Assessment of post tsunami coral reef resource in Pongi Balu coast, south Andaman Islands

Dilip Kumar Jha[1,*], N. V. Vinithkumar[1], J. Santhnakumar[1], A. K. Abdul Nazar[2] and R. Kirubagaran[1]

[1]National Institute of Ocean Technology, Port Blair 744 103, India
[2]Central Marine Fisheries Research Institute,
Regional Research Centre, Mandapam Camp 623 519, India

In the present study, an assessment of the status of coral reefs along the Pongi Balu coast, south Andaman Islands, which is a part of the Mahatma Gandhi Marine National Park, has been made by scuba diving, low draft glass-bottom boat and visual interpretation in some places during low-tide condition. The coral reef boundaries have been accurately determined with the help of a low draft glass-bottom boat fitted with a real time kinematics global positioning system, and the existing coral reefs map of the area has been updated using the geographic information system technique. A total of 161.6 ha of previously existed live coral reefs were surveyed along the Pongi Balu coast and out of that 'live coral' was found over 81.4 ha and 'dead coral' was found over 60.6 ha whereas 19.6 ha area was found to have been lost from the existing coral reefs and categorized as 'no coral'. The study highlights a few natural and anthropogenic factors affecting the existing coral reefs and hindering the re-establishment of coral reefs in the study area.

Keywords: Coral reefs, geographic information system, satellite data, south Andaman.

CORALS are solitary or colonial polypoid coelenterates living in a secreted skeleton of their own. Some grow as massive solid structures, others as large branched colonies. The coral colonies grow continuously in size by budding of the polyps and often form extensive masses known as coral reefs. These reefs play a vital role in the ecosystem because they protect the shore and also provide breeding grounds for a diverse group of marine organisms. The coral reef ecosystem is highly productive because of its symbiotic association with algae called '*zooxanthellae*'. The Andaman and Nicobar (A&N) Islands have a considerable stock of marine resources and are richly fringed by mangroves, coral reefs, sea grasses and seaweed ecosystems[1]. It is well known that coral reefs are economically important for the livelihoods and social welfare of coastal communities, providing up to 25% of the total catch of fish[2]. Further, about 135 species of coral in 59 genera have been reported from the A&N Islands[3]. The Andaman reefs contain about 80% of the maximum coral diversity found anywhere in the world, making them the richest coral reefs in the Indian Ocean and an area of global significance[4,5]. The total area of coral reefs in India is estimated to be 2374.9 km^2 and out of that, about 959.3 km^2 is in the A&N Islands[6]. Table 1 lists the different components of coral reefs in the A&N Islands along with their spatial coverage.

Periodic mapping and monitoring of coral reef ecosystems are critical to the conservation of their biodiversity. Several authors[7] have emphasized the integration of geographic information system (GIS) and remote sensing for mapping the coastal wetlands and coral reefs of the A&N Islands. In 2004, the Andaman and Nicobar Centre for Ocean Science and Technology (ANCOST), a unit of the National Institute of Ocean Technology (NIOT), as a part of its coastal zone monitoring activity carried out a detailed mapping of coral reefs in the Mahatma Gandhi Marine National Park (MGMNP) of south Andaman island using IRS LISS III data with sufficient field checks. A coral reef map of the area was prepared using GIS.

The A&N Islands experienced a catastrophic tsunami on 26 December 2004. It has been estimated that the Andaman and Nicobar group of islands lost about 50,000 ha of its reefs due to this tsunami and about 11,300 ha of reefs on these islands were covered by sediments of sand, mud or detritus[8]. Since then the coral reefs in this region are recuperating and the corals are re-establishing their colonies. Meanwhile, the coral reefs of the A&N Islands, similar to any other place in India, are being subjected to pressure due to anthropogenic activities. These include construction activities along the coast, coastal tourism, growth in habitation along the coast and coral fishing resulting in the disposal of freshwater and contaminated sewage into the sea and sedimentation of the coral reefs. Sedimentation in the reef environment decreases the overall biological productivity of the entire ecosystem.

The study area, Pongi Balu coast, falls within the boundary of MGMNP. This is a protected area for marine life including corals and nesting sea turtles under the Wildlife (Protection) Act of 1972. The MGMNP spreads across an area of 28,150 ha in the Andaman Islands and is home to

Table 1. Spatial coverage of different components of coral reefs in A&N Islands

Components of coral reefs in A&N Islands	Area (sq. km)
Reef flat	795.7
Sand over reef	73.3
Mud over reef	8.4
Coralline shelf	45.0
Coral heads	17.5
Reef vegetation	8.9
Vegetation over sand	10.5
Total	959.3

Source: Ref. 6.

*For correspondence. (e-mail: dilipjha75@yahoo.com)

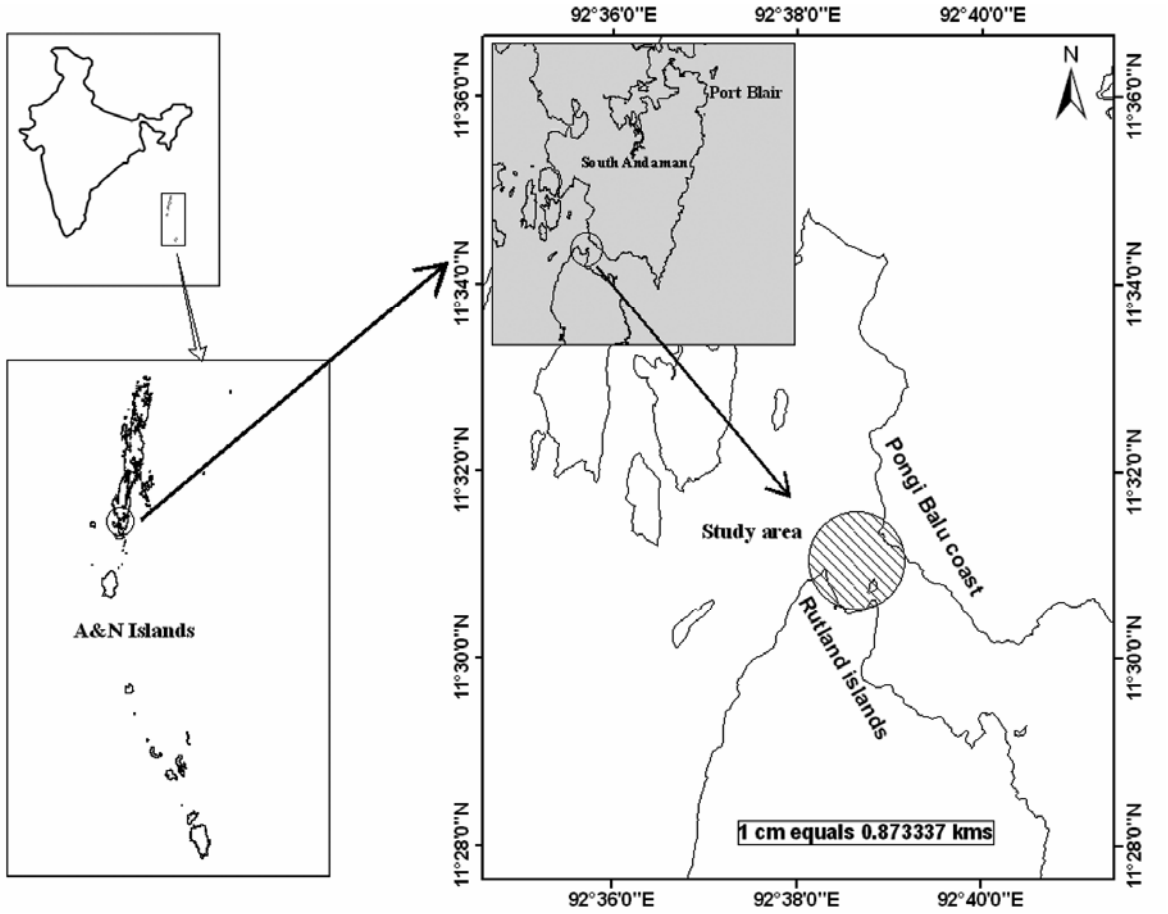

Figure 1. Map showing the study area.

222 species of corals other than many endangered marine animals[9]. Pongi Balu is bounded by the geo-coordinates 11°30′0″–11°34′0″N lat. and 92°38′0″–92°40′0″E long. and is about 20 km from Port Blair (Figure 1). This coast is known to be flanged by coral reefs with rich coral biodiversity. The geomorphology along the coast is denudational hill and the soil type is classified as fine loamy according to classified satellite data. The study area is found to have sandy beach as well as rocky coast without seawall protection along the Pongi Balu coast. The depth along this coast is between 0.9 and 14 m with the tidal amplitude recorded to be about 2.4 m.

In 2004, a detailed mapping of the coastal land use/land cover including coral reefs was carried out by ANCOST, Port Blair using IRS LISS III data to prepare a GIS database for the coastal resources of south Andaman Islands. The Indian Space Research Organization's (ISRO) National Natural Resources Management System (NNRMS) format was adopted for land use/land cover classification and a geo-database was prepared using ArcGIS® software[10,11]. During that activity, a detailed survey of coral reefs in MGMNP was made and a coral reefs map was generated. During the 26 December 2004 tsunami, the coral reefs of MGMNP were badly affected by the water surge and subsequent sedimentation due to the washed away shore materials. The coral reefs in the southern part of MGMNP, near Pongi Balu coast, were most affected. Over the last five years, the coral reefs have recovered a lot. The present study is aimed at assessing the coral reef resource at the Pongi Balu coast alone covering an area of 161.6 ha where only 'live coral' existed prior to the tsunami event. The GIS database of 2004 has been used as a base reference to compare the changes in coral reef features since the tsunami event.

Reef monitoring by ground truthing was carried out during 2008–2009 with the help of a RTK–GPS with a base station located in south Andaman Island. Underwater studies were carried out by scuba diving and with a low draft glass-bottom boat. Monitoring was done by using the line intercept transect[12] method. Along the coast where the coral reefs were exposed during low tide condition, surveys were undertaken and the transition points were obtained. In shallow water, a glass-bottom boat was used for surveying and at the reef slope where the water is relatively deep, surveys and transition points were accomplished through scuba diving. The coral reef boundaries were accurately determined with the help of a glass-bottom boat with a RTK–GPS by sailing the boat along

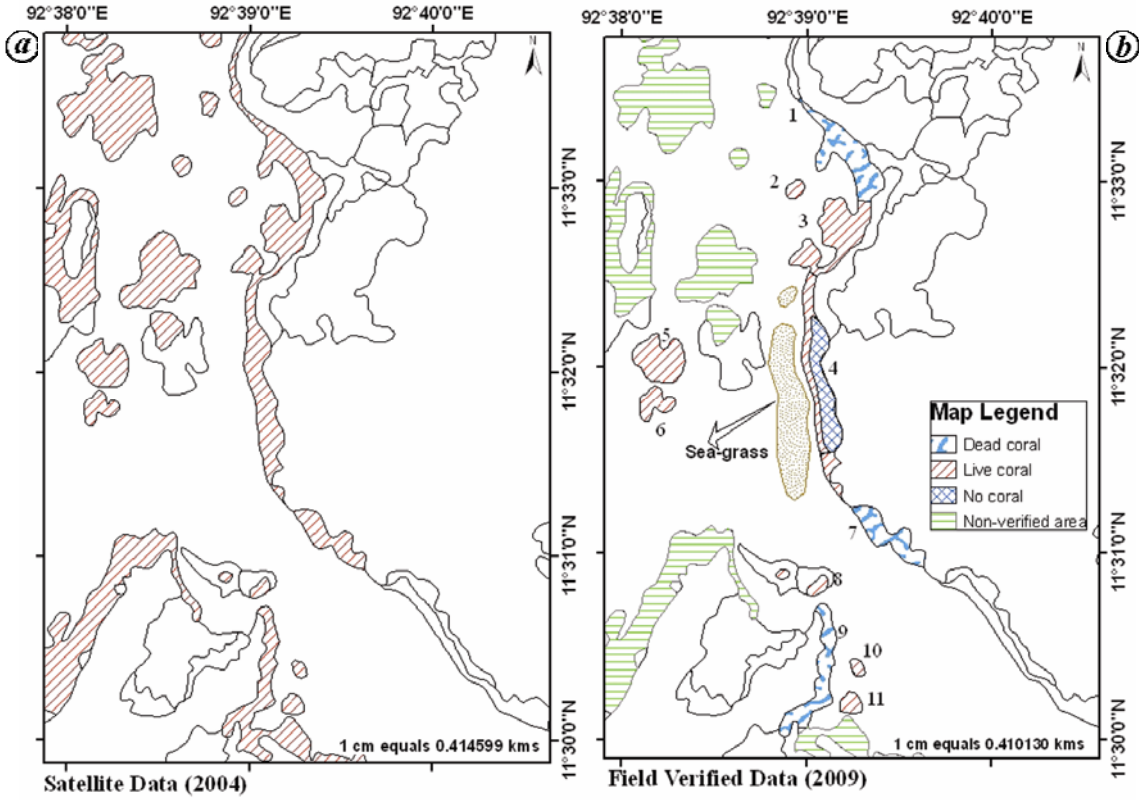

Figure 2. Maps showing pre-tsunami (***a***) and post-tsunami (***b***) spatial coverage of coral reefs at Pongi Balu coast.

Table 2. Comparison of coral reef area during pre-tsunami and post-tsunami condition at Pongi Balu coast

Coral reef coverage in the study area				
Pre-tsunami (2004)		Post-tsunami (2009)		
Category	Area (ha)	Category	Area (ha)	Total area surveyed (%)
Live coral	161.6	Live coral	81.4	50.4
		Dead coral	60.6	37.5
		No coral	19.6	12.1
Total	161.6	Total	161.6	100.0

the reef boundaries. All the surveys were done during the lowest low tide conditions for better clarity of underwater features. The surveys were conducted for three categories of coral reef features, viz. presence of 'live coral' with coral types and species information, presence of 'dead coral' and the absence of coral as 'no coral' in the areas where coral reefs existed earlier. The location of these categories along with their area of extent was measured using a hand held GPS (Garmin eTrex vista; of ±3 m accuracy). This exercise was repeated three times during the lowest low tide condition to minimize the positional error for 'live', 'dead' and 'no coral' boundaries.

The GPS data was later processed in MS Excel software. The data was linked to the earlier created geo-database and new polygons were created showing 'live coral', 'dead coral' and 'no coral' categories. The areas of extent of each category were computed and compared with the previous coral reef area. An assessment was made on the change in coral reef features since the tsunami event. The existing coral reefs map of the Pongi Balu area has been updated with the new survey results.

The survey revealed that out of 161.6 ha, only 81.4 ha (50.4% of area) remained as reef with 'live corals' whereas 60.6 ha (37.5% of reef area) was found to have 'dead coral with algae'. The live corals include both hard (Scleractinia) and soft corals. Of the total hard corals recorded, 75% were found to be *Porites* sp. (massive corals) whereas the remaining were branched corals (Acropora and non-Acropora branching). A total of 19.6 ha (12.1% area) was found to be lost from the earlier reef, which is categorized as 'no coral'. Figure 2 shows the pre-tsunami and post-tsunami spatial coverage of coral reefs at Pongi Balu. Figure 2 *b* also shows the survey locations starting from site 1 to site 11 where distinct coral reef patches were observed. The area (in ha) of extent of the pre-tsunami and post-tsunami coral reef features is given in Table 2.

The damage caused by the 26 December 2004 tsunami was more near the Pongi Balu coast where the reef was broken and only coral boulders and rock fragments could be seen now (Figure 3 *a*). This area is also under natural/

Figure 3. Field photographs of Pongi Balu coast showing signatures of erosion/deposition. ***a***, Lower intertidal zone. ***b***, Coral boulders along Pongi Balu coast. ***c***, Washed away seaweeds. ***d***, Beach erosion along the coast.

anthropogenic pressure as indicated by a number of point sources of freshwater runoff observed along the coast. About five such points were noticed which bring considerable amounts of sediments along with freshwater to the reef area during the rainy season. The rainy season in the A&N Islands spans over eight months, and the freshwater and sediments adversely affect the coral ecosystem by lowering the water salinity and blocking the sunlight[13]. Patches of dead coral reefs were also found at sites 1, 7 and 9 (Figure 2) in the Pongi Balu coast. These are the areas where corals could not re-establish their colonies after the tsunami and are now invaded by turf algae and seaweeds (algal assemblage). Studies revealed that the runoff from the land also brings nutrients with it and resulted in favourable conditions for algal growth in the reef. This also helped the growth of seaweeds in this area. An area of about 47.11 ha was found covered with seaweeds (Figure 2 *b*), which indicates that there is a decline in the coral resource of the study area.

Figure 3 presents a few field photographs showing the signatures of erosion/deposition along the Pongi Balu coast. The washed away coral reef fragments in the form of coral boulders (rock) and rubble were observed on the shore (Figure 3 *b*). A part of the intertidal zone along the Pongi Balu coast was exposed during the lowest low tide (Figure 3 *a*). The washed away seaweeds were found along the coast (Figure 3 *c*). Over 47.11 ha of previously occupied reef area was observed to be covered with seaweeds at the reef slopes. These seaweeds have gradually occupied the reef area. The seaweeds and algae have caused severe damage to the coral reefs as they can never be replaced by corals again. It has been reported[14] that the expansion of seaweed growth in the reef ecosystem would lead to reef degradation and create a phase shift from coral dominated to algal dominated and/or coral depleted area, which may occur in the present case if steps are taken to harvest the seaweed regularly. It has also been emphasized[15] that there is a need to harvest the seaweed routinely to protect the coral reef, although no seaweed harvesting has been practiced to overcome these issues in this region.

During the tsunami, some of the land along the coastal areas of south Andaman Island was lost to the sea and there are also reports of land subsidence of 1 m along the south Andaman coast[16]. This led to erosion of the coastal areas and sediment deposition over the coral reefs. This

was much evidenced in the Pongi Balu coastal stretch during the study (Figure 3 *d*). The A&N administration is, however, planning to undertake the necessary measures such as the construction of seawall and the creation of mangrove plantation to prevent further erosion.

The coral reef resources of the Pongi Balu coast were assessed to quantify the change in coral reef area between the pre-tsunami and post-tsunami conditions using GIS technique. A total of 161.6 ha of previously existing coral reefs were monitored along the Pongi Balu coast and out of that 'live coral' was found over 81.4 ha and 'dead coral' over 60.6 ha whereas 19.6 ha area was found to have been lost and categorized as 'no coral'. This showed that there is a reduction in coral reef area from 2004 to 2009. Also, a part of the coral reef where live coral colonies existed before the tsunami is now reduced to a reef with dead corals and algae. Seaweeds have also invaded a part of the reef, causing irreversible damage. It was also observed that there are many places along the coast where freshwater runoff is degrading the coral reefs. This runoff carries along with it a lot of sediments and nutrients, inhibiting the growth of coral colonies. There are also places along the coast which need to be protected from erosion that leads to the subsequent sedimentation of the coral reefs.

Hence, it is suggested that the freshwater runoff to the sea, which brings a lot of sediments during the rainy season, is checked. Mangrove plantations along the coast are a good option to control sedimentation on the coral reefs. Sea walls can also be constructed at many places to check the erosion of the coast. It is also recommended that the seaweeds are harvested frequently to check their growth, as they invade the coral ecosystems and replace them. Further, it is also necessary to survey the entire coastal region of the A&N Islands and prepare/update the coral reef resources map of the region. Regular monitoring of coral reefs will help in conserving the rich ecosystem.

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