

Deep sea benthos of the Western and Central Indian Ocean

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Abstract - Quantitative investigations on deep sea benthos from 112 stations between latitude 21°N - 21°S and longitude 51°E - 94°E and in the depth range of 1500 to 6000 m, revealed a rich biota having relatively low species diversity in the western and the central Indian Ocean. Mean population density varied from 233322 m^{-2} in 1500-1999 m depth zone to 50269 m^{-2} in 5500-5999 m depth zone. Both macro- and meiobenthos decreased in abundance with increasing water depth. The rate of decrease in faunal abundance as assessed from regression coefficient was high in deeper depths and low in relatively shallow depths.

The benthic biomass was uniformly high (0.11 - 12.75 g m^{-2}) with highest mean biomass of 5.92 g m^{-2} in $< 2000\text{ m}$ depth and lowest of 0.12 g m^{-2} in $> 5500\text{ m}$ depth. The rate of decrease in biomass differ significantly with increasing water depth, macrofauna dominating in shallower depths and meiofauna dominating in deeper waters. Diverse but rich benthic fauna and high values of standing crop are dependent on high organic production in the overlying water column of the western and the central Indian Ocean. Correlation between biomass of organic matter in the water column and the benthic standing crop was statistically significant.

INTRODUCTION

Until recently quantitative studies on deep sea benthic fauna from Indian Ocean were few and were based on few samples collected from very wide area. THIEL (1966) has reported the meiobenthic fauna from the Somali coast. Other studies include those of NEYMAN *et al* (1973), SOKOLOVA and PASTERNAK (1964) and PARULEKAR *et al*, (1982).

As a part of the continuing study on deep sea biology, the density and biomass macrobenthos and meiobenthos were recorded from an extensive bathyal and abyssal region in the central and western Indian Ocean and the Andaman Sea. The purpose of this investigation is to compare the quantitative abundance of the two size classes of benthos from different sedimentary zones and at different depths in the relatively unexplored region of the Indian Ocean.

MATERIALS AND METHODS

Samples were collected from 112 stations in the central and western Indian Ocean and the Andaman Sea between $20^{\circ}15'\text{N}$ and $20^{\circ}12'\text{S}$ and 51° and 94°E (Fig.1) in the depth range of 1500 to 6000 m.

Four benthic samplers such as van Veen grab (0.7 m^2), Peterson grab (0.1 m^2), Box corer ($50\text{ X }50\text{cm}$), and a Spade corer were used. In spite of the difference in sampling methods, uniformity was maintained while taking the subsamples. The meiofauna were subsampled by plexiglass hand core (4.5 cm inner dia) from relatively undisturbed sediment. The core samples were divided into 2 cm sections and preserved in 4% neutralized Formaline - Rose Bengal solution. The animals in the sediment were separated using $500\text{ }\mu\text{m}$ and $63\text{ }\mu\text{m}$ sieves.

Macrofaunal subsamples were taken using a plexiglass quadrant (170 cm^2). Macrofauna were defined as those animals which were retained on a $500\text{ }\mu\text{m}$ screen. All

meio and macrofauna were identified to taxon level wherever possible. While the density was determined from counts of the individuals, wet weight was determined on a single pan Sartorius balance (0.001 mg accuracy) after blotting excess water. From each sediment sample, a small aliquot of sediment was used for analysis of particle size and organic carbon.

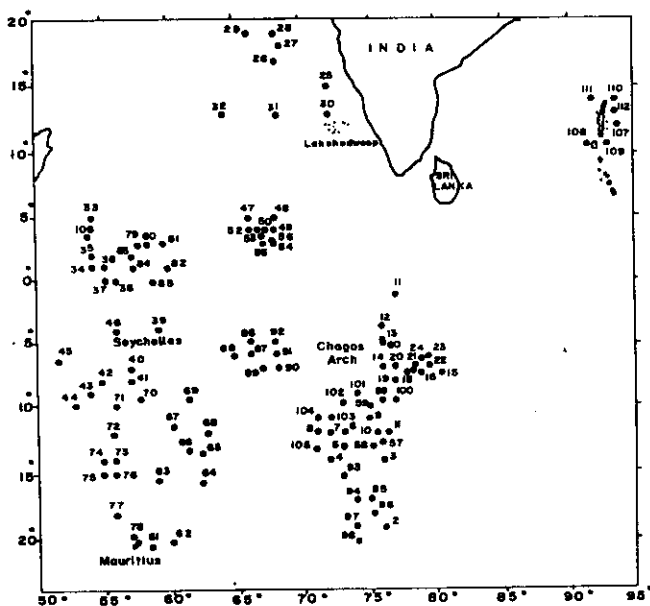


Fig.1. Positions of stations during the present study.

RESULTS AND DISCUSSIONS

Faunal density and biomass

Six meiofaunal and twelve macrofaunal taxa were recorded, with mean population density varying from 233322 m^{-2} in the 1500-1999 m depth zone to 50269 m^{-1} in the 5500-5999 m depth zone (Table.1). As shown in Table 2 and 3, nematodes accounted for about 53.3% of the total number of meiofaunal organisms. Foraminiferans (17.6%) and harpacticoids (16.8%) were the other important meiofaunal taxa besides ostracods, turbellarians and kinorhynchs. Amongst, the twelve macrofaunal taxa, polychaetes were the most important group with 100% prevalence and accounted for 63.9%. Isopods and polychaetes and nematodes, harpacticoids and foraminiferans were distributed at all the depths. Among crustaceans, isopods occurred more frequently than either amphipods or tanaidaceans.

The density of the agglutinating rhizopod protozoans (which were encountered in a number of samples) could not be ascertained due to their composite structure and unavoidable fragmentation and were recorded whenever present (SHIRAYAMA, 1983). However, they are accounted in the biomass estimates. Such rhizopod masses have earlier been reported from the northern and western Pacific (THIEL, 1983; SHIRAYAMA, 1983) and some parts of the central Indian Ocean (PARULEKAR *et al*, 1982).

A rich and varied fauna was associated with polymetallic nodules. As assessed from regression coefficients both for the macrofauna (Fig.3, $Y=2.776-0.00018X$, $r=-0.968$, $n=112$) and meiofauna (Fig.4, $Y = 5.608-0.00015X$, $r=-0.936$, $n=112$) density decreased steadily with increase in depth. Occurrence of macro to meiofauna in the total benthic population was in the ratio of 1:324-660 (mean:1:467). Contribution of macrofauna and meiofauna to the total standing crop exhibited a reciprocal relationship with macrofauna contributing more than 60% in relatively shallow depths and meiofauna largely contributing to biomass in deeper waters. Thus with increasing water depth, the role of meiobenthos becomes more important than that of macrobenthos.

Table 1. Benthic fauna - population density and biomass at different depths in the Western and Central Indian Ocean. Values in parenthesis are mean of the total number of observations.

Depth (m)	Number of observations	Population density (No. m ⁻²)	Biomass (g m ⁻²)
1500-1999	5	183100-452750 (233322)	2.85-12.75 (5.92)
2000-2499	6	112554-200650 (168651)	0.66-3.65 (2.65)
2500-2999	4	100765-111460 (105657)	0.41-2.46 (1.92)
3000-3499	6	102320-103970 (102715)	0.39-2.19 (1.05)
3500-3999	13	98300-102900 (99083)	0.24-1.92 (0.74)
4000-4499	21	82758-102680 (88995)	0.22-0.76 (0.55)
4500-4999	24	60920-88280 (71477)	0.15-0.35 (0.25)
5000-5499	28	45970-66285 (54713)	0.11-0.38 (0.19)
5500-5999	5	44150-56120 (50269)	0.11-0.13 (0.12)

Table 2. Population density of macro and meiofauna with mean values in parenthesis at different depths in the Western and Central Indian Ocean.

Depth (m)	Macrofauna (No. m ⁻²)	Meiofauna (No. m ⁻²)
1500-1999	215-492 (410)	182885-452258 (232912)
2000-2499	198-505 (462)	112356-200145 (168189)
2500-2999	177-405 (325)	100588-111055 (105332)
3000-3499	134-365 (205)	102186-103605 (102510)
3500-3999	105-289 (182)	98195-102602 (98903)
4000-4499	112-235 (192)	82646-102445 (88703)
4500-4999	77-172 (108)	60843-88108 (71369)
5000-5499	72-155 (105)	45898-66130 (54608)
5500-5999	65-122 (92)	44085-55998 (50177)

Table 3. Depth-wise percentage faunal composition of macro and meiofauna.

Faunal group	1500-1999	2000-2499	2500-2999	3000-3499	3500-3999	4000-4499	4500-4999	5000-5499	5500-5999
MACROFAUNA									
Polychaeta	57.2	68.6	56.2	62.2	71.0	62.5	92.2	43.4	82.2
Echiuroidea	-	1.8	-	5.4	-	10.8	-	-	-
Sipunculida	2.2	-	2.8	2.2	-	-	-	2.2	-
Cumacea	1.8	2.3	-	-	5.2	2.2	-	3.8	-
Amphipoda	12.3	8.2	6.6	10.6	9.6	6.5	-	-	6.4
Tanaidacea	8.6	4.9	2.8	-	-	4.4	-	6.4	-
Isopoda	4.9	5.2	4.3	16.4	3.2	6.5	5.2	18.6	4.4
Pelecyropoda	9.4	6.2	12.5	3.2	5.2	-	-	-	-
Gastropoda	-	0.6	8.2	-	-	6.5	-	7.2	-
Ophiuroidea	1.6	2.2	4.3	-	3.2	-	-	18.1	2.6
Brachiopoda	2.0	-	2.3	-	2.6	0.6	2.6	-	4.4
Rhizopoda	-	*	-	*	*	-	*	*	-
MEIOFAUNA									
Nematoda	39.6	42.2	38.9	60.9	58.8	64.8	50.0	55.2	68.5
Harpacticoida	10.6	10.2	22.5	14.4	13.4	8.7	26.4	23.5	22.3
Ostracoda	8.3	12.5	3.6	2.0	16.7	8.7	-	12.8	-
Turbellaria	8.3	10.2	-	4.5	5.5	-	6.8	-	-
Kinorhyncha	-	4.5	3.6	-	-	-	4.2	-	-
Foraminifera	33.2	20.4	31.4	18.2	5.6	17.6	12.4	8.5	9.2

* gelatinous mass difficult to enumerate

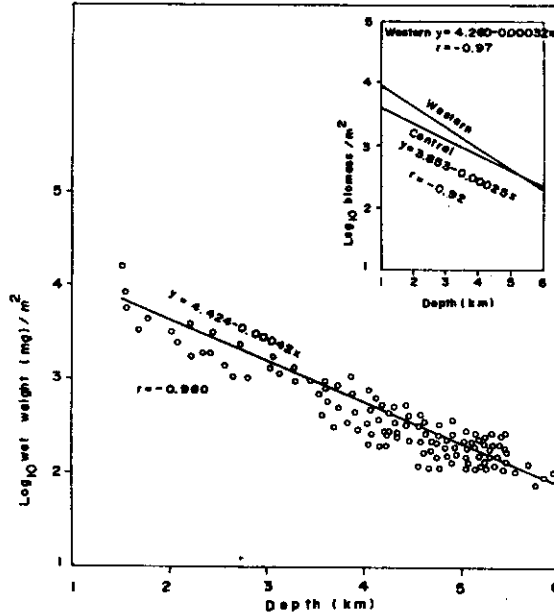


Fig. 2. Regression analysis of biomass (wet weight) to water depth.

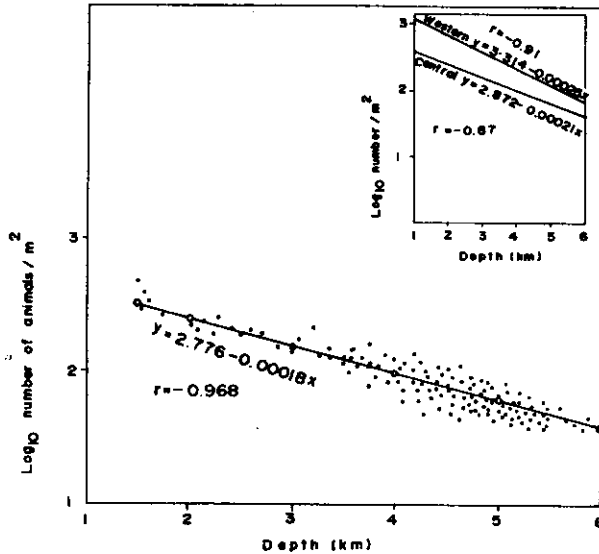


Fig. 3. Regression analysis of macrofauna to water depth.

Benthic Biomass - The benthic biomass varied between 0.11 to 12.75 g m^{-2} with a highest and lowest mean of 5.92 g m^{-2} and 0.12 g m^{-2} calculated for $< 2000 \text{ m}$ and $> 5500 \text{ m}$ depths, respectively. These biomass values were many times higher than previously reported from comparable depths in the Indian ocean (PARULEKAR *et al*, 1982) and were significantly related to the water depths (Fig.2, $Y=4.424-0.00042X$, $r=-0.960$, $n=112$). Variations in the benthic biomass may be due to the changes in sediment texture and water depths (PARULEKAR and ANSARI, 1981).

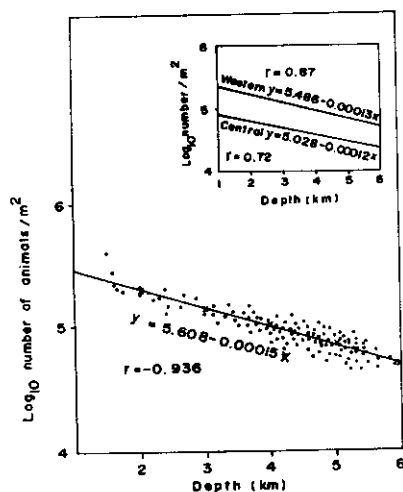


Fig. 4. Regression analysis of meiofauna to water depth.

While discussing the importance of substratum in controlling the abundance of benthic organisms, THOMAS (1970) suggested that the sediment covering coarser bottom has pronounced effect on the benthic biota. SHIRAYAMA (1983) stated that within the size range of meiobenthos, the rate of decrease in biomass with increasing water depth is higher in the case of large-sized individuals than smaller-sized ones. Further, biomass of nematodes decreased with increasing water depths and a decrease in the percentage of smaller sized individuals caused increase in the median size index. THIEL (1975) predicted that size of meiobenthos decreases with increasing water depths. Observing the same tendency in case of macrobenthos, ROWE and MENZEL (1971) reported a more rapid decrease in biomass than in number of individuals with increasing depth as in the present study.

Varied but rich benthic fauna and high biomass values are dependant on high organic production in the overlying water column of the western and central Indian Ocean (PARULEKAR *et al*, 1982; INGOLE *et al*, 1991). The results obtained by several workers in different ocean regions indicate that food availability is the major factor controlling distribution patterns of deep-sea benthos. Detritus and bacteria form the main food for deep-sea benthos (TIETJEN, 1971; TIETJEN, DEWING, ROWE, MACKO and WILKE, 1989). Detritus is produced mainly in the euphotic zone and reaches benthos after passing through the benthopelagic zone. The absolute amount of organic matter reaching seafloor therefore depends on the level of production in the surface water. A clear indication of the effects of surface productivity on benthic biomass has been reported by MANN (1982) and PARULEKAR *et al*, (1982).

Biomass is high at high latitudes than near the equator (ROWE, 1983). If deep-sea biomass is closely related to surface production, why should this happen? The answer probably lies in the reasoning that seasonal spurts of primary productivity are poorly coupled with pelagic consumption at high latitudes thus allowing more organic matter to escape from epipelagic zone without being consumed.

The abundance of benthic fauna varied, noticeably with increasing depths and distance from the shoreline. Food and interstitial space availability are considered to

be the most important environmental factors in controlling the abundance of deep-sea meiobenthic organisms (SHIRAYAMA, 1982). The fauna was more abundant in an area close to land, where nutrient supply is expected not only from the overlying euphotic zone but also from the land mass and inter- and subtidal waters (SHIRAYAMA, 1983). Since the majority of sampling stations were located nearer to the land masses or on the ridges and banks such as, Mauritius Rodrigues Bank, Saya de Mala Bank, Seychelles Mauritius Ridge, Chagos Arch, and Maladweeps Archipelago the rate of decrease of nutrient supply with depth can rightly be considered to be responsible for reduced faunal density in the deeper waters (ROWE, 1971).

Regions of lowest biomass were characterized by macrofaunal abundance of < 100 animals m⁻² that weigh around 0.05 g. Such communities were found on the abyssal plains of the central areas of ocean basins far from shore at depths of 4.5 to 6 km. The low biomass may be a function of low surface production or an efficient utilization of energy by the pelagic biota. However, it needs further authentication, with relevant data on environmental and biological variables both in time and space.

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