Addition of nitrogen as urea had resulted in substantial increase in N_2O emissions. The increase was highest at 80% max. WHC while it was lowest under submergence. The study indicated that continuous submergence during rice crop would reduce nitrification and accumulation of NO_3^-, thereby reducing N_2O production. In other crops, where stagnation of water is avoided and crops are grown in aerobic or partially aerobic conditions, N_2O emission may be higher mainly due to high nitrification and to some extent, via denitrification of accumulated NO_3^- in periods of water saturation. DCD can reduce N_2O emission appreciably in soils at different moisture regimes, except at submergence, where nitrification inhibitors may not be very efficient in mitigating N_2O emissions as nitrification proceeds slowly under submergence. It has already been established at field scale that from the point of view of crop production, use of DCD is economically feasible. The present study shows that DCD is also capable of mitigating N_2O emissions considerably from the soil at different moisture regimes.

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Age of relict coral reef from the continental shelf off Karaikal, Bay of Bengal: Evidence of Last Glacial Maximum

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Coral *Acropora* sp. collected from the relict coral reef at –125 m depth off Karaikal, Bay of Bengal yielded a radiocarbon age of 18390 ± 220 yr BP. The depth of occurrence of relict coral reef and its age attest to the lowest sea-level position of the Last Glacial Maximum (LGM). It is inferred that in the eastern continental shelf of India, the sea-level rose at the rate of 4.61 m/kyr, since the LGM until about 11,000 yr BP.

DURING upper Quaternary period, the relative sea-level changed rapidly throughout the world. The effects of these relative sea-level changes have imprints of testimony on coastal processes, shifting of shoreline, etc. The Indian coast has ample evidences of high and low shoreline positions either as depositional or erosional features.

Along the west coast of India, imprints of various sea-level positions since the Last Glacial Maximum (LGM) have been well recorded with radiometric (^{14}C) dates[1–7]. Although such sea-level imprints are abundant along the east coast of India, high sea-level positions are well studied together with absolute radiometric (^{14}C) datings[8–12], whereas only sparse radiometric (^{14}C) data are available for low sea-level positions[13–17]. In this paper, the lowest sea-level evidence from a relict coral reef on the outer continental shelf off NE of Karaikal and its radiocarbon (^{14}C) age have been presented.

During R. V. *Samudra Manthan* cruise no. 127, echo sounding (3.5 kHz) data were collected over the continental shelf off Point Calimere – Pondicherry, Bay of Bengal along shore parallel and perpendicular transects at 10 km intervals. Sediment samples from the mid- and outer continental shelf by van Veen grab on 5 km grid were collected.

The continental shelf is about 80 km wide off Point Calimere and 45 km off Karaikal with the slope of about 00°30′ and shelf break occurs at an average depth of 200 m. Echo profiles revealed the presence of prominent terrace features at – 90 m, – 100 m and –110 m depths and shore parallel ridges at – 60 m, – 70 m, –85 m, –95 m, –115 m and –125 m depths, indicative of former low strandline positions.

The shelf is generally carpeted by clayey sand, sandy clay, sandy silt and silty clay. The sandy ridges are mainly composed of abundant degraded and inarticulated shells, shell fragments and ooids. Calcareous algal concretions are more common in the outer continental shelf area.

Notable geomorphic features picked-up from echo sounding records of the outer continental shelf were dredged. Abundant coral chunks and debris were collected (Figure 1) NE off Karaikal from the irregularly crested ridge at – 125 m depth (Sample no. 8595, Location 11°11.06′N; 80°03.92′E). The scanning of corals revealed that they are freshly broken from the reef during dredging and mostly belong to the genus *Acropora* sp. and *Pocillopora* sp. *Acropora* sp. is a colonial branching type with branchlets of 4 to 7 cm long, 8 to 10 mm thick and the tips slightly pointed. Towards the lower part, the branchlets are fused and finally become massive at the base. The branches of *Pocillopora* sp. are cylindrical at the base and 1 to 1.5 cm broad at the top. Usually, *Pocillopora* sp. grows into colonies of 25 cm height with hemispherical outline. *Acropora* sp. which is generally restricted within 5 m of water depth was selected for radiocarbon (^{14}C) dating and cleaned thoroughly to avoid contamination.

The mineralogy of the coral determined by X-ray diffraction revealed that *Acropora* sp. contains only aragonite (100%), thus confirming no recrystallization of primary aragonite. The coral debris (*Acropora* sp.) was radiocarbon (^{14}C) dated at Birbal Sahni Institute of Palaeobotany, Lucknow following the Radiocarbon Calibration Programme Rev. 3.0.3 of the University of Washington[18]. Radiocarbon (^{14}C) age was calculated using the half-life value of 5570 ± 30 years.

Colonial growth of tropical corals usually flourish in calm shallow seas with water temperature around 22°C (ref. 19). The observations in the study area suggest that a low sea-level stand around –120 m depth facilitated the thriving of a coral reef at –125 m depth. *Acropora* sp. collected from – 125 m water depth yielded a radiocarbon (^{14}C) age of 18390 ± 220 yr (calibrated) BP.

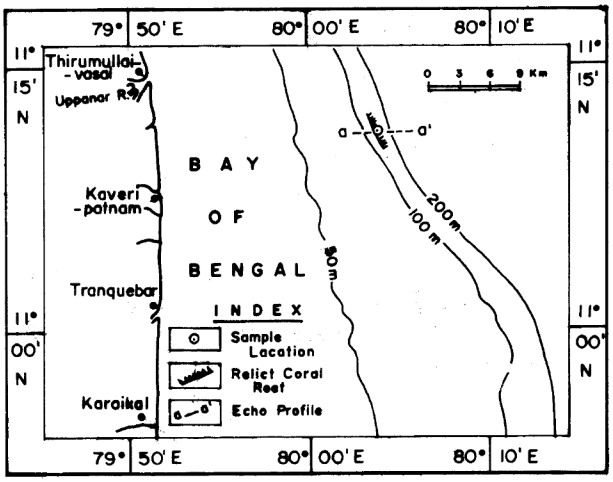

Figure 1. Location map.

The continental shelf off Point Calimere – Karaikal is one of the widest in the east coast of India, where former sea-level positions are well preserved. Earlier studies confirm such evidences between –50 m and –130 m depths[20,21]. In the shelf of the study area, the lowest shore parallel ridge is recorded at – 125 m (Figure 2).

Worldwide studies indicate that the sea-level retreated maximum between –121 m and – 130 m depth about 18,000 yr BP, i.e. during the LGM[22,23]. Subsequently, the warm period began and the sea-level rose to the present one with pauses. The coral reefs drilled offshore of Barbados and their age point that the sea-level was at – 121 ± 5 m below the present sea-level during the LGM[22]. A study along the Atlantic continental shelf of USA confirms the lowest sea-level of the LGM at – 130 m (ref. 23). Similarly, the oxygen (^{18}O) isotope records and ^{14}C dating of deep sea samples from the Bay of Bengal and Arabian Sea suggest a mean age of the LGM as ~ 18,000 yr BP with a standard deviation of 1500 yr (ref. 24). On the basis of oxygen (^{18}O) isotope studies, the sea-level during the LGM has been estimated to be about – 130 m (ref. 25). On comparison of the above documentations with the ^{14}C dating obtained for the relict coral reef off Karaikal, it is surmised that the lowest sea-level corresponding to the LGM was at –120 m depth in the study area. This age of 18,390 ± 220 yr BP attests to an evidence of the lowest sea-level position during the LGM in east coast of India, which is hitherto not recorded by absolute radiometric dating.

A relict coral reef at – 115 m depth from the continental shelf off Mahabalipuram has been dated 14510 ± 190 yr BP (ref. 17). Algal barriers at – 85 m and – 100 m depths off Visakhapatnam have been dated 10790 ± 190 yr BP and 12530 ± 170 yr BP (ref. 16). The relict coral reef off Karaikal (the present study) has yielded an age of 18390 + 220 yr. BP. Although the

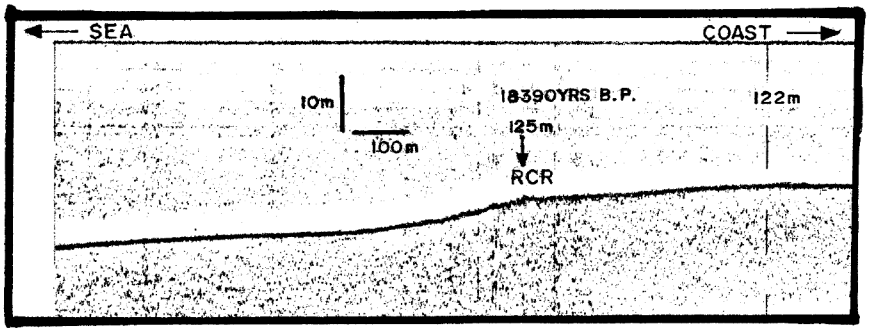

Figure 2. Echo profile (3.5 kHz) showing the relict coral reef (RCR).

above dates are from widely spaced geographic locations, a tentative rate of sea-level rise was deduced from the maximum age of 18,390 years (off Karaikal from –120 m depth) and the minimum age of 10,790 years (off Visakhapatnam from –85 m depth). It is inferred that in the eastern continental shelf of India, the sea-level rose at the rate of 4.61 m/kyr since the LGM until about 11,000 yr BP (Younger Dryas).

Earlier studies suggested that sea-level fluctuations all along the east coast of India have been caused by a combined effect of neotectonic movements and glacio-eustatic sea-level changes. As the age and LGM (–120 m) level off Karaikal support other reports world-wide[22–25], it is envisaged that the continental shelf off Karaikal did not undergo any significant vertical movement after the LGM period.

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