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DISTRIBUTION OF BENTHONIC FORAMINIFERS IN BOTTOM SEDIMENTS OF THE NORTHWESTERN PART OF THE BAY OF BENGAL

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ABSTRACT

The distribution of benthic foraminiferal fauna in the bottom sediments of NW Bay of Bengal has been investigated from 50 stations. The different species are not equitably distributed throughout the area. An attempt has been made to analyse the pattern of distribution of the more important families. The mode of analysis of distribution pattern followed in this work can be used effectively for determining the paleoenvironment of ancient shelf areas which bordered the main land and whose physical environmental conditions were controlled by large river systems.

INTRODUCTION

In the past a number of workers have studied foraminifers from the bottom sediments of the Bay of Bengal. But most of these studies were largely confined to the southern part of the Bay. So far no attempt has been made to study the foraminifers from the northwestern part of the above region.

The area of investigation, the northwestern part of the Bay of Bengal is interersting from an ecological point of view. This is primarily, because, opening of

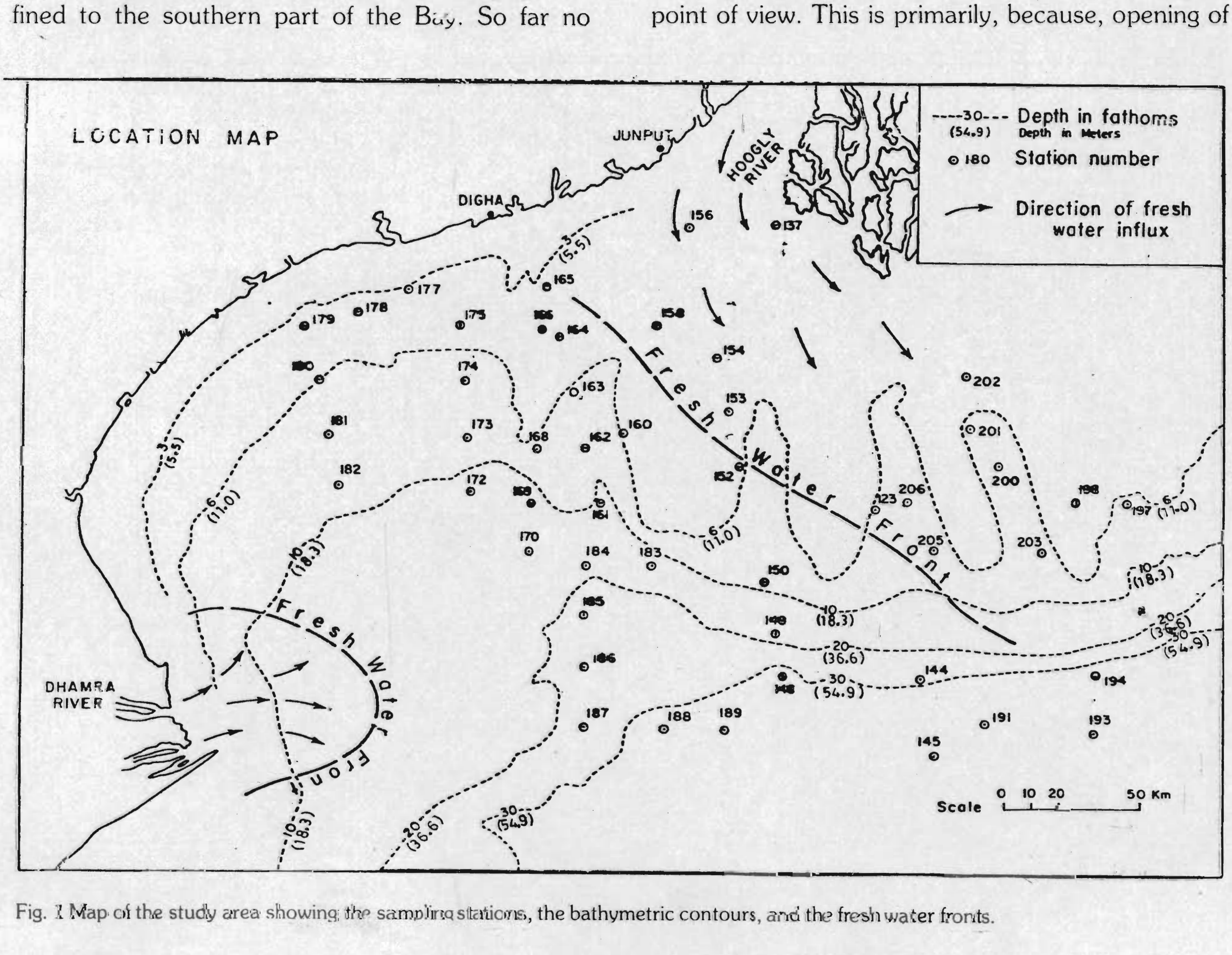

Fig. 1 Map of the study area showing the sampling stations, the bathymetric contours, and the fresh water fronts.

the Hooghly and Brahmani - Dhamra river systems, which seasonally bring in not only considerable fresh water but also a large amount of fine to coarse sediments. Consequently the important environmental factors, like salinity and turbidity, undergo a cyclic change annually.

As the present study is based on bottom samples collected by the Marine Geology Unit of the Geological Survey of India several years ago, it is not been possible to get an idea about the distribution of living foraminifers in the area. In this work attempt is being made to study the distribution of the benthic forams in the bottom sediments of the area.

From the study of the samples, no clear picture could be obtained about the benthic community. The microskeletal contents of the sediment is seen to be composed mostly of tests of foraminifers and, to a lesser extent, carapaces of ostracodes, and echinoid spines. The biological environmental factors could not be ascertained. However, the major physical environmental factors are known fairly accurately.

PHYSICAL ENVIRONMENT

The maximum depth does not exceed 60 m. This area falls within the inner neritic zone.

The circulation of surface waters is clockwise during summer and anticlockwise during winter months (Varadachari and Sharmam, 1967). During monsoon, however, the main circulation is from the mouth of the Hooghly River towards the southeast. This presumably affects salinity distribution rendering the eastern and southeastern part of the study area less saline during the rainy season.

Tides are rather high in this region. Average neap tide and spring tides are of the order of 1.5 and 5.25 m. The maximum height of the spring tide observed is 6.5 m (Chakraborty, 1977).

Apart from the heavy monsoonal rains, this region is visited by strong cyclonic storm several times a year, which causes strong turbulence in the upper layers of the water mass, affecting the substrate of the shallower regions.

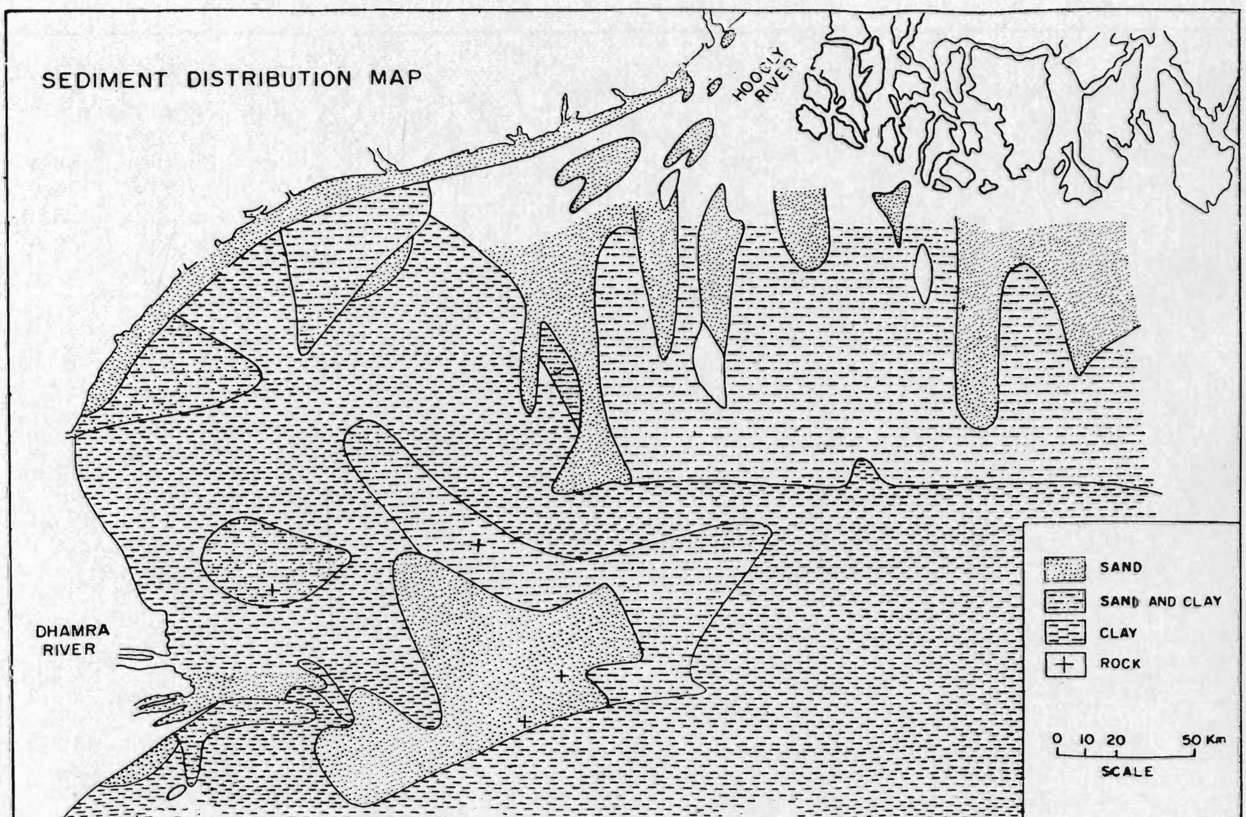

Fig. 2 Map showing the distribution of bottom sediments in the area of investigation (after Mallik, 1975).

RELATION BETWEEN THE NATURE OF THE SUBSTRATE AND THE DISTRIBUTION PATTERN OF DIFFERENT GROUPS OF FORAMINIFERA

Figure 2 shows the nature and distribution of the bottom sediment (Mallik, 1975). If this map is superimposed on the map showing the distribution of total benthonic foraminifera, no relation exists between the two. This is true not only for the distribution pattern of total benthonic foraminifera but also for that of most of the individual groups. The only conclusion that can be drawn is that the distribution of majority of the benthonic foraminifers in the area under investigation shows no relation with the nature of the substrate. This is in accordance with the view of Phleger (1960, referred to in Loeblich and Tappan 1964, pc 128) that the character of the sustrate is a relatively unimportant environmental factor.

The distribution of the Textulariids on the other hand have some relation with the substrate, although it is not the major controlling environmental factor. Since, Textulariids require coarser grains for the construction of their tests, in this locality the area of their abundance more or less coincides with the area where the substrate is composed of sand-sized grains.

DISTRIBUTION OF BENTHONIC FORAMINIFERS

The study shows that benthic forams consisting of 44 genera and 18 families have been identified by Choudhury Pal (1977) from the bottom sediments collected from 50 stations. Sample locations in the bay are shown in Figure 1. The species are, however, very unevenly distributed throughout the area. In some stations the number of species may be as low as 2 (Station No. 161), whereas in others this number may go upto 117 (Station No. 170). Statistical study has brought out certain interesting aspects of the species distribution pattern. The koch index for biotal dispersity is 19.46 (Reyment, 1971). This value may be considered to be low and indicates that the different species are not equitably distributed throughout the area. This points to the fact that the

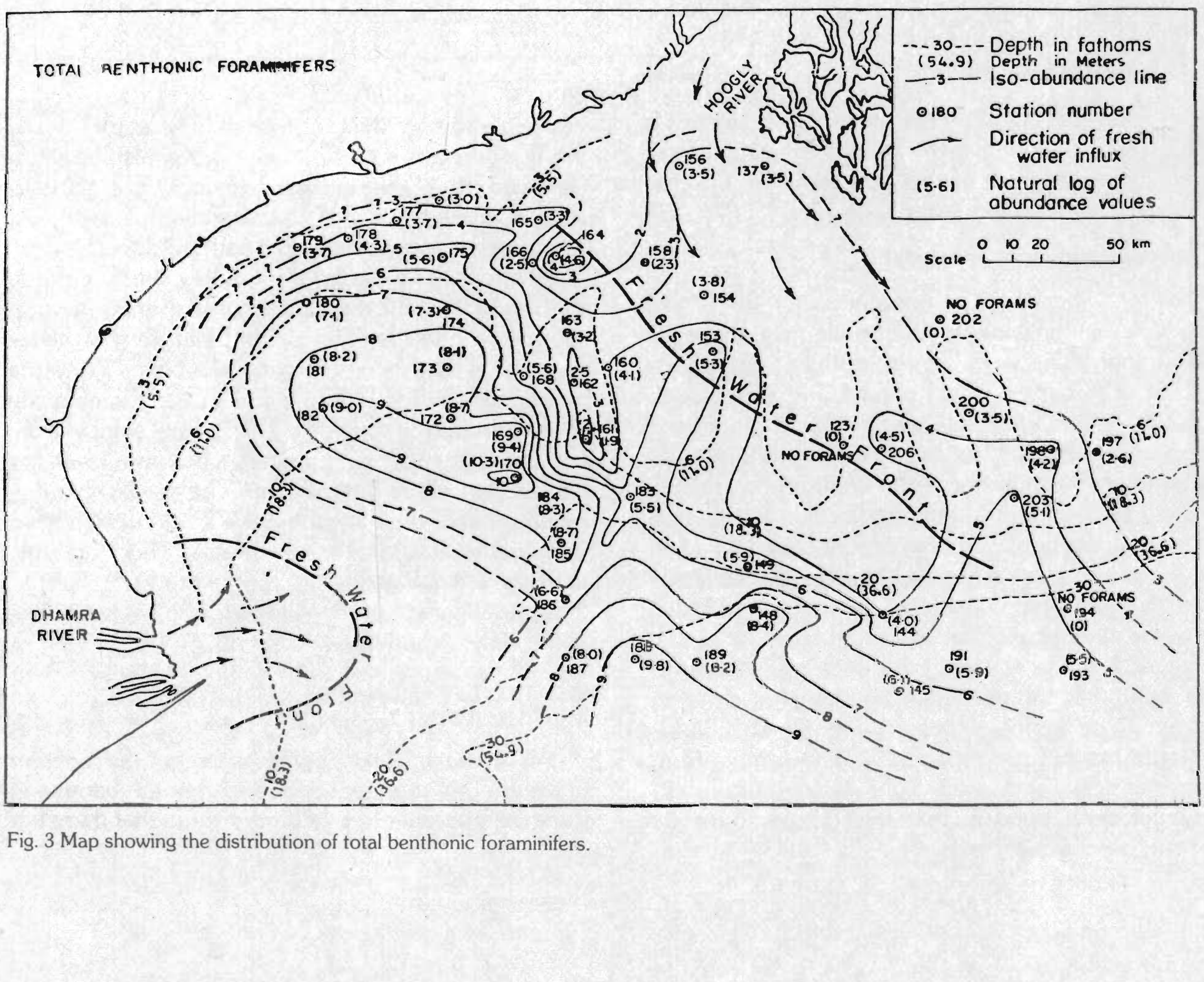

Fig. 3 Map showing the distribution of total benthonic foraminifers.

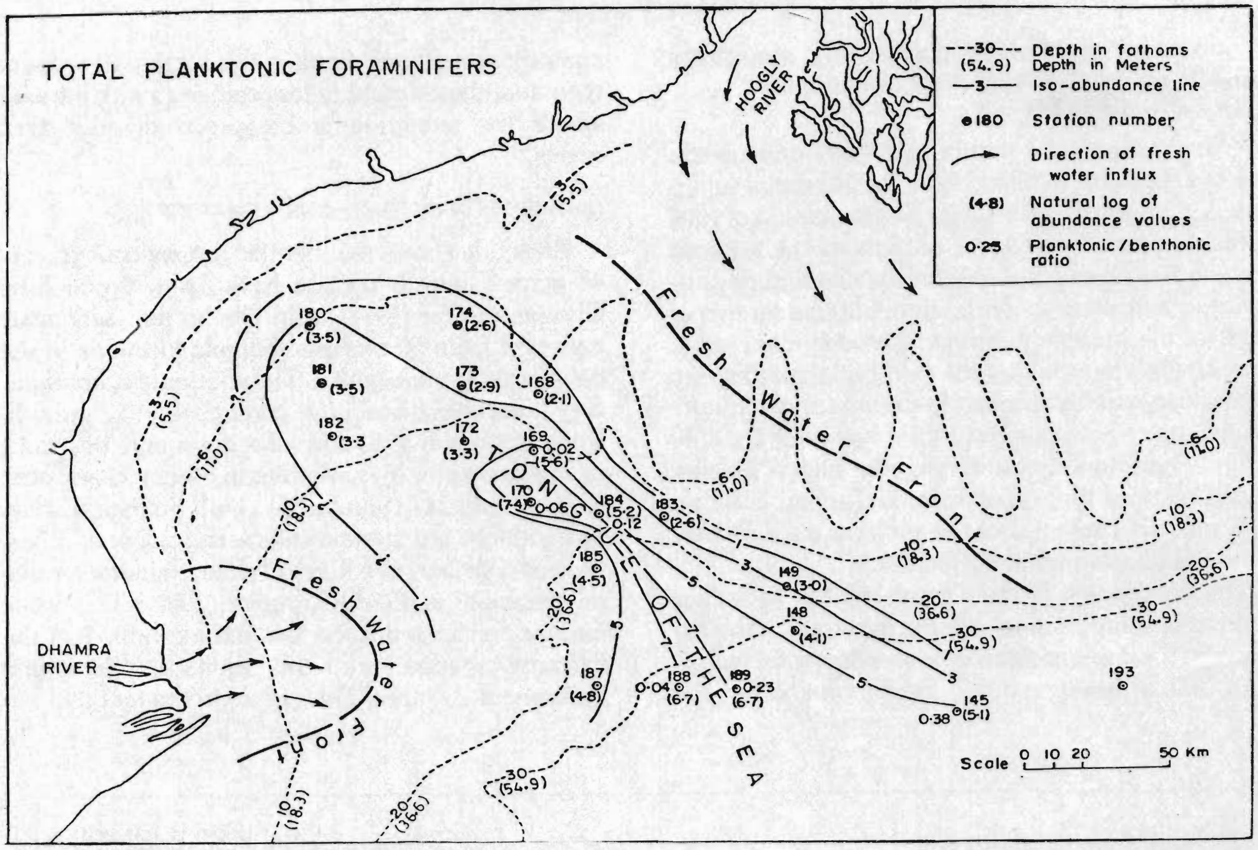

Fig. 4 Map showing the distribution of total planktonic foraminifers.

area has diverse physical environmental conditions. It is interesting to note that this index for the planktonic foraminifers occuring in this area is 20.76 which is marginally higher (Ghosh and Choudhury, 1976).

TOTAL BENTHONIC FORAMINIFERS

The total abundance of foraminifers (count/10 gm) also varies within wide limits. For example, there are only 7 specimens/10 gm in the sample from station no. 161. The highest count recorded is from station no. 170, which is 28,950 specimens/10 gm of the sample. An attempt has been made to analyse the patterns of distribution of total benthonic foraminifers and of the more important families in the area under investigation. The analyses are based on a series of iso - abundance maps. Groups below the family level have not been considered herein as these have no major palaeoecological significance.

Figure 3 shows the pattern of the distribution of total benthonic foraminifers. The map shows that in the area there is a major closure of the iso-abundance contours around station no. 170. The sample from this station also shows the highest concentration of foraminifers. It appears that this closure owes its existance to two different factors. The nature of the surface currents is one of them. It may also be safely assumed that the surface currents are partially responsible for the high concentration of benthonic foraminifers in station no. 170 and the closure mentioned above. The clousure owes its existence partly to the nature of the distribution of such shallow water groups as rotaliids. The second feature that needs mention is that there is a general tendency towards an increase of total foraminifers in the bottom sediment towards the open sea. This is quite evident from the nature of the iso - abundance contours at the central part of the bottom map. The third interesting feature is that the pattern shows an elongation from the centre towards the northwest. This conforms with the tongue of the sea deciphered from planktonic foraminifera in the same area as shown in Figure 4. (Ghosh and Choudhury, 1976).

RELATION BETWEEN DEPTH AND ABUNDANCE AND THE NUMBER OF SPECIES.

It is observed from Fig. 5, showing the relation between the depth and abundance of benthonic foraminifers measured in count/10 gm., that there is a concentration of points in the lower part of the graph within 20 m depth limit and abundance of 2000 count/10 gm. The same plot shows a gradual increase of abundance value with increasing depth upto 15 m limit. However, no distinct relationship is noticeed when abundance data from all the stations are considered. Two trends may be observed, one parallel to the depth axis and the other parallel to the abundance axis. This duality in the trend cannot be explanined by the bathymetric factor alone. In this area abundance and distribution of foraminifers are largely controlled by salinity, which in turn is modified by fresh water fronts.

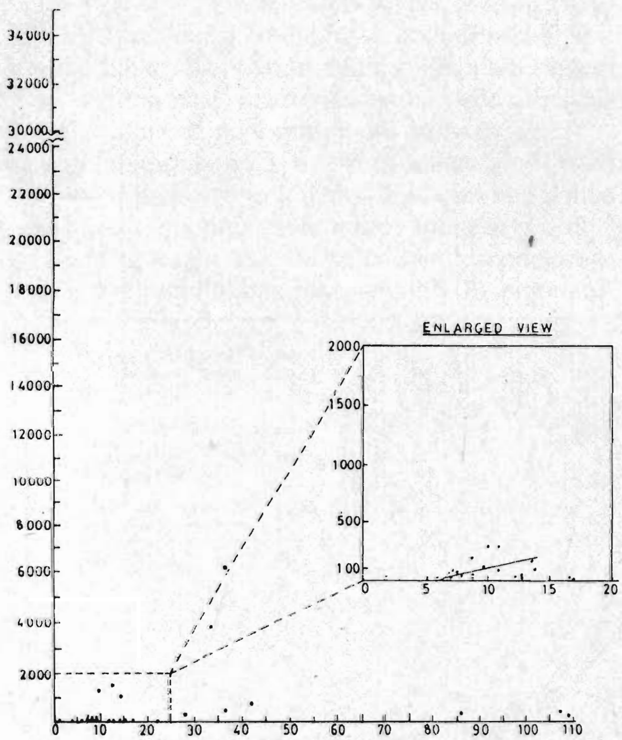

Fig. 5 Graph showing the relation between depth and the abundance of benthonic foraminifers, measured in count/10 gm.

Fig. 6 showing the relationship between the depth and the number of species, reveals a trend of increasing species, upto the depth of 20 m. However, when the study is extended to larger range covering the whole study area, no such trend emerges indicating thereby that number of species is not dependent on depth factor in this area. This is further confirmed by the values observed at the stations - 145, 191 and 193 (fig. 6) which are highly incompatible with the depth. These are also the stations located near the fresh water fronts on the outer fringe of the tongue.

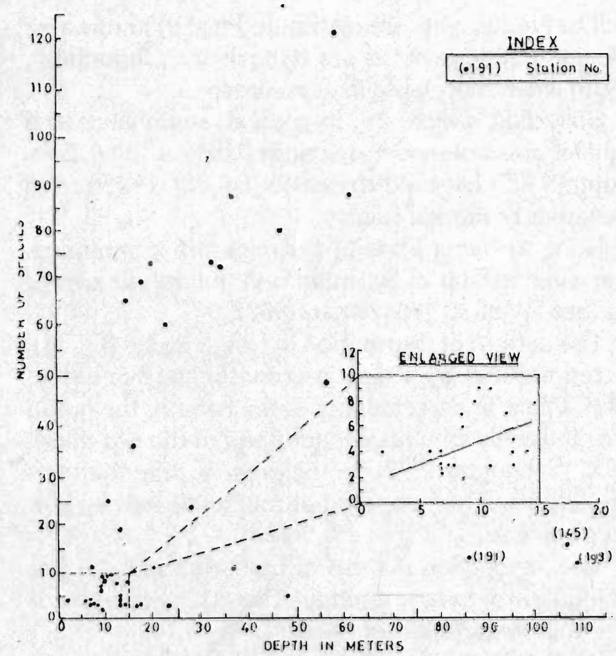

Fig. 6 Graph showing the relation between depth and the number of species.

It may be concluded from figs. 5 & 6 that in the shallower parts of the area (upto 20 m depth), both the number of species and abundance increase with depth. In other words both the number of species and concentration of forminifer tests decrease towards the shore line. The absence of any mutual relationship of depth with abundance and number of species also establishes that depth and salinity are not correlatable within the area of investigation. It also suggests that there are some zones in the fringe areas of the tongue where the influence of the fresh water fronts of Hooghly and Dhamra - Brahmani River systems has caused lower salinity even at higher depths.

DISTRIBUTION OF DIFFERENT GROUPS OF BENTHONIC FORAMINIFERS

Agglutinated foraminifers (Fig. 7) are common in front of the mouths of the Branmani-Dhamra River system where coarser materials are available for the construction of their tests. The elongated pattern is in construction of their tests. The elongated pattern is in conformity with the NW-SE traversing tongue (fig. 3). The zone of concentration is controlled by fresh water fronts and availability of coarser material.

The distribution pattern of Milliolids (Fig. 8) indicates that this group is moderately tolerant to varying environmental factors.

The Nodosariids are distributed (fig. 9) in this area along the tongue of the sea (Ghosh and Choudhury, 1976) where normal salinity prevails.

Bolivinids, which are, in general, stenohaline and inhabit areas of moderate depth (Walton, 1964; Sengupta, 1977) have a distribution (fig. 10) restricted to the areas of normal salinity.

None of the species of *Bulimina* are common as the usual habitat of *Bulimina* is in the deeper part of the sea (Walton, 1964; Sigal, 1952).

The pattern of distribution of Uvigerinidae (fig. 11), is represented by a very narrow tongue-like extension. this is in agreement with the habit of the group which usually inhabits deeper parts of the sea (Sigal, 1952; Sengupta, 1977). In the present case the tests are large and, hence, are not much effected by surface currents.

The distribution pattern of Discorbiids (Fig. 12) is in the form of a narrow tongue-like extension towards the northwetern part of the area.

Rotaliids are widely distributed (Fig. 13) as they are tolerent to widely varying physical environmental conditions. There is a broad similarity between the distribution pattern of the total benthonic foraminifers and this group. Ammonia and Asterorotalia form the dominant elements of the foraminiferal fauna in the shallower parts.

The distribution pattern of Eponididae (fig. 15) show the presence of an elongated pattern like the other stenohaline forms.

The group cibicididae (fig. 16) is confined mostly to inner and central shelf areas where depths are moderate and salinity normal.

Cassidella and *Virgulina* of Caucasinidae group are extremely rare.

The distribution pattern of Nonionidae (Fig. 17) is very similar to that of Cibicididae.

The distribution way of Alabaminidae (Fig. 18) reveals the presence of a narrow, elongated pattern similar to other stenohaline deep water groups.

The pattern of the distribution of Anomalinidae (Fig. 19) is similar to that of Cibicididae and similar conclusion may be drawn in this case also.

In the offshore region three distinct foraminiferal associations could be recognised. (I) *Dominated* by *Ammonia*, (II) *Asterorotalia and* (III) *Bolivina*. There

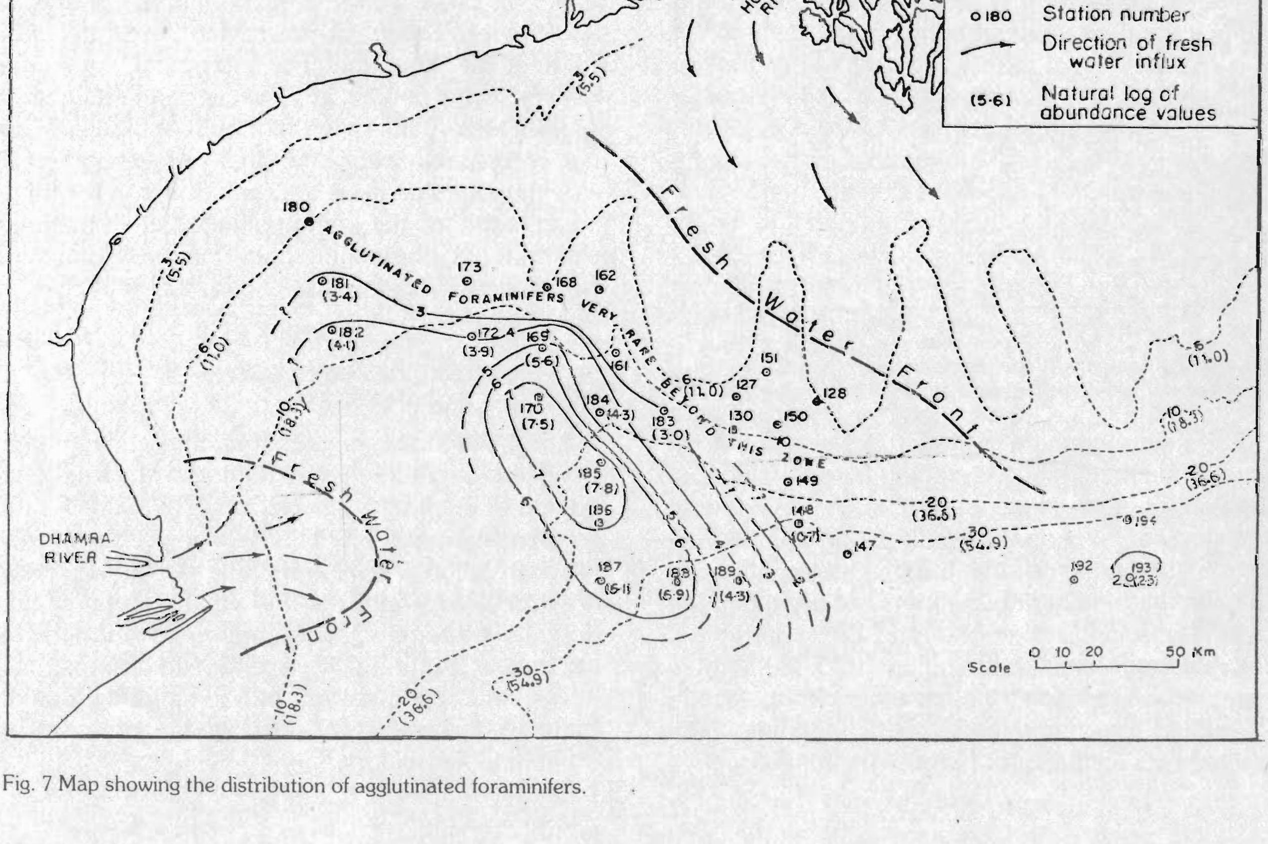

Fig. 7 Map showing the distribution of agglutinated foraminifers.

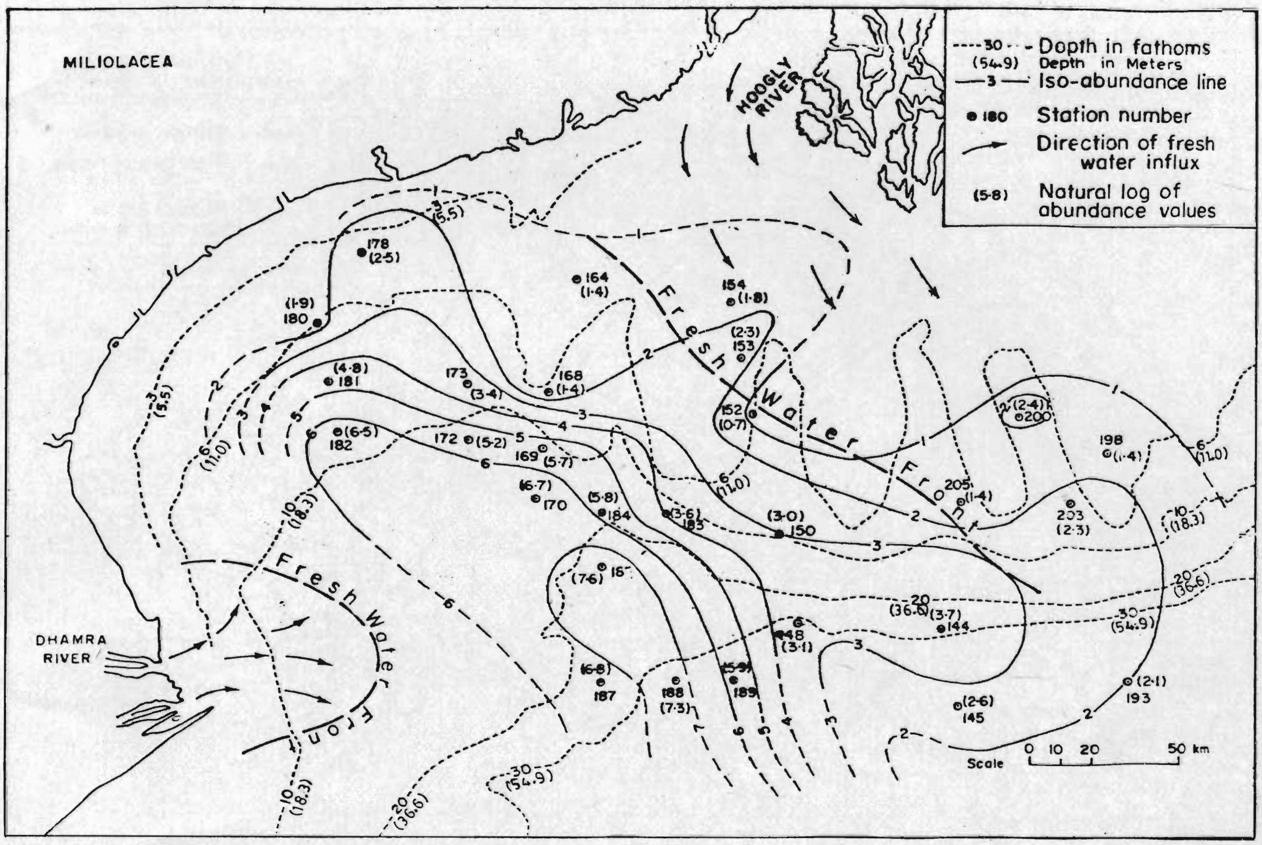

Fig. 8 Map showing the distribution of Miliolacea.

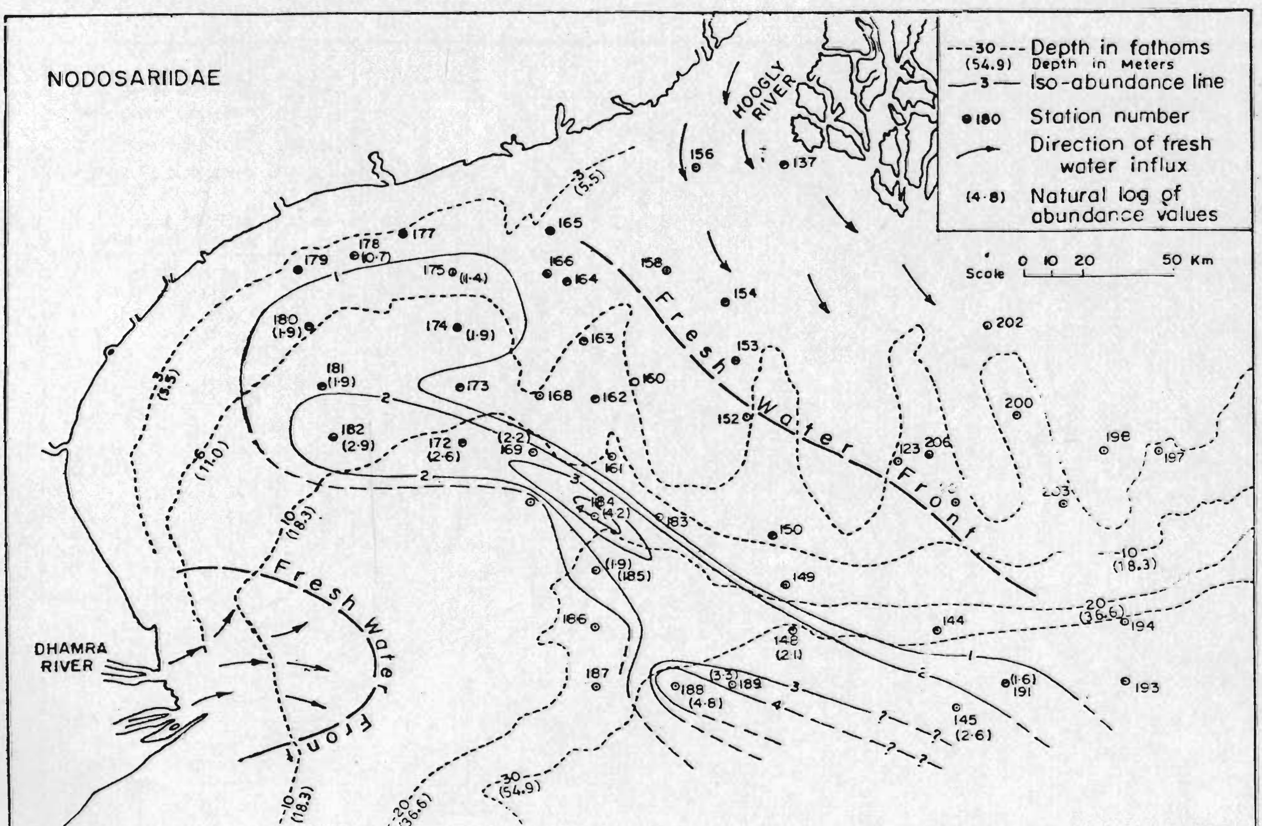

Fig. 9 Map showing the distribution of Nodosariidae.

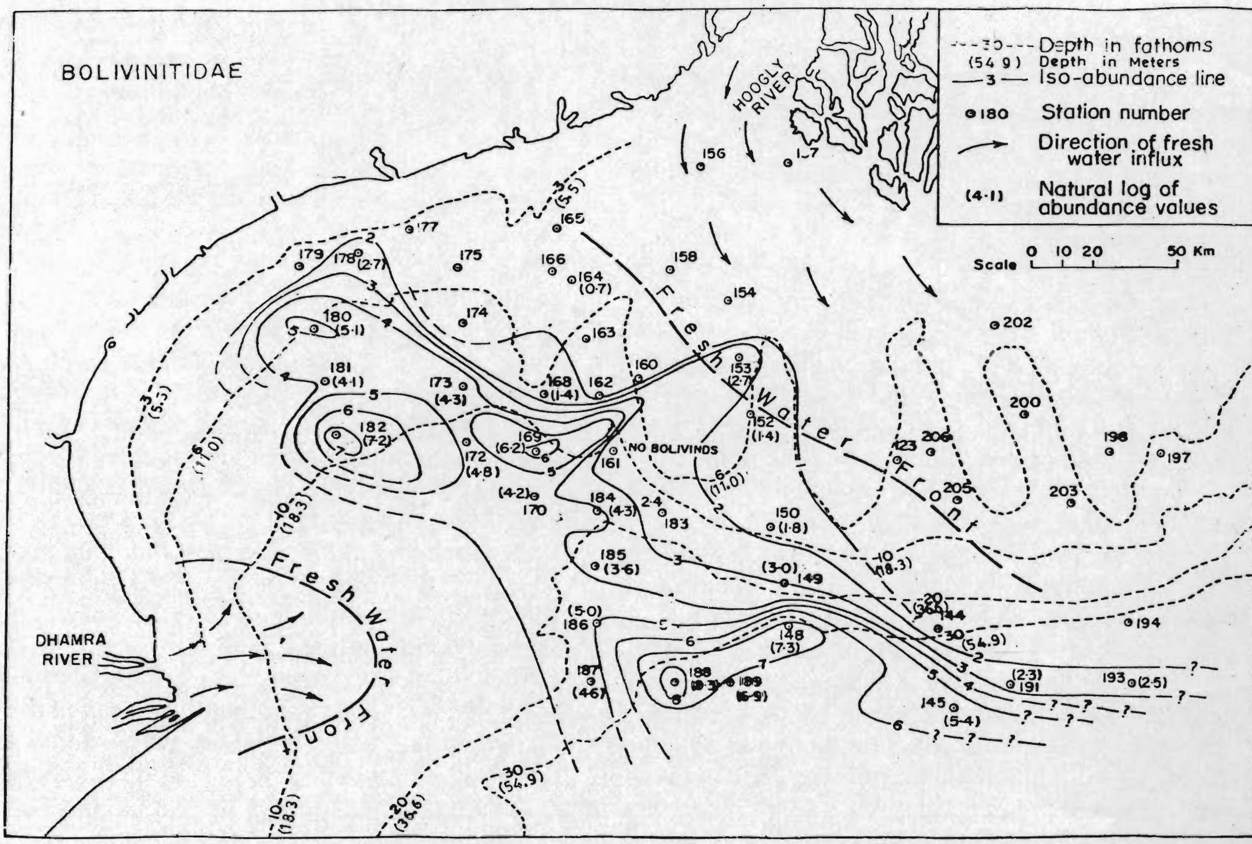

Fig. 10 Map showing the distribution of Bolivinitidae.

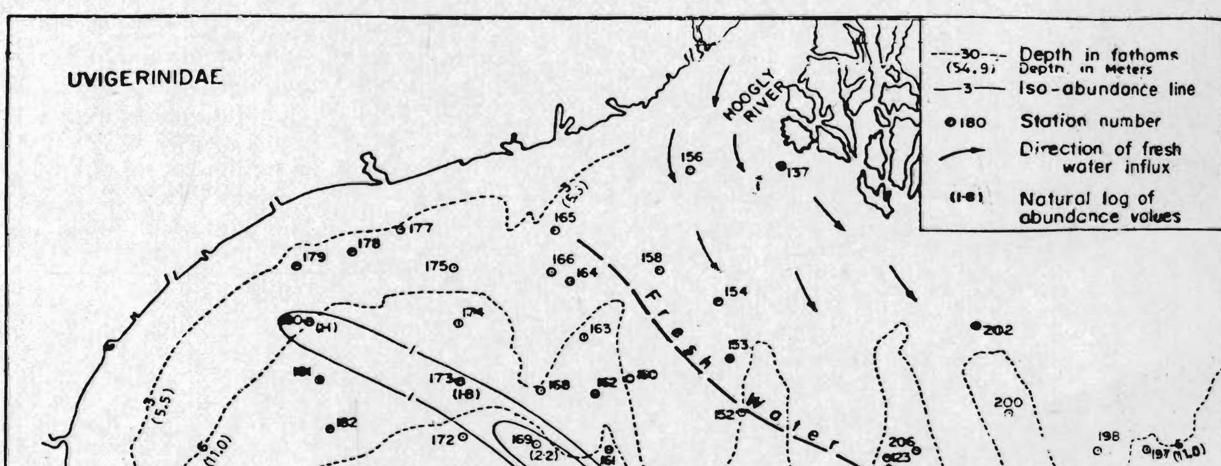

Fig. 11 Map showing the distribution of Uvigerinidae.

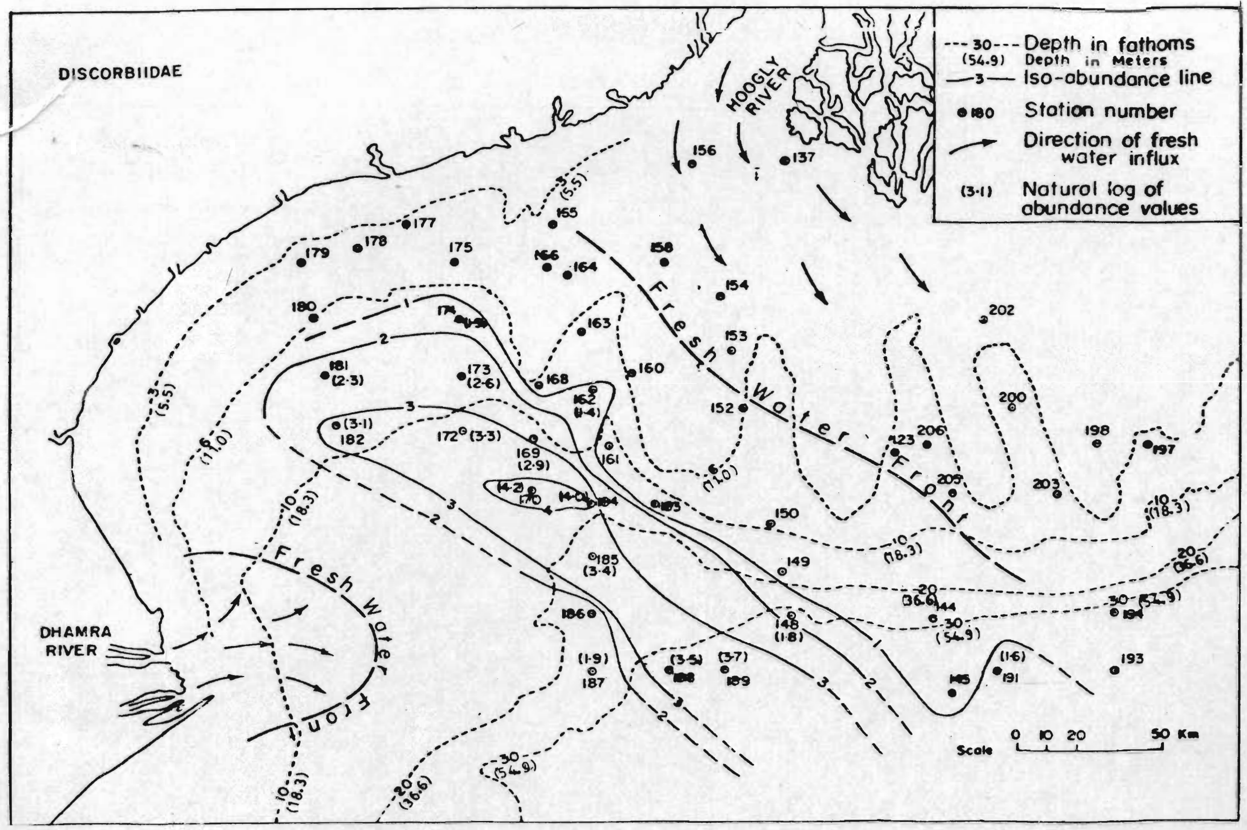

Fig. 12 Map showing the distribution of Discorbiidae.

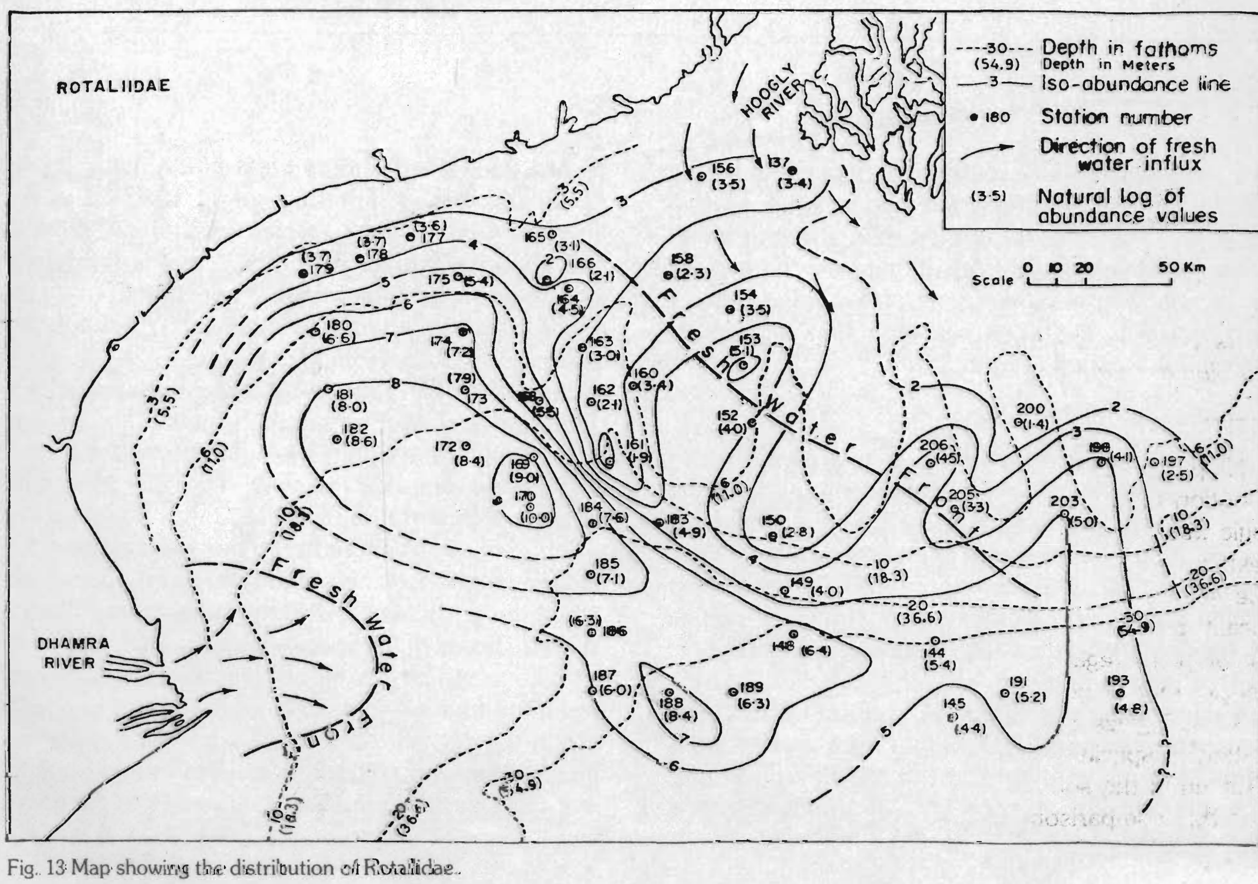

Fig. 13 Map showing the distribution of Rotaliidae.

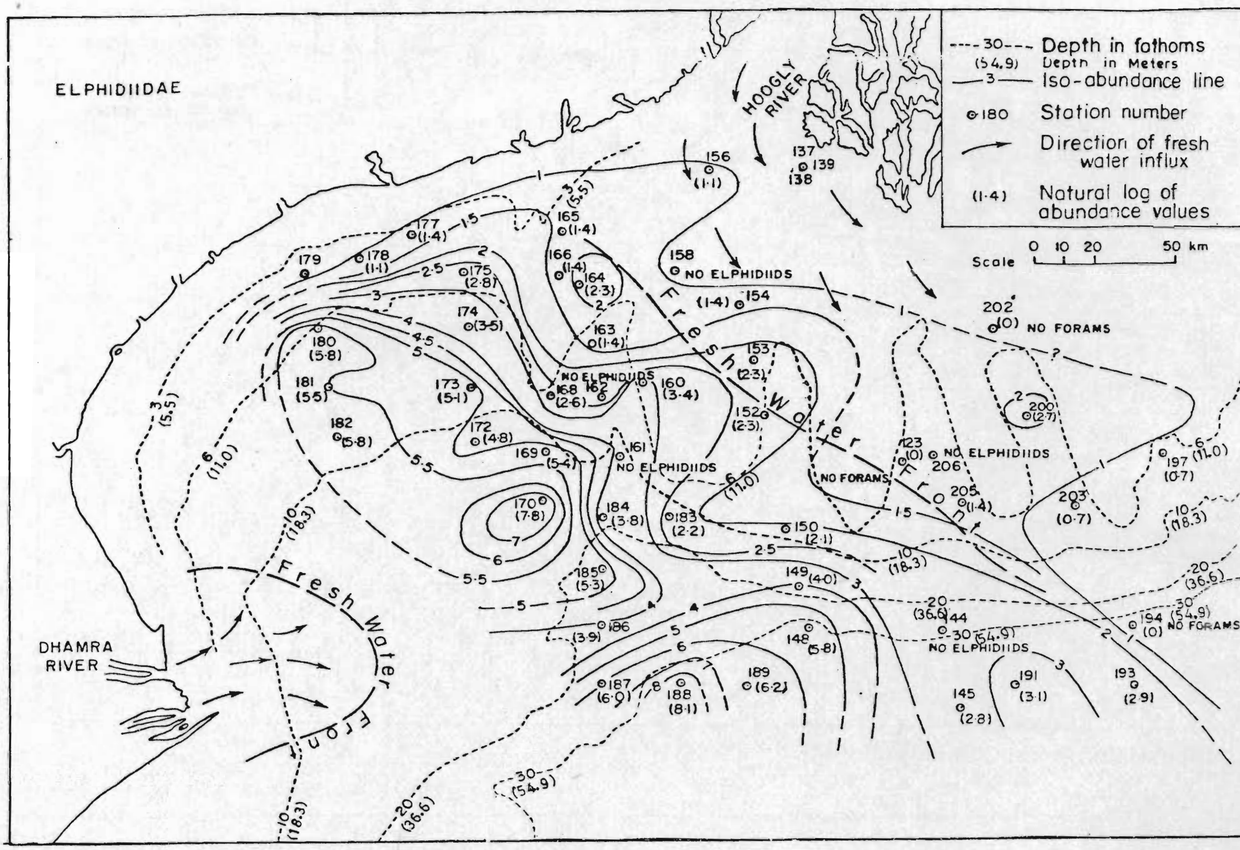

Fig. 14 Map showing the distribution of Elphidiidae.

are areas where the association is dominated by the first two. *Ammonia* dominated association, however, appears to be more extensive than the one dominated by *Asterorotalia*. Both of them are characteristic of relatively shallower part of the area. Deeper parts towards the open sea are characterised by *Bolivina* dominated association.

DISTRIBUTION OF INDIVIDUAL

No particular attempt was made to analyse the distribution and abundance of individual species. The logic was that most of the species have a somewhat restricted geographic occurrence and, in many cases, the same species occurring in even two adjacent localities differ at the variety level. However, certain major point regarding the distribution of individual species may be noted.

Table 1 gives a comparative account of the distribution of species in the present area and in areas situated in the southern part of the Bay of Bengal. For this comparison the paper of Vendantam and Subha Rao (1970) is more important as he has given abundance values. The study of the table shows that there are a number of species which occur more or less abundantly in the region off Pentakota where the above authors worked. More important of these are *Bigenerina nodosaria, Quinqueloculina vulgaris, Brizalina spathulata, Nonion grateloupi.*

Sengupta (1977) has listed a number of species in accordance with their depth hahitats. The present area mostly falls within the limits of the inner-shelf and partly wihin central-shelf. Typically inner-shelf species (Sengupta, 1977, figs. 2, 3, 4 and tables I and II) that occur abundantly in the present area are *Ammonia beccarii, Brizalina spathulata, Quinqueloculina lamarckiana, Elphidium advena* and *Nonion scapha.* Some of the species which are referred to by the above author (op. cit.) as typically inhabiting central to outer shelf, and which are common to abundant in the present area, are *Textularia agglutinans, Quinqueloculina vulgaris, Cibicides Pseudoungerianus* and *Cibicides refulgens.* It is likely that the above

TABLE-I

Table showing a comparative account of the distribution of benthonic foraminifers identified from the northwestern part of the Bay Bengal.

Abbreviations: A = abundant to very abundant in 1 station; AA = abundant to very abundant in 2 to 5 stations; AAA = abundant to very abundant in more than 5 stations; C = Common; P = Present; R = Rare; CC, CCC etc. has the same meaning as in the case of AA, AAA etc. A = 20%; C = 15–20%; P = > 5%; R = < 5%; X = present and - absent in those cases where abundances are not given by the author.

	Species	Present locality	Littoral zone along the east coast of India (Ganapati and Satyavati, 1958)	Bay of Bengal** Southern part (Vedantam and Subba Rao, 1970)	Coast and Lagoon of Cochin (Seibold, 1975).
1.	*Bigenerina nodosaria* D'Orbigny, 1826	C	—	C	—
2.	*Textularia agglutinans* D'Orbigny, 1839	PP	X	A	—
3.	Textularia earlandi Parker, 1952	PP	—	—	X
4.	*Textularia* of *T. Foliacea* Heron - Allen and Earland	P	—	R	X
5.	*Cuingueloculina lamarckiana* D'Orbigny, 1839	CC	X	R	—
6.	*Quingueloculina vulgaris* D'Orbigny, 1826	CC	X	AA	—
7.	*Quingueloculina (Pseudotriloculina) rupertiana* (Brady-1881)	P	X	—	—
8.	*Sigmoilina* of *S. Tenuis* (Czizek, 1848)	RR	—	A	—
9.	*Triloculina tricarinata* D'Orbigny, 1826	C	X	R	X
10.	*Lentieulina calcar* (Linnaeus, 1758), var. *paucispinosa*, n. var.	RR	X	C	—
11.	*Pseudonodosaria pseudocamerata* n. sp.	PP	X	—	—
12.	*Brizalina saminuda* (Cushman, 1911), var. *humilis* Cushman Mc Cull	P	—	R	—
13.	*Brizalina spathulata* (Williamson, 1858)	CC	—	C	—
14.	*Brizalina vadeseens* Cushman, 1933	PP	X	AA	—
15.	*Bulimina marginata* D'Orbigny, 1826.	R	—	R	X
16.	*Amonia beccarii* (Linnaous, 1758) *Varpluriloculata*	RR	X	AA	—
17.	*Amonia boocarii* (Linuaoas, 1958), var *tapida* (Cushman, 1926)	CCC	—	CC	X
18.	*Asterorotalia inflate* (Millet, 1904)	PPP	—	—	X
19.	*Asterorotalia trispinosa* (Thalmaan, 1933)	AAA	—	A	X
20.	*Pseudorotalia Schroeteriana* (Parkor and Jones 1862)	PP	—	A	—
21.	*Elphidium advena* (Cu[illegible]man, 1922)	CCC	—	—	X
22.	*Elphidium crispum (Linnaeus, 1958), Var suberispum* Cushman and McCulloch, 1940.	R	—	—	X
23.	*Cibicides refulgens*. Montfort, 1808, *Varpustulata* n. var.	PPP	X	—	—
24.	*Monion asterizens* (Fiehtel and Moll, 1978)	C	—	—	X
25.	*Monion grateloupi* (D'Orbigny, 1839)	C	—	AA	—

** A, C and R has the meaning shown at the beginning of the table. However, the authors do not give the corresponding percentage and hence, the abundance indicators shown in this column may not exactly correspond to that shown in column for the present area.

species are not stenobathic and may occur in shallower parts of ths shelf. The other likely explanation is that these species differ from those that have been reported from outer shelf areas (deeper parts) at the variety level.

PALEOECOLOGICAL IMPLICATIONS

The present study on the ecologic distribution of benthonic foraminifers in the bottom sediments of the northwestern part of Bay of Bengal can be used effectively for paleoecological and paleoenvironmental analyses. The nature of the distribution of different groups in shallow seas, in areas confined to the inner shelf bordering continental masses, is primarily modified by salinity, turbidity, temperature and surface circulation playing an important role. The effect of these physical parameters on the distribution patterns of different group varies considerably, depending on the tolerance of the group concerned to the varying factors. Thus Rotaliids and Elphidiids have a distribution pattern that is least modified by the factors mentioned above. On the other hand, in such groups as Bolivinids, Nonionids and Uvigerinids, the pattern is considerably modified, as these groups are, presemably, adapted to a narrow range of physical environmental conditions.

The above conclusions are based on the distribution of suprageneric groups which, consequently, have longer ranges than the constituent species. This has obvious advantage in paleoecological and paleoenvironmental analyses.

If it is possible to obtain a large number of correlable bore hole samples from an area, the mode of analysis adopted here will not only give an idea of the direction of the shoreline but also indicate the presence or absence of large rivers opening into the basin, which might have been responsible for modifying the physical environmental factors effecting the habitats of foraminifers.

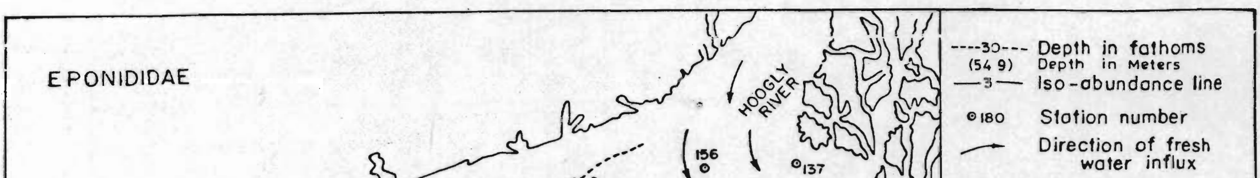

Fig. 15 Map showing the distribution of Eponididae.

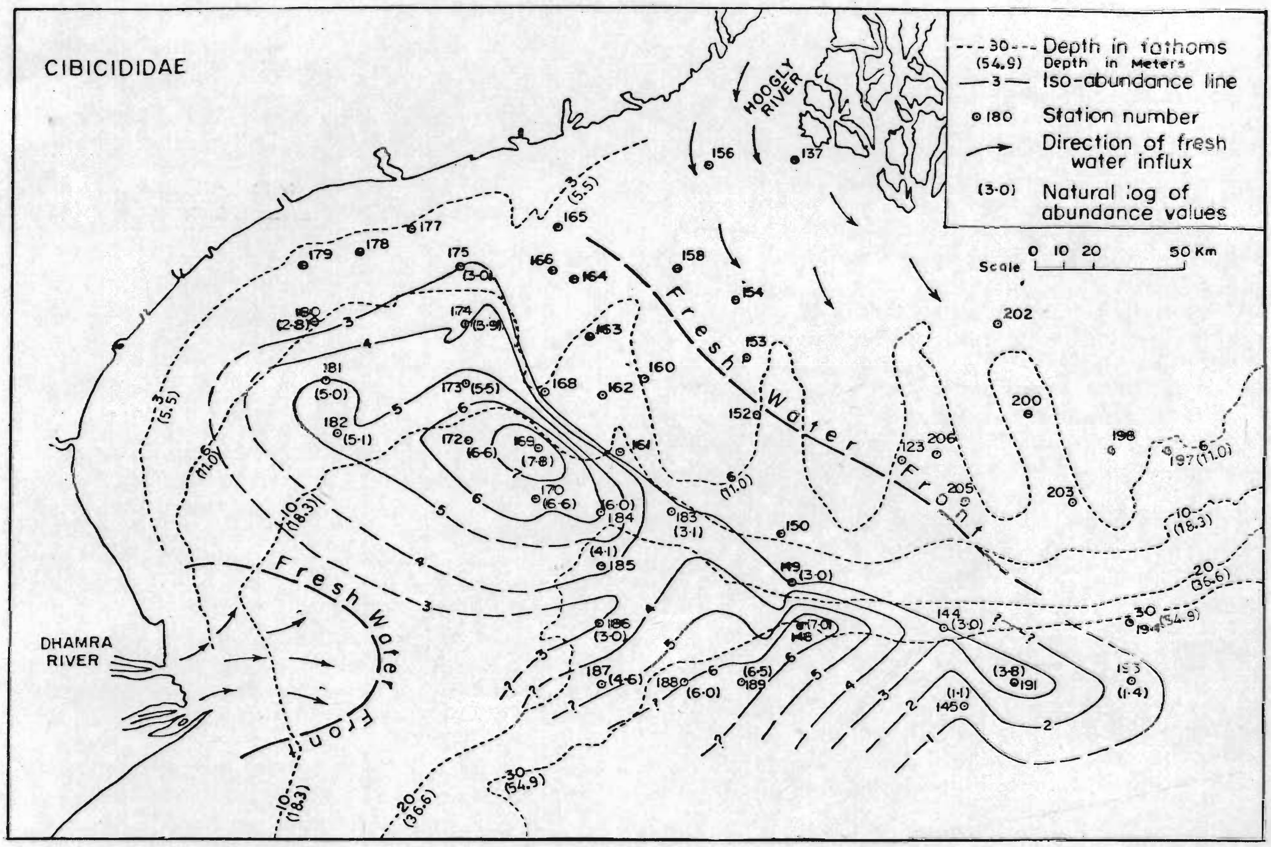

Fig. 16 Map showing the distribution of Cibicididae.

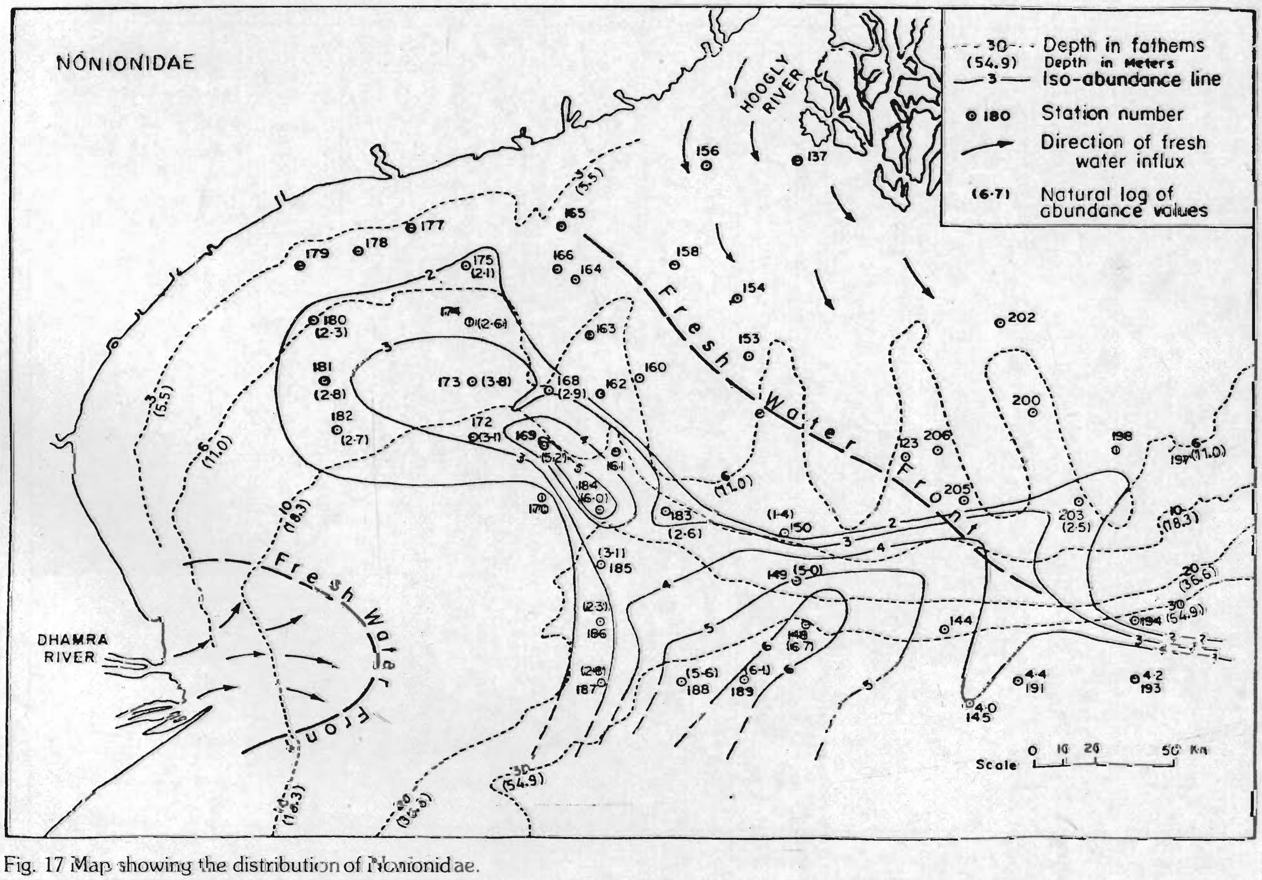

Fig. 17 Map showing the distribution of Nonionidae.

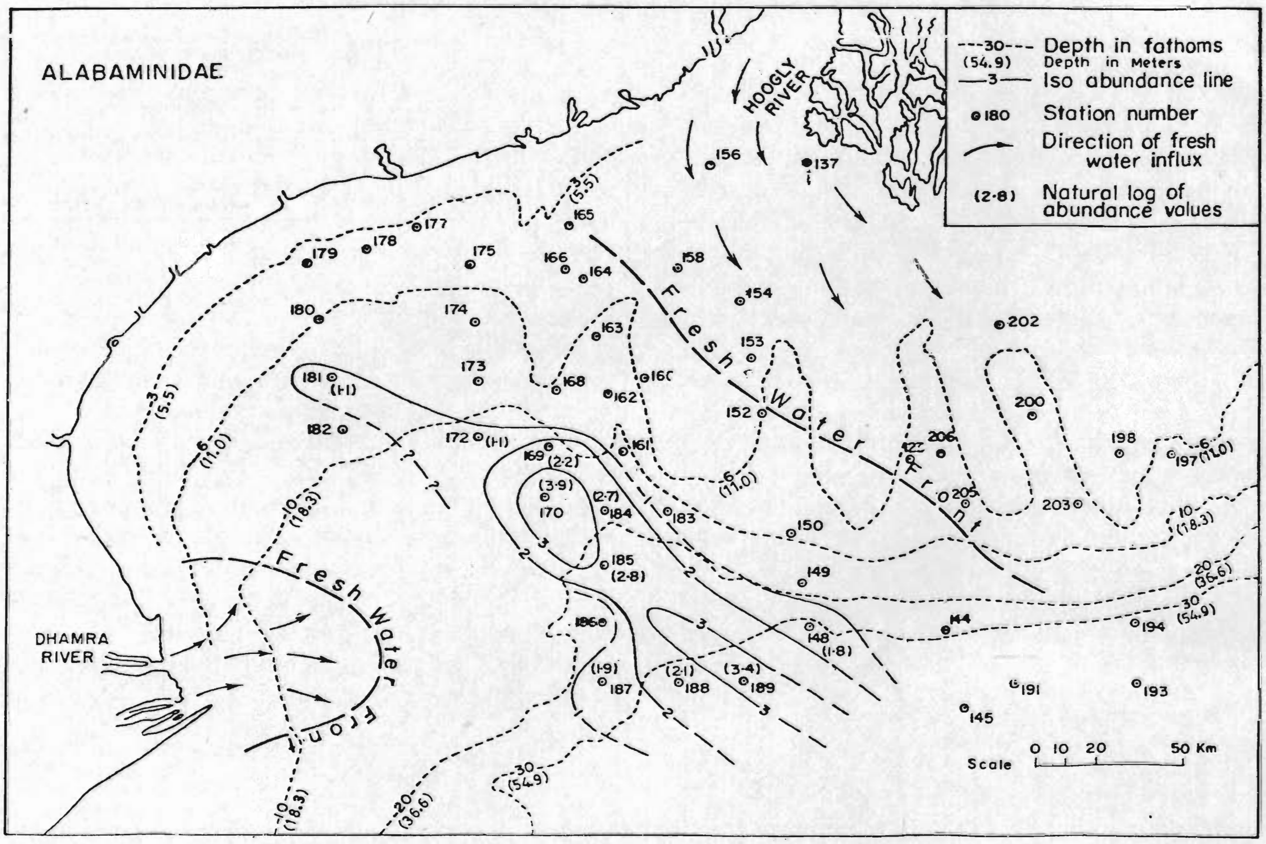

Fig. 18 Map showing the distribution of Alabaminidae.

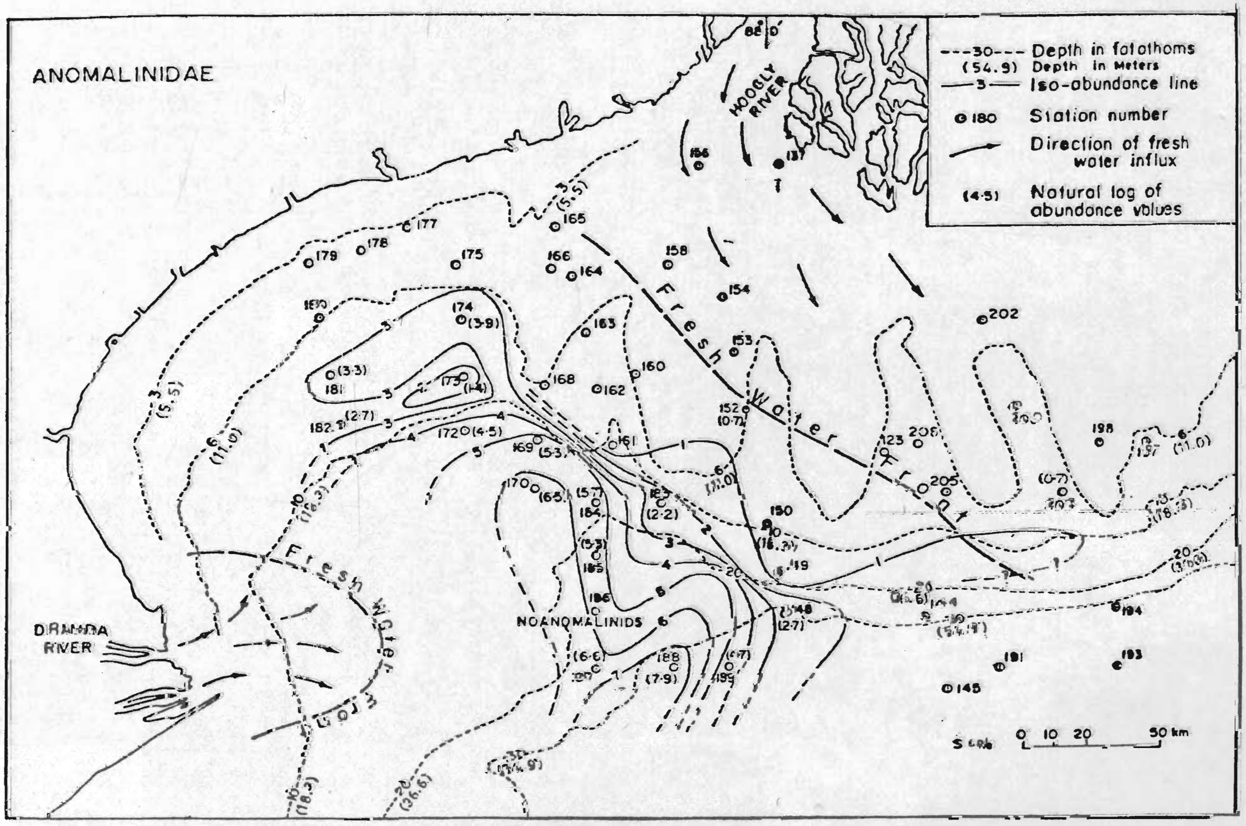

Fig. 19 Map showing the distribution of Anomalinidae.

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REFERENCES

BANDY, O.L., 1964 General correlation of foraminiferal structure with environment, in Imbrie, J. and Newell, N., Eds., Approachies to Paleoecology. John Wiley and Sons, Inc., New York, pp 75 - 90 9 figs.

CHOUDHURY PAL, ELONEE, 1977, Systematics and Ecologic distribution of foraminifers from the bottom sedimens of the northwestern part of the Bay of Bengal and the beach sands of adjacent coasts Ph.D. Thesis unpublished, Indian Institute of Technology, Kharagpur, 1 - 327.

GANAPATI, P.M. & SATYAVATI, P., 1958. Report on the foraminifera in bottom sediments in the Bay of Bengal off east cocoast of India. *Andhra Univ., Mem. Oceanogr.*, **2:** 100-127, pla. 1 - 6.

GHOSH, B.K. & CHOUDHURY, E., 1976. Distribution of planktonic foraminifers in bottom sediments of the nothwestern part of the Bay of Bengal. *Ind. J. Earth Sci,* **3** (1): 133 - 116.

MALLIK, T.K., 1975. A note on grain size variation of sediments at the mouth of the Hooghly river, Bay of Bengal. *Ind. J. Earth Sc.,***2,** (2): 142 - 153.

MOORE, W.E., 1957. Ecology of Recent Foraminifera in Northern Florida Keys: *Amer. Assoc. Petrol. Geol., Bull.,* **41:** 727 - 741, figs. 4.

NIYOGI, D., 1970. Geological background of beach erosion at Digha West Bengal *Bull. Geol. Min. Metall. Soc. India,* **43:** 1 -36.

REYMENT, R.A., 1971. Introduction to Quantitative paleoecology. Elsevier Publishing Company, Amaterdam, 226 p.

SEIBOLD, I., 1975. Benthonic Formaminifera from the coast and lagoon of Cochin (South India). *Revista Espanola De Micropaleontologia,* **7,** (2): 175 - 123.

SENGUPTA, B.K., 1977. Depth - distribution of modern benthic foraminifera on continental shelves of the world ocean. *Ind. J. Earth, Sci.,* **4.** (1): pp. 60 - 83.

SIDDIQUIE, H.N., SHRIVASTAVA, P.C. & MALLIK, T.K. 1971. Cruise report: Marine Geological cruises of R.V. Anusandhani. *Indian Minerals,* **24;** 383 - 386.

SIGAL, J. 1952. Ordre des Foraminifers in, Piveteau, J., Ed., Traite de Paleontologie Masson et Cie, Paris: ;. 133 - 301.

VEDANTAM, D. & SUBHA RAO, M. 1970. Recent foraminifera from off Pentakota, east coast of India. *Micropaleontology,***16,** (3): 324, pls. 1 - 3.

WALTON, W.R. 1964. Recent Foraminiferal Ecology and Paleoecology. In, Imbrie, J. and Newell, N. eds., Approaches to Paleoecology, John Wiley and Sons, Inc., New York: 151-237. -237.