

## Macrobenthos of the Shelf Off North Eastern Bay of Bengal

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An extensive survey (76,363 km<sup>2</sup>) of shelf benthos along the north east coast of India revealed that the macrobenthic production is rich and is comparable with that of the west coast. The biomass and population count varied from nil to 150.6 ( $\bar{x} = 10.61 \pm 3.2 \text{ gm}^{-2}$ ) and from nil to 12,572 ( $\bar{x} = 839 \pm 120 \text{ m}^{-2}$ ) respectively. Loose sand sheltered rich fauna whereas muddy substrata had very poor fauna. Twenty nine major taxa were identified. Polychaeta formed the dominant group followed by Bivalvia and Amphipoda. These 3 groups together formed 87.55% of the total faunal distribution. Most of the benthic fauna showed contagious distribution with high percentage of faunal similarity. The number of faunal taxa decreased with increasing depth. It is postulated on the basis of macrobenthic production that the demersal fish catch could be doubled against the present exploitation without causing any over-exploitation.

Benthic studies along the shelf region of the east coast are rather few<sup>1-5</sup>. An extensive survey of the shelf off Andhra Pradesh, Orissa and West Bengal has been carried out during the 76 and 77 cruises of *R V Gaveshani* in June 1980. The data presented here deal with the macro fauna-distribution, faunal similarity, dispersion, population density and standing crop in relation to substratum and depth and an evaluation of potential demersal fishery resources. Such studies help in the assessment of demersal fishery resources and water quality<sup>6,7</sup>.

### Materials and Methods

The area surveyed lies between 15°45' and 21°6'2" N lat. and 81°12'5", 88°11'2" E long. and covers an area of about 76,363 km<sup>2</sup> within the depth range of 18 to 230 m. A total number of 150 stations were sampled (Fig. 1) using a 0.18 m<sup>2</sup> Peterson Oken 70 grab and subsequent analyses were carried out by the method reported earlier<sup>8</sup>. The biomass represented wet weights excluding hard parts. Visual observations were made on the nature of sediments and these were confirmed by rapid partial analysis method in the laboratory as described by Holme and McIntyre<sup>9</sup>. Depths were confirmed from echographs.

### Results and Discussion

**Sediment distribution**—Observations revealed the occurrence of 6 main types of substrata having varied percentage of shell fragments, sand, silt and clay. Clay substrata were observed at 80 stations (Table 1). Such deposits were prevalent in the vicinity of river mouths of Godavari, Mahanadi, Hooghly and also along the outer shelf. Loose sand was observed in the nearshore areas. At few stations, bottom deposits were mainly sandy with an admixture of silt and clay.

**Faunal composition**—Polychaeta were dominant (68.52%) followed by mollusca (11.77%), crustacea

(10.23%), nematoda (2.02%), echinodermata (1.03%) and other groups (5.42%). Twenty nine taxa were identified and their composition is given in Table 1. Polychaeta were represented by the genera: *Eunice*, *Nephtys*, *Amphrodita*, *Glycera*, *Terebella*, *Sabellaria*, *Marphysa*, *Paranereis*, *Pseudonereis*, *Nereis*, *Owenia* and *Diapatra*. Mollusca were represented mainly by bivalvia such as *Cardium*, *Macra*, *Pholas*, *Pecten*, *Solen*, *Arca*, *Perna* and *Donax*. Gastropoda were typified by *Natica*, *Bursa*, *Conus Oliva* and *Nerita* whereas *Chiton* and *Dentalium* represented Polyplacophora and the Scaphopoda respectively. Among the Decapoda, brachyuran crabs were represented by *Leucosia*, *Xenopthalmus*, *Charybdis* and *Lepidopas*. Other decapoda included Penaeidea such as *Penaeus*, *Metapenaeus*, *Mysis*, *Acetes*, *Lucifer* and *Alpheidea* belonging to the genus *Alpheus*. Euphausiacea were also observed. Amphipoda was represented by *Ampelisca* sp. *Urothoe* sp. belonged to the sub-order Hyperiididae, *Eriopsis* sp. and *Macra* sp. falling under the sub-order Gammaridae. Pericarida was represented by cumacean shrimps (Cumacea) and tanids (Tanaidacea). Hoplocaridae was represented by the Stomatopoda, *Squilla* sp. Macrobenthic nematoda and turbellaria were the representatives of Aschelminthes and Platyhelminthes, respectively. Brittle stars (*Ophiothrix* sp.) and sea cucumbers (*Holothuria* sp. and *Actinopyga* sp.) represented Echinodermata. Other groups included Nemertinea (Nemerteans), Entoprocta (Entoproct-bryozoans), Sipuncula (*Dendrostomum* sp.), Echiurida (*Ochestoma* sp.). Cephalochordata was represented by the amphioxus *Branchiostoma lanceolatum*. Vertebrates were exemplified by the juveniles of thread fin fish, *Polyneus heptadoctylus* Cuvier.

**Faunal distribution**—Percentage composition and prevalence of different groups are given in Table 1.

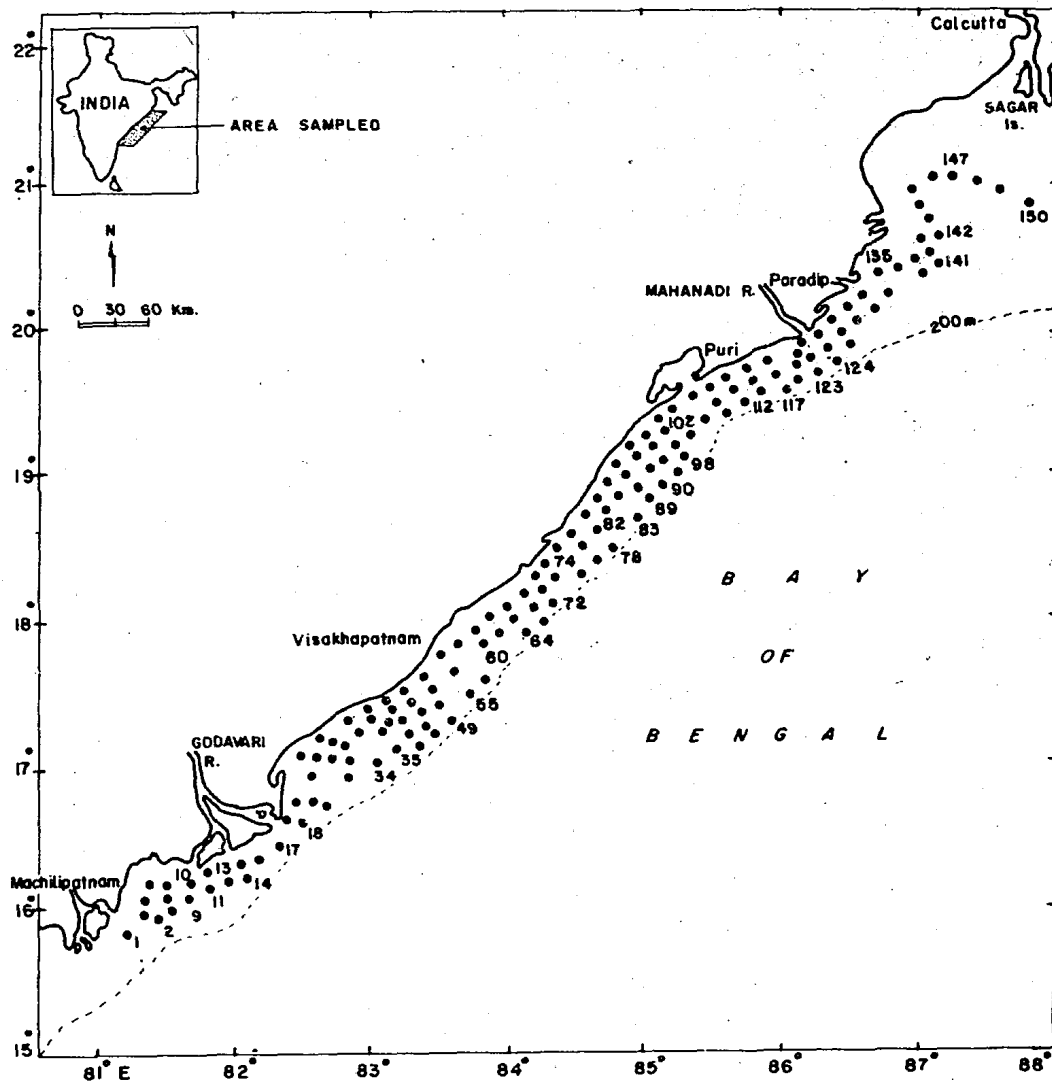


Fig. 1—Station positions

High or low values indicate the magnitude of distributional variations. Accordingly, Polychaeta showed wide distribution whereas Polyplacophora, Scaphopoda, Stomatopoda and Holothuria showed very rare occurrence. The faunal groups present at only 1 station were Polyplacophora (st 99), Stomatopoda (st 102), Holothuroidea (st 146) and Scaphopoda (st 75); those occurring at 2 stations were Porifera (sts 143 & 146), Turbellaria (sts 99 & 101), Cephalochordata (sts 75 & 108), and those observed at 3 stations were Nemertea (sts 146, 135 & 110), Sipuncula (sts 94, 108 & 109), Echiurida (sts 42, 109 & 136) and Penaeidea (sts 48, 111 & 143). Other groups were present at 4 or more stations.

*Faunal distribution in relation to depth*—Distribution of different faunal groups in relation to depths showed striking difference (Table 2). The number of faunal elements decreased with increase in

depth, with nearshore regions harbouring more diverse fauna. Polychaeta and Bivalvia were observed at almost all the depths but were dominant at depths ranging from 20 to 40 m and 80 to 100 m, respectively. Porifera, Scaphopoda, Stomatopoda, Ostracoda, Gammaridea, Holothuroidea, Cephalochordata and juvenile fish were observed only in the 20 to 40 m depth zone whereas Polyplacophora was observed only in 100-120 m depth zone. Juvenile fish, apart from occurring at depths over 180 m, also occurred at 20 to 40 m zone.

*Faunal distribution in relation to sediment*—Table 1 reveals the abundance of different faunal groups in relation to the type of sediment. Polychaeta dominated silty sand while Bivalvia the sandy clay. Nematoda, brachyuran crabs, sipunculid worms, Anthozoa and Cephalochordata showed preference to sandy substratum and alpheidea and Ophiuroidea to silty

Table 1—Sediment-wise Faunal Abundance\* ( $m^{-2}$ ), Total Faunal Composition, Prevalence and Index of Dispersion of Each Faunal Group

	Sand	Sandy clay	Clayey sand	Silty sand	Silty clay	Clay	% Composition	% Prevalence	Morisita's index of dispersion†
Porifera	4	—	3	—	—	—	0.09	1.33	74.36
Hydrozoa	7	—	3	24	—	2	0.38	5.33	18.47
Anthozoa	26	—	—	12	—	—	0.38	2.00	88.93
Turbellaria	—	—	10	—	—	1	0.19	1.33	93.51
Nemertinea	—	—	7	—	7	2	0.28	2.66	49.72
Nematoda	37	2	10	12	—	20	2.02	5.99	51.15
Entoprocta	4	12	3	12	15	2	0.61	7.33	14.91
Polyplacophora	—	—	7	—	—	—	0.09	0.66	150
Gastropoda	4	2	—	—	—	1	0.19	2.66	37.02
Scaphopoda	4	—	—	—	—	—	0.05	0.66	150
Bivalvia	30	364	153	153	140	9	11.44	24.00	49.55
Polychaeta	819	517	1072	1804	1195	299	68.52	77.33	3.29
Sipuncula	11	—	—	—	—	3	0.33	3.33	33.39
Echiurida	4	—	—	—	—	1	0.14	2.00	39.43
Ostracoda	15	—	—	—	—	—	0.19	1.33	93.51
Copepoda	4	5	—	—	15	5	0.56	4.00	45.68
Stomatopoda	7	—	—	—	—	—	0.09	0.66	150
Cumacea	—	—	3	—	15	2	0.28	3.33	33.00
Tanaidacea	4	5	3	—	—	4	0.42	5.99	16.42
Hyperideia	140	57	97	153	162	21	7.17	27.33	7.35
Gammaridea	7	—	—	—	—	1	0.14	1.33	82.95
Euphausiacea	—	—	—	—	44	1	0.33	2.66	45.67
Penaeidea	4	—	3	—	—	1	0.14	2.00	49.43
Alpheidae	18	12	17	24	7	—	0.84	9.33	12.83
Brachyura	30	2	14	12	—	1	0.07	7.99	13.85
Holothuroidea	—	—	3	—	—	—	0.05	0.66	150
Ophiuroidea	18	2	21	47	15	2	0.98	8.66	15.20
Cephalochordata	11	—	—	—	—	—	0.14	1.33	83.81
Juvenile fish	—	2	3	—	—	1	0.19	2.66	37.02
Unidentified	7	7	21	236	118	7	2.67	13.33	
Population‡	1215	686	1453	2489	1733	386			
Biomass $g\ m^{-2}‡$	16.26	6.96	41.18	18.21	9.69	3.69			
No. of observations	16	24	17	5	8	80			

\* Mean values

† Significant at 5% level of  $\chi^2$  for 149 degrees of freedom

‡ Mean total

sand. Turbellaria was restricted to clayey sand and silty clay showed Hyperideia abundance. In general, it was observed that the seston feeding animals were mainly restricted to sandy areas with low percentage of silt and clay whereas detritus and deposit feeders were restricted to muddy areas. On the other hand, predators and epifaunal elements displayed no substrate-specificity.

*Spatial dispersion*—The spatial dispersion of different faunal elements were calculated using Morisita's index of dispersion<sup>10</sup>. All the groups showed contiguous distribution and the values were significant at 95% confidence limits. However, the values differed widely from group to group (Table 1). The wide variation is an indication of the extent of random and contiguous distribution. Accordingly, Polychaeta

showed the most contiguous distribution while Polyplacophora and Holothuroidea showed the most random distribution.

*Faunal homogeneity*—The degree of uniformity or affinity was studied adopting the 'trellis diagram' technique<sup>11</sup>. The index of affinity for all possible pairs of samples was calculated and rearranged to give an idea of the degree of uniformity of the population. As a result, groups which are ecologically alike were grouped together. For convenience, the total stations were split into 3 sets (as per the station numbers) as it was not possible to compute indices of affinity for all the 150 stations taken together. The 'trellis diagram' for the 3 sets are shown in Fig. 2. Stations with no fauna have been omitted. It is obvious from the figure that there are 4 major ecological groups. High indices of

Table 2—Depth-wise Faunal Abundance\* ( $m^{-2}$ ) and Biomass ( $gm^{-2}$ )

	Depth, m											
	<20	20-40	40-60	60-80	80-100	100-120	120-140	140-160	160-180	180-200	200-220	>220
Porifera	—	2	—	—	—	—	—	—	—	—	—	—
Hydrozoa	4	5	2	—	—	—	—	12	6	—	—	—
Anthozoa	—	9	2	—	—	—	—	—	—	—	—	—
Turbellaria	—	—	2	—	—	44	—	—	—	—	—	—
Nemertinea	4	6	—	—	—	—	—	—	—	—	—	—
Nematoda	7	17	8	—	—	—	—	—	136	—	—	—
Entoprocta	11	7	6	—	—	—	—	12	—	—	—	—
Polyplacophora	—	—	—	—	—	30	—	—	—	—	—	—
Gastropoda	—	4	—	—	—	—	—	12	—	—	—	—
Scaphopoda	—	1	—	—	—	—	—	—	—	—	—	—
Bivalvia	55	54	34	167	918	44	118	35	—	—	6	20
Polychaeta	502	883	457	423	616	870	649	568	391	67	218	20
Sipuncula	4	7	—	—	—	—	—	—	—	—	—	—
Echiurida	4	2	—	—	—	—	—	—	—	—	—	—
Ostracoda	—	5	—	—	—	—	—	—	—	—	—	—
Copepoda	26	4	4	—	—	—	—	—	—	—	—	—
Stomatopoda	—	2	—	—	—	—	—	—	—	—	—	—
Cumacea	11	2	—	10	—	—	—	—	—	—	—	—
Tanaidacea	4	4	2	10	7	—	—	12	—	—	6	—
Hyperiidacea	77	87	34	20	92	44	531	—	89	—	—	—
Gammaridea	—	4	—	—	—	—	—	—	—	—	—	—
Euphausiacea	11	4	2	—	—	—	—	—	—	—	—	—
Penaeidea	—	1	—	—	—	—	—	12	—	8	—	—
Alpheidae	4	16	4	20	—	—	—	—	—	—	—	—
Brachyura	4	15	2	—	—	—	—	12	—	—	—	—
Holothuroidea	—	1	—	—	—	—	—	—	—	—	—	—
Ophiuroidea	15	18	4	—	—	—	—	—	—	—	—	—
Cephalochordata	—	4	—	—	—	—	—	—	—	—	—	—
Juvenile fish	—	1	—	—	—	—	—	—	—	—	—	—
Unidentified	30	44	19	—	—	—	59	12	6	8	6	20
Population†	773	1209	582	650	1633	1032	1357	687	628	83	236	60
Biomass $g m^{-2}$ †	9.99	20.68	5.09	1.23	3.77	25.23	2.13	4.17	1.49	6.86	3.89	4.64
No. of observations	16	48	31	6	9	4	1	5	10	7	10	3

\*Mean values; †Mean total

affinity were obtained because identification was carried out only up to the group level. Closer scrutiny of the 4 major groups showed that they generally had similar substrata thus indicating an animal-sediment relationship. Station with clay substrata had indices of affinity from 75 to 100; those with clayey sands and sandy clay had values from 50 to 75; those with sandy deposit had values from 25 to 50 while those with silty clay and silty sand substrata had values from 0 to 25. As the stations with sandy, silty clay and silty sand substrata had low indices of affinity, it shows that these substrata support diverse fauna.

**Biomass and population density**—The biomass varied from nil at 29 stations to  $150.6 gm^{-2}$  at 146 stations ( $\bar{x} = 10.61 \pm 3.2$ ). Similarly, the population density varied from nil at 29 stations to  $12.572 m^{-2}$  at 36 stations ( $\bar{x} = 839 \pm 120$ ). Polychaeta, Bivalvia and Amphipoda contributed substantially to the population density whereas biomass was mainly contri-

buted by Polychaeta, Bivalvia and larger organisms like juvenile fish, shrimps and Holothuroidea. Biomass distribution (Fig. 3) showed high values at south and north of Visakhapatnam, off Puri and off Sandheads, while outer shelf showed lower values. Though faunal density was highest at 120-140 m depth zone and lowest at >220 m depth zone, high biomass values were obtained at 100-120 m depth zone. Similarly faunal distribution in relation to the type of sediment showed high population density in silty sand and low in clay deposits while biomass values were high in clayey sand.

Benthic biomass, population density and faunal homogeneity differed from place to place. There were large differences in the abundance and spatial dispersion of the fauna. Sublittoral benthic faunal abundance and the number of taxa usually decreased with increase in depth<sup>12,13</sup>. In the present investigation, though the number of taxa reduced with increasing depth, no regular decrease in faunal

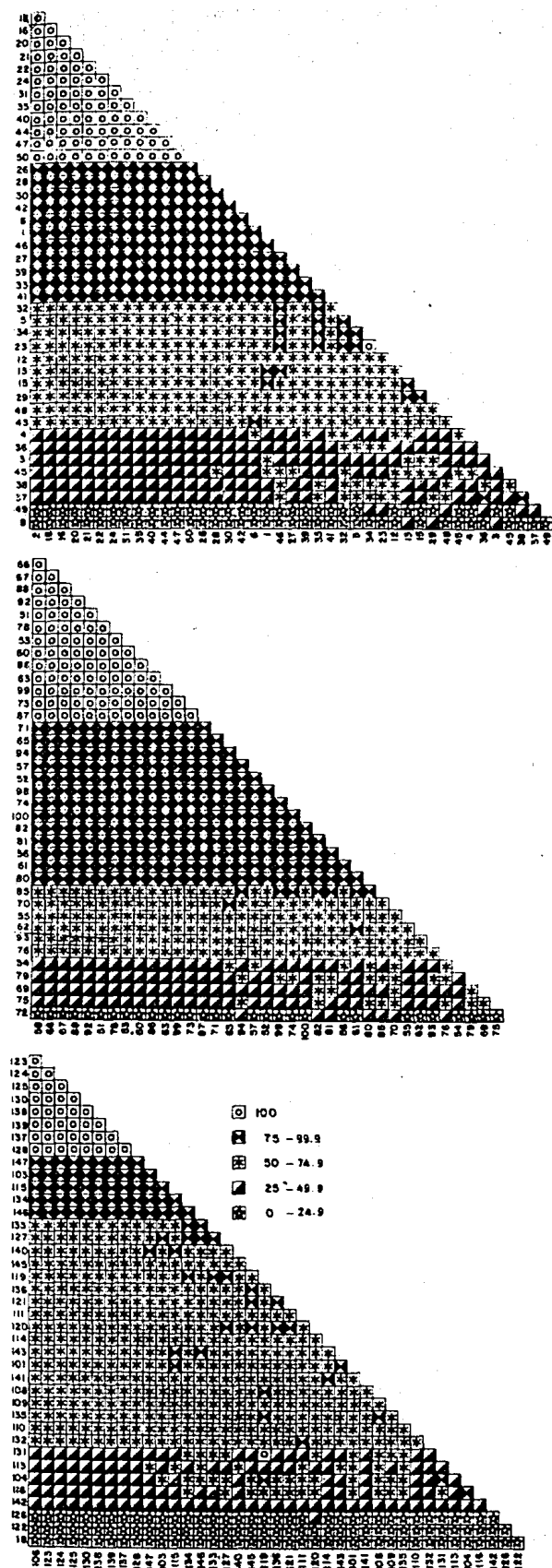


Fig. 2.—'Trellis diagram' comparing the average faunal index of affinity at different stations for major taxa

abundance was observed. This is mainly due to the difference in sediment characteristics in different depth zones, as the population density widely varies with the nature of substrata (Table 1). Earlier workers reported that the Bay of Bengal was less productive<sup>14,15</sup>. The results of the present investigation show that the Bay of Bengal is equally productive and the values can favourably be compared with the west coast shelf area<sup>13</sup>. This also agrees with earlier observations<sup>3,4</sup>. Available data on the west coast<sup>5,13,16</sup> show that the faunal abundance on the east coast is 3 times greater than west coast though the average biomass value is slightly lower. Faunal groups which are prevalent in the east coast included Cephalochordata, Alpheidae, Euphausiacea, Holothuroidea and thread fin fishes. Along the east coast, depth zone of 20-40 m and 100-120 m harbour rich fauna whereas on the west coast<sup>13</sup> rich fauna occurs at depths from 10-20 m. As far as the depth-wise distribution of Nemertinea and Ostracoda is concerned, a similar trend is noted on both the coasts where the former occur at depth up to 40 m, and the latter at 20-40 m depth zones. Such qualitative and quantitative differences can be attributed to interaction in the abiotic and biotic factors such as water characteristic and its enrichment including bottom sediment, current regime and recruitment and mortality of benthic community inhabiting that area<sup>5,17,18</sup>. The richness of fauna near the mouth of Hooghly (Fig. 5) supports earlier observations<sup>3,5</sup> which ascribe<sup>3</sup> this to an eutrophic structure of the shelf mainly due to huge riverine inflow bringing in loads of organic detritus which are preserved in a biochemically active state.

Faunal abundance in relation to sediment showed that loose sands sheltered rich fauna whereas muddy substrata were relatively impoverished. The specificity of faunal density to the type of substratum largely depends on feeding habits. Presumably, fine particles of clay sediments result in the clogging of the filter feeding apparatus of the filter feeders, hence, its 'avoidance' from inhabiting the fine particle size substrata. In such regions, deposit feeders abound provided there is an adequate supply of food. Such animal sediment relationship has been reported by earlier workers<sup>18-20</sup>.

An average standing crop of  $10.61 \text{ g m}^{-2}$  when converted to estimate annual benthic production<sup>21</sup> gives a value of  $21.22 \text{ g m}^{-2} \text{ yr}^{-1}$ , and organic carbon equivalent<sup>22</sup> of  $1.805 \text{ g C m}^{-2} \text{ yr}^{-1}$ . Available information indicates that the particulate organic carbon production in the column water of Bay of Bengal<sup>22</sup> is  $20.404 \text{ g m}^{-2} \text{ yr}^{-1}$ , showing a more or less direct trophic relation. The benthic production of  $21.22 \text{ g m}^{-2} \text{ yr}^{-1}$  or  $21,220 \text{ kg km}^{-2} \text{ yr}^{-1}$  for the area surveyed can sustain  $2,122.00 \text{ kg km}^{-2} \text{ yr}^{-1}$  of bottom

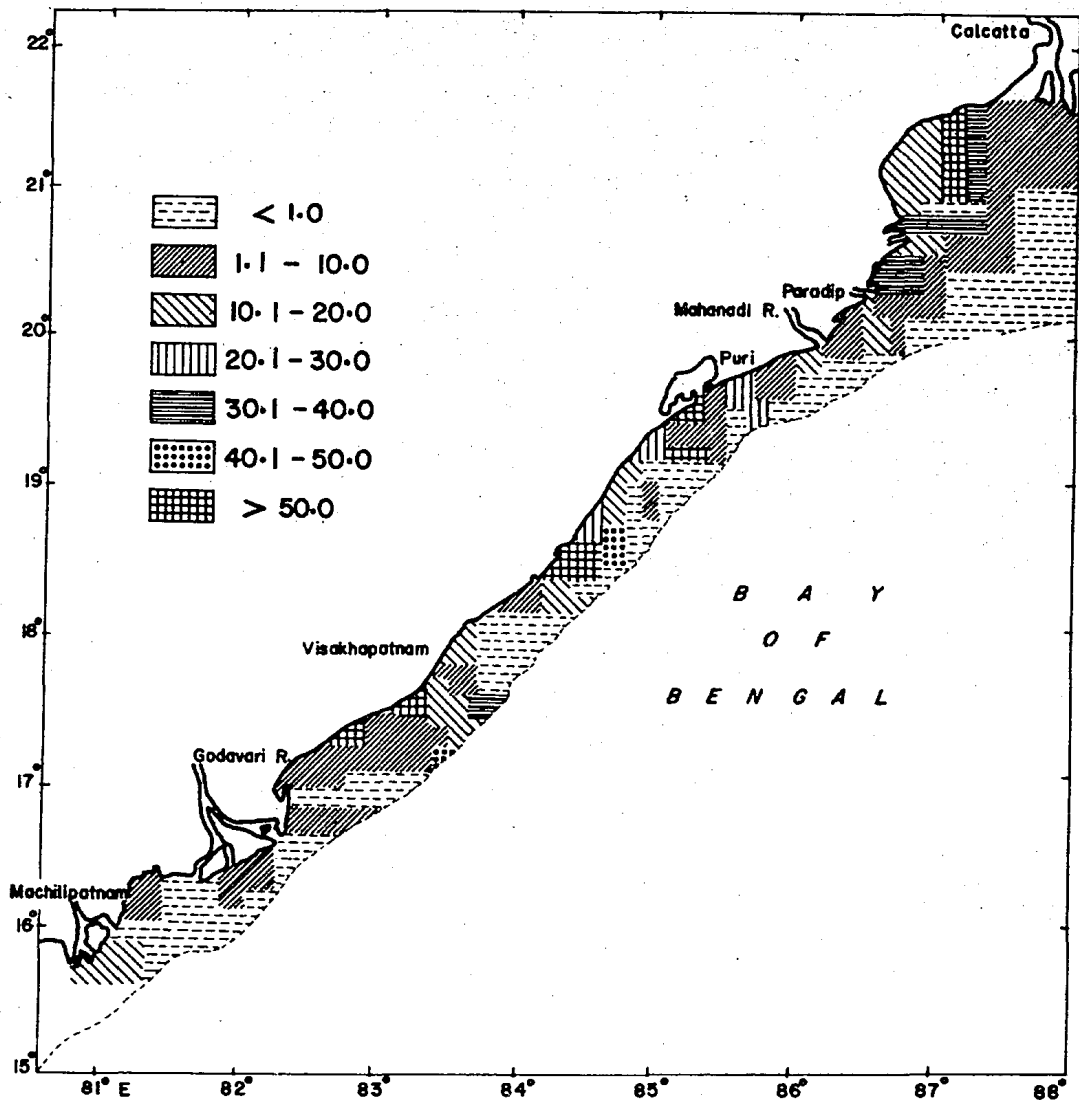


Fig. 3—Biomass distribution ( $\text{g m}^{-2}$ )

fishes taking into consideration the hypothetical trophic pyramid<sup>24</sup>. Accordingly, estimated potential demersal fishery resources for the continental shelf area of Andhra Pradesh, Orissa and West Bengal will be 1,62,042 tons  $\text{yr}^{-1}$ . The annual exploitable demersal fishery will be 97,225 tons  $\text{yr}^{-1}$  by taking 60% of the total estimated potential<sup>25</sup> as against the present annual exploitation yield<sup>26</sup> of 33,680 tons. It may be concluded that demersal fish exploitation can safely be doubled without causing over-exploitation of fishable stock.

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