First oceanographic expedition to survey the impact of the Sumatra earthquake and the tsunami of 26 December 2004

Between the Christmas of 2004 and the New Year's Day of 2005, South Asian countries like India, Indonesia, Thailand, and Sri Lanka received a twin-shock. A major earthquake of magnitude M_W 9.3 occurred at about 0640 h on 26 December 2004 near Aceh, northwest of Sumatra, Indonesia triggering a tsunami surge that engulfed the coastal areas of Indonesia, Thailand, Sri Lanka and the eastern margin and Andaman and Nicobar Islands of India. Preliminary locations of large aftershocks following this earthquake show that approximately 1000 km length of the plate boundary slipped as a result of the earthquake. Subsequent scientific reports also indicated that this earthquake has resulted in a micro level tilt in the orbital axis of the earth and an increase in the speed of its rotation. Though some of these findings need to be further substantiated, the fact remains that the Sumatra earthquake had caused significant changes to the earth's tectonic processes. Some earlier studies also suggest the break-up of Indo-Australian plate as the probable cause for the Sumatra earthquake.

The Andaman and Nicobar area, including Car Nicobar, Katchel and Campbell Islands were not only affected by the earthquake, but also by the tsunami surge. It is now believed that a subsidence of 1–2 m had affected the Andaman and Nicobar Islands with the maximum downthrow at Indira Point near Great Nicobar. This resulted in a permanent sea-level rise of the same order, thereby inundating the coastal settlements and narrowing down the beach stretches of the island. Andaman and Nicobar Islands have experienced as many as 200 aftershocks subsequent to the tsunami impact till date, with magnitudes of the order of 3–6.5. The Sumatra earthquake and resultant tsunami surge might have caused significant changes in the marine environment, not only in the physiography and tectonics of the region, but also in the environmental parameters of the upper column of the ocean waters.

The first oceanographic expedition to tsunami-affected areas was planned utilizing the services of the multidisciplinary ocean research vessel, *ORV Sagar Kanya*, the flagship of the country involving participation of oceanographers from NCAOR and NIO, Goa and NIO, Regional Centre (RC), Visakhapatnam. The vessel sailed from Goa on 3 January 2005 and reached Chennai on 15 January and immediately sailed for a cruise in Bay of Bengal, Andaman and Nicobar region. The vessel returned to Chennai after 37 days, completing the post-tsunami cruise on 21 February 05.

The emphasis of the cruise was to study the post-tsunami impact on marine environment in the Bay of Bengal and Andaman and Nicobar regions, involving a team of 31 scientists from NCAOR (9), NIO, (8), NIO, RC, Visakhapatnam (7), NPOL, Kochi (1) and NORINCO, Chennai (6). The multidisciplinary and multiparameter data collection covered some of the areas where data were available from earlier visits and also some new areas. Figure 1 gives the cruise track and sample location map of the study area.

The following data were generated (a) Time series environmental data (such as temperature–salinity, currents, water quality, etc.) within a few weeks after the earthquake and tsunami, which would help to study the impact of these mega events on coastal and deep-sea marine environment.

(b) Underway-geophysical data (swath bathymetry, gravity, sub-bottom profiling, etc.), which may help in demarcating the physiographic and tectonic changes in the Bengal Fan, across the Andaman–Nicobar trench and in the Andaman Basin, encompassing both Indian and Burmese plates.

(c) Gravity and spade cores over the Andaman and Nicobar trench axis, Andaman Basin and Bengal Fan to study the probable variations in sediment structure of the upper column.

(d) Creation of new database in these regions, as well as re-occupation of some of the areas where oceanographic data were available earlier, the Andaman Basin being one such case.

(e) Biological species data in the coastal waters of Andaman and Nicobar Islands and Andaman Basin, to study changes in their distribution pattern following the tsunami surge.

(f) Study tour of the earthquake/tsunami affected areas in and around Port Blair, when the vessel stopped there for a short period. Photographs of the areas inundated by tsunami surge and subsidence due to the earthquake were taken. Beach samples were collected in areas of interest and physical damages caused due to the events were also observed in some areas and relevant data were collected.

(g) All these investigations were carried out in the Andaman and Nicobar trench, in the presence of high frequency aftershocks (nearly 200 in one month) of magnitude more than 5.0, throughout the survey period.

The sea surface temperature increased from 27°C off Chennai to 28°C at 92°40′. The mixed layer depth, which was inferred from temperature profiles, varied from 50 to 100 m between 80°52′ and 87°E and thereafter, it decreased to 70 m towards Andaman. A temperature maximum of 29°C was observed at 84°E at ~80 m. Along the west–east section, the near-surface salinity varied from 32.8 to 33.9 psu, with low salinity water (31.7 psu) identified near the Andaman Islands. A conspicuous feature identified in the vertical profiles is the occurrence of high salinity core (35.2 psu) at 100 m between 83° and 84°E; in the same region, the temperature maximum (~29°C) was also encountered. In general, surface freshening occurred near Andaman region.

The long-range profiles (Figure 1) taken across the Bengal Fan following 10 and 13°N, recorded the characteristic bathymetry and gravity anomalies associated with the continental margin, the continent – ocean boundary and the deep sea Bengal Basin, including the 85E and 90E ridges.

Towards the east, a sharp gravity low of the order of 124 mGal has been noticed over the Andaman trench region. The Andaman fore-arc region is characterized by a broad gravity high of 122 mGal, with a width of 150 km. This overall broad gravity high is associated with a series of highs and lows of the order of 20–25 mGal. These anomalies may be due to the presence of volcanic intrusions.

In the back-arc basin, a distinguished regional feature has been observed parallel to the Andaman Island chain between the latitudes 10°30′N and 12°30′N. This feature has been marked based on the characteristic gravity high with variable width and amplitude along. The free-air gravity anomaly over this feature varies in amplitude between 150 and 75 mGal, having a variable width of 70–30 km.

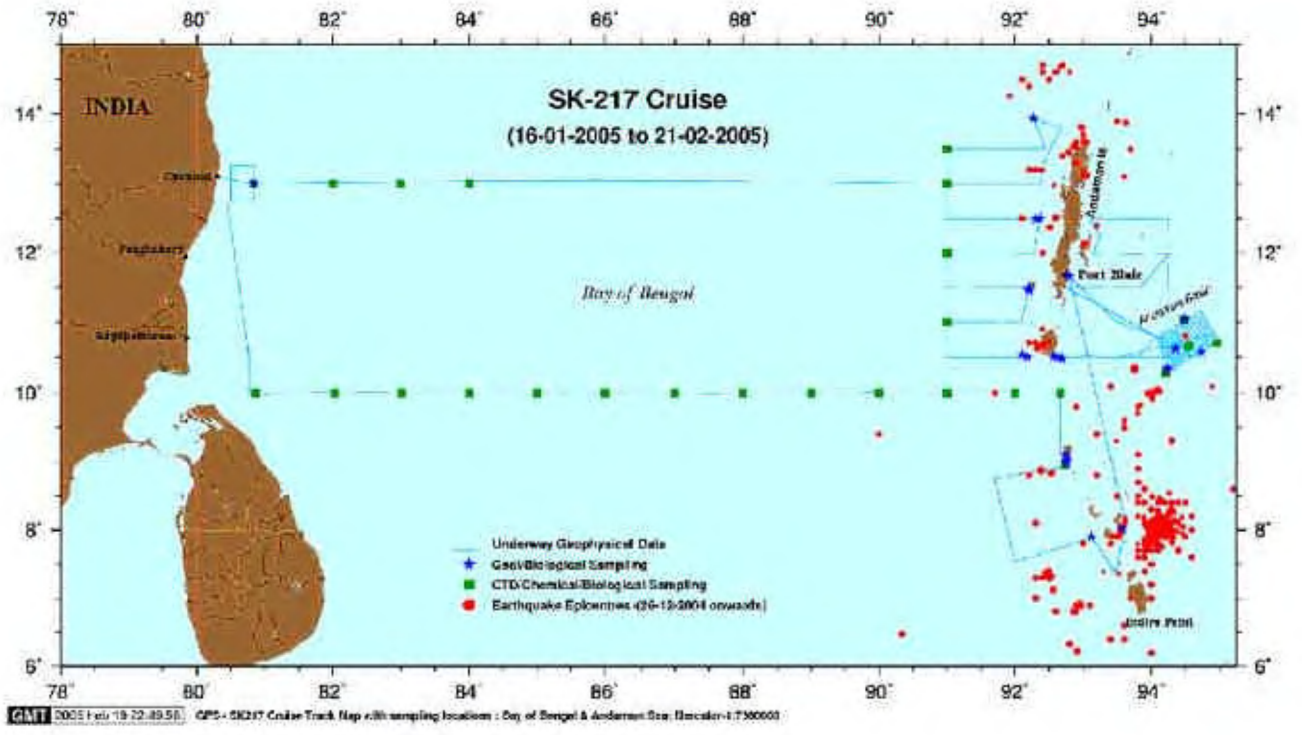

Figure 1. Cruise track and location map of study area.

The Andaman trench is characterized by a significant gravity low with broad gravity highs on both the sides due to the Ninety East Ridge on the west and volcanic intrusions on the east respectively. The irregular nature in the eastern side gravity high suggests a series of volcanic outpouring. The overall amplitude variation of the gravity anomaly over the trench area is from 60 to 100 mGal. Along 13°N the gravity anomaly is characterized by a high, over the 90°E Ridge and a low, over the 85°E Ridge.

A detailed analysis of bathymetry, free-air and sub-bottom profiler data and their correlation with earlier geophysical data collected in this region would help us demarcate any physiographic and tectonic changes that could have taken place in the Bengal Fan and Andaman and Nicobar region, due to the major earthquake of 26 December 2004.

Chemical and biological parameters as well as sediment cores need to be analysed at the shore.

During the entire survey period in the Nicobar region, earthquakes of magnitude more than 5.0 occurred at a fairly high frequency (at the rate of 2 to 3 per day), according to the daily information we were receiving from NIO, RC, Visakhapatnam, compiled from different sources. These are mainly the aftershocks of the Sumatra earthquake of 26 December 2004 of magnitude of 9. Plotting of the epicentres indicated that the area east of Katchal and Nancowry Islands is associated with more than 75 aftershocks, forming a huge cluster around this part of the Nicobar region (shown in red in Figure 1). Most of these events occurred after 24 January 2005. We had experienced vibrations on the vessel for few seconds on 24 January around 0946 h due to one such event of magnitude 6.3, with the epicentre located around 140 km SW of Katchal Islands. This epicentre position was confirmed by three independent sources, and the vessel was hardly 120 km east of this epicentre at the time of the event.

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