

Macrofaunal diversity in the Central Indian Ocean Basin

S. Pavithran*, B. Ingole, M. Nanajkar and B.N. Nath

Abstract. The deep-sea is characterized by four stable physical variables: hydrostatic pressure, temperature, salinity and oxygen. This harsh environment is comprised of diverse benthic faunal groups. Presently these organisms are at threat due to the increasing interest of mankind in the non-living resources and destructive deep-sea fishing practices present in these areas. The polymetallic nodule is one such resource, looked upon as an alternative to land-based minerals. The Central Indian Ocean Basin (CIOB) abyss is densely covered with these nodules. Commercial mining can cause danger to the species present, some of which may be as yet unknown to science. The deep-sea fauna in the CIOB is the least studied among the three oceans, hence, the aim of the current work is to investigate the composition and feeding patterns of the macrofauna in the CIOB. A total of 27 species were obtained in the current study with a dominance of polychaetes. The CIOB was composed of deposit feeding macrofauna, this is supported by the positive correlation between fauna and sediment organic carbon ($p < 0.05$). Compared to the other oceans, the density of macrofauna is low in CIOB, since it is sustained by low surface primary productivity.

HUMAN INTEREST IN THE DEEP-SEA

Due to the depletion of land resources, mankind is looking towards the ocean as an alternative resource. Even though the commercial utilization of deep-sea biota started in the 1970's, the present economic development suggests that deep-sea minerals may not be mined profitably for at least another 20 years.

The non-living resources of the deep ocean floor are increasingly being turned to as an alternative to land-based resources. For example, offshore oil and gas reserves now constitute a major portion of overall energy sources (IEA 1996); increasing demand for metals has turned global attention towards the deep-sea polymetallic nodules.

Nodules occur in all oceans, including the Indian Ocean where one of the highest nodule concentrations is in the Central Indian Basin. Manganese nodules, with up to 24 weight percent (wt%) manganese, 2.17 wt% of combined nickel and copper and 0.14 wt% cobalt, are found in an area in the Central Indian Ocean that extends from 10°S to 16°30'S and 72°E to 80°E (Jauhari and Pattan 2000; Mukhopadhyay *et al.* 2002; Prasad 2007). This area is identified as the Indian Ocean Nodule field, which has an average nodule abundance of $\approx 4.5 \text{ kg m}^{-2}$.

Although the economic feasibility of deep-sea mining at present remains doubtful due to low metal prices and expensive mining technology, it could be a reality in future.

In addition to the polymetallic nodules, the abyss is also known to harbor diverse faunal assemblages. The high diversity of most deep-sea communities is well known (Gage 1996). These animals are adapted to high pressure, low temperature, stable oxygen and salinity conditions. Any mining activities in the deep-sea are expected to disturb and introduce a new set of environmental conditions to the benthic communities of the oceanic basin (Nath and Sharma 2000).

Efforts to evolve methods for conserving the environment have lead to more than a few investigations on the effect of polymetallic nodule mining, such as the DISCOL experiment (The disturbance and re-colonisation; Schriever *et al.* 1997); NOAA-BIE (National Oceanic and Atmospheric

Administration - benthic impact experiment; Trueblood *et al.* 1997); JET (Japan's deep-sea impact experiment; Shirayama 1999); IOM-BIE (Interoceanmetal - benthic impact experiment; Radziejewska and Modlitba 1999) and INDEX (Indian deep-sea environment experiment; Ingole *et al.* 2005 and references therein). These studies have shown that any disturbance in the deep-sea will hamper the abyssal benthic communities, both on a short term as well as long term basis and recolonization may take a several decades.

Benthos is the collective term used for organisms inhabiting the seabed. The benthos is usually categorized arbitrarily according to the mesh sizes used in sieving. Macrobenthos consists of those organisms, which are retained on a 500 μm (0.5 mm) mesh sieve (Holme and McIntyre 1971). Deep-sea benthos tends to be much smaller than its shallow water counterparts, so the sieve mesh sizes used to separate deep-sea macrofauna often varies between 500 μm to 250 μm . The basic food for deep-sea macrofauna is the phytodetritus supplied by the euphotic zone. Only 1-3% of the surface production is known to reach the abyss. Thus their abundance in the deep-sea is limited by availability of food. They can easily be sampled with the aid of grabs and box corer.

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Figure 1.
The Russian Vessel A.A
Sidorenko, was taken on
wet lease from the State
Geological Enterprise
Yuzhmoregeologiya
under the Ministry of
Natural Resources of
the Russian Federation
from July 1999 by the
Department of Ocean
Development, India.



The benthic fauna are known to play a diverse role in the deep-sea: (1) Benthic grazing has proven to be an important factor in balancing the carbon budget in shallow ecosystems. In the deep-sea, where food input tends to be episodic or seasonal, there is evidence that some infaunal organisms “cache” food below the sediment-water interface (Jumars *et al.* 1990). Some organisms, for example malpuganid polychaetes, transfer organic matter below the redox boundary through storage of food in their burrows (Levin *et al.* 1997). (2) Sediment-dwelling organisms also influence the mixing of organic and inorganic matter in the upper sediments through bioturbation. By keeping the upper sediments well oxygenated, bioturbation has a direct impact on chemical transformations within the sediments. Bioturbation may also change sediment surface topography and the pits and mounds created by benthic fauna can impact where particles are likely to collect on the seafloor (Yager *et al.* 1993). Individual deep-sea animals mix the sediment at about the same rate as shallow-water animals, suggesting that movement rates and metabolic rates of infauna may not be too dissimilar to such rates in shallow water (Thistle 2003). (3) Macrofauna is known to control the concentration and accretion of metals in the deep-sea. Polychaetes associated with manganese crusts feed on agglutinating foraminifera and

concentrate the inorganic components of the prey. Studies have shown that foraminiferan stercomata have been found in the guts of small polychaetes living on manganese crusts (Riemann 1983). These worms may thus be responsible for a further concentration of metal oxides collected by their prey and subsequent deposition on manganese crusts. Thus, the benthic polychaete indirectly helps in the nodule growth.

However, some problems chronically plague deep-sea research. Foremost among these is that the data on deep-sea species are limited because of an inability to sample them freely. Collecting deep-sea animals is time consuming and expensive (Menzies *et al.* 1973). Researchers are thus forced to work with limited numbers of small samples, all too often taken in intervals of time and space that are inappropriate for answering evolutionary questions. For example, a major monograph on deep-sea isopods was based on only 97 specimens collected at widely separated localities around the globe (Wolff 1962). According to Rowe and Sibuet (1983) unfavorable nature of our own environment - high and variable temperature, low pressure - is also a major obstacle in the understanding of the behavior and ecology of deep-sea animals. Many deep-sea systematists have never seen specimens of their specialty group in their

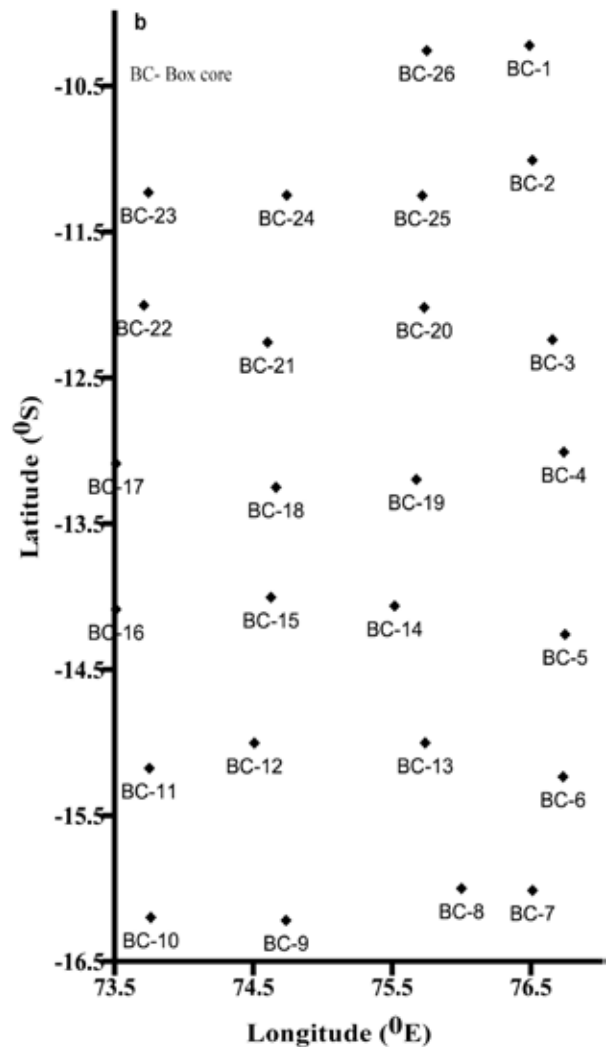
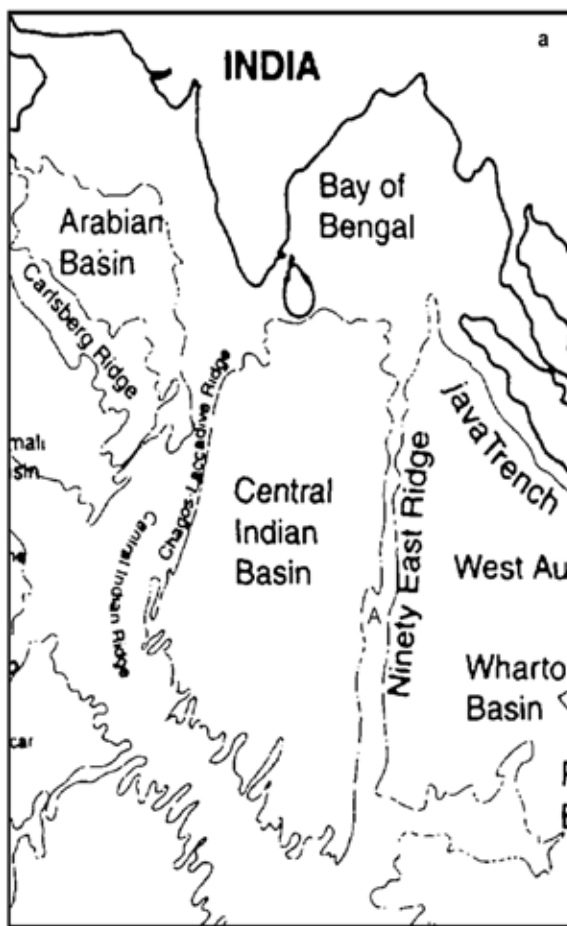
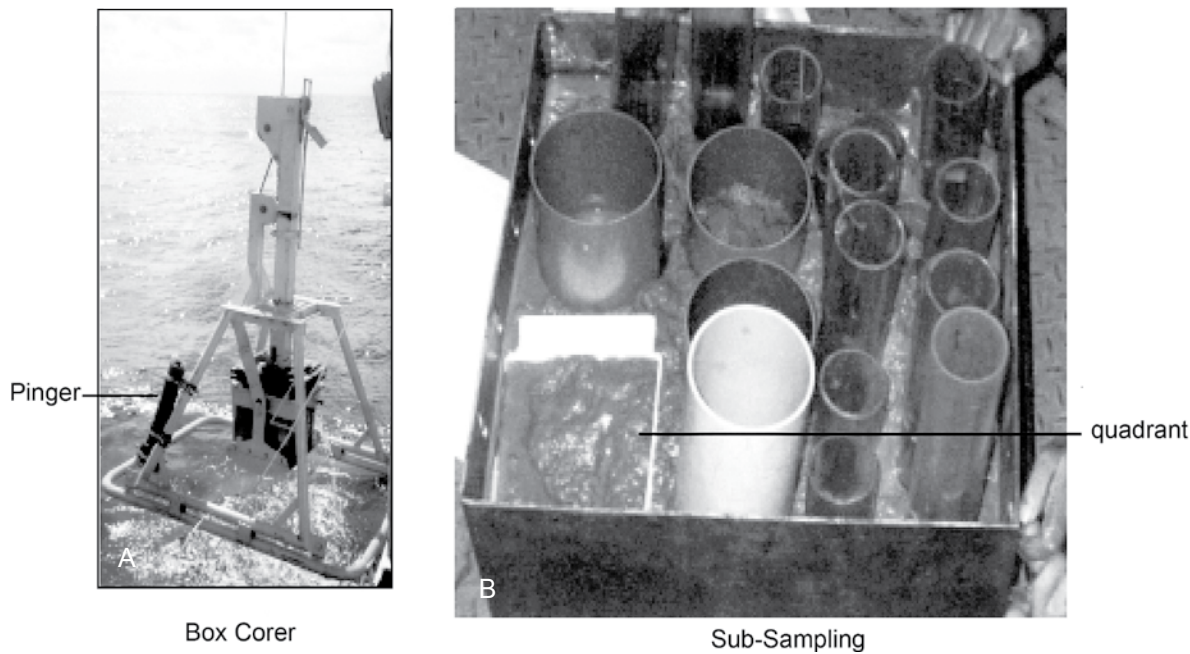


Figure 2. Location of the study area and sampling stations. (Source: Ingole and Koslow 2005)



Figures 3. A, Box corer: sampler with the pinger; B, Sub-sampling using a quadrant.

natural habitats, except for an occasional rare photograph, assuming the animals are large enough. Due to the variation in pressure in the natural environment and on board ship, the soft-bodied organisms (polychaetes, oligochaetes etc.) are usually damaged or in bad condition by the time they reach the systematists. Also due to the low density of the deep-sea organisms, usually only one or very few representatives of a particular species are obtained in the samples. This poses a major difficulty for identification of the organisms to the species level.

IMPORTANCE OF THE STUDY

Considering the fact that the Indian Ocean is the least studied as compared to the Atlantic and Pacific Ocean in terms of deep-sea benthic biology and taxonomy, the present study was undertaken in the CIOB, under the INDEX program. Study of macrofauna in the Indian Ocean is confined to group level (Ingole *et al.* 2005 and references therein). This is the first study, which attempts to identify macrofauna up to the family/genus/species level in the Central Indian Ocean. This documentation of the deep-sea biodiversity will be useful in understanding the global species distribution and their role in different habitat. In addition, the present study will provide baseline data on macobenthic biodiversity in the abyssal Indian Ocean.

The samples for the present study were collected onboard R.V. *Akademic Alaxender Sidorenko* (AAS-61) in the Central Indian Ocean Basin (CIOB) (Fig. 2A). Sampling was carried out at one degree spacing between latitude 10° and 16° S and longitudes 73.5° and 76.5° E (Fig. 2B). total of 26 stations were sampled to study the macrofauna.

Sediment samples were collected with a 0.25 m² spade box corer (50X50X50 cm size). All the box core operations were carried with a pinger to precisely monitor the descent of

sampler (Fig. 3A). The subsamples for macrofauna were taken with the help of a quadrant (15X15X10 cm, 3 subsamples for each station; Fig. 3B). All the sub-samples were preserved in neutralized 5% formalin-Rose bengal solution prepared in filtered seawater. These samples were later sieved using 500µ stainless steel sieves; the organisms retained on the sieves were collected and sorted group-wise. Sediment organic carbon estimation was carried out using wet oxidation method (El Wakeel and Riley 1957). A precision of 0.01% is routinely obtained in our laboratory (Nath *et al.* 1997)

FAUNAL COMPOSITION AND ABUNDANCE IN THE CIOB

The total density of macrofauna ranged between 0-67 no.m⁻² in the CIOB, with a mean density of 30±21sd, n=26. A total of 12 taxa were obtained from the 78 sub-samples taken from 26 locations. Polychaetes were the most diverse group comprising 11 species, followed by 5 species of nematode, 3 species of Tanaidacea, 2 species of isopoda and one species each of Halacarida, Harpacticoida, Veneroida (bivalves), Amphipoda, Archaeogastropoda (gastropod), hexactinellida (glass sponge), Thoracica (cyprid larvae) and unidentified larval forms. Kruskal Wallis ANOVA showed a significant difference in species density between the stations (H=487.3, p<0.0001, n=702).

Polychaetes were the highest contributor to the total macrofaunal density (40%; 12 no m⁻²) followed by Nematoda (15%; 5 no m⁻²). The other dominant groups were the Isopoda (11%), Tanaidacea (10%), Halacaridae (4%) and Archaeogastropoda (2%). While Harpacticoida, Veneroida, Amphipoda, Hexactinellida, Thoracica and unidentified larval form comprised of 3% each of the total fauna.

Among the 11 polychaete species, unidentified polychaetes belonging to family Ampharetidae (27%) was the most

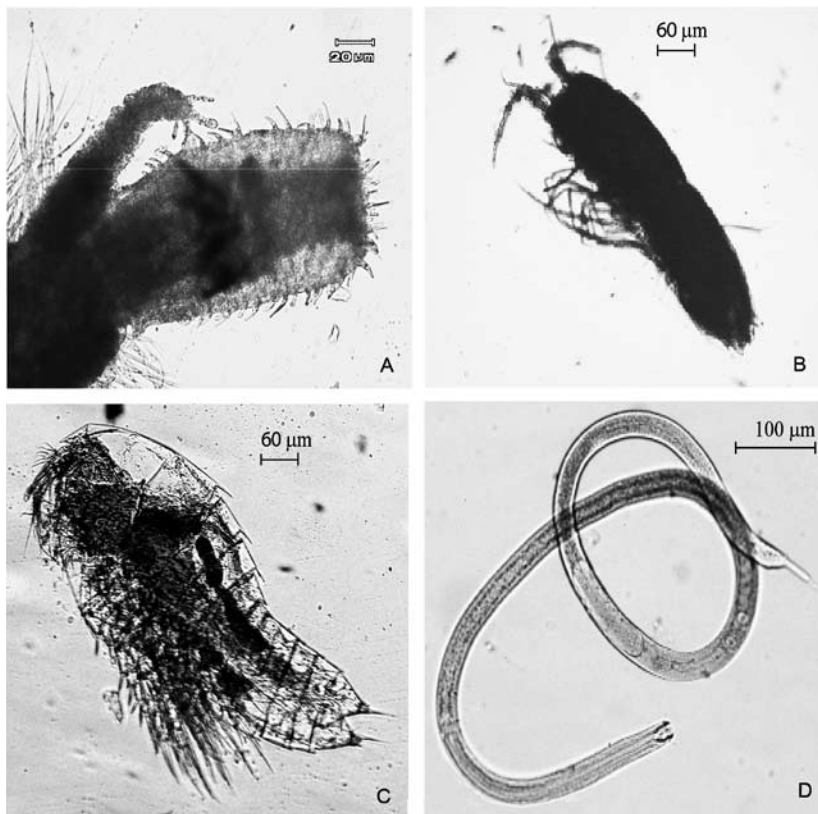


Figure 4. Representatives of macrofauna in the CIOB: A, *Glycera* sp.; B, *Haploniscus* sp.; C, *Parameiropsis* sp.; D, *Adoncholaimus* sp.

dominant, followed by another unidentified species belonging to Ariciidae (14%) and *Brada* sp., (12%). *Flabelligera* sp., *Glycera* sp., (Fig. 4A), *Euphrosine myrtosa* and unidentified Eunicidae and Maldanidae constituted 7% each to the total polychaete community. While *Exogone* sp., and unidentified Sabellidae and Spionidae constituted 4% each to the total polychaetes. Most of the members belonging to amphaterids are surface deposit feeders (Fauchald and Jumars 1979) and known to dominate the deep-sea macrofauna (Wilson and Hessler 1987). Furthermore, these polychaete families are well represented bathyally where food is scarce (Hessler and Jumars 1974). Thus, their dominance in the abyss of CIOB which is sustained by low surface primary productivity (Matondkar *et al.* 2005) is not surprising. The surface deposit feeders constituted 71.4% of the polychaetes while, the carnivorous and the subsurface deposit feeders constituted 14.3% each (Figure 5A). On morphological grounds, it is postulated that the carnivorous habit is the primary feeding mode among the *Glycera* sp., and that an unknown, probably small number of species have become detritivores. It is further suggested that, bathyal and abyssal glycerids can use both modes (Fauchald and Jumars 1979) and hence were capable of adapting to the less productive CIOB for their survival. The Euphrosinidae (*Euphrosine myrtosa*) are also carnivorous in nature and in the deep-sea their major diet is known to be foraminiferans. The surface deposit feeding stratagem of deep-sea *Flabelligera* sp., *Brada* sp., Sabellidae family and Eunicidae were investigated and documented by Fauchald and Jumars (1979) and Thistle (1979). These surface deposit feeders also contributed

substantially to the polychaetes composition in the CIOB. The subsurface deposit feeding nature of Maldanidae family (*Axiothella* sp. and *Maldane* sp.) was confirmed by Fauchald and Jumars (1979). Studies of some smaller macrofauna have revealed a response where the organism, by means of a relatively simple change in behavior, may change to feeding on suspended particles rather than on particles lying on the sediment surface. These interface feeders can switch to suspension feeding, depending on flow energy, by a simple re-orientation of feeding appendages into the overlying water (Dauer *et al.* 1981).

Even though, nematodes are normally considered a meiobenthic taxa, the large sized (>0.5 mm) nematodes were retained on the macrobenthic mesh sieve (0.5 mm) and hence were considered in macrofauna. *Leptosomatium* sp., was the dominant among identified nematodes (24%), followed by *Trileptium* sp., (19%), *Viscosia* sp., (19%), *Adoncholaimus* sp., (19%; Fig. 4D), and unidentified nematodes (19%). The feeding type categorization is based on the basis of shallow water feeding strategies described by Wieser (1953) and Tietjen and Lee (1977). In the present study, 60% of the nematodes were predatory omnivores; the remaining 40% belonged to the selective deposit feeders (Figure 5A). The most dominant predatory omnivores were *Viscosia* sp., followed by *Adoncholaimus* sp. and *Trileptium* sp. While, *Leptosomatium* sp., was the most dominant selective deposit feeders. Due to the low density and extreme living conditions, the predator-prey encounter in the deep-sea will be very less compared to the coastal environment; hence, the feeding strategy might vary in the deep-sea. It also depends on the strike rate of the predator and their success in predation (Moens *et al.* 1999, 2000). The deep-sea fauna are known to change their feeding preference due to low food availability. It has been demonstrated elsewhere that, oncholaimid nematodes preferentially feed in organically enriched microhabitats, probably utilizing a mix of particulate and dissolved compounds, and that predation is merely a facultative strategy (Moens *et al.* 1999).

The other dominant faunal groups constituted 45% to the total faunal density. Among the 3 species of Tanaidacea, *Leptognathia* sp., constituted 11% to the other macrofaunal groups, and 6% each was represented by *Apeudes* sp. and *Collettea* sp. The two species of Isopoda, *Macrostylis* sp., and *Haploniscus* sp., (Figure 4B), contributed 14% each to the other macrofauna in the present study. While, 9% contribution was by Halacaridae, followed by *Anatoma* sp.? (4%). Amphipoda, *Parameiropsis* sp., (Figure 4C; Harpacticoida), *Thyasira* sp., (Veneroida), unidentified species of hexactinellida, Thoracica and unidentified larval form contributed 6% each to the other dominant macrofauna. Though, the knowledge about the biology of these deep-sea species is limited, similar stratagem (deposit feeding) might be adapted by them due to the limited organic matter availability, which result in their survival in the deep-sea.

Comparison of macrofaunal abundance between the sampling station revealed that faunal density was positively correlated

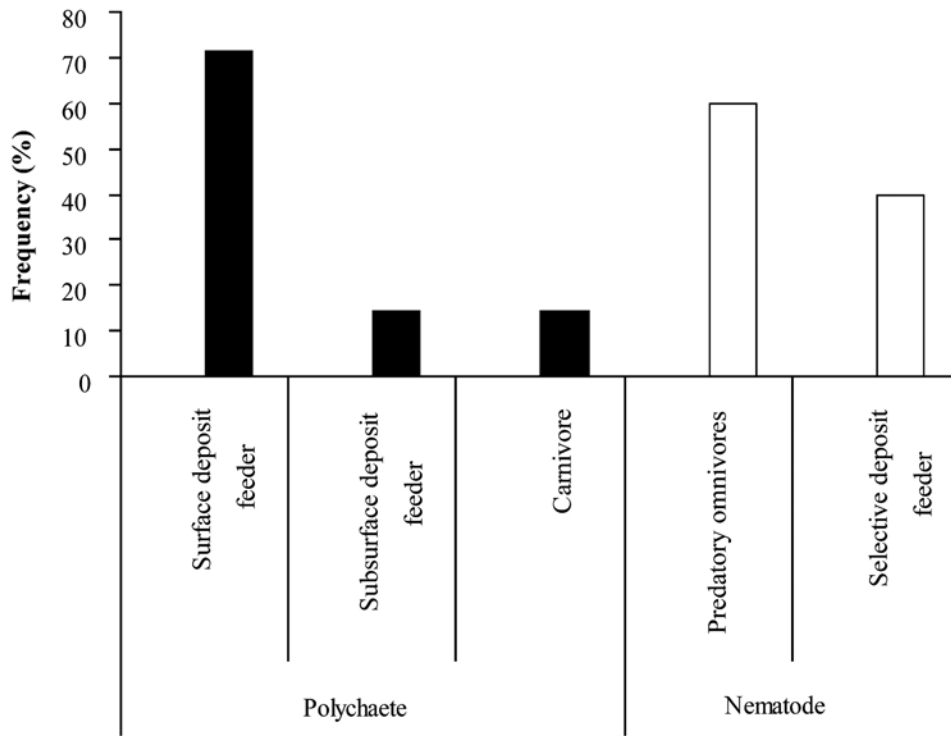


Figure 5A. Composition (%) of polychaetes and nematodes based on feeding pattern.

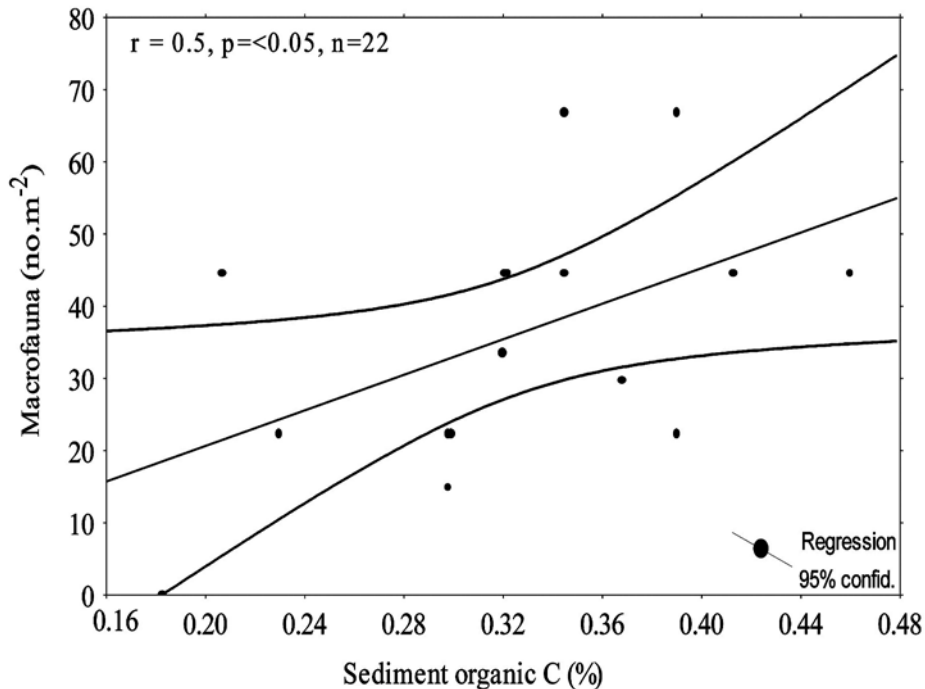


Figure 5B. Relationship between sediment organic carbon and macrofauna during March 2003.

with organic carbon content ($p < 0.05$; Figure 5B), suggesting that the density of macrofauna augments with increase sediment organic carbon. The present study reports a mean organic carbon value of 0.2%. The low organic content in the CIOB is attributed to a well-oxidized environment (Nath and Mudholkar 1989) and low sediment accumulation rates (Pattan *et al.* 2005) that allow more remineralization at the

sediment water interface. The low organic content in the CIOB indicates a well-oxidized environment. Such a situation may be possible due to the influx of Antarctic Bottom Water (AABW) into the Central Indian Basin through the saddle at around 5°S along the Ninety East Ridge (Warren 1982). The AABW enriched in the dissolved oxygen helps the organic carbon to get oxidized (Nath and Mudholkar 1989).

CONCLUSION

The abyss of world oceans harbors a diverse community of macrofauna. The current study reported a total of 27 species, with highest density and diversity obtained by the polychaetes in the CIOB. These organisms are dependent on the surface primary production for their food. Exploitation of the manganese nodules in the future would be a threat to these deep-sea benthic communities and is likely to affect tens to hundreds of thousands of square kilometers. The ecosystem recovery may require decades to millions of years (e.g., for nodule re-growth) and may cause the loss of less known deep-sea species. It may possibly lead to the extinction of some rare species as well as species still unknown to science. Our limited knowledge of the taxonomy, species structure, biogeography and basic natural history of deep-sea animals prevents accurate assessment of the risk of species extinctions from large-scale mining and other human threats. Hence there is a vital need to study these little known abyss organisms.

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