Impact of the December 24, 2004 Tsunami on coral reefs of Andaman and Nicobar Islands, India

The Andaman & Nicobar Islands are a low mountainous chain of islands, which rise from a submerged north-south trending ridge separating the Andaman Sea from the Bay of Bengal between 6°45′13″ 41 N and 92°12′93″ 57 E. This island group includes 306 islands and 226 rocks, with a coastline of about 1962 kilometers. The islands located north of 10° N Latitude are known as Andamans (Figure 1) while those located south of 10° N Latitude are called Nicobars with a total area of 8249 square kilometers. These islands are supposed to have arisen from the ocean bed in the Mesozoic period about 110 million years ago and have since then undergone several periods of partial submergence and elevation. Fringing, Patch and Barrier reefs are present here, covering about 948.8 square kilometers. The total mangrove area is approximately 762 km^2. There are 106 Protected Areas, 96 designated as wildlife sanctuaries, 9 National Parks and one Biosphere reserve. Among the 9 National Parks, 2 are Marine National Parks (Mahatma Gandhi Marine National Park and Rani Jhansi Marine National Park).

6000 species were recorded from Andaman & Nicobar Islands, amounting to 7.5% of the total Indian fauna (3% of the Terrestrial Fauna and 4.6% of Marine Fauna). So far 235 species of scleractinian corals, 111 species of soft corals, 112 species of sponges, 411 species of crustaceans, 1422 species of mollusks, 425 species of echinoderms, 750 species of fishes, 14 species of reptiles, 50 species of marine birds and 64 species of algae have been reported from Andaman and Nicobar islands. As per the year 2001 census, 25 islands in Andaman group and 13 islands in Nicobar group are inhabited with a total population of 356,265 people. Recently there was an undersea earthquake in the Indian Ocean. A rupture occurred off Banda Aceh in northern Sumatra (3°09' N, 94^0 26' E) at 00:58:49 GMT (06:28:51hrs IST) on Sunday December 26, 2004, with a magnitude of Mw = 9.3. The rupture spread northward at roughly 2.8 km s^{-1} for approximately 8 minutes over a 1300 km-long aftershock zone. Comparisons with the aftershock areas of other great earthquakes indicate that the Sumatra-Andaman earthquake did indeed have a moment magnitude of ~9.3. Its rupture, in both duration and extent, is the longest ever recorded.[1] The earthquake generated a tsunami surge that was among the deadliest disasters in modern history. According to official data, the tsunami took a toll of 3513 lives, including 1177 children. About 350 children were orphaned and 85 of the 322 government schools on the islands were washed away, another 34 were left completely dilapidated. As many as 46,000 tsunami-victims have been in 207 relief camps.

The Indian Ocean tsunami caused extensive damage to coral reefs of the Andaman and Nicobar islands. Most of the islands' coastline was eroded by the tsunami surge and sediments were dumped on adjacent reefs. These island reefs were not affected by the bleaching event in 1998. It has been found that the area has moved southwestward about 4-5 meters at North Andaman (Diglipur), about 4.5 meters at Middle Andaman and about 3 - 4.5 meters at South Andaman. In addition to this the North Andaman landmass was lifted up by 0.60-0.90 cm resulting in a fall in the water level. Due to this, almost all reef flats on

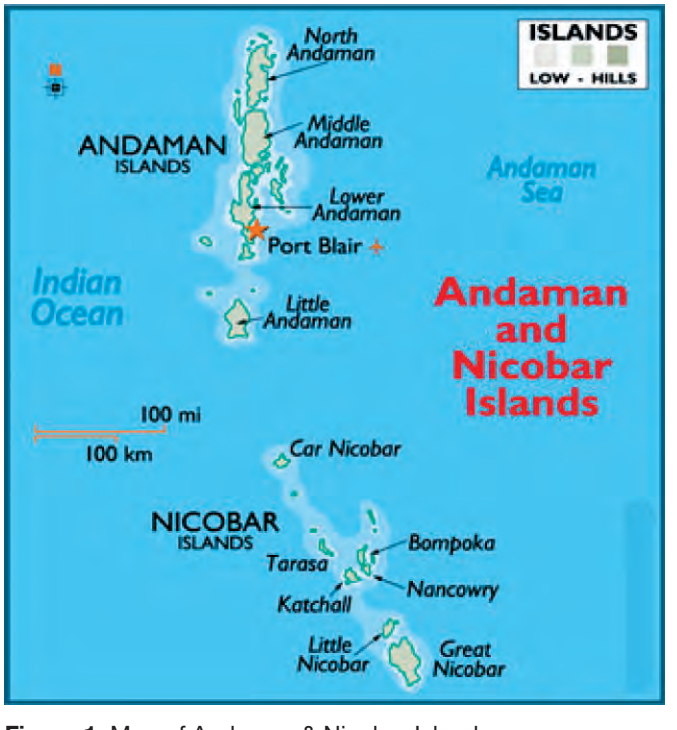

Figure 1. Map of Andaman & Nicobar Islands.

Figures 2&3. Mass mortality of corals on reef flat at Anderson Island.

Figure 4. Incredible coral damage around North Reef.

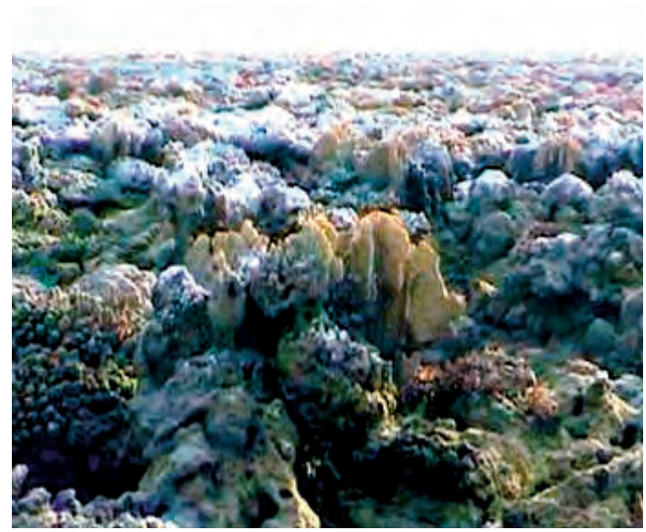

Figure 5. Mass mortality of corals at reef flats of Interview Island.

the western side of northern group of islands (i.e west coast of Interview Island, North Reef Island, Latouche Island, South Reef Island, West Island, Landfall Island, East Island and Anderson Island) were exposed and dried up (Fig 2-5). Almost all corals in the reef flats and other associated fauna seemed dead beyond regeneration, appearing like a graveyards of corals. The corals in reef slope were not as affected by the tsunami and the live coral percentage is 55-60%. In contrast, South Andaman subsided by 1-2 m, and seawater inundated the agriculture fields and coastal mangroves. The western coast of the North Sentinel Island, which is further south in South Andaman, was uplifted by half a meter.

Extensive coral reef surveys were made at Mahatma Gandhi Marine National Park at South Andaman during the month of January 2005 using SCUBA diving and snorkeling. It consists of 15 islands of different sizes, scattered over a total area of 281.50 km^2. In Jolly Buoy, Redskin and North Bay reefs, overturning of large corals especially *Porites lutea* colonies was observed. There was more damage on the northeastern side of Jolly Buoy Island where nearly 10m^2 of reef area was covered by sand. The Jolly Buoy Island lies in a northeast/southwest direction. On the northeastern side, the beaches and near shore land areas were around 6-10 m wide and were devastated by the tsunami. At one site, nearly 20m^2 area of coral reef was buried under the sediment and no corals were visible. Most of the branching

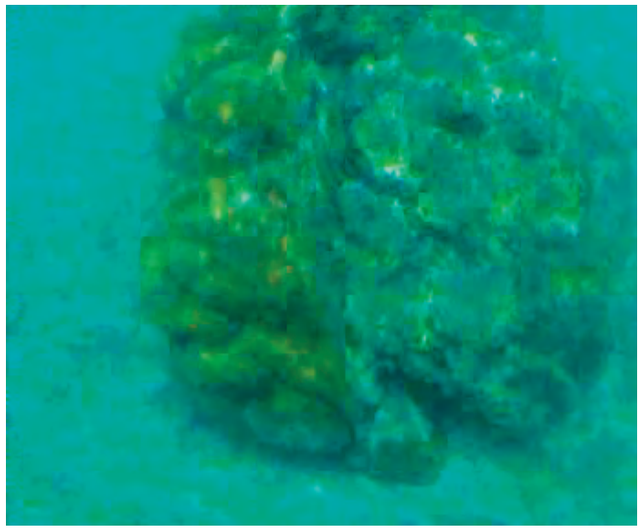

Figure 6. Overturned massive coral *Porites lutea.*

Figure 9. Sand deposited over on coral beds in MG National Park.

Figure 7&8. Uprooted massive coral *Porites lutea.*

Figure 10. Sand deposition on *Porites* colonies in MG National Park.

corals belonging to the genera *Acropora*, *Hydnophora* and *Montipora* were broken into small pieces and some washed away. Large size boulder corals, *Porites* spp., (more than 1m wide), were overturned and most of the colonies were uprooted (Fig 6-8). Some colonies were completely buried under sediment excepting the top portion (Fig 9&10). The island reef was remarkable for its richness of mushroom coral species belonging to the family Fungiidae. Most of these

Figure11. Massive *Porites* coral washed to the Land of Car Nicobar Island.

specimens were washed away by the tsunami and existing live mushroom corals were suffocated by sedimentation and likely result in death. The survey showed 50% mortality in north-eastern reef of Jolly Buoy Island. The reef at the southwestern side was not much affected by the tsunami, and the reef slope corals were in pristine condition.

The corals around the Nicobar group of islands were extensively damaged due to heavy sand and silt deposits brought by tsunami waves. The Nicobar Islands include serpentine gabbros, marine deposits of the late Tertiary including sandstones, slates, clay marls and plastic clays and coral reefs of recent origin. About 6000 ha of coconut gardens were affected by tsunami and 20,000 coconut trees were uprooted. The corals were washed away onto the land at Car Nicobar island(Fig 11&12). The tsunami caused the worst damage to this island and the wave reached almost more than 7 meters in height. The area between 7°45′–8°15′N and 93°25′–93°40′E consists of Camorta, Trinkat, Nancowry, and the Katchall

Figure 12. Uprooted coconut trees along with coral fossils in Car Nicobar Island.

islands. Extensive coral reef flats of about 2.5 km^2 occur at the northeastern and northwestern side of the Camorta Island. These reefs were severely damaged by the earthquake and tsunami. On the northeastern side about 2.0 km^2 of landmass was eroded and all sediments were dumped onto the reef. The reef flats around the Trinkat Island extend up to 2.5-3.0 km^2 from shore. Due to the earthquake and tsunami the island was divided into two parts. A heavy load of sediments were deposited over the reef and led to mass mortality of corals. The windward reef on the northeastern side of Nancowry Island was the worst affected by the tsunami, resulting in a mass mortality of corals. The tsunami in the Nancowry group of islands caused extensive damage to mangroves and 94% of mangroves were submerged. On Katchall Island alone 1550 ha, or 38% of mangroves were submerged. The coral reefs of these islands somehow played an important role in attenuating the tsunami wave height, thus lessening its destructive effects. Similar phenomena were observed in the Philippines during 1992.[2]

Detailed coral reef survey in Great Nicobar Island showed the live coral coverage of the island was 55%.[3] The coral reefs here were not affected by the bleaching event in 1998. Unlike the Andaman Island reefs, the dominant reef building corals in Nicobar Island was *Acropora* sp. Of the 55% live coral coverage, *Acropora* was 26% and the boulder coral *Porites* was restricted to 6%. The subsidence of 2-3 meters affected the Great Nicobar Island and a maximum down throw at Indira Point (Southern most land part of India). The lighthouse on Indira point and the adjacent land are still under the sea. Large amount of mud and trees settled down over the reef flats smothering the corals. The corals in the reef flats of Great Nicobar Islands, particularly on the western side, were in pristine condition before the tsunami. These reefs are now covered by sediment.

Coral reefs of Andaman and Nicobar islands are the biodiversity hotspots of India. The post tsunami survey results showed the reduction of moray eels, sharks, triggerfishes, boxfishes, puffer fishes and angelfishes. The coral associated fauna i.e. polychaetes, nudibranchs, flat worms,

alpheid shrimps, Mantis shrimps, hermit crabs and brachyuran crabs belonging to the genera *Trapezia*, *Phymodius, Cymo* and *Chlorodiella* were not found during the survey. Eight species of birds in the Andaman group and five species of birds in the Nicobar group of islands were reported as endemic. A small Megapode island on the western side of Great Nicobar Island was completely sunk under sea. This island was the habitat of the endemic bird *Megapodius nicobariensis.* It builds mounds in coastal areas and, therefore, suffered from habitat destruction and degradation before the tsunami. A mud volcano erupted on Narcondam, on June 7 2005, which had been lying dormant for nearly a century. The Barren Island, which is the only active volcano in the country, erupted once again on May 28 2005, after remaining silent for a decade. Hence, these bird species may have been severely affected by the tsunami and other subsequent changes.

Research has indicated a real danger of another earthquake in the region.[4] The prediction was based on the increase of co-seismic stress on the contiguous Sunda trench subduction zone and neighboring vertical strike-slip, Sumatra fault.[5] The prediction came true on 28 March 2005, the Sunda megathrust in Indonesia ruptured again, producing another great earthquake three months after the previous one. An earthquake in the Sumatra fault might be expected in the near future. The Andaman & Nicobar Islands are in earthquake prone zone 5, part of the Sumatra fault. The proposed coral reef survey in the Nicobar group of Islands by the Zoological Survey of India after the monsoon will reveal more details.

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