norm at this time of year, but the problem appears to have been exacerbated by the tsunami. At Intendance beach on Mahe no nest damage was recorded (Anders Dimblad).

There are little foreseen long term impacts on the nesting beaches as Seychelles beaches are highly dynamic and erode and accrete every year during the North west monsoon and southeast trade winds depending on the direction towards which they are facing. However gradual erosion at the top of the beach near the tree line could ultimately cause the trees to become unstable and fall. If this happens it will greatly affect the stability of the beaches.

#### *Impacts to seagrass beds*

Most of the seagrass beds that were destroyed by the tsunami have now recovered to pre-tsunami state. Based on this statement it can be said that the tsunami has had little short term impact on the foraging habitat of green turtle (*Chelonia mydas*). However, a number of reef sites in the Seychelles inner islands have been affected by the tsunami. This could potentially affect food sources of hawksbill turtles (*Eretmochelys imbricata*) that feed on sponges from coral reefs in the short term (Obura and Abdulla 2005; UNEP 2005).

#### *Impacts to conservation infrastructure*

Short term impact on conservation infrastructure has been mostly in the Marine National Parks where patrol boats were damaged and outboard engines were destroyed. This prevented proper monitoring of park activities in the first 2 months after the tsunami. As a result the turtle nesting sites monitoring was not carried out with the same regularity as in the past. Communication equipment and infrastructure such as housing for the rangers were also heavily damaged. As a result funds that could have been used for conservation action on the ground were re-channeled to repair damage caused to infrastructure. There was no loss of life of any conservation personnel. Long term impact of the tsunami to conservation infrastructure is that it has more or less delayed new projects in some of the marine parks by about 1 year as funds had to be re-channeled in the year 2005 to repair things that were previously in good working order.

## United Kingdom - British Indian Ocean Territory

*Prepared by Charles Sheppard*

British Indian Ocean Territory (BIOT) was impacted by the Tsunami of December 2004. The tsunami occurred during the peak hawksbill turtle nesting season & during a period when green turtles also nest. (Note: hawksbill turtles have a clearly defined nesting season, while green turtles probably nest year-round.).

The tsunami destroyed nests when it washed away large amounts of sand and coastal vegetation along the following (surveyed) sections of coastline (Sheppard, 2005):

#### *Diego Garcia Atoll:*

- Diego Garcia. On the north eastern coast of the atoll, large waves smashed through the vegetation along a section of a few hundred metres. In the damaged area, shoreline shrubs

and all young and intermediate -size palms were removed. But, north and south of that on the same coastline, there was no evidence of damage.

*Great Chagos Bank:*

- Eagle Island. On the east coast waves punched through a section of several hundred metres and stripped away the *Scaevola* bushes and young palms. This effect continued around the northern tip and down the western facing side for some hundreds of metres too, illustrating the complicated refraction patterns of the waves.
- North Brother. The little beach was drastically changed & enlarged, and the entire eastern half was clearly affected.
- South Brother. Areas of shoreline shrubs removed at the south-eastern end.

*Solomon Atoll:*

- Boddam Island. Apparently no areas of stripped vegetation, but sand banks were shifted and much sand was apparently pumped into the lagoon. Substantial erosion occurred and there were "steps" of 1-2 m high everywhere. Yacht visitors reported that several turtle nests high on the shores had their eggs exposed - to be eaten by hermit crabs & rats.

Coastal erosion is a serious long term ongoing problem in Chagos (Sheppard et al., 2002). The tsunami probably accelerated coastal erosion by 1-2 years (Sheppard, 2005).

There were no impacts to marine turtle conservation projects or their infrastructure.

Overall Sheppard (2005) inspected most of the islands of the group in February 2005 and assessed insofar as possible what impact the tsunami had on the coastline and near shore habitats. The tsunami of 2004 is unlikely to have had any impact on leatherback turtles of the British Indian Ocean Territory (BIOT) and minimal impacts on green and hawksbill turtle populations.

## Oman

The tsunami hit the coastline of Oman, however, no reports of major damage to coastal communities have been found. It is not known whether any impacts occurred to marine and coastal environments. It is likely that there were very few, if any, impacts on marine turtle nesting or foraging populations.

## Islamic Republic of Iran

The tsunami reached the coastline of Iran, but there have been few accounts of specific impacts to coastal communities or the marine and coastal environment. It is likely that there were very few, if any, impacts to marine turtle nesting or foraging populations.

## Yemen

The tsunami reached the coastline of Yemen. UNEP (2005) provide a detailed assessment of the impacts of the tsunami on Yemen's peoples and environment. To briefly summarise, the main impacts occurred to the coastline of Socotra Island and the coastline of Al Mahra Governorate. The most severe reported impacts occurred on the livelihoods of fishermen who lost valuable boats, nets and traps. There is a concern that nets and traps that were washed out to sea may increase mortality of threatened marine wildlife. No quantitative assessment of the impact on the marine ecosystems have occurred, however good baseline data for many reef and mangrove areas exist due to the recent completion of large GEF and IUCN funded projects. It is not known what impacts the tsunami had on marine turtle populations in Yemen.

## Somalia

The impacts of the tsunami on Somalia's marine environment or marine turtle populations (nesting and foraging) are not known. The tsunami had the largest impact on communities in the Puntland region in north east Somalia, however the damage was felt along 650km of Somalia's Indian Ocean coast. According to the UNEP's National Environmental Desk Assessment (UNEP 2005), "due to the absence of appropriate national institutions there are no mechanisms to assess the damage to coral reefs by natural hydrological related disasters and human activity and plans for their protection. An assessment of the coral reefs is therefore needed to determine the extent of damage caused by the tsunami and other natural disasters as well as general degradation arising from long years of pressure from human activities and management neglect". In addition the UNEP (2005) report has provided details of increased health problems to Somali communities due to the stirring up of hazardous, and often radioactive waste deposits along the beaches of North Hobyo (South Mudug) and Warsheik (north of Benadir). The current situation along the Somali coast presents a very serious environmental hazard for east Africa (see Marine Pollution Bulletin, 2005, 50; 492).

## Kenya

*Prepared by Gladys Okemwa*

The tsunami had a moderate impact on the coast of Kenya. Weather conditions on the 26 December were sunny and calm and within the normal range for the northeast monsoon. The tsunami occurred at low tide and consisted of a sudden upsurge in the tide level by two to three metres above the highest spring tide level. Most of the impacts were in the central part of the coast adjacent to Mamburi. The tsunami occurred during the low part of the nesting season (nesting mainly occurs between June and October). The potential short and long term impacts on the nesting beaches were inundation of nests still incubating, increased debris on the beaches, erosion of the foredune and subsequent alteration of beach profiles. The potential short and long term effects on foraging habitats include increased stress and degradation of sea grass and coral reef habitats and potentially permanent shifts in important turtle foraging areas.

However, these impacts have not been well investigated and no quantitative data exist. In the absence of data on impacts to habitat it is difficult to examine the actual influences the tsunami had on marine turtle populations. However, it is suspected that the direct take of marine turtles for food may increase to offset the increased economic pressure placed on fishing-based communities.

In addition to the environment impacts, the tsunami also had a moderate impact on conservation programs and conservation infrastructure. Hatcheries established to protect marine turtle nests were flooded and received some structural damage, there was the loss or flooding of some research equipment and access roads to nesting beaches. These impacts will inevitably slow the progress being made by Kenyan authorities to protect marine turtle populations in Kenya. Overall more awareness and education is needed especially at a national level on the environmental impacts of the tsunami, including the generation of quantitative data. Efforts should be put in place to maintain and replenish (where possible) natural preventative barriers such as mangroves and coral reefs. Early warning and contingency plans also need to be developed.

## United Republic of Tanzania

*Prepared by Catharine Muir*

The tsunami had a low impact on the coast of Tanzania. The tsunami hit during low tide and consisted of two small waves approximately 0.5 to 1 metre in height. No major impacts on the coastal zone have been observed or documented. There is some anecdotal evidence of small scale infrastructure damage at the port in Dar es Salaam. There were no impacts on marine turtles, or marine turtle conservation projects.

## French territories of the Indian Ocean (Mayotte, Réunion and Iles Eparses)

*Prepared by Stephane Ciccione*

The tsunami had a very low impact, with waves approximately two metres high washing in on the northern and western sides of the islands. Anecdotal reports indicate that there was no loss of life, and approximately 200 boats and some port infrastructure were damaged at La Reunion. There were no impacts on conservation infrastructure. There were no impacts on marine turtle nesting beaches, nor are there believed to have been any impacts on the offshore habitats.

## Madagascar

The tsunami had a low impact on Madagascar's coast. Wave ranging in size from 1.5 to 10m hit the southeastern towns of Manakara, Sambava and Vohemar. There is no information on whether the tsunami affected turtle nesting beaches or foraging habitats. However, no leatherback turtle nesting has been recorded from Madagascar and whether Madagascan waters serve as important habitat for the species is unknown (George Hughes pers. comm.)

## South Africa

*Prepared by Ronel Nel*

The tsunami had a low impact on the coast of South Africa. The province of KwaZulu-Natal was protected by the island of Madagascar. Hence, although the tsunami occurred in the peak of the turtle nesting season there was no impact on any of the marine turtle nesting beaches. The Eastern Cape was most affected, and the furthest eastern point that the tsunami reached was Struisbaai. There are no known impacts of the tsunami on important marine turtle foraging habitats.

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