DISTRIBUTION AND ECOLOGY OF RECENT BENTHIC FORAMINIFERA FROM TARUT BAY, ARABIAN GULF, SAUDI ARABIA

THESIS

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SUMMARY

Samples from 121 stations in Tarut Bay, on the Arabian Gulf coastline of Saudi Arabia, were examined for their foraminiferal content. 109 of these contained Foraminifera. The environment is hypersaline (45‰ up to 75‰) and sampling stations included bare sediment substrates as well as vegetated substrates. Depth of water, temperature, salinity and substrate were recorded. 43 foraminiferal taxa were recognized, 14 of which constituted 90% of the dead population and 93% of the living. These 14 taxa are regarded as the common taxa and their distribution plotted on maps. Living and dead specimens of most of these taxa have a similar distribution. The distribution is patchy because it is controlled by the type of substrate and to a less extent by water depth. 3 assemblage zones have been recognized: Intertidal, Shallow Subtidal (0-3 m) and Deeper Subtidal (3-13 m). These are recognized by the relative abundance of the different common taxa.

The fauna has a low diversity for both living (α = 1-4) and dead (α = 1-5), and is dominated by Miliolina (c. 55%) of which the most abundant are Quinqueloculina spp., Triloculina spp., Spiroloculina spp., Spirolina arietina and Peneroplis planatus. The suborder Rotaliina (c. 39%) is next in abundance with

Ammonia beccarii varieties and *Elphidium* spp. The Textulariina (c. 6%) are represented by *Textularia* spp. and *Eggerella scabra*.

Living/Dead ratios have been examined and taken to indicate no relationship between this ratio and rate of sedimentation.

The fauna of Tarut Bay is compared with that of other hypersaline environments in the Arabian Gulf and in the Red Sea. These faunas have certain characteristics which can be regarded as typifying the hypersaline environment: low diversity, dominance of Miliolina, and rarity of Textularina.

CONTENTS

CHAPTER 1

INTRODUCTION

THE ARABIAN GULF

The Arabian Gulf is a shallow subtropical epi-continental sea, is nearly enclosed, and is about 1000 km long and 200-300 km wide, covering an area of some 226,000 km^2. It is characterized by its shallowness, with an average depth of only 35 m, reaching a maximum depth of about 100 m in the 60 km wide passage of the Strait of Hormuz which connects it with the Indian Ocean.

Another characteristic feature is the abnormal hypersalinity, due to its partial isolation from the Indian Ocean and the excessive evaporation (144 cm/year, Privett, 1959, and 124 cm/year, Butler, 1969). The latter is due to it being surrounded by arid land masses with high summer temperatures up to 50^{o}C, and very low rainfall.

Surface salinities in the central parts of the Gulf average 37-40‰ while the shallow parts on the Arabian side have salinities of 40-50‰, rising to 60-70‰ in remote lagoons and coastal embayments such as the Gulf of Salwah and Tarut Bay.

The sediments exhibit a primarily longitudinal pattern, with terrigenous sediments off the Iranian coast and dominantly carbonates and evaporites in the shallow waters off the Arabian coast. Fluvio deltaic sediments dominate in the north-west with the delta of the Euphrates Karun known as the Shutt Al Alarb. Detailed information about the Arabian Gulf can be found in Emery (1956), Sugden (1963a, b), Evans (1966) and a special volume about the Persian Gulf (Purser, 1973).

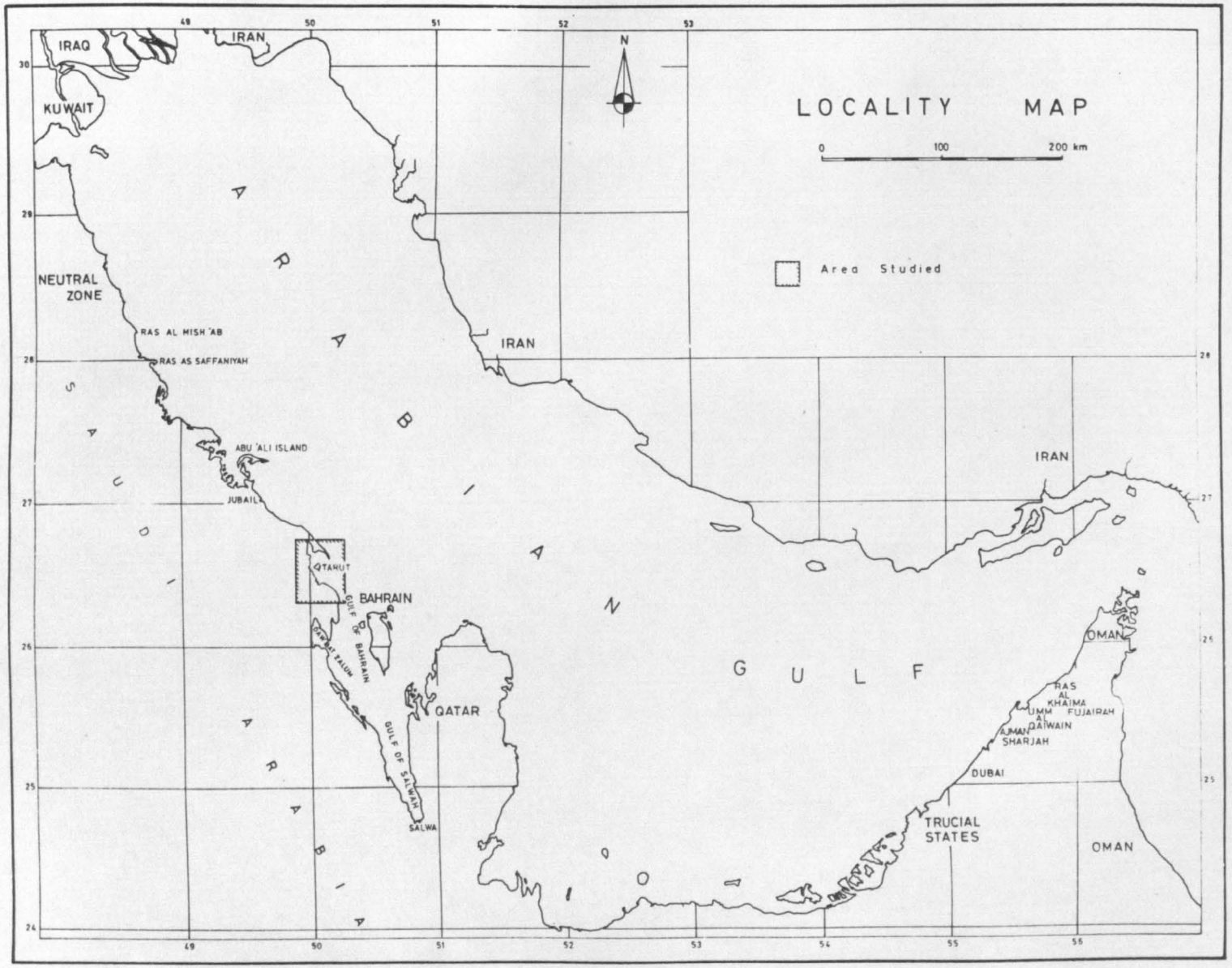
LOCALITY MAP
0 100 200 km
Area Studied
N
IRAQ
KUWAIT
IRAN
NEUTRAL ZONE
RAS AL MISH'AB
RAS AS SAFFANIYAH
ABU 'ALI ISLAND
JUBAIL
QTAHUT
BAHRAIN
GULF OF BAHRAIN
QOWAIL FALUN
QATAR
GULF OF SALWAH
SALWA
ARABIAN GULF
OMAN
RAS AL KHAIMA
UMM AL QAIWAIN
AJMAN
SHARJAH
DUBAI
TRUCIAL STATES
OMAN
SAUDI ARABIA

Fig. 1

THE ARABIAN GULF COASTLINE OF SAUDI ARABIA

The Saudi Arabian coastline of the Arabian Gulf (Fig. 1) extends for a little more than 450 km, from Ras Almish AB in the north-west to Salwah in the south-east. A brief description of this stretch of coastline is summarized below from Basson et al., (1976). The eastern coast of Saudi Arabia appears as a nearly straight line on a large-scale map. However, closer examination reveals the presence of extensive systems of bays and lagoons such as Tarut Bay. Moreover, this stretch of the coast can be divided into two distinct sections of nearly equal length on both physical and biological grounds. The northern section from Ras Almish AB to Ras Tanura on Tarut Bay (Fig. 1) forms part of a gentle arc which continues across the Baharin Islands to the northern tip of the Qter Peninsula. This part of the coastline trends roughly north-west - south-east and is exposed to waves generated by prevailing northerly winds of the Gulf. Regular diurnal or semi-diurnal tides occur all along this part of the coast and the maximum tidal range is a little over 2 m. The coast-line has a more southerly trend from Dammam southwards and lies nearly parallel to the direction of the prevail-ing winds. Almost all of this southern section of the coastline lies within the Gulf of Salwah and is protected from wave-action, not only by its orientation, but also

by the stretch of extremely shallow water lying between Saudi Arabia and Bahrain. These shallows also form a barrier to tidal water movements and therefore the tidal range is much reduced in the Gulf of Salwah. Tarut Bay lies between Dammam and Ras Tanura at the junction of the northern and southern portions of the coastline just described. It shows many features in common with other Arabian coastal bays and lagoons, but is unique in several respects and hence has been chosen for this investigation.

FORMER FORAMINIFERAL STUDIES

Although the Foraminifera of the Arabian Gulf have attracted the attention of a number of workers since the close of the eighteenth century, the Saudi Arabian coastline is still to be considered as "terra incognito" as far as its foraminiferal faunas are concerned.

Most studies have been concerned with the eastern, south-west and north-western sides of the Gulf. Fichtel and Moll presented the first published work on Foraminifera from the Arabian Gulf in 1798, erecting a number of new species including Eponides repandus, Elphidium macellum and Cancris auriculus, all originally described as new species of the genus Nautilus.

The modern epoch commenced with Henson (1950) who briefly discussed some living miliolids of the Gulf in his study on "Middle eastern Tertiary Peneroplidae". Houbolt (1957) briefly dealt with Foraminifera from off-shore Qatar, but his main object was to investigate the sedimentological problems of carbonate deposits in that part of the Gulf. He recorded about 20 genera and grouped them into 6 assemblages, each of which was taken to characterize a particular depth as follows:

1. Rotalia-Elphidium assemblages (3-5 fathoms)
2. Textularia-Miliolidae assemblages (6-14 fathoms)

3. Heterostegina assemblage (below 14 fathoms)
4. Cibicides assemblage (between 14-15 fathoms)
5. Rotalia-Cibicides assemblages (12-43 fathoms)
6. Rotalia-Elphidiella assemblages (marls of the central part of the Gulf)

Murray studied the distribution of both living and dead Foraminifera along the coast of the United Arab Emirates in a series of publications between 1965 and 1970. His first paper (1965a) was the description of a new benthonic species Rosalina adhaerens from inshore shoals waters. The second (1965b) was the study of 116 samples of Abu Dhabi town. The environments sampled were divided into shallow hypersaline lagoon, tidal drainage channel, delta-shaped oolite band and nearshore shelf. Each of these was found to have a characteristic assemblage of both dead and living Foraminifera. The next paper (1966a) was a study of the Foraminifera of the shoal water carbonate environments around the island of Halat Al-Bahrani. Living Foraminifera were sparse but the dead fauna was found to be dominated by miliolids.

Murray next described the distribution of the Foraminifera of Khor Al Buzam (Trucial coast) (1966b) and from three profiles across the shelf of the northern Trucial coast (1966c). In the latter, living Foraminifera were absent on the sediment surface, but dead Foraminifera

were abundant and also showed stages of transportation.

In two papers published in 1970, Murray discussed the distribution of living and dead Foraminifera. The first paper (1970a) indicated that living Foraminifera are actually associated with seaweed, sea-grass, dead coral crust and sediment substrates in the hypersaline Abu Dhabi lagoon. In the second paper (1970b) Murray states that living Foraminifera are mainly found in association with hair-like epiphytic plants, and are generally rare in the bottom sediments. This gives them a clumped distribution and also suggests that seaweeds and sea-grass are worthy of closer examination in the study of the living fauna.

Several papers on Foraminifera were published as results of the Meteor Expedition of 1965 along the Iranian coast. Lutze, Grabert and Seibold (1971) recorded and observed the living Foraminifera Heterostegina depressa (Lutze, Grabert and Seibold) in the Gulf on shallows and sides of islands in the Central Basin.

In 1974 Lutze published a catalogue containing 52 species, with a short discussion of the taxanomic problem and notes on the distribution of the Foraminifera. Haake (1975) published a catalogue of 54 miliolid species. He found that the frequency of most species generally increases with water depth, decreasing sedimentation rate,

and increasing grain size respectively, and has maximum values at water depths between 50 and 75 m. However, he found that the frequency of some species decreases with water depth.

In 1976 Lutze and Wolf indicated that several species preferred fine-grained sediments near river deltas ("delta spp."; Nonionella opima (Cushman), Nonion asterizans (Fichtel & Moll), Bolivina striatula (Cushman), Ammobaculites persicus Lutze). They noticed that the dominant distribution pattern was a distinctive depth zonation with a marked change at 35-40 m depth (a "shallow" fauna with Ammonia, Elphidium etc.; a "deep" fauna with Buliminacea, Cassidulina minuta (Cushman) and Cancris auriculus (Fichtel & Moll).

Anber (1974) analysed the foraminiferal content of 56 bottom samples from offshore of Kuwait, recognising 120 species and subspecies.

Cursory notes about the Foraminifera have also been included in the discussions of recent carbonate sedimentation in the Gulf; Hughes, Clarke and Keij (1973), Siebold et al. (1973), Wagner and Togt (1973) and Evans et al. (1973).

AIMS OF STUDY

There are three aims for this study:-

1. To evaluate the distribution of the Recent benthic Foraminifera of the Saudi Arabian coast as exemplified by Tarut Bay. It is hoped that the other parts of the Saudi Arabian coast will be assessed in future studies.

2. To complete the picture of the distribution of the benthic Foraminifera of the western part of the Arabian Gulf, taking into consideration that previous studies have been restricted to its southern and south-western parts.

3. An attempt to compare the recorded Foraminifera from the Saudi Arabian coast with other parts of the Arabian Gulf and adjacent regions.

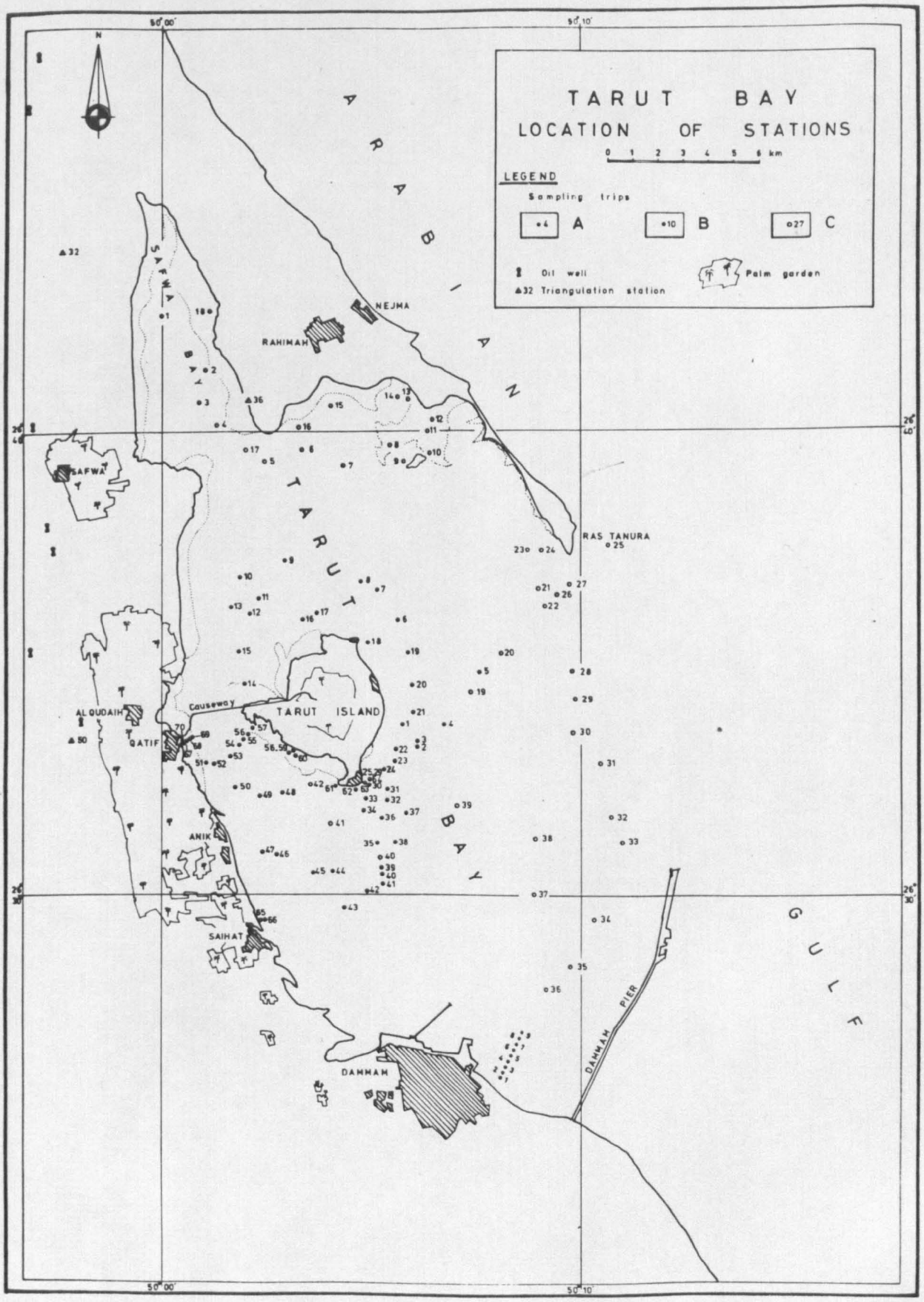
TARUT BAY
LOCATION OF STATIONS
0 1 2 3 4 5 6 km
LEGEND
Sampling trips
•4 A
•10 B
•27 C
Oil well
Palm garden
△32 Triangulation station
ARABIAN GULF
TARUT BAY
TARUT ISLAND
SAFWA
NEJMA
RAHIMAH
RAS TANURA
AL QUDAIH
Causeway
QATIF
ANIK
SAIHAT
DAMMAM
DAMMAM PIER
50° 00'
50° 10'
26° 40'
26° 30'
N

Fig 2

CHAPTER 2

TARUT BAY AND METHODS OF STUDY

Tarut Bay is a sheltered, shallow, warm, hypersaline bay located in the central part of the Saudi Arabian coast between lat. $26^{o}25'$ - $26^{o}45'$N and long. 50^{o}-$50^{o}10'$E (Fig. 2). It covers an area of approximately 440 km^2, including the small Tarut Island (17 km^2) in its centre which gives the bay its name. The bay has many towns along its western coast; from north to south these are Safwa, Qatif, Saihat and Dammam, the latter being the biggest city on the Saudi coast. Ras Tanura, the major oil-exporting port, is situated in the north-east. Thus Tarut Bay is an economically important area.

ENVIRONMENTS OF TARUT BAY

Intertidal and Subtidal Zones

The two principal environments recognized are the Intertidal and Subtidal Zones. These can be further subdivided on the basis of the type of substrate, vegetation, and depth as follows. Within the Intertidal Zone a rock shelf occurs in many places consisting of a soft greyish limestone made up of broken shells, sand and mud particles all cemented together. It is believed to be the product of Holocene lithification (Shinn, 1969). This rock shelf is occasionally covered by a thin veneer of gravel or coarse calcareous sand full of the shells of Certhidea sp. which are sometimes encrusted by filamentous green algae. In high energy areas sand flats are formed which have a high content of organic matter, frequently giving them a greyish colour. Distinct ripple marks can be seen at low water. In low energy areas mud flats are formed of very fine silty calcareous sediments. These are often cut by extensive meandering tidal channels, with tidal pools of varying sizes along them. There is no clear demarcation line between these three subzones which are rather patchy and sometimes overlap each other. The Subtidal Zone has been divided on the basis of bathymetry into shallow (depth range from the low water to 3 metres) and deep (depth range from 3 metres to 13

metres). The three subzones of the Intertidal area extend into the Subtidal Zone, but in addition to these a fourth subzone, formed by areas of seagrass, can be recognized.

Marine vegetation

The Intertidal and Subtidal environments each have a well-defined vegetation. The vegetation may be sparse or dense according to local environmental conditions such as topography and nature of the substrate. In areas of rocky substrate the vegetation is noticeably sparse, whereas in protected areas, sandy or muddy bottoms enable seedlings to root and marine vegetation to flourish. Intertidal vegetation, particularly on the mud flats, can be differentiated into 4 zones ranging from land to seawards as follows:-

The marsh grass zone:

This zone might well be regarded as belonging to the supratidal region and is occupied by salt-tolerant grass and grass-like plants such as the red Phragmites communis (Basson et al. 1976).

The halophyte zone:

This is the true uppermost portion of the Intertidal region which has salt-tolerant flowering plants or

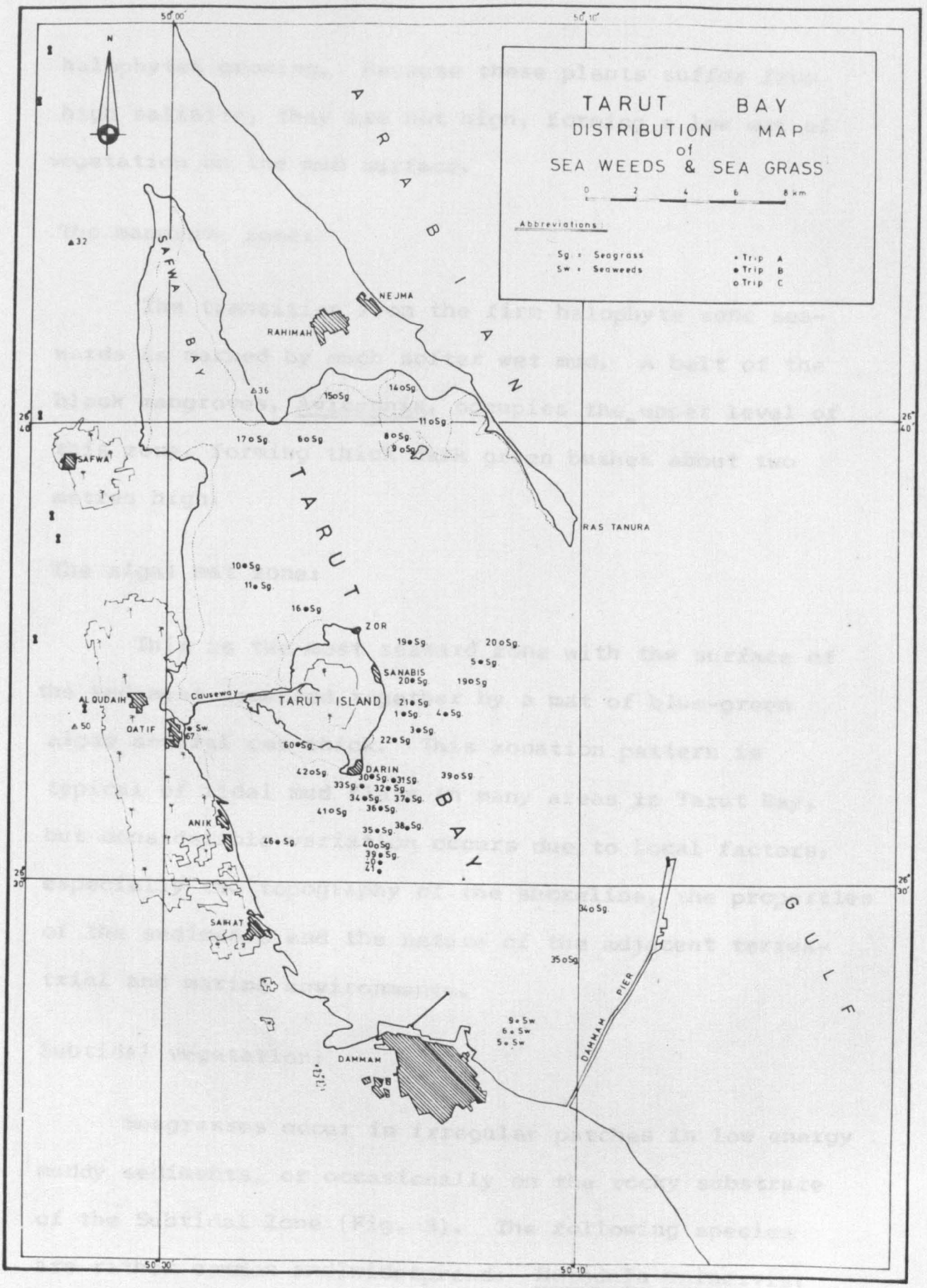
TARUT BAY
DISTRIBUTION MAP
of
SEA WEEDS & SEA GRASS
0 2 4 6 8 km
Abbreviations
Sg. = Seagrass
Sw. = Seaweeds
• Trip A
● Trip B
o Trip C
N
ARABIAN GULF
TARUT BAY
SAFWA BAY
TARUT ISLAND
Causeway
NEJMA
RAHIMAH
SAFWA
RAS TANURA
ZOR
SANABIS
AL QUDAIH
QATIF
DARIN
ANIK
SAIHAT
DAMMAM
DAMMAM PIER
50° 00'
50° 10'
50° 30'
26° 40'
26° 30'

Fig 3

halophytes growing. Because these plants suffer from high salinity, they are not high, forming a low mat of vegetation on the mud surface.

The mangrove zone:

The transition from the firm halophyte zone seawards is marked by much softer wet mud. A belt of the black mangroves, Avicennia, occupies the upper level of this zone, forming thick dark green bushes about two metres high.

The algal mat zone:

This is the most seaward zone with the surface of the sediment cemented together by a mat of blue-green algae several cms thick. This zonation pattern is typical of tidal mud flats in many areas in Tarut Bay, but considerable variation occurs due to local factors, especially the topography of the shoreline, the properties of the sediments and the nature of the adjacent terrestrial and marine environments.

Subtidal vegetation:

Seagrasses occur in irregular patches in low energy muddy sediments, or occasionally on the rocky substrate of the Subtidal Zone (Fig. 3). The following species are rather common and widespread: Halodula uninervis, Halophila ovalis, and Halophila stipulacea (after Basson

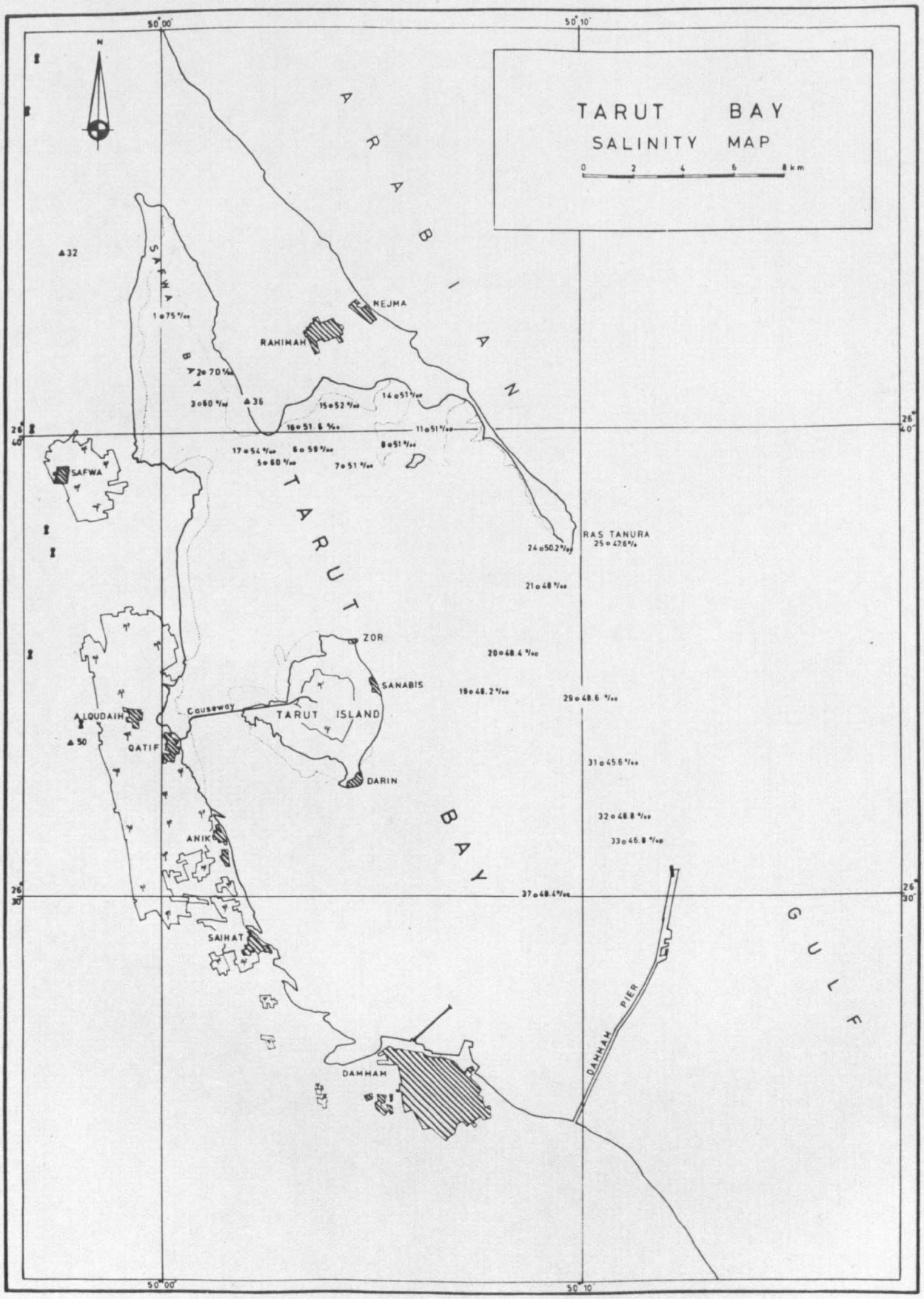
TARUT BAY
SALINITY MAP
0 2 4 6 8 km
N
50° 00'
50° 10'
26° 40'
26° 30'
ARABIAN GULF
TARUT BAY
SAFWA BAY
SAFWA
RAHIMAH
NEJMA
TARUT ISLAND
Causeway
ZOR
SANABIS
DARIN
AL OUDAIH
QATIF
ANIK
SAIHAT
DAMMAM
DAMMAM PIER
RAS TANURA
25 o 47.6 ‰
1 o 75 ‰
2 o 70 ‰
3 o 60 ‰
14 o 51 ‰
15 o 52 ‰
16 o 51.6 ‰
11 o 51 ‰
17 o 54 ‰
8 o 59 ‰
8 o 51 ‰
5 o 60 ‰
7 o 51 ‰
24 o 50.2 ‰
21 o 48 ‰
20 o 48.4 ‰
19 o 48.2 ‰
29 o 48.6 ‰
31 o 45.6 ‰
32 o 48.8 ‰
33 o 46.8 ‰
37 o 48.4 ‰
▲32
▲36
▲50

Fig. 4

et al. 1976).

Measured environmental parameters

Factors which may have some influence on the sub-environments of Tarut Bay, and which were measured for the study are as follows:-

Salinity:

Tarut Bay is characterized by higher than normal salinity. Fig. 4 shows the distribution of 37 stations where the salinity ranges from 45‰ at the open bay to 75‰ at its inner isolated northern extension. The average salinity is 52‰.

Temperature:

Generally speaking, there is a marked change in temperature from summer to winter in the Arabian Gulf. Surface temperature in the Saudi Arabian coastal waters can range from 10°C in the winter to 35°C in the summer (Basson et al. 1976). In this study the samples were collected in the spring of 1979 and 1980. 1979 was generally warmer though only a slight difference was observed in the recorded temperature. The shallowness of the bay means that there is only a small difference between the temperature of the surface and bottom waters (see Appendix 1).

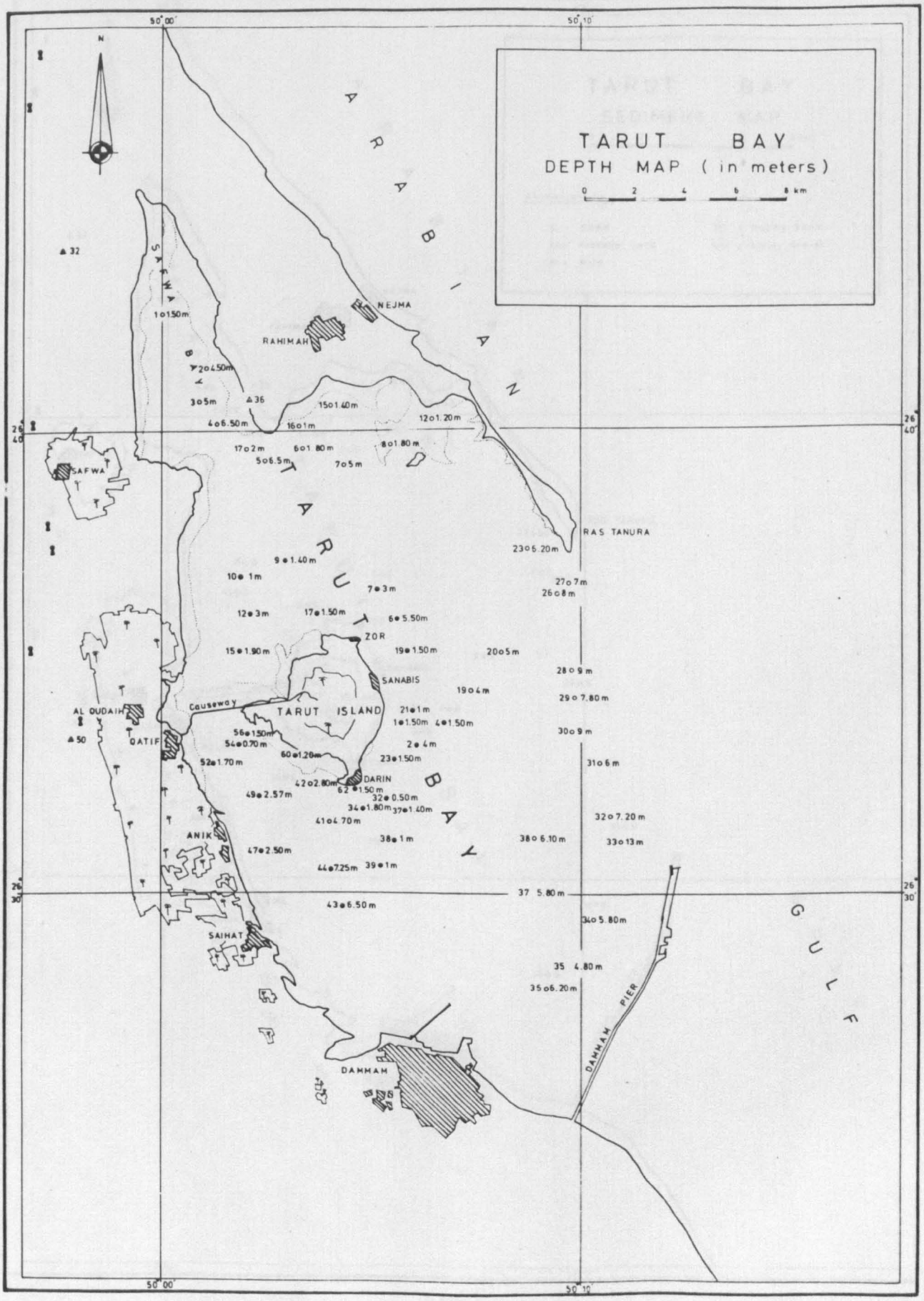
TARUT BAY
DEPTH MAP (in meters)
0 2 4 6 8 km
N
50° 00'
50° 10'
26° 40'
26° 30'
ARABIAN GULF
TARUT BAY
SAFWA BAY
SAFWA
NEJMA
RAHIMAH
RAS TANURA
ZOR
SANABIS
TARUT ISLAND
Causeway
AL QUDAIH
QATIF
DARIN
ANIK
SAIHAT
DAMMAM
DAMMAM PIER
▲32
▲36
▲50
1o1.50m
2o4.50m
3o5m
4o6.50m
5o6.5m
6o1.80m
7o5m
8o1.80m
9●1.40m
10●1m
12●3m
15●1.90m
17●1.50m
19●1.50m
20o5m
21●1m
23●1.50m
27o7m
28o9m
29o7.80m
30o9m
31o6m
32o7.20m
33o13m
34o5.80m
35 4.80m
35o6.20m
37 5.80m
38o6.10m
38●1m
39●1m
41o4.70m
42o2.80m
43●6.50m
44●7.25m
47●2.50m
49●2.57m
52●1.70m
54●0.70m
56●1.50m
60●1.20m
62●1.50m
32●0.50m
34●1.80m
37●1.40m

Fig 5

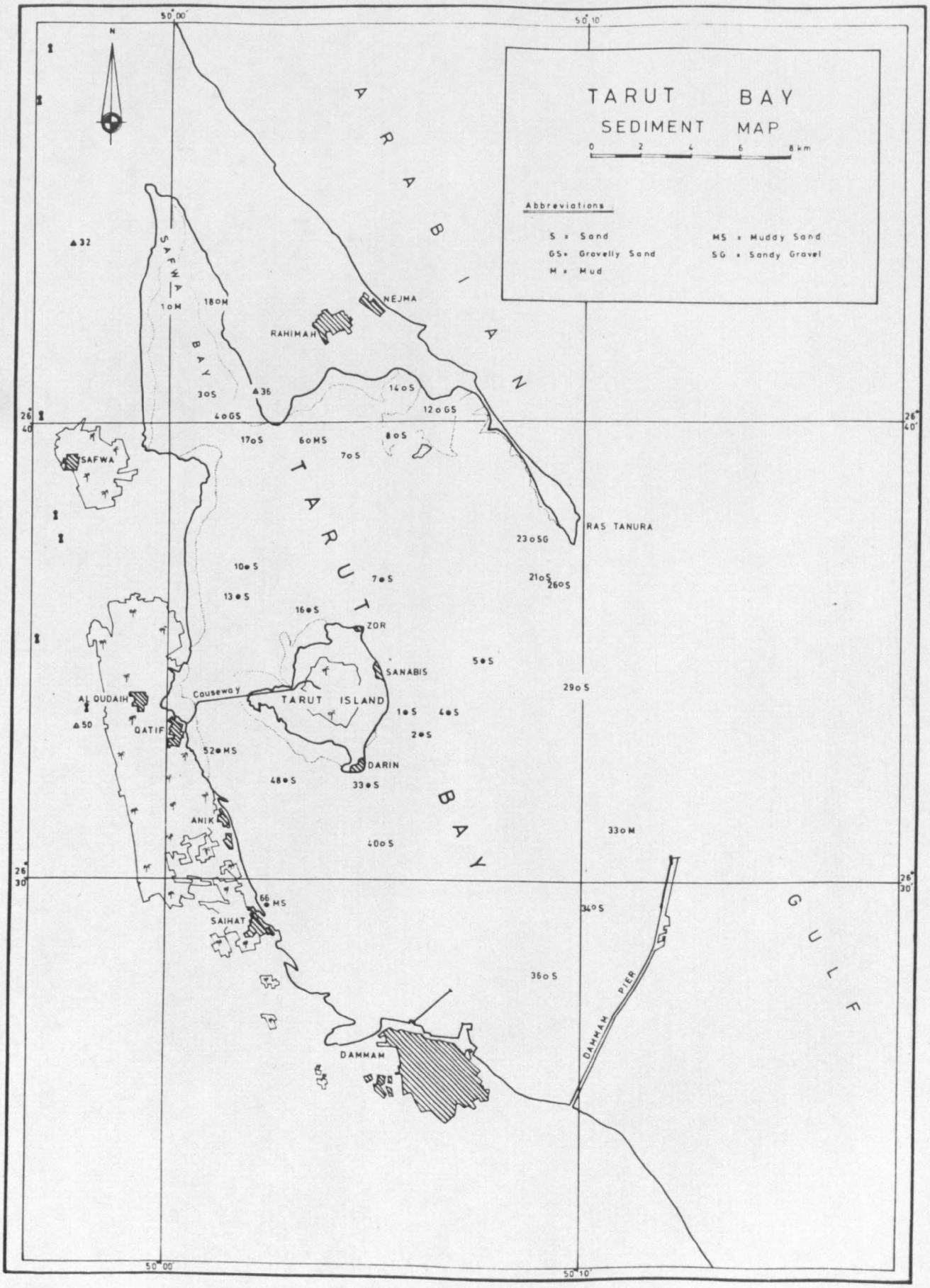
TARUT BAY
SEDIMENT MAP
0 2 4 6 8 km
Abbreviations
S = Sand
MS = Muddy Sand
GS = Gravelly Sand
SG = Sandy Gravel
M = Mud
50° 00'
50° 10'
26° 40'
26° 30'
N
ARABIAN GULF
TARUT BAY
SAFWA BAY
SAFWA
NEJMA
RAHIMAH
RAS TANURA
ZOR
SANABIS
TARUT ISLAND
Causeway
AL QUDAIH
QATIF
DARIN
ANIK
SAIHAT
DAMMAM
DAMMAM PIER
▲32
▲36
▲50
10M
180M
30S
40GS
17oS
60MS
7oS
8oS
14oS
12oGS
23oSG
10●S
13●S
7●S
16●S
21oS
26oS
5●S
29oS
1●S
4●S
2●S
52●MS
48●S
33●S
40oS
33oM
66●MS
34oS
36oS

Fig 6

Depth:

Tarut Bay is uniformly shallow. Fig. 5 shows that the depth ranges from the low water mark (Shallow Subtidal)to about 13 metres in the Deeper Subtidal.

Type of sediment:

The sediments of Tarut Bay can be classified into 7 divisions according to grain size and the percentage of the different grain sizes. These are gravel, sandy gravel, gravelly sand, sand, muddy sand, sandy mud and mud (see below for details, and Fig. 6).

Tides:

Tidal information is based on tables for Ras Tanura station formulated by the Aramco Company 1979-1980. There is a twice daily tide with an average range of 2 m.

MATERIAL AND METHODS

Fieldwork

121 samples from bottom sea sediments, seagrass and seaweeds were collected during 3 trips to the area (Fig. 2). The first trip (A) was on 27th February 1979 when 9 samples were collected at 250 m intervals on a traverse through the Intertidal Zone north of, and parallel to, Dammam Port Pier. The samples were collected with an ebbing tide, using a tray of dimensions 10 x 10 x 2 cm. The samples from this trip were preserved in 95% alcohol.

The second trip (B) was on the 7th April 1979, when 70 samples were collected, 60 of them on a traverse around Tarut Island, using a van veen grab (225 cm^2) from aboard a local fishing boat. The clarity and shallowness of the water allowed the observation of the nature and composition of the substrate, whether bare sediment, seagrass or seaweed. The remaining 10 samples were collected from the Intertidal Zone using the tray described above. The samples from this trip were preserved in 10% neutralized formalin.

During the third trip, which was on 9th and 10th April 1980, 42 samples were collected on a traverse passing through Safwa Bay to the open Bay of Tarut, once

again using a van veen grab from aboard a fishing boat. The samples from this trip were kept in 95% alcohol. It should be noted that the boats used during sampling were not equipped with any aids for depth recording and location finding. The locations of the samples were established by taking bearings using a Brunton compass on the first and third trips, and by prismatic compass on the second trip. Depth was measured at each station by a weighted line subdivided into metres.

The temperature of the surface and bottom water were determined with a salinometer. The salinity had to be measured by diluting one volume of sea water with one volume of fresh water, due to the hypersaline salinities being beyond the limits of the instrument.

Submarine photographs were taken but the results were not successful. All samples were kept in plastic bags and were transferred to the University laboratory in Jeddah.

Laboratory methods

The samples were prepared for foraminiferal analysis by washing over 10 and 200 mesh sieves to remove both gravel and very fine particles. The residue was stained in rose bengal for one hour (Walton 1952), then rewashed over a 200 mesh sieve to remove excess stain and dried

at 60°C. To facilitate counting the Foraminifera were concentrated by slowly adding the dried sieved sediments to carbontetrachloride, the Foraminifera floating on the surface being collected by passing the solution through filter paper. The sediment residues were checked to see whether complete separation had taken place.

Most of the samples contained a high concentration of Foraminifera so it was necessary to take a small fraction of 0.25 gm which was spread over a standard picking tray. Counts were made for each of the recognized taxa of both living and dead. The average number of living specimens counted per sample was 345 whereas for the dead it was 1306 (Appendix 2, 3). The percentages of the three suborders and the recognized taxa were calculated for each sample. If the sample was large enough the sediment was analysed by sieving a weighted amount of dry sediment using 10 - 18 - 35 - 60 - 120 - 200 mesh sieves. According to the Wentworth Scale (1922) the fraction retained between the 18 - 200 mesh sieves is sand and that which passes through the sieves is mud. The sediments were then arranged into 7 groups by the percentage weight of their different components, as follows:-

1. Gravel: gravel > 80%
2. Sand gravel: gravel > sand > 10% > mud
3. Gravelly sand: sand > gravel > 10% > mud
4. Sand: sand > 80%
5. Muddy sand: sand > mud > 10% > gravel
6. Mud: mud > 80%
7. Sandy mud: mud > sand > 10% > gravel

The sand fraction was plotted on semi-log paper to obtain a cumulative frequency curve from which phi values were determined (see Appendix 4). Selected specimens representing most of the identified species were examined by the Scanning Electron Microscope (S.E.M.) and the appropriate photographs were taken.

The data has been analysed on the basis of the relative abundance of the common taxa, plotting of distribution maps, triangular diagrams and diversity indices, and consideration of Living/Dead ratios. These methods are discussed more fully within the text.

SOURCES OF ERROR

In the field

1. The small Van Veen grab collects an area of 225 cm^2. The closure of the grab was sometimes imperfect and washing of material took place during transit through the water to the boat, particularly in deeper water. Another problem arose in sampling rocky and seagrass areas where it was often necessary to have repeated attempts at sampling which disturbed the sediment.

2. Position was established by compass and these positions might be affected by drifting caused by the wind.

3. The salinity measurements are approximate because they were determined by dilution of a volume of fresh water with hypersaline water.

In the laboratory

1. The use of rose Bengal (Walton 1952) may be unreliable. It was observed, particularly amongst the Miliolacea, that stained red protoplasm projected from the aperture, while the test remained unstained. This might lead to an increase in the ratio of the

dead population.

2. During counting it is likely that some specimens are missed or misidentified. However, to avoid this the population count was increased from the customary count of 250-300 by considering all individuals within the small fraction.

It is believed that the above mentioned errors still lie within a permissible range.

CHAPTER 3

DISTRIBUTION AND ECOLOGY OF THE FORAMINIFERA

INTRODUCTION

121 samples were collected from the study area, of which 109 yielded Foraminifera. 65 of the latter were samples from the bare sediment and 44 from vegetation. 43 taxa have been recognized which include distinct species as well as genera such as Quinqueloculina in which species discrimination is difficult. 14 of these taxa form 90% of the dead and 92% of the living population (Table 1). Dead foraminiferal counts amount to 142360 and living 37655.

This chapter has two main aims. The first is to discuss the individual environments in the area in relation to the presence-absence and relative abundance of the 14 common taxa. This is dealt with in a series of distribution maps. The second aim is to discuss the general features of the foraminiferal population in the area by examining their diversity, the proportions of the foraminiferal suborders and finally to trace and discuss the living-dead ratios.

Table 1

The 14 common taxa in the order of abundance.

Taxa	No. of Dead	No. of Living
1. Quinqueloculina spp.	26230	7370
2. Ammonia beccarii	17950	6285
3. Elphidium aff. advenum	14625	3435
4. Triloculina spp.	14350	3000
5. Spiroloculina spp.	12070	2192
6. Spirolina arietina	9830	3320
7. Peneroplis planatus	8860	3060
8. Eponides murrayi	7040	1015
9. Elphidium reticulosum	4440	1250
10. Elphidium aff. discoidale	3975	465
11. Peneroplis pertusus	2580	505
12. Textularia spp.	2390	600
13. Discorbina patelliformis	1830	565
14. Eggerella scabra	1365	1675
Total	127535	34737

INDIVIDUAL ENVIRONMENTS

Tarut Bay is an area of shallow hypersaline waters, which can be subdivided into two main environments: the Tidal Zone and Subtidal Zone. The latter is further subdivided on the basis of the bathymetry into Shallow Subtidal and Deeper Subtidal (see the chapter on Tarut Bay). In this part the distribution of the 14 common taxa within these three zones is considered on the basis of their presence-absence and relative abundance. The living fauna is considered to be more reliable in expressing the nature of the environments than the dead fauna, although the pattern of distribution of the latter follows that of the living fauna in the area. The relative abundance of the living and dead of the 14 taxa within the three zones have been summarized in Tables 2 and 3.

Table 2

The relative abundance of live specimens of the 14 common taxa in the three environmental zones.

Taxa %	Inter-tidal Zone (a)	Shallow Subtidal Zone (b)	Deeper Subtidal Zone (c)
1. Quinqueloculina spp.	18	20	21
2. Ammonia beccarii	25	19	2.3
3. Elphidium aff. advenum	17	9.5	0.8
4. Triloculina spp.	4	7	14.8
5. Spiroloculina spp.	0.6	6	10.6
6. Spirolina arietina	16	7.9	5.8
7. Peneroplis planatus	14	8.6	1.5
8. Eponides murrayi	-	4	2
9. Elphidium reticulosum	4	4	2.2
10. Elphidium aff. discoidale	0.5	2	-
11. Peneroplis pertusus	0.4	2	0.7
12. Textularia spp.	-	0.2	7.2
13. Discorbina patelliformis	-	2	1.4
14. Eggerella scabra	-	1	18.5

Table 3

The relative abundance of dead specimens of the 14 common taxa in the three environmental zones.

Taxa %	Inter-tidal Zone (a)	Shallow Subtidal Zone (b)	Deeper Subtidal Zone (c)
1. Quinqueloculina spp.	20	18	18
2. Ammonia beccarii	19	13.5	6
3. Elphidium aff. advenum	18	11	3
4. Triloculina spp.	4	8	17
5. Spiroloculina spp.	1.5	8.4	13
6. Spirolina arietina	15	6	4.8
7. Peneroplis planatus	11	6.6	2.7
8. Eponides murrayi	0.2	6	5.2
9. Elphidium reticulosum	4	3.6	0.7
10. Elphidium aff. discoidale	0.8	4	-
11. Peneroplis pertusus	1.2	2	1.2
12. Textularia spp.	-	0.3	7
13. Discorbina patelliformis	-	1.8	0.8
14. Eggerella scabra	-	0.2	3.4

a. The Intertidal Zone

The major taxa occurring in this part of the environment in order of abundance are: Ammonia beccarii 25%, Quinqueloculina spp. 18%, Elphidium aff. advenum 17%, Spirolina arietina 16%, Peneroplis planatus 14%. The characteristic feature of the Intertidal Zone is the high percentage of Ammonia beccarii, followed by Quinqueloculina spp., Elphidium aff. advenum, Spirolina arietina and Peneroplis planatus. Another feature is the absence of Eponides murrayi, Textularia spp., Discorbina patelliformis and Eggerella scabra. The remaining species occur in very low percentages.

b. The Shallow Subtidal Zone

The major taxa occurring in this zone are: Quinqueloculina spp. 20%, Ammonia beccarii 19%, Elphidium aff. advenum 9.5%, Peneroplis planatus 8.6%, Spirolina arietina 7.9%, Triloculina spp. 7% and Spiroloculina spp. 6%. The main feature of this zone compared with the Intertidal Zone is the lower percentage of Elphidium aff. advenum and the greater abundance of Triloculina spp. and Spiroloculina spp.

c. The Deeper Subtidal Zone

The main taxa present here are: Quinqueloculina spp. 21%, Eggerella scabra 18.5%, Triloculina spp. 14%, Spiroloculina spp. 10.6%, Textularia spp. 7.2% and Spirolina arietina 5.8%. The main feature is the abundance of Eggerella scabra and Textularia spp. compared with the two previous zones. The 14 common taxa are widespread and it is their change in relative abundance that enables the three subdivisions to be distinguished. Some are absent from some zones: Eponides murrayi, Textularia spp., Discorbina patelliformis and Eggerella scabra are never recorded from the Intertidal Zone and Elphidium aff. discoidale is not recorded from the Deeper Subtidal Zone.

DISTRIBUTION MAPS

The spacing between samples was often very close so to avoid unnecessary duplication, the relative frequencies of the 14 common taxa have been examined and recorded in detail for 63 samples. The frequencies of occurrence have been divided into the following categories following the work of Hageman (1979):-

Very rare < 3%

Rare 3-6%

Common 7-12%

Frequent 13-25%

Abundant 26-50%

Dominant > 50%

It should be noted that 4 of the taxa discussed, namely Quinqueloculina spp., Triloculina spp., Spiroloculina spp. and Textularia spp. each represent a group of species which are difficult to discriminate. Any attempt would be unreliable and would distort the broad pattern of foraminiferal distribution. They have therefore been considered as groups of species for plotting on the maps. When considering the distribution maps it should be borne in mind that ecologists recognize three main distribution patterns: random, uniform and clumped. In the case of the Foraminifera the clumped pattern has two causes: micro-environment and reproduction. In regions of sub-

marine vegetation there is always patchy distribution of the Foraminifera because the plants provide a discontinuous substrate (Lee et al. 1969, Murray 1970b).

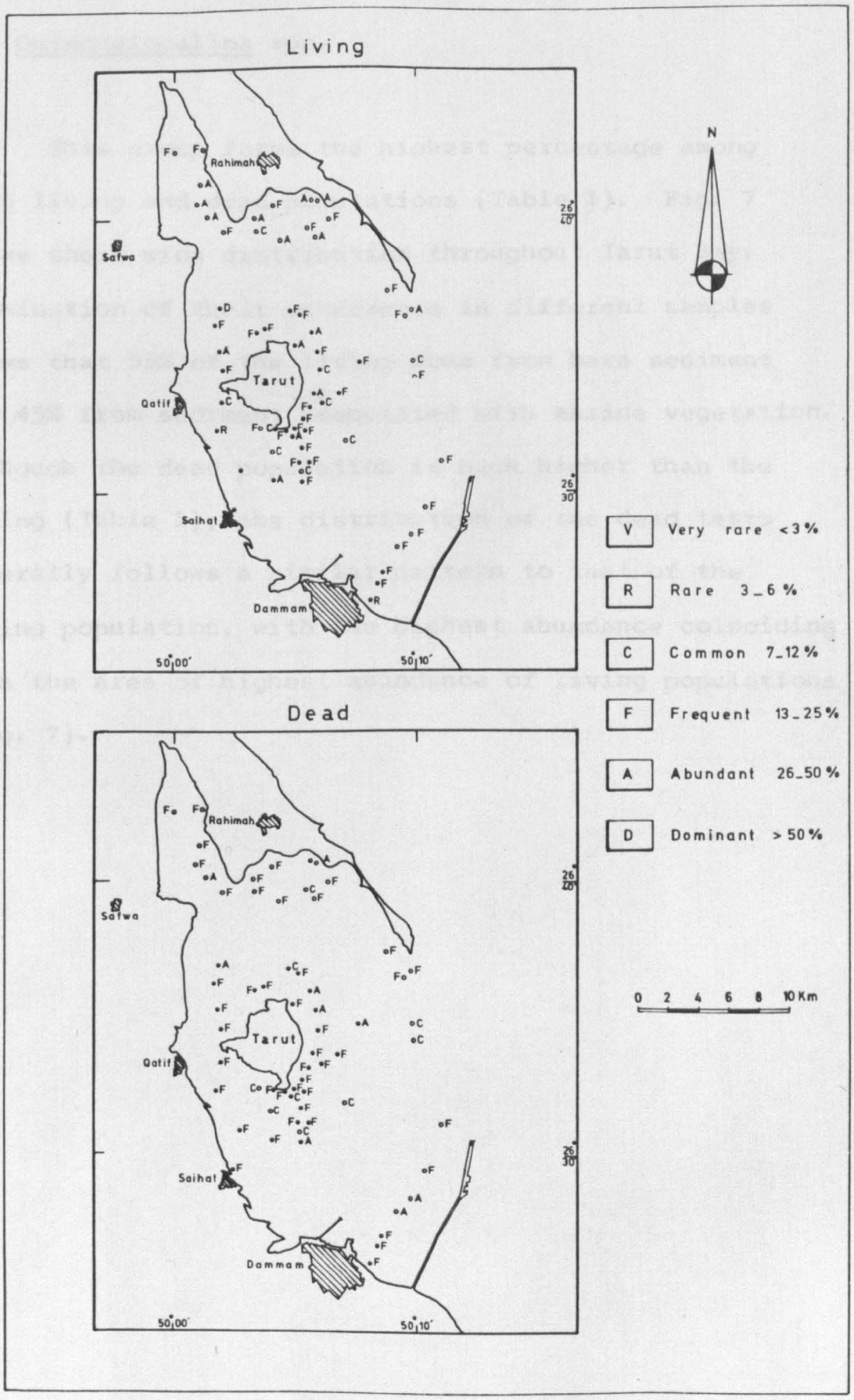

Fig. 7 _ Distribution map of Quinqueloculina spp.

1. Quinqueloculina spp.

This group forms the highest percentage among both living and dead populations (Table 1). Fig. 7 shows their wide distribution throughout Tarut Bay. Examination of their occurrence in different samples shows that 55% of the living come from bare sediment and 45% from sediment associated with marine vegetation. Although the dead population is much higher than the living (Table 1), the distribution of the dead tests generally follows a similar pattern to that of the living population, with the highest abundance coinciding with the area of highest abundance of living populations (Fig. 7).

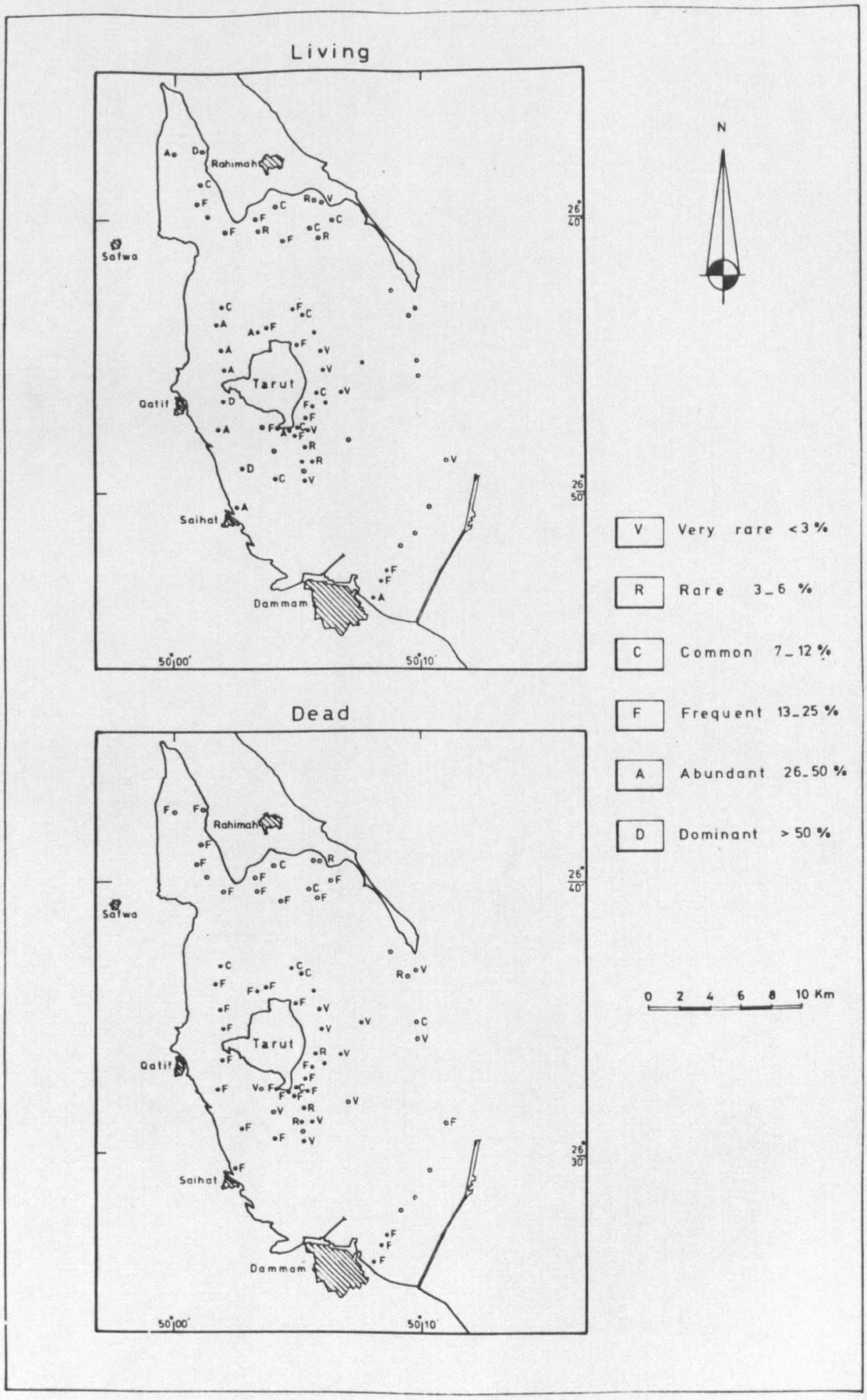

Fig. 8 _ Distribution map of Ammonia beccarii

2. Ammonia beccarii (Linne)

This is one of the main species, dominating both living and dead faunas. Fig. 8 shows that the living population has a restricted distribution, being most abundant, in terms of percentage of the fauna, in restricted areas of the Shallow Subtidal Zone. Its greatest abundance seems to be in the more isolated and restricted areas such as Safawa Bay and the west side of Tarut Island. Its next greatest abundance is in the Intertidal Zone and it becomes rare on the east side of Tarut Island and nearly absent towards the Deeper Subtidal Zone of the open bay. 78% of the recorded living Ammonia beccarii are found in samples of bare sediment, leading to the conclusion that this species lives mainly on the sediment. The distribution of the dead population, shows the same pattern as the living population, although it is commoner in the open Deeper Subtidal Zone. This could be interpreted as drifting of dead tests from the Intertidal Zone and Shallow Subtidal Zone during the ebbing tide.

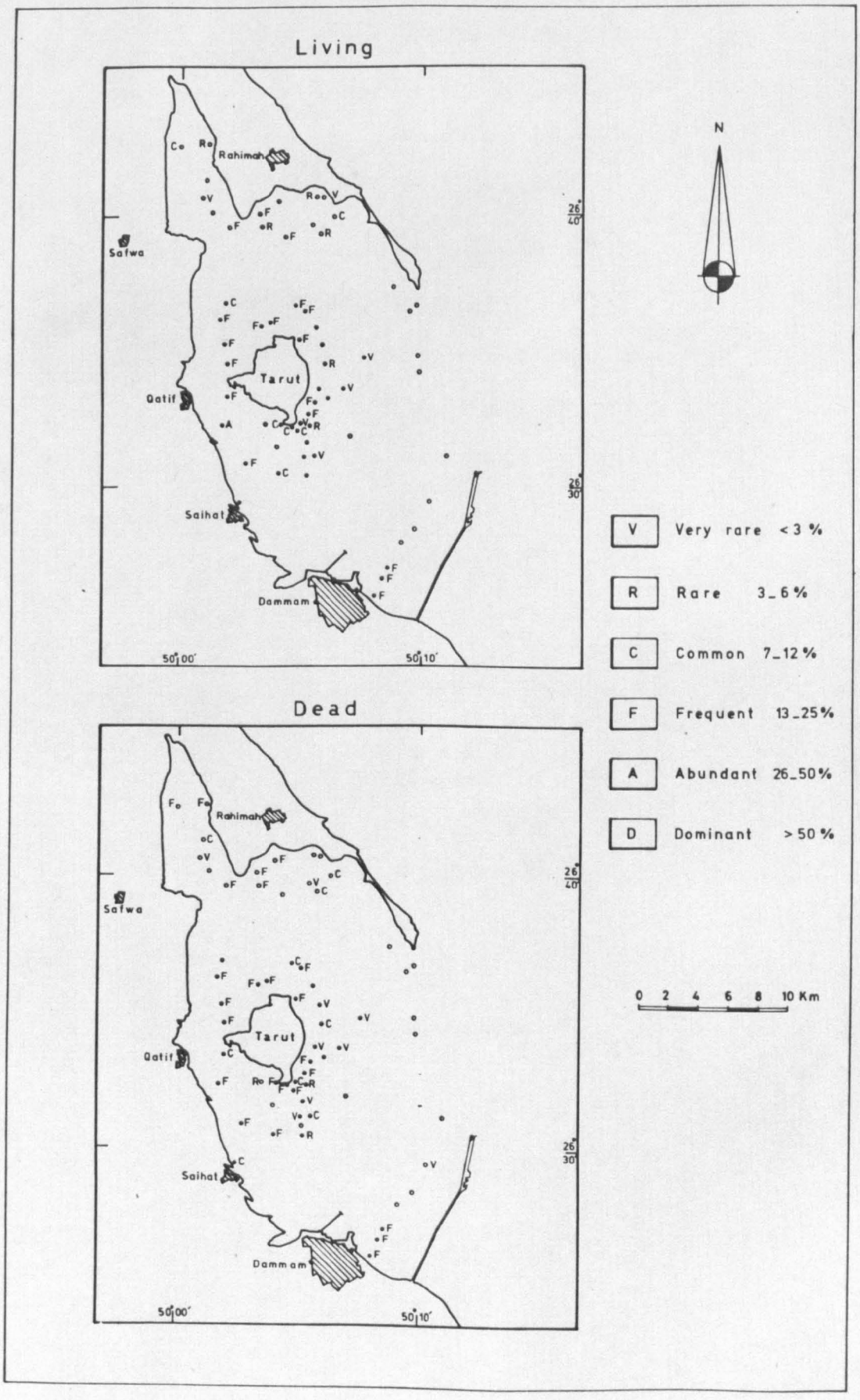

Fig. 9 _ Distribution map of Elphidium aff. advenum

3. Elphidium aff. advenum (Cushman)

This common species has a restricted distribution with its highest occurrence in the Shallow Subtidal Zone around Tarut Island and the north-east of the bay and the Intertidal Zone in the south-west (Fig. 9). It is absent in the open deeper water. Live populations are recorded mainly from bare sediment (71%). The distribution of the dead population follows the same pattern as the living with minor occurrence in the Deeper Subtidal Zone.

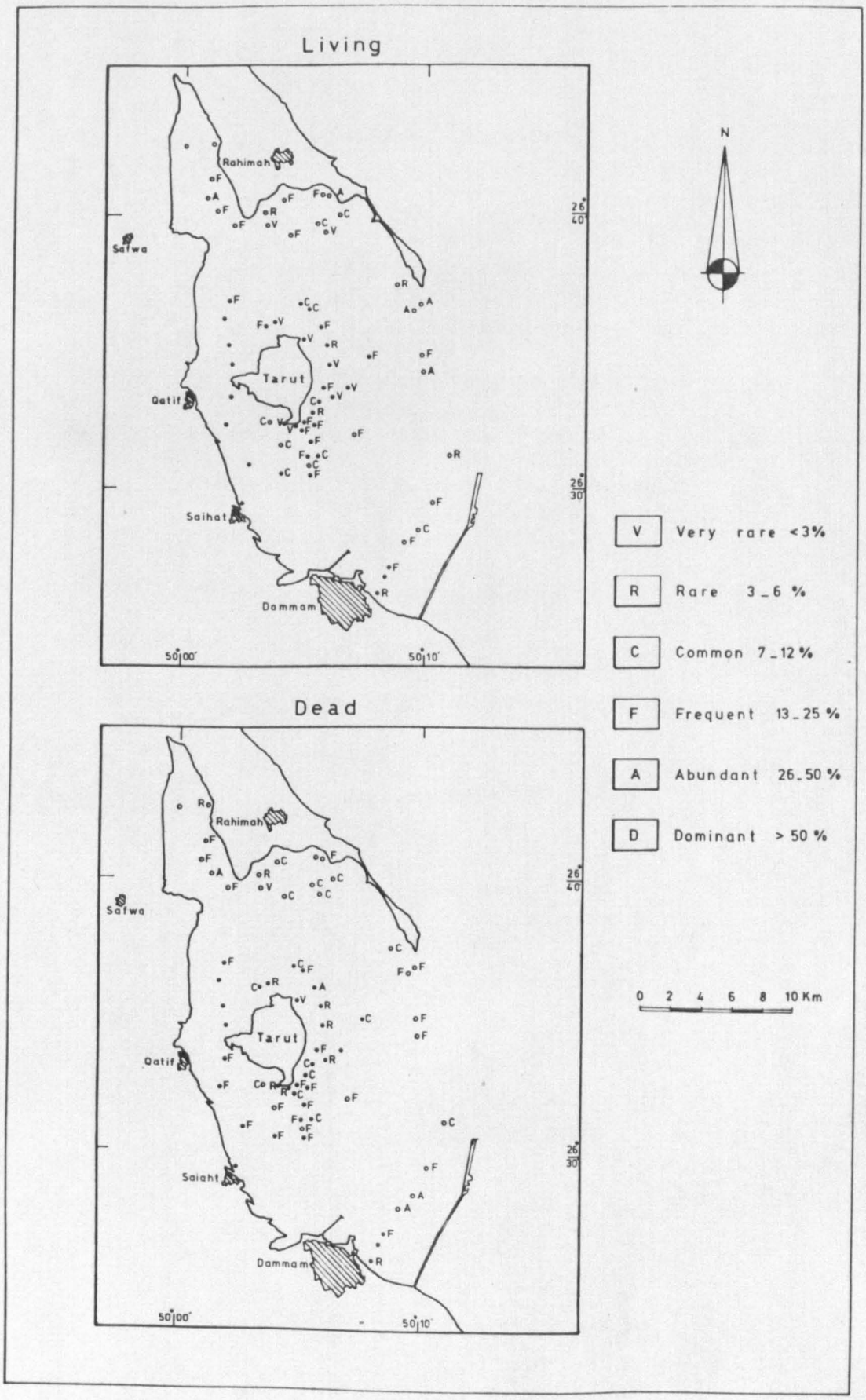

Fig. 10. Distribution map of Triloculina spp.

4. Triloculina spp.

This second group of Miliolina species also shows great infraspecific variation, making it difficult to consider the distribution of individual species. Fig. 10 shows the group to be widely distributed throughout the bay, the dead fauna being more widespread than the living, especially on the west side of Tarut Island. In general both living and dead have their lowest occurrence in the Intertidal Zone, a greater abundance in the Shallow Subtidal Zone and the greatest abundance in the Deeper Subtidal Zone (Table 2 & 3). This group of species is found equally within the bare sediment and sediment associated with vegetation.

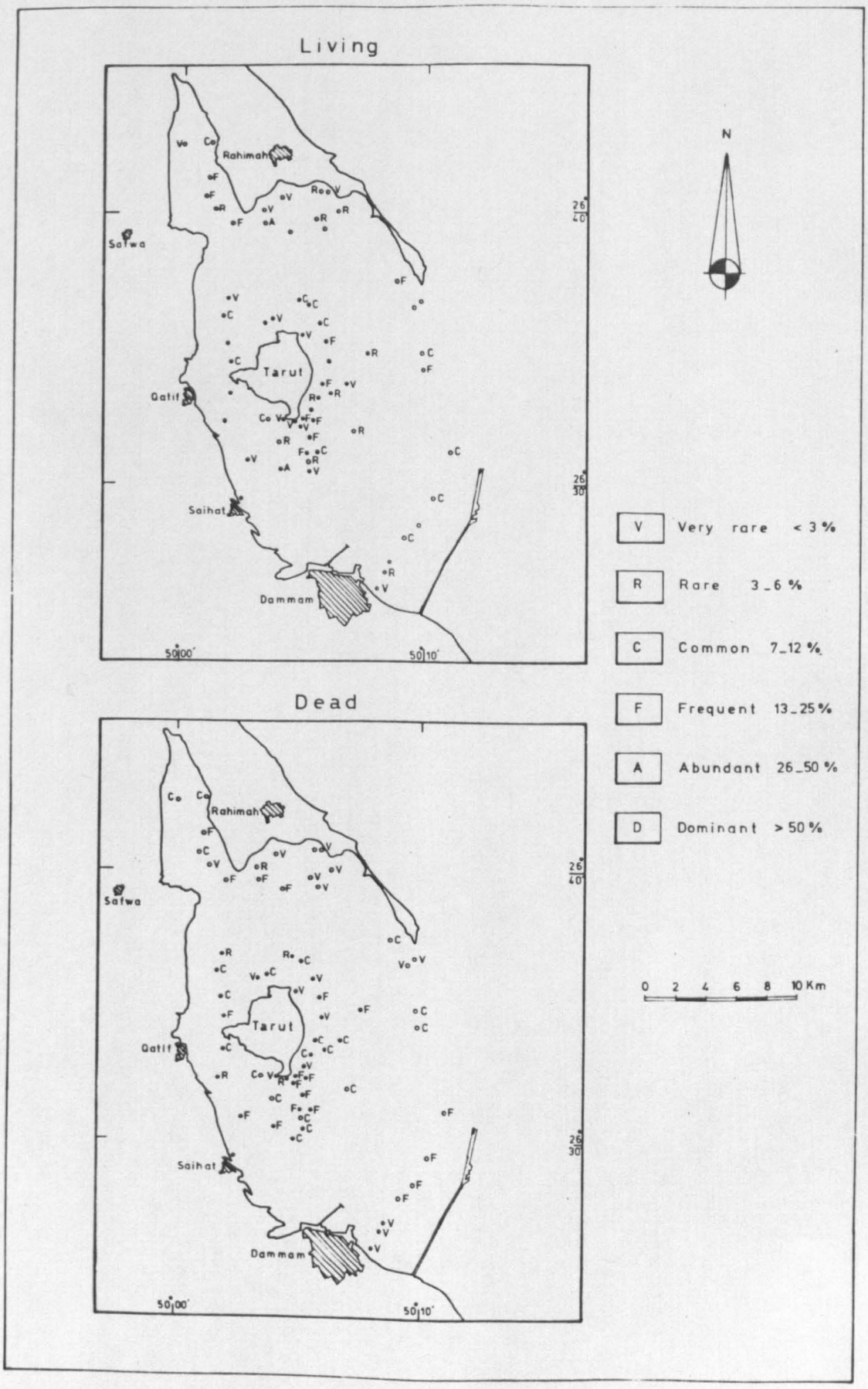

Fig.11 - Distribution map of Spiroloculina spp.

5. Spiroloculina spp.

This group of species showed wide distribution throughout the bay (Fig. 11), with minor occurrence in the Intertidal Zone and highest occurrence in the Subtidal Zone. The genus lives equally in bare sediment and the sediment in association with vegetation. The dead population shows a similar distribution to the live population.

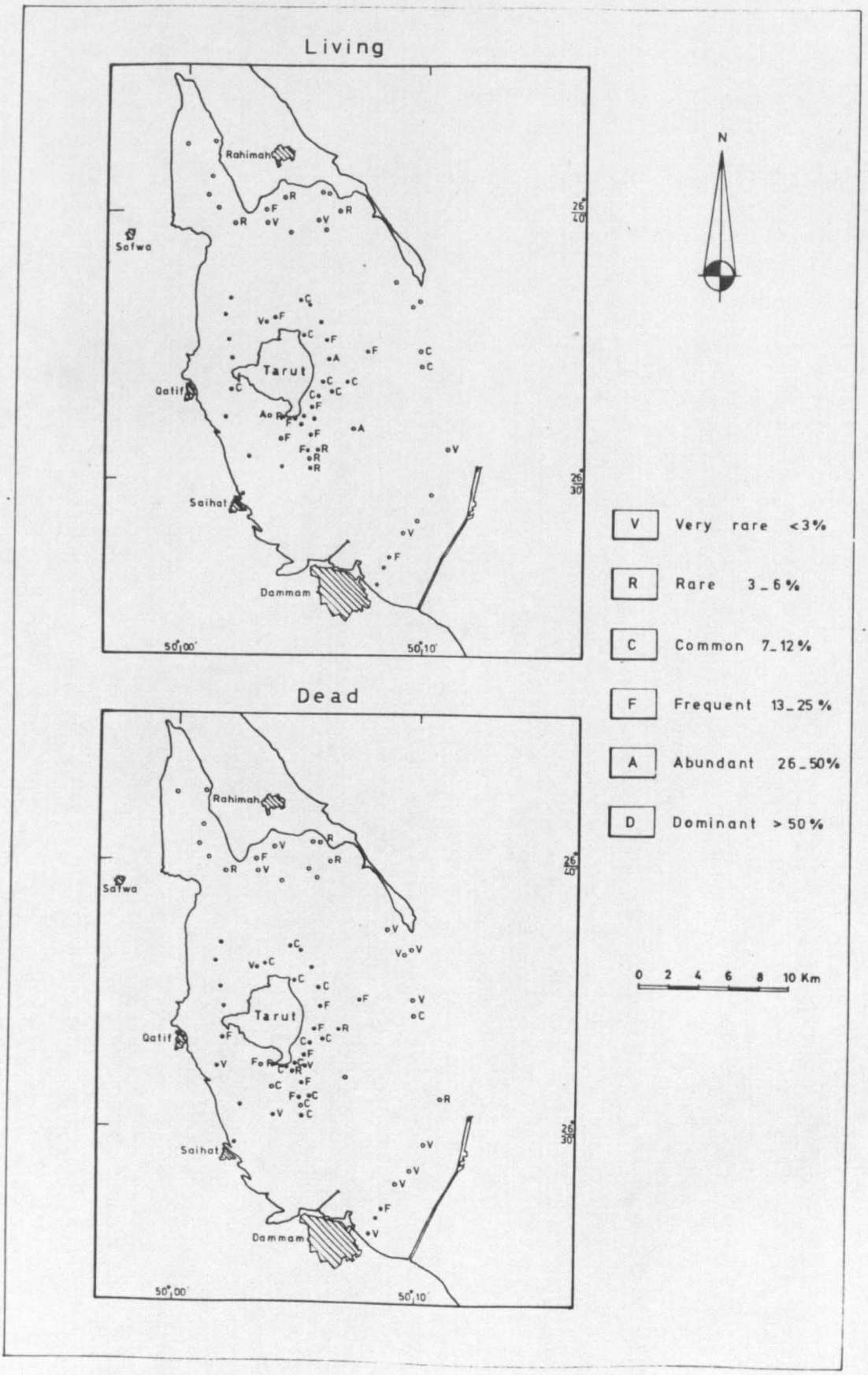

Fig.12_Distribution map of Spirolina arietina

6. Spirolina arietina (Batsch)

Fig. 12 indicates that this species, to some extent, occurs mainly on the east side of Tarut Island and the north-east of the bay. These areas are dominated by seagrass, leading to the conclusion that Spirolina arietina lives mainly within the sediment associated with seagrass in the Shallow Subtidal Zone, as well as the green algae in the Intertidal Zone. The species is rare in the deeper open Subtidal Zone, Safwa Bay and the west side of Tarut Island. The distribution of the dead population is the same as the living population.

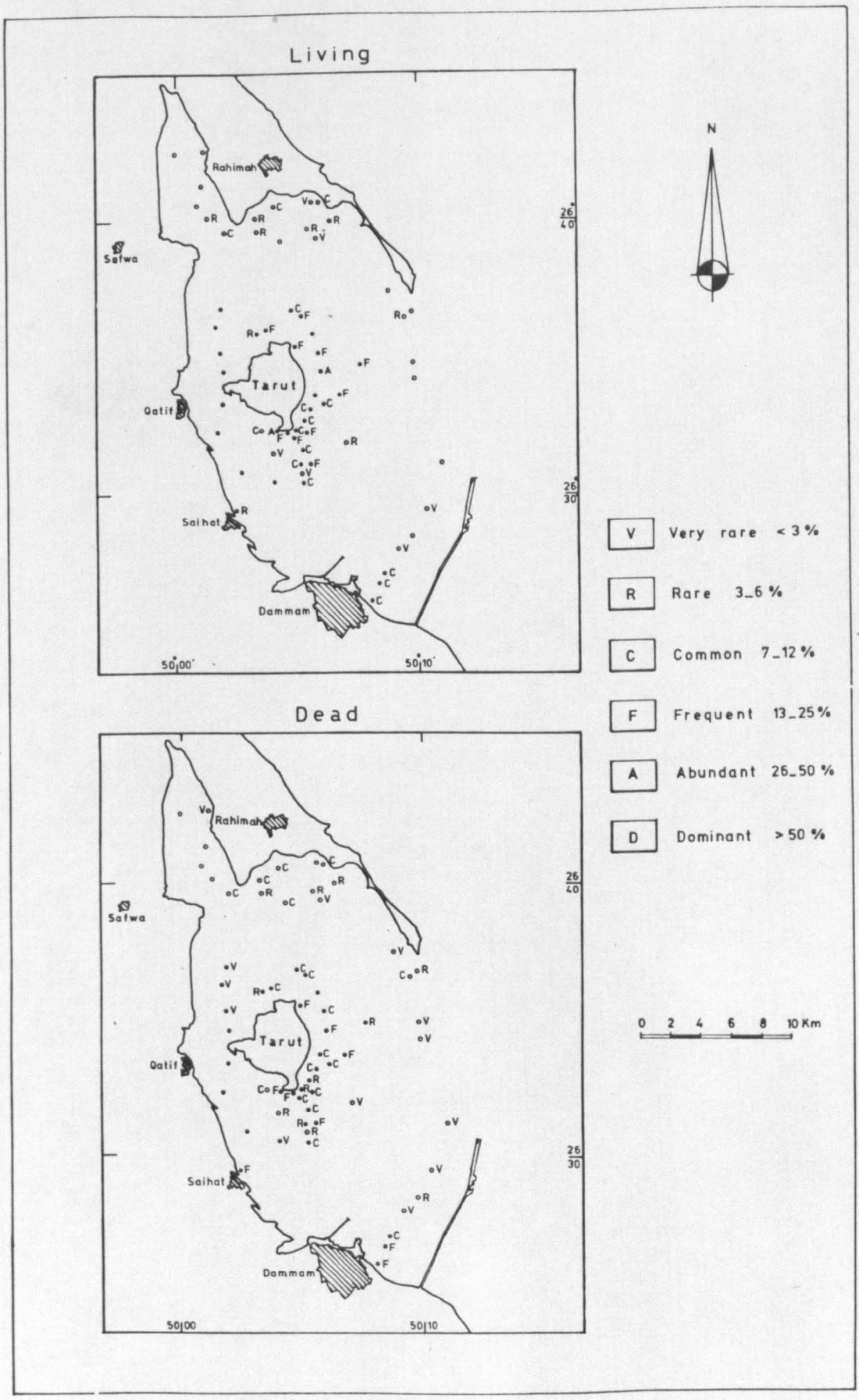

Fig.13 - Distribution map of Peneroplis planatus

7. Peneroplis planatus (Fichtel & Moll)

The distribution of this species is illustrated by Fig. 13, showing a restricted distribution to the east side of Tarut Island in the Shallow Subtidal Zone dominated by seagrass, and the south-east part of the bay. The distribution of the living forms extends to the Intertidal Zone where the species is recorded from both bare sediment and green filamentous algae. It is not found in Safwa Bay and the east side of Tarut Island. The dead population is more widely distributed but still follows the same pattern as the living population.

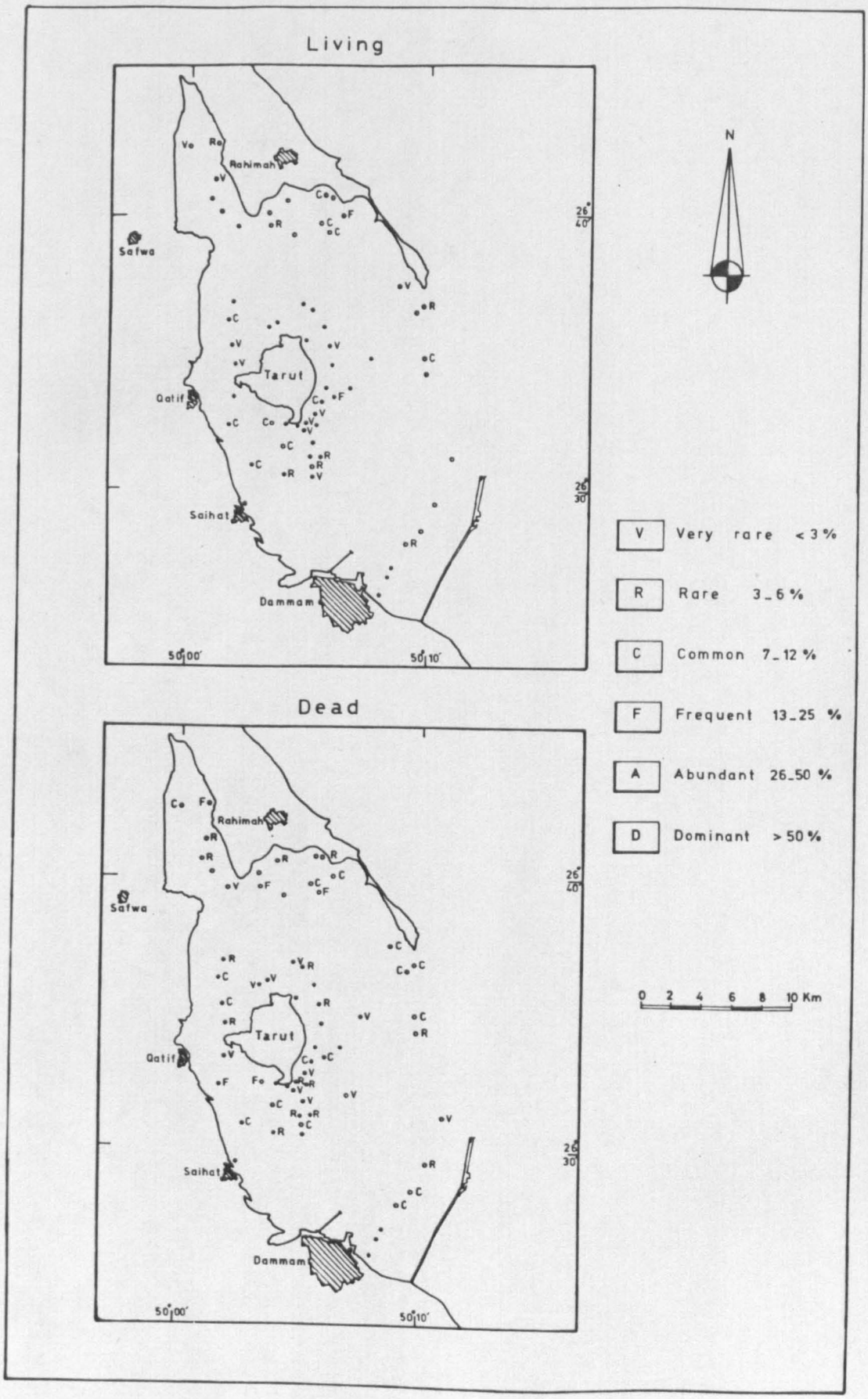

Fig.14 _Distribution map of "Eponides" murrayi

8. "Eponides" murrayi (Heron, Allen & Earland)

The living of this species have a restricted distribution, mainly to the Shallow Subtidal Zone on the south side of Tarut Island and the north-east part of the bay (Fig. 14). Minor occurrences are found in the Deeper Subtidal Zone. Live specimens have not been recorded from the Intertidal Zone. 70% of the living fauna is recorded from sediment associated with seagrass. The dead population has a much wider distribution, extending from the Intertidal Zone to the Deeper Subtidal Zone.

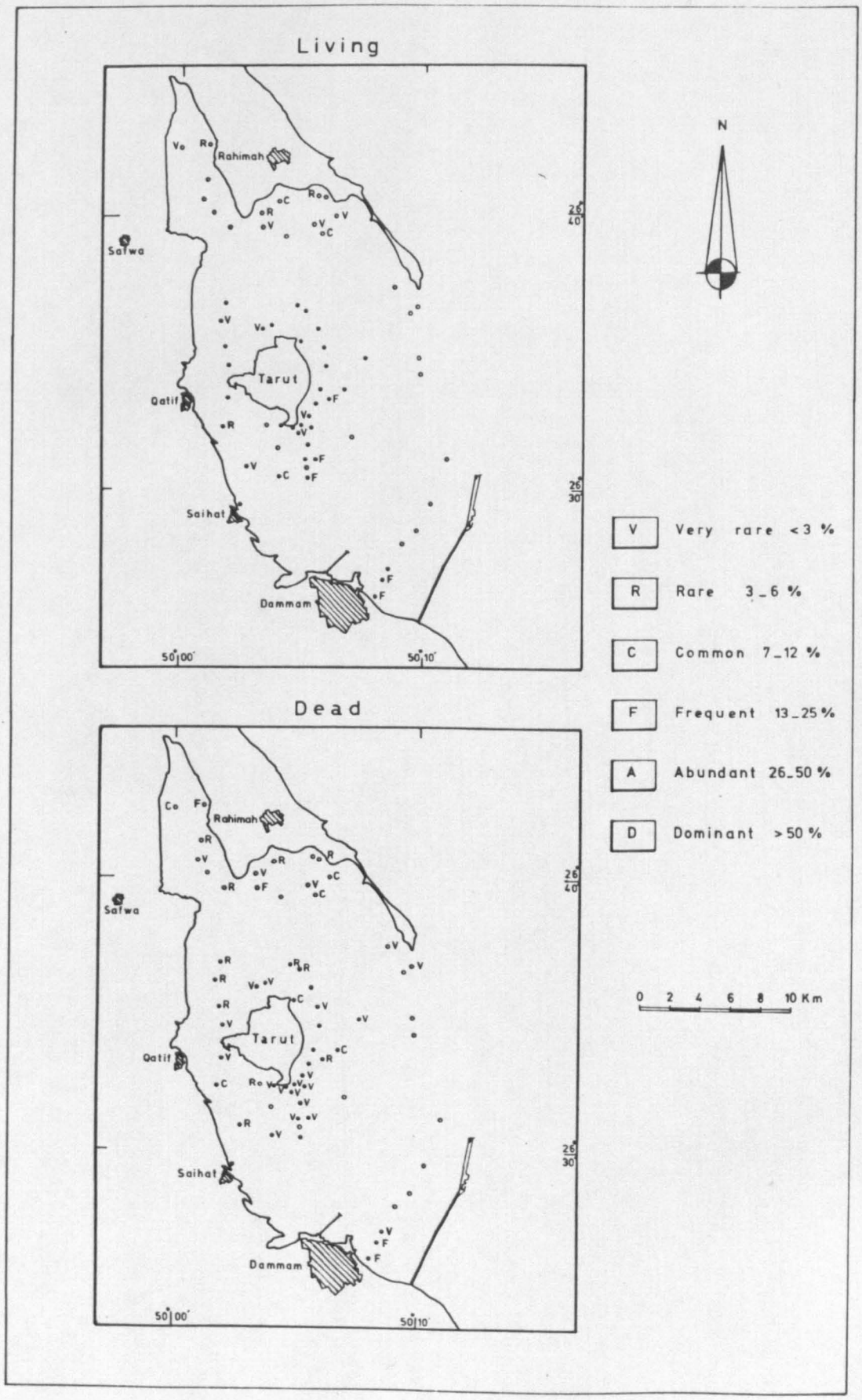

Fig.15 _ Distribution map of Elphidium reticulosum

9. Elphidium reticulosum (Cushman)

The distribution of this species is illustrated in Fig. 15, indicating a restricted distribution, mainly to the Intertidal Zone with algae and to the Shallow Subtidal Zone with seagrass. Dead faunas are more widely distributed in Safwa Bay where there is no seagrass or algae and in the Deeper Subtidal Zone. These might have drifted from the shallow zone during an ebbing tide.

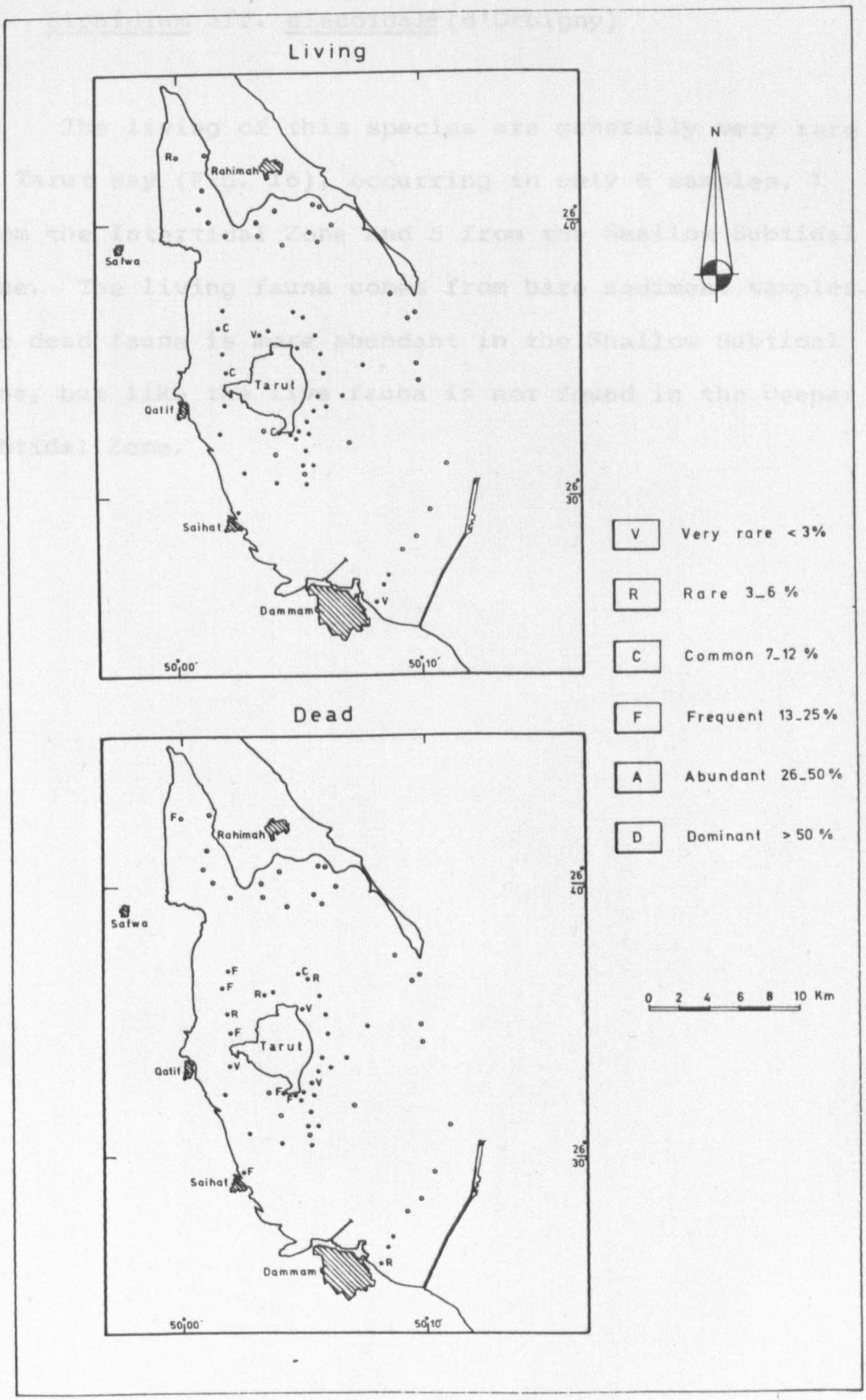

Fig.16 - Distribution map of Elphidium aff. discoidale

10. Elphidium aff. discoidale (d'Orbigny)

The living of this species are generally very rare in Tarut Bay (Fig. 16), occurring in only 6 samples, 1 from the Intertidal Zone and 5 from the Shallow Subtidal Zone. The living fauna comes from bare sediment samples. The dead fauna is more abundant in the Shallow Subtidal Zone, but like the live fauna is not found in the Deeper Subtidal Zone.

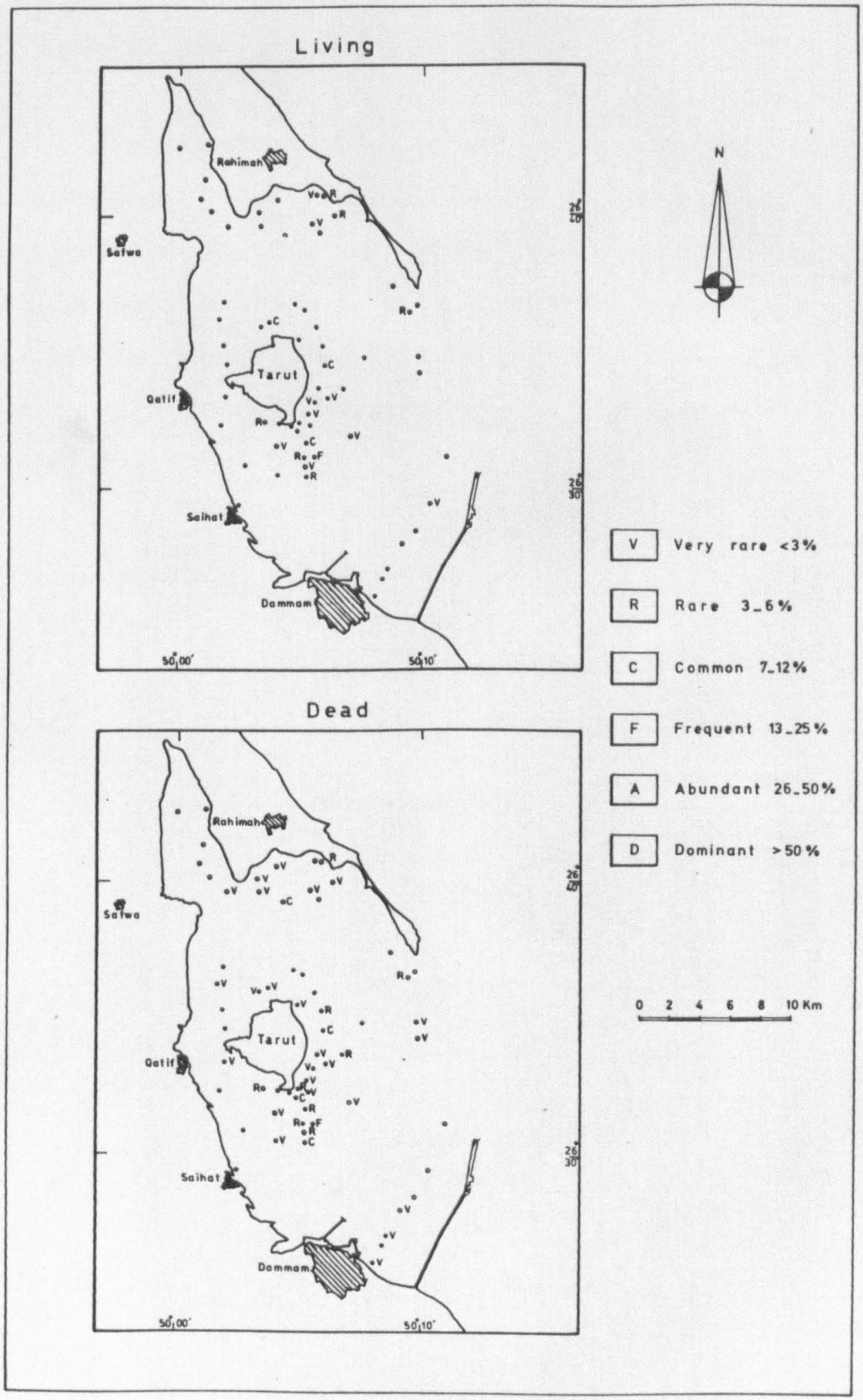

Fig.17 _ Distribution map of Peneroplis pertusus

11. Peneroplis pertusus (Forskal)

Live specimens of this species are generally very rare in Tarut Bay. Fig. 17 shows the living fauna has a restricted distribution, being concentrated in the Shallow Subtidal Zone in areas dominated by seagrass. The living fauna has a minor occurrence in the Intertidal Zone. The dead specimens show a similar distribution.

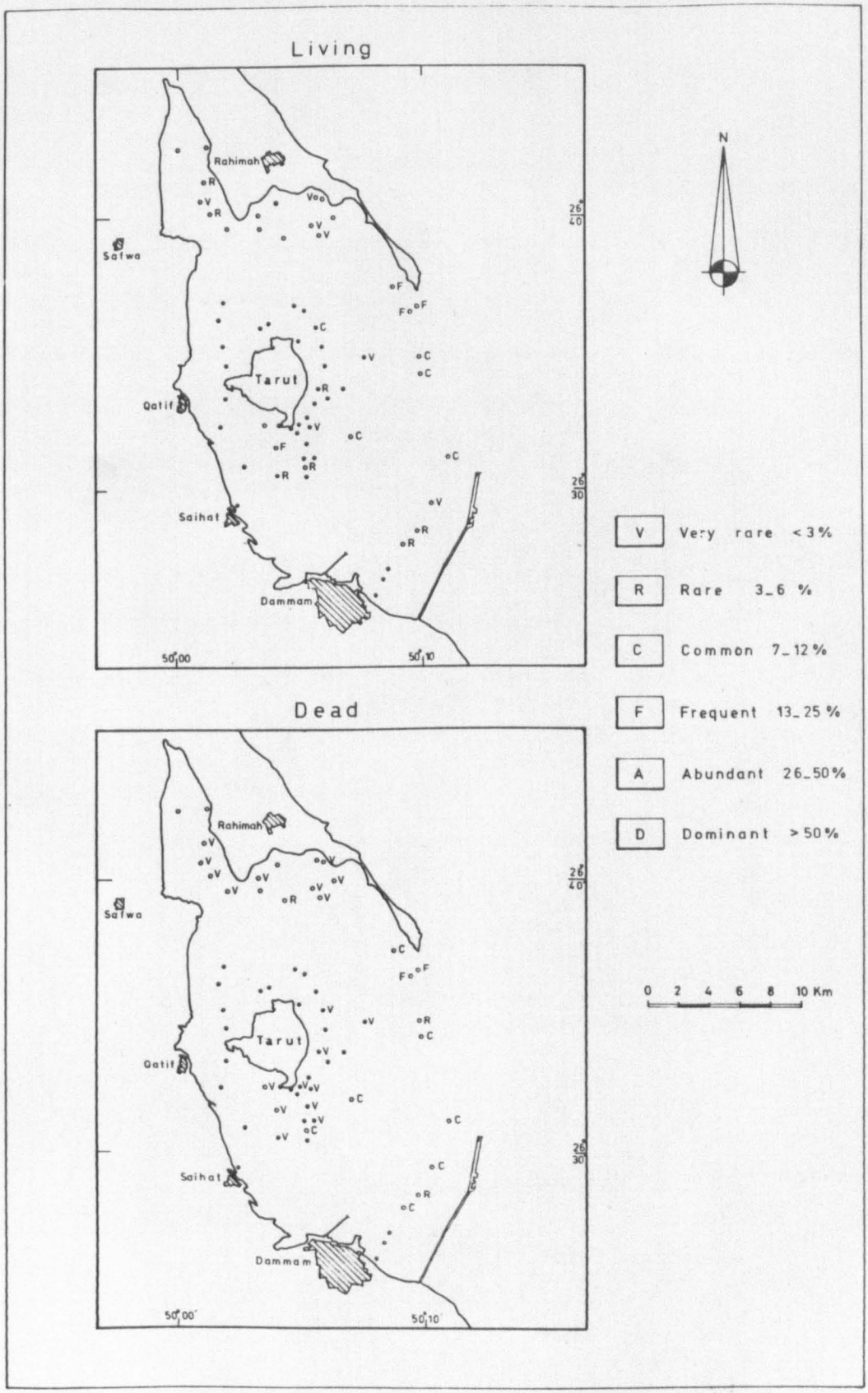

Fig.18 - Distribution map of Textularia spp.

12. Textularia spp.

There is a large number of species of this genus which are often difficult to separate. Two species have been clearly recognized and are discussed in the systematic and ecological chapter. The areal distribution (Fig. 18) of this group indicates a restricted distribution mainly in the Deeper Subtidal Zone with minor occurrence in the Shallow Subtidal Zone. It has not been recorded from the Intertidal Zone. 70% of the recorded fauna is found from the bare sediment, leading to the belief that this genus lives on the sediment. The distribution of the dead fauna reflects very clearly the pattern of the living population.

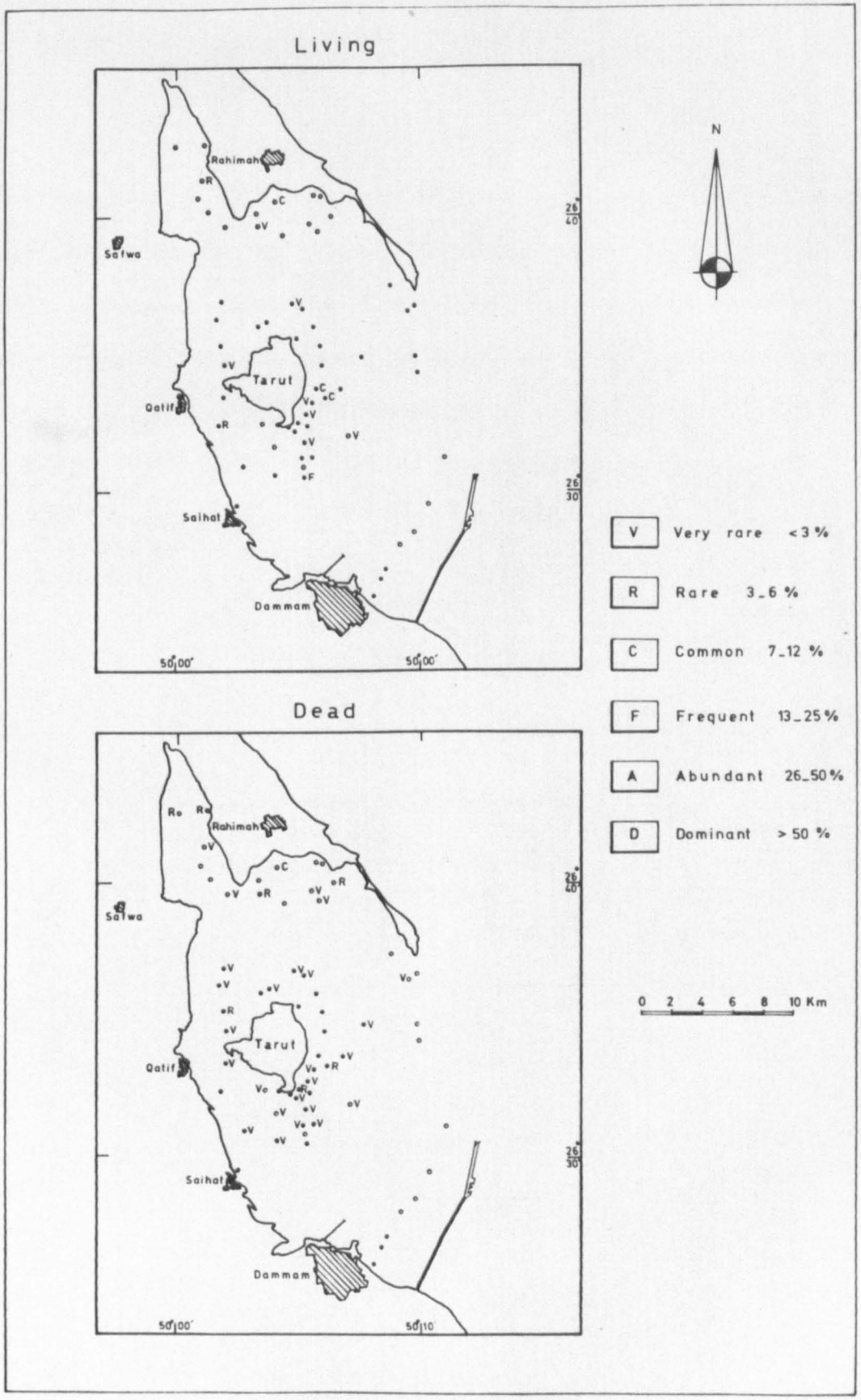

Fig.19 _Distribution map of Discorbina patelliformis

13. Discorbina patelliformis (Brady)

This species is generally one of the rarest in Tarut Bay. Fig. 19 shows it has a restricted distribution mainly to the Shallow Subtidal Zone. The species is not recorded from the Intertidal Zone. 70% of the living population is found in samples from bare sediment and the forms are found clinging to stones and shells. The dead fauna is more widely distributed in the bay although rarely common.

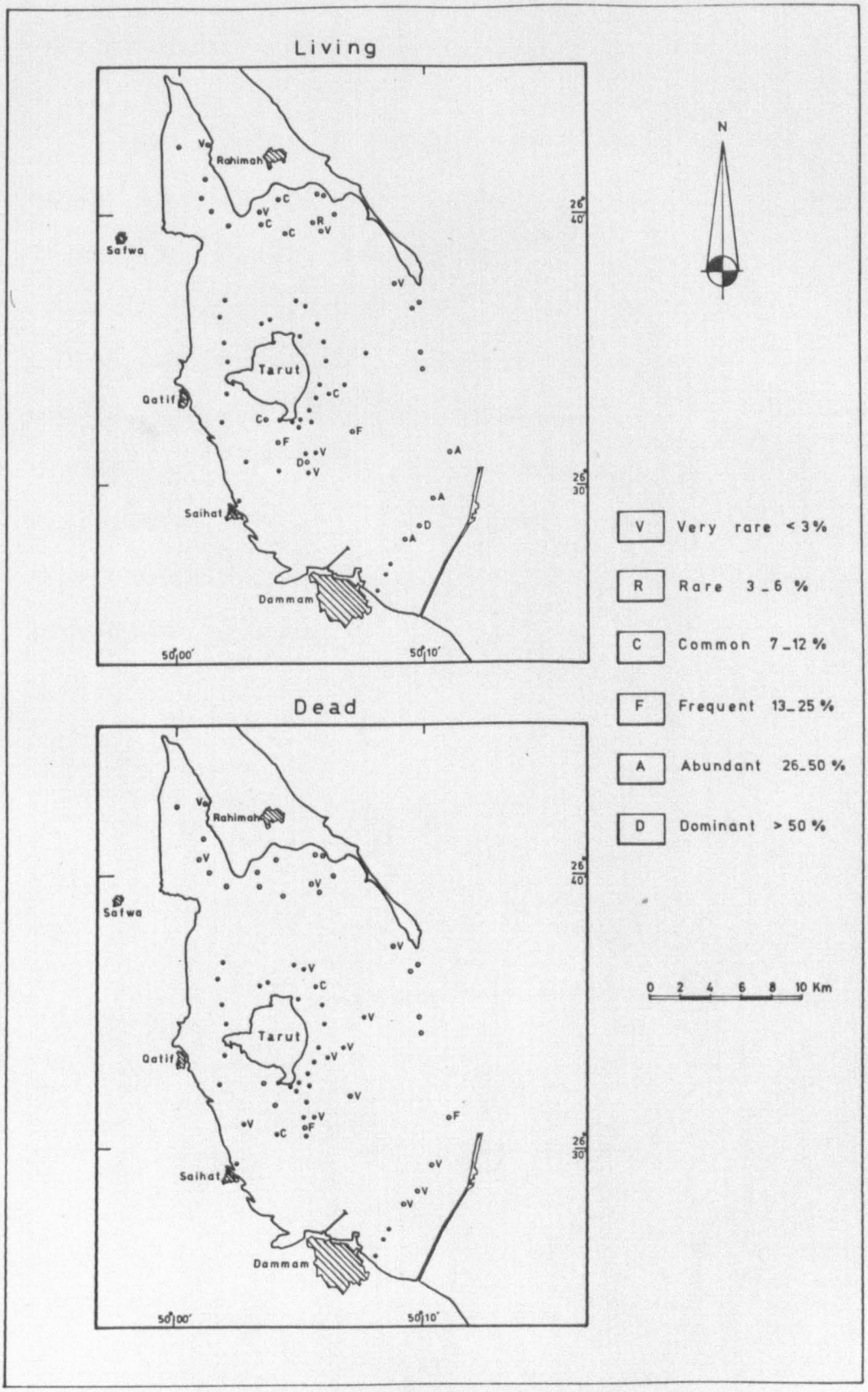

Fig.20 _Distribution map of Eggerella scabra

14. "Eggerella" scabra (Williamson)

The remarkable feature of this species is that the number of living specimens recorded exceeds the number of dead in the area. The distribution of the living fauna in Fig. 20 shows that the species is mainly found in the Deeper Subtidal Zone, with minor occurrence in the Shallow Subtidal Zone. It has not been found in the Intertidal Zone. The living fauna is recorded equally from samples of seagrass and bare sediment. The dead faunas show a similar distribution to the living fauna, although with lower frequencies.

GENERAL FEATURES OF THE FORAMINIFERAL POPULATION

a. Diversity

Diversity is the relationship between the number of individuals in an assemblage and the number of species (Murray 1973). In 1976 Murray pointed out that there are several reasons for wishing to quantify diversity. Firstly, there is the problem of comparing samples of different size. Is an assemblage of 250 individuals and 15 species as diverse as another of 500 individuals and 21 species? Secondly, it is a matter of general observation that there are more species in some environments than the other. If these variations can be quantified they will be less subjective and therefore more useful. Thirdly, some ecologists believe that diversity is a measure of maturity and stability of an environment and if this is true, "diversity can be used in the interpretation of the history of a sea" (Murray 1976, p.48). However, there are a great number of methods available to present the diversity.

In the present study, two methods of diversity measurement have been used for both living and dead faunas.

1. The index of Fisher et al. (1943). This is calculated from the following equation:

$$\alpha = \frac{n_1}{x}$$

where n_1 can be found from N(1-x) where N is the size of population and x is a constant less than one. However, the alpha index can easily be read from a graph produced by Murray (1968, p.73) (Fig. 21) by plotting the number of individuals against the number of species. This index has been used extensively by Murray (1968, 1973) to discriminate between different environments.

2. The number of species per sample. This can be read directly from the population data (see Appendix 2, 3). However, this measure is affected by the number of individuals in a sample, whereas the alpha index tries to compensate for this.

In the present study the diversity based on the alpha index is illustrated in Fig. 22 which indicates that diversity in Tarut Bay is generally low, ranging between $\alpha = 1$ to $\alpha = 5$ for both living and dead, although apart from one sample, living diversity ranges between 1 and 4. It has been observed that samples with high numbers of species are from seagrass areas and rocky areas covered with a veneer of coarse calcareous sand. This could be related to the presence of enough food and oxygen in these areas. Sanders (1968)

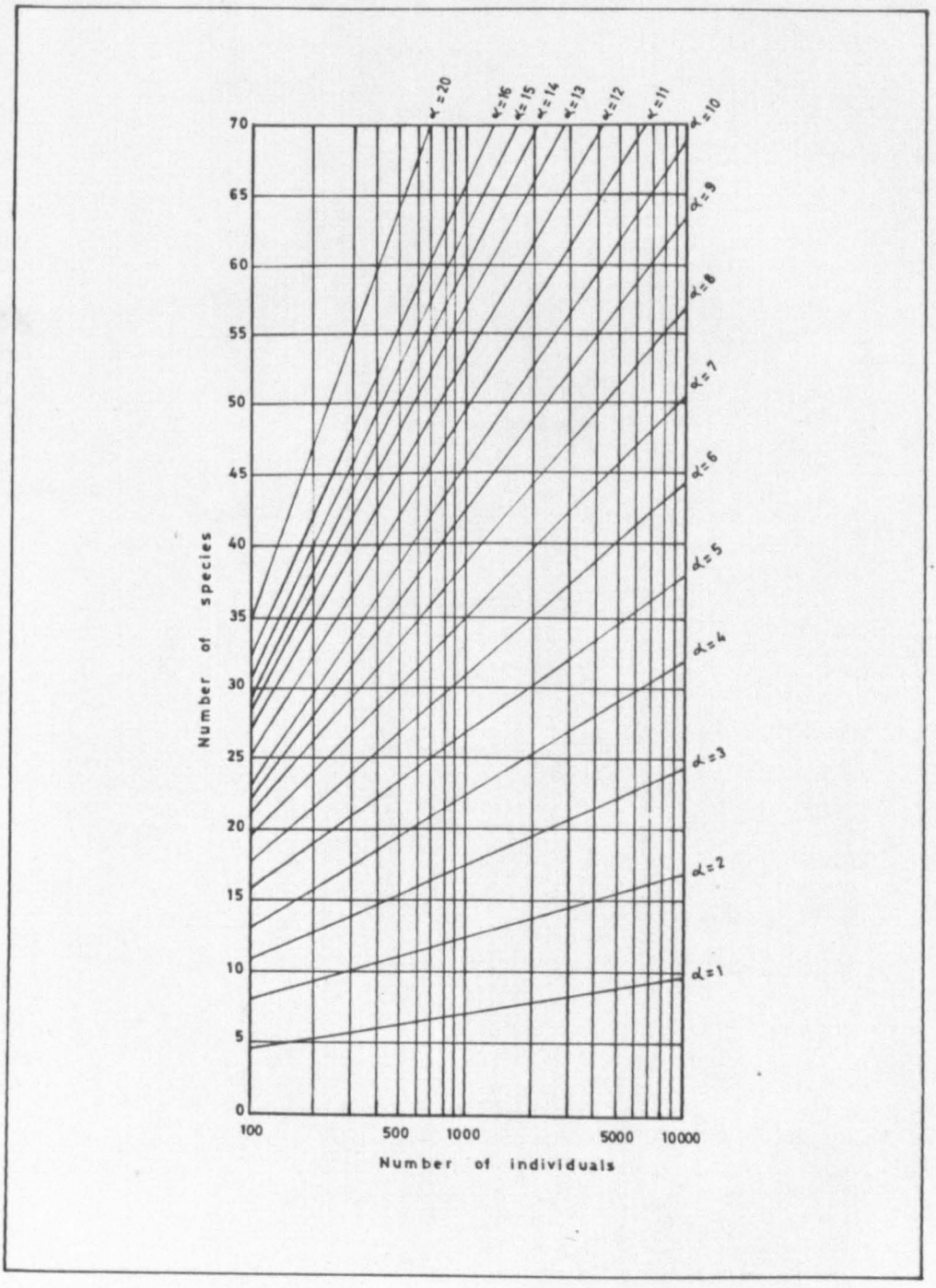

Fig. 21, Base graph for Fisher α diversity values (Murray 1973)

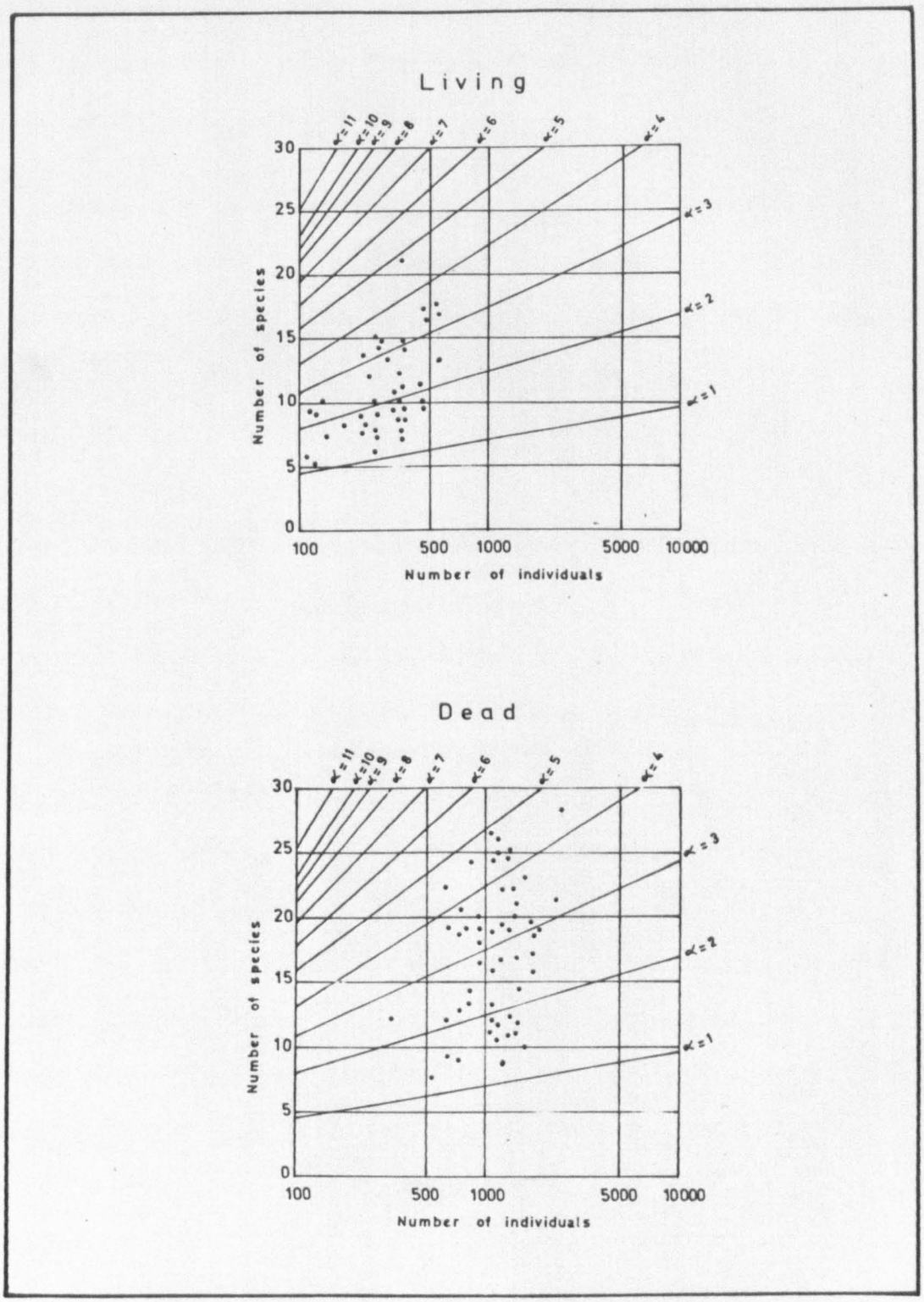

Fig.22 - Diversity plots

suggested that where the environmental parameters were stable (temperature, salinity and oxygen) more species would be present, i.e. highest diversities occur in more stable environments.

There is no marked difference in the diversity based on the alpha index between the faunas of the three environmental zones within the bay. Examination of the number of species of the living fauna in the samples shows that the highest average number 10 occurs in the Shallow Subtidal Zone, followed by an average of 7 in the Intertidal Zone and 6 in the Deeper Subtidal Zone. The dead fauna have their highest average number 18 in the Deeper Subtidal Zone, followed by 15 in the Shallow Subtidal Zone and 12 in the Intertidal Zone.

Discussion: It has been stated by Sugden (1963) and Den Hartog (1970) that the Arabian Gulf generally contains an impoverished Indo-Pacific fauna and flora, which means that many species common in the open waters of the adjacent Indian Ocean are not found in the Gulf due to adverse environmental conditions. Consequently, the diversity of the biological communities in the Gulf is thought to be low in comparison with that of similar communities living under more equable conditions elsewhere. The diversity observed in Tarut Bay is low and seems to support the previous statement, as does the result from Abu Dhabi recorded by Murray (1970b). There

is some doubt as to whether these results reflect the true diversity of the Arabian Gulf. It is important to remember that diversity depends upon the number of species recognized and it has already been pointed out that species discrimination is difficult for certain genera. The species concept adopted will obviously affect the diversity recognized. Brasier (1975a) suggested that diversity indices offered the best means of distinguishing between normal marine tropical regions with high diversity and hypersaline lagoon habitats with low diversity. This contrasts with the high diversity recorded from the hypersaline environment of Jeddah Bay (Red Sea) by Bahafzallah (1975).

b. Triangular plot

The use of triangular diagrams (Fig. 23) has proved important in ecological and palaeoecological studies of Foraminifera. Two approaches have been used, firstly plotting the relative percentages of the three types of wall structures in Foraminifera (Bandy and Arnal 1960, Bandy et al. 1964a,b,c, Walton 1964, Atkinson 1971) and secondly by plotting the three suborders of the classification of Loeblich and Tappan (1964) (Murray 1968, 1973, Wright and Murray 1972). The second procedure has been adopted in this study. Figures 24 and 25 indicate that most samples plot along the side of the Miliolina and

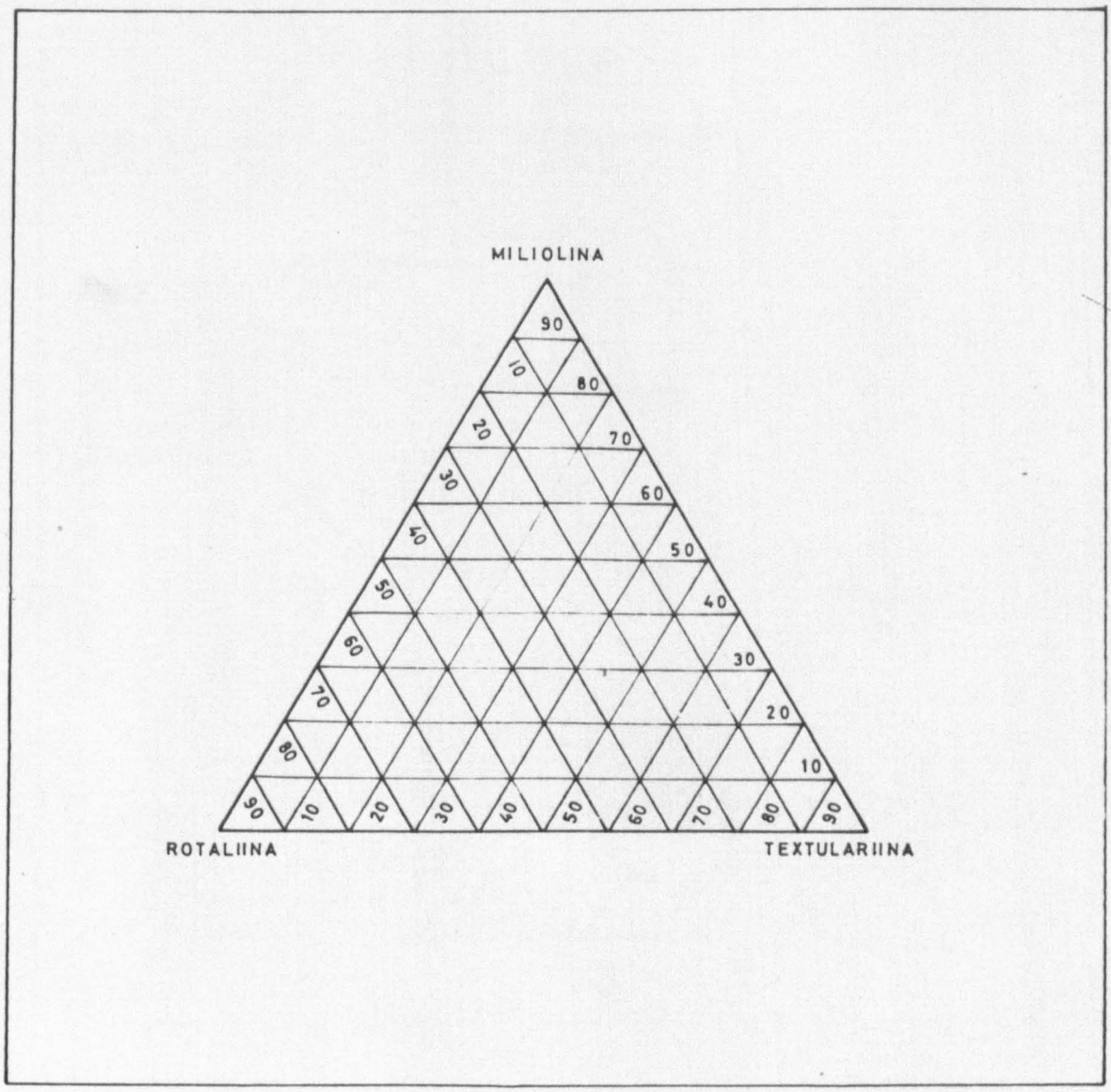

Fig. 23, Triangular diagram for the ratio of the three suborders (Murray 1973).

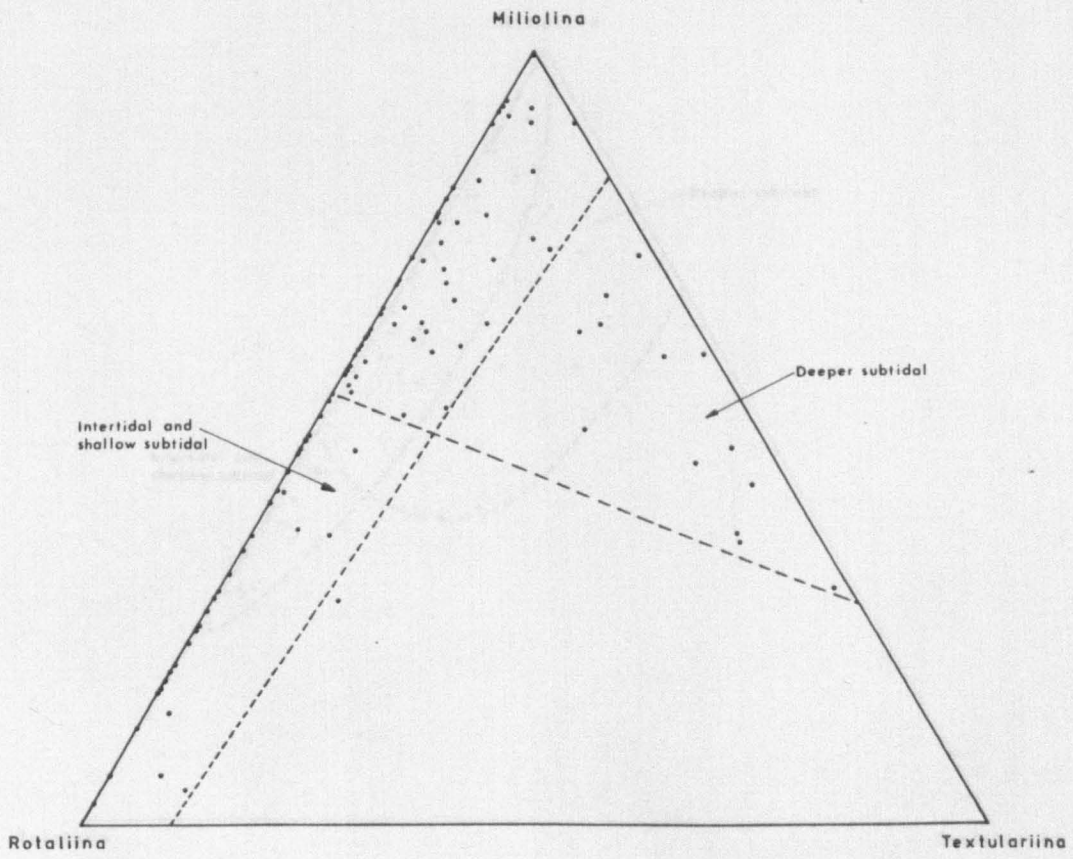

Fig.24 _Triangular plot of the ratio of three suborders (Living)

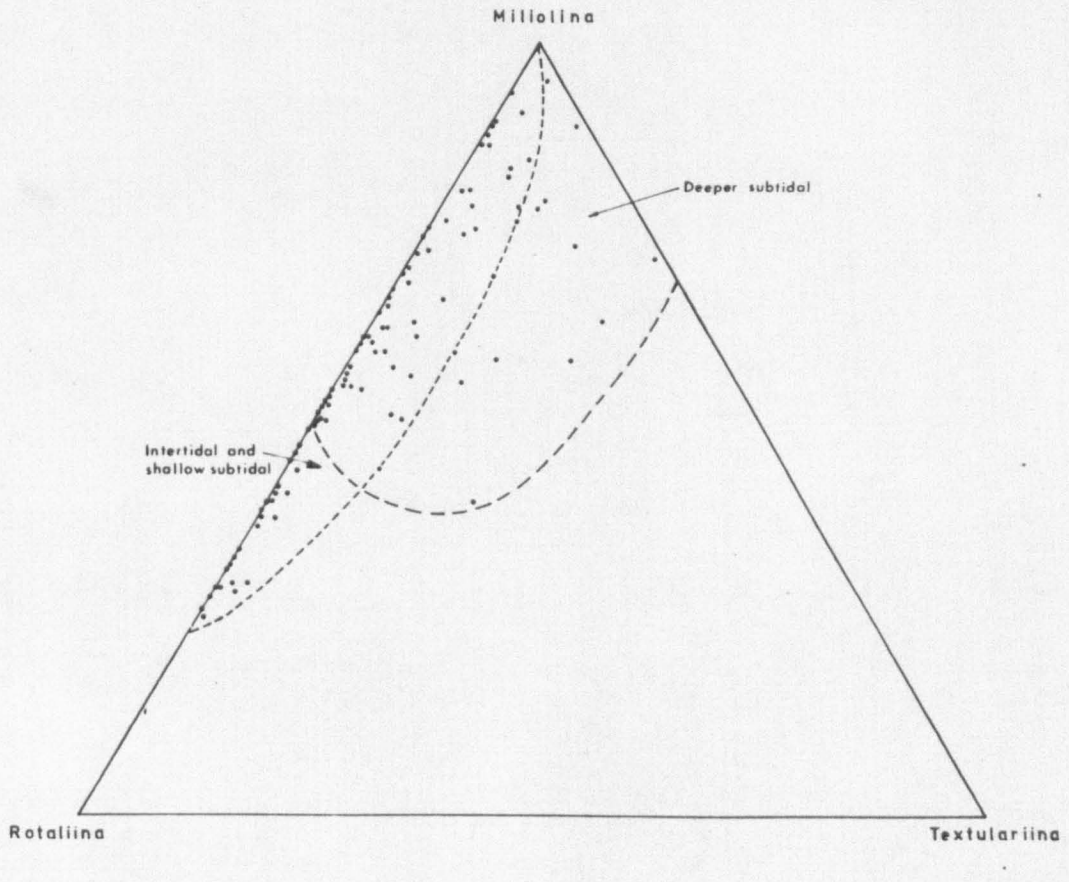

Fig.25 - Triangular plot of the ratio of three suborders (Dead)

Rotaliina, with a few exceptions due to the presence of high percentages of agglutinated forms such as Eggerella scabra and Textularia spp. They come from the Shallow and Deeper Subtidal Zones and because Eggerella scabra is more abundant live than dead the diagram for the living population shows a higher percentage of Textulariina. It is worth mentioning here the percentage of the three suborders in relation to the total population for the living (37655): Textulariina 6.3%, Miliolina 54.4% and Rotaliina 39.3% and for the dead population (142360) Textulariina 3.1%, Miliolina 55.4% and 41.5% for the Rotaliina.

Discussion: The results are comparable with those of Murray (1968) for the hypersaline and normal marine group, i.e. Tarut Bay is dominated by the suborders Miliolina followed by Rotaliina and with rare Textulariina. This result supports the published data from other hypersaline environments: Murray (1970b), the Abu Dhabi region, the southern part of the Arabian Gulf; Bahafzallah (1975), Jeddah Bay, Red Sea; and Brasier (1972) from the normal marine and hypersaline tropical waters around Barbuda, West Indies. Brasier (1975b) suggested that miliolid dominant assemblages cannot be taken to indicate hypersaline conditions. They also occur at normal salinities in these shallow-water tropical carbonates. Greiner (1969) stated that

tropical shallow-water and lagoon areas are dominated by porcelaneous (Miliolina) and not by hyaline (Rotaliina) forms. His interpretation of this was that the shallow water with high temperatures is super-saturated with $CaCO_3$ and is thus ideal for the precipitation of unoriented calcite crystals for Miliolina test, but does not allow oriented crystals growth of the hyaline test. The results from Tarut Bay support part of this argument, i.e. the abundance of Miliolina, but disagree with rarity of Rotaliina.

c. Living and dead ratio

Walton (1955) devised a formula:

$$L/D = \frac{\text{Living population}}{\text{Dead population}} \times 100$$

as a means of assessing the rate of sedimentation. Walton, Phleger (1960) and others have considered that higher live/dead ratios coincide with higher deposition rates. However, Murray (1967) suggested that the only reliable method of assessing the rate of sedimentation from foraminiferids is to compare the annual production with the number of dead individuals.

In the present study the living and dead ratios of 62 samples from different parts of the study area have been examined and recorded against some ecological parameters and summarized in Table 4. The aim here is to evaluate the main factors which might distort the

Table 4

Depth of water, type of sediment, grainsize, seaweed, seagrass or bare sediment in representative sample related to L/D ratio.

Sample No.	L/D ratio	Depth of water (m)	Type of sediment	Grainsize in (mm)	Seaweed, seagrass or bare sediment
7-C	8	5	Sand	1.8	Bare sediment
44-B	10	7	Sandy mud	-	Bare sediment
6-C	10	1.8	Muddy sand	3	Seagrass
55-B	11	1	Sand	1.3	Bare sediment
46-B	12	2	Sand	-	Bare sediment
9-C	13	1.7	Sand	2.6	Seagrass
35-C	13	5	Sand	1.2	Seagrass
66-B	13	0	Muddy sand	1.5	Bare sediment
27-C	14	7	Sand	1.6	Bare sediment
15-C	15	1.4	Sand	1.6	Seagrass
42-C	16	3	Sand	1	Seagrass
33-B	17	0.5	Sand	2.4	Seagrass
18-C	17	1.4	Sandy mud	2.2	Bare sediment
28-C	17	9	Sand	2.2	Bare sediment
62-B	18	1	Sand	2	Bare sediment
26-C	18	8	Sand	1.5	Bare sediment
17-C	20	2	Sand	2.3	Seagrass
38-B	21	1	Sand	-	Seagrass
50-B	21	1	Sand	-	Bare sediment
2-C	21	4.5	Sand	1.5	Bare sediment
16-B	21	1.2	Sand	1.2	Seagrass
29-C	21	8	Sand	0.9	Bare sediment
31-B	22	0.5	Sand	1.6	Seagrass
8-C	22	1.8	Sand	2	Seagrass
15-B	22	2	Sand	-	Bare sediment
33-C	22	13	Mud	-	Bare sediment

Table 4 (continued)

Sample No.	L/D ratio	Depth of water (m)	Type of sediment	Grainsize in (mm)	Seaweed, seagrass or bare sediment
1-C	23	1.5	Mud	-	Bare sediment
19-B	24	1.5	Sand	-	Seagrass
39-C	24	6	Sand	1	Seagrass
36-B	25	1	Sand	-	Seagrass
11-C	25	1.5	Sand	1.8	Seagrass
6-A	26	0	Sand	-	Seaweed
13-C	27	1	Sand	1	Bare sediment
41-C	27	5	Sand	1	Seagrass
7-B	28	3	Sand	2.2	Bare sediment
35-B	30	1.3	Sand	-	Seagrass
4-B	31	1.5	Sand	0.9	Seagrass
16-C	31	1	Sand	1.3	Bare sediment
18-B	34	1.2	Sand	2.4	Bare sediment
3-C	34	5	Sand	1.5	Bare sediment
14-C	34	1.2	Sand	2	Seagrass
40-C	34	5.5	Sand	1	Seagrass
13-B	35	1.6	Sand	1.6	Bare sediment
24-B	35	1	Sand	-	Seagrass
14-B	36	1.7	Sand	-	-
6-B	39	5.5	Sand	1.5	Bare sediment
20-B	39	1	Sand	1.6	Seagrass
61-B	39	1.2	Sand	2.3	Bare sediment
23-C	39	6.2	Sandy gravel	1.3	Bare sediment
1-A	43	0	Sand	-	Bare sediment
22-B	43	1.3	Sand	-	Bare sediment
8-B	44	1.4	Sand	1.5	Bare sediment
34-C	46	6	Sand	1.3	Seagrass
9-A	47	0	Sand	-	Seaweed
4-C	48	6.5	Gravelly sand	1	Bare sediment
10-B	50	1	Sand	1.6	Seagrass
36-C	60	6	Sand	1	Seagrass
5-B	65	1.7	Sand	1.3	Seagrass
3-B	100	1.5	Sand	-	Seagrass

L/D ratio in the area. Inspection of the data in Table 4 shows the L/D ratio is not uniform, but has values of between 8% and 100%. These values appear to be distributed randomly, with no clear relationship with either substrate or water depth. The highest values are found in samples from seagrass, but samples from seagrasses also have low values.

Discussion: The lack of correlation between substrate, depth and L/D ratios suggests that the rate of sedimentation is not important in Tarut Bay in explaining the L/D ratio. Other factors which unfortunately were not assessed might have played some role in this ratio. These factors are the organic content and the oxygen content of the sediment. With respect to the organic content, hypersaline environments often have a high organic productivity (Phleger and Ewing 1962, Wright 1965). The latter found that high foraminiferal populations were associated with dense vegetation, and the same was observed to be true in Tarut Bay. In contrast, the sediments of the hypersaline Abu Dhabi lagoon had low standing crops and Murray (1970) concluded from this that the living foraminiferal populations in carbonates were largely restricted to the seaweed because of the low organic content of the sediment. Emery (1956) has stated that the southern part of the Gulf has a lower organic content in the sediment than in

any other part of the Gulf. It is also worth noting, however, that a high organic content can lower the productivity due to the accumulation of toxins and the depletion of oxygen (Bader 1952). This has been observed in Tarut Bay in mangrove areas and in muddy sediments where high organic contents have a low living population. Seigle (1968) suggested that some Foraminifera live symbiotically with algae in order to avoid this condition. Said (1950) noted that in the well oxygenated areas of the Red Sea, the total number of the benthonic Foraminifera are directly proportional to the percentage of nitrogen (- organic content). In Tarut Bay it has been found that some samples of coarse sand which are assumed to be well oxygenated have high L/D ratios, while others have low ratios. This may be due to a lower organic content in the sediment.

In conclusion, it is thought that live and dead ratios in Tarut Bay do not reflect the relative depositional rates in the area. The balance between the organic and oxygen content in the sediment might have a great influence on the L/D ratios.

CHAPTER 4

REVIEW OF THE DISTRIBUTION AND ECOLOGY OF THE FORAMINIFERA IN THE SOUTHERN PART OF THE ARABIAN GULF

The most important work on the distribution of Foraminifera in the southern part of the Arabian Gulf is that of Professor Murray published between 1965 and 1970. He studied the faunas from the coast of the U.A.E.: the shallow shelf (1966c), Kohar al Bazam lagoon (1966b), Halat al Bhrani (1966a) and the Abu Dhabi area (1965a, 1970a, b). Murray concluded that foraminiferal assemblages of bare sediment were small, the main productive areas being associated with submarine vegetation. The faunas of the Abu Dhabi lagoon will be reviewed in detail so that a comparison can be made with Tarut Bay. Abu Dhabi is chosen because it has yielded reasonably large numbers of live Foraminifera compared with other areas described by Murray.

The environment was considered by Murray to be extreme. The tidal cycle was irregular, with a maximum range of 2.1 m in the open Gulf to 0.6 m in the inner lagoon. Salinity increased from 42‰ in the open Gulf to 50‰ in the outer lagoon and 70‰ in the embayments of the inner lagoon. The temperature range in the open

Gulf was 20°C (winter) to 33°C (summer) compared with 16-40°C in the inner lagoon. Murray reported the occurrence of four main plant groups considered to be important in the study of the living forms. These were seaweeds growing on rocky subtidal areas, seagrass which was confined to subtidal soft sediments, mangroves present in the intertidal zone and blue-green algae which formed mats in the protected area of the intertidal zone. He differentiated the environment into oolith delta, outer channel, inner channel, coral bank, outer lagoon and inner lagoon. The samples for the earlier papers were collected for Murray between 1961-1962 by various expeditions from Imperial College, London under the general leadership of Dr. G. Evans. Murray made the following points:-

1. The general scarcity of the living Foraminifera in the area and their absence from the intertidal zone and shallow water.

2. The majority of the Miliolacea probably live attached to weeds which were not sampled.

3. The most important feature of the distribution of the living Foraminifera was that they were not uniformly distributed but like the macrofauna (e.g. corals, gastropods, bivalves) they had restricted areas of occurrence and their dead

remains were transported some distance prior to burial.

4. The foraminiferal remains in the dead population were discussed on the basis of the sedimentary environments in which they occurred.

a. Both the inner and outer lagoons were said to be easily distinguished from other environments by the abundance of Peneroplidae such as Peneroplis and Spirolina, followed by Ammonia beccarii and Quinqueloculina spp., although the fauna of the inner lagoon tends to be more restricted than that of the outer.

b. The channel was closely related to the lagoon it drains and hence contains the same fauna, with local abundance of Rosalina adhaerens. The presence of Spirolina acicularis, Spirolina arietina and Elphidium reticulosum were characteristic of these two environments only.

c. The reef and back reef lagoon had a high abundance of Quinqueloculina spp., but few other species were present.

d. The oolith delta was characterized by a high proportion of broken Foraminifera showing incipient conversion to ooliths. Quinqueloculina spp. were

always abundant and were accompanied by Triloculina spp., Peneroplis pertusus, Peneroplis planatus, Rosalina n. sp., Ammonia beccarii and "Eponides" murrayi. Elphidium crispum was typically present although was not confined to this environment.

e. The near shore shelf was characterized by a low percentage of broken forms and by the dominance of small sized Foraminifera. It contained a similar fauna to that of the delta, with rarity of the larger forms such as Peneroplis planatus.

From samples collected by Murray during November and December 1965 he made (1970a) the following points:-

1. The living Foraminifera were mainly restricted to seaweeds growing on rocky areas and to a lesser extent to seagrass which was not particularly flourishing at that time.

2. The living populations were sparse on the bare sediment, which might be free of the organic matter and microflora necessary for living Foraminifera.

3. Dead forms are transported from productive areas to a settling place. The lagoonal and near shelf sediments are relatively richer in forms than oolith sands and that might be due to a slower rate of accumulation of these sediments.

4. The effects of transportation were most clearly demonstrated by Peneroplis planatus, whose dead empty tests become rarer further away from their living areas.

5. He concluded that, in general, carbonate environments differ from the clastic environments in that the latter have living forms on and in the sediment. This was an important ecological difference and it means that palaeoecological interpretations of fossil carbonate should always assume that forms have been transported, whereas this is not always the case for fossil clastic sediments.

Murray resampled the area during March 1969. He noted (1970b) significant changes in the distribution of the marine flora, especially the decrease in algae and the increase in seagrass, and that the living Foraminifera were fairly abundant in the area. These changes were attributed to recent environmental modifications resulting from numerous recent civil engineering works and the higher contribution of sewage derived nutriants resulting from the increased human population. From comparison of the foraminiferal assemblages, Murray made the following points:-

1. The diversity of the foraminiferal assemblages was low, ranging from $\alpha = 1$ to $\alpha = 7.5$. Individual

environments within the lagoon could not easily be separated on the basis of diversity except for the inner lagoon and inner channel which had $\alpha < 3$ while the remaining environments mostly had $\alpha > 3$.

2. A marked dominance of Miliolina and occasionally Rotaliina and generally a low abundance of Textulariina was observed in all subenvironments.

3. The standing crop valued range from 1 to 47 per loc^2 excluding seaweed samples.

4. The biomass values range from 0.01 to 4.06 mm^3 per loc^3 of seafloor in the inner lagoon.

5. Peneroplis planatus was found to be the dominant species in both the living and dead fauna throughout the area.

6. The associated species included Peneroplis pertusus, a great variety of Quinqueloculina and Triloculina species, Miliolinella sp., Vertebralina striata, Elphidium spp. and Ammonia beccarii varieties.

7. The assemblages seemed to be fairly homogeneous and comparison of similarities between similar plants (e.g. seaweed/seaweed) and dissimilar plants (seaweed/seagrass) produced values with a peak at 60 percent similarity, while there was very low similarity between plant and sediment assemblages.

Murray stated that the abundance of the living Foraminifera on seaweeds, seagrass and similar protected environments was because the living forms generally preferred these as both food and protection were more readily available. Consequently, living Foraminifera did not usually flourish on the bare carbonate sediment surface, with the exception of ooliths. In the oolith delta the dominant living Foraminifera was Rosalina adhaerens which lived clinging either to ooliths or to shell debris. On seaweed and seagrass the usual dominant form was Peneroplis planatus. As the sea flora was generally patchy in its distribution, the associated living Foraminifera were naturally very patchy and irregular in their distribution. The living Foraminifera were described under a series of environmental headings, but these environments were reported to be inhabited by essentially the same species, with variations in relative abundance.

Murray referred to his earlier paper (1965b) for the distribution and abundance of dead forms in the Abu Dhabi region. From this it appeared that in terms of diversity, the dead values tend to be slightly higher, but the results were not very different. On the triangular plot the field occupied by living and dead was much the same, with the exception of a few samples containing significant numbers of Textulariina due to

the presence of the clinging species Rotaliammina mayori in oolith delta samples and Trohammina cf. T. pacifica in the outer lagoon samples.

Generally it was reported that the dead foraminiferal assemblages were not unlike those of the living. Nevertheless, in view of the widespread distribution of the living forms in March 1969, it was found necessary to modify his earlier ideas (1965) concerning transport of dead Foraminifera. While it was clear that the weeds were the source areas and dead Foraminifera contributed to the surrounding sediments, there was no longer any reason to suppose that Peneroplis planatus was transported over long distances, as it was known to live in most of the areas where it was found dead.

CHAPTER 5

COMPARISON OF TARUT BAY WITH OTHER AREAS

This section attempts to survey the main points of similarity and differences between the fauna of Tarut Bay and other hypersaline environments around the Gulf and adjacent regions.

a. ABU DHABI LAGOON

Following the work of Murray and also, thanks to Professor Murray, having examined material from the region, the following remarks can be made.

Features in common between Tarut Bay and Abu Dhabi

1. The dominance of Miliolina, followed by Rotaliina, and the rarity of Textulariina in both living and dead populations.

2. The fauna of the two areas is characterized by a low diversity and are very similar.

3. The super family Miliolacea exhibits a great deal of morphological variation, particularly Quinqueloculina and Triloculina species.

The main differences between the two areas

1. The Abu Dhabi region is dominated by Peneroplis planatus, with associated species such as Peneroplis pertusus, a great variety of Quinqueloculina and Triloculina species, Miliolinella sp., Vertebralina striata, Elphidium spp. and Ammonia beccarii varieties. Tarut Bay on the other hand is dominated by Quinqueloculina spp., with associated species such as Ammonia beccarii varieties, Elphidium aff. advenum, Triloculina spp., Spiroloculina spp., Spirolina arietina and Peneroplis planatus.

2. The forms of Tarut Bay live on or within the bare sediment as well as the vegetation. This differs from the conclusions of Murray (1965b, 1970a, b) who found the forms of the Abu Dhabi to be only associated with seaweed and seagrass.

Comments

The dominance of Quinqueloculina spp. in Tarut Bay and Peneroplis planatus in the Abu Dhabi lagoon may be due to ecological or zoogeographical causes. The latter species is commoner in the south western part of the Gulf and becomes rare northwards. It was found to be very rare by Anber (1974) at Kuwait. Other Peneroplids

such as Peneroplis pertusus, Spirolina arietina, are common in Tarut Bay and regions further south but have disappeared northwards at Kuwait. Peneroplids have not been recorded from the Iranian side of the Gulf.

b. JEDDAH BAY, RED SEA

Bahafzallah (1975, 1979) reported on the Foraminifera of Jeddah Bay, a hypersaline environment with salinity ranging from 37 to 42‰ in the winter and 39 to 48‰ in the summer. From his studies of the benthonic forms of the bay, together with personal communications, and examining material from the area, the following points can be made:

1. The living and dead populations are dominated by the super family Miliolacea, particularly species of Quinqueloculina, Sorites and Triloculina.

2. The living Foraminifera have a higher diversity than faunas from Tarut Bay which is attributed to the more variable and more hypersaline environment of the latter. The mean value of diversity in Jeddah Bay is $\alpha = 13$.

3. The fauna of the bay is dominated by Miliolina, followed by Rotaliina and only sparse Textulariina.

4. The dead assemblages closely resemble those of the living.

5. It was inferred that the environment was very favourable for the Foraminifera and there was little postmortem change in the fauna.

6. Bahafzallah found that many of the Jeddah Bay forms live in association with seagrass, with a wide distribution throughout the area, and that all species are also found living on sediment substrates.

7. The fauna of the area can be divided into three broad groups based on their distribution: those distributed throughout the bay, those found mainly offshore and those found nearshore.

c. CONCLUDING REMARKS ON HYPERSALINE ENVIRONMENTS

Some general remarks can now be made concerning Foraminifera of hypersaline environments, utilising the results obtained from Tarut Bay and previous work within the region, such as Abu Dhabi region (Murray 1970a, b) and Jeddah Bay on the Red Sea (Bahafzallah 1975, 1979).

1. The faunal subdivisions tend to be related to the micro-environments existing within the wider environment.

2. Faunas are always characterized by the dominance of the suborder Miliolina and to a less extent Rotaliina, with a scarcity of Textulariina.

3. The diversity depends on the degree of variability within the environment, but is generally characterized by low diversity compared with the normal marine environment.

4. Morphological variation and abnormalities amongst some of the Foraminifera, in particular Miliolids, is probably a response to the various types of substrate and the wide fluctuations in salinity that occur in these marginal habitats. This is borne out in the study of Brasier (1972, 1974, 1975a, b) of the forms from the hypersaline Caribbean Sea, where he found it cannot be assumed that all species

are primarily weed dwellers in shallow water carbonate sediments. Mobile carbonates appear to contain their own specialized microfauna adopted for survival in conditions that might be compared with a desert.

CHAPTER 6

ECOLOGICAL AND SYSTEMATIC REMARKS

This chapter is devoted to general remarks on the ecology and systematics of the taxa recognized in the area. The number of specimens for each of the 14 common taxa have already been given in Table 1 and their distribution has been discussed fully. In the following account the number of specimens is only given for the remaining taxa.

In the present study the subdivisions of the higher taxonomic units are based on the wall structure and its composition, after Loeblich and Tappan (1964), whose classification has been followed. There are problems with this classification, as pointed out by Brasier (1974) who suggested an environmental control rather than genetic for certain features of the very plastic Miliolids. Murray (1966b) avoided naming species of the genera Quinqueloculina and Triloculina after he found great difficulty in matching juvenile forms with highly variable adults. He used instead a series of morphological groups. Professor Murray kindly made material available for study and it is believed that the same morphological groups exist in Tarut Bay. Species of some of the forms have been identified by utilising the

Lutze Collection from the Iranian coast of the Gulf in the British Museum. Professor Lutze kindly supplied his papers and comparative material, and in a personal communication stated that systematics of the Gulf Foraminifera is chaotic. Other material examined is the Bahafzallah collection from Jeddah Bay (1975). The works of Haake (1975) and Anber (1974) have also been used in the identification of material. As can be seen from these comments, the systematics of the Foraminifera from the Gulf needs a lot of work, but as the aim of this study is primarily ecological, such work is beyond the scope of the thesis.

Suborder: TEXTULARIINA

Delage & Hérouard, 1896

Ammobaculites sp.

Plate 1, Fig. 1

35 living and 85 dead specimens were recorded from three samples (65 - 66 - 70), Trip B, from the Intertidal Zone, mangrove area.

Remarks: This species is similar to Ammobaculites persicus Lutze. It is recorded from the Iranian side of the Gulf (Lutze 1974). The specimens from Tarut Bay are smaller in size and the agglutinated particles are smoother than in Lutze specimens.

Textularia spp.

This includes a number of species which were grouped together for the distribution maps. Amongst them only two species could be clearly identified, T. foliacea and T. conica. The record of Textularia in the present study, together with those of Murray (1966c), Lutze (1974) and Anber (1974), indicate the genus has a wider range of salinity than suggested by Boltovskoy and Wright (1976), who gave its range as hyposaline to normal marine.

Textularia foliacea Heron, Allen & Earland

Plate 1, Fig. 2

Textularia foliacea Heron, Allen & Earland, 1915, Trans.

Zoo. Soc. London, 20, p.628, Pl. 47, Figs 17-20.

The species was recorded from the shelf of the Trucial Coast in the south western part of the Gulf (Murray 1966c), from Kuwait (Anber 1974) and Jeddah Bay (Bahafzallah 1975).

Textularia conica d'Orbigny

Plate 1, Fig. 3

Textularia conica d'Orbigny, 1839, Foraminifères, In: Ramon de la Sagra, Histoire Physique et Naturelle de l'Ile de Cuba, p.143, Pl. 1, Figs 19, 20.

This species was recorded from the Iranian side of the Gulf (Lutze 1974), from offshore Kuwait (Anber 1974) and Jeddah Bay on the Red Sea (Bahafzallah 1975).

Bigenerina sp.

Plate 1, Fig. 4

25 living and 120 dead specimens were recorded, mainly from the Subtidal Zone. 20 living specimens were collected from sediment associated with vegetation and the remainder from bare sediment.

Remarks: This species is placed into Bigenerina because the early portion of the test is biserial, the latter part uniserial with a terminal aperture (Loeblich & Tappan 1964). However, some individuals of Textularia are known to be uniserial in the later portion of the test.

Eggerella scabra (Williamson)

Plate 1, Figs 5, 6

Bulimina scabra Williamson, 1858, On the Recent Foraminifera of Great Britain: Ray. Soc. Publ., p.65, Pl.5, Figs 136, 137.

As previously mentioned, the most remarkable feature about the distribution of this species is that the number of living specimens exceeds the dead in the samples collected. This may be because the small fragile test is easily destroyed after death or it may be that dead tests are carried out to deeper water by tides or currents. Abou-Ouf (1974) found this species dominated foraminiferal assemblages from deeper water in the Firth of Clyde, western Scotland, where the water has a salinity of 30-33‰; however, the Firth of Clyde living specimens were very rare in comparison with dead.

Remarks: Haynes (1973) created a new genus Eggerelloides, genotype E. scabra. Thus the species referred to here as Eggerella scabra would be called Eggerelloides scabrum if Haynes new taxon is accepted. The specimens from Tarut Bay are much smaller than those from Western Europe (cf. Pl. 1, Figs 5 & 6, 0.42 mm cf. 0.85 m), and this difference in size has been used to separate the two forms. Collins (1958) erected the new species E. australis for a small species [L = 0.29 mm] from the Great Barrier Reef of Australia, which was considered by Lutze (1974) to be conspecific with specimens from the

Iranian coast of the Gulf. Lutze considered the size difference to warrant subspecific separation only, naming his species Eggerella scabra australis. Neither author mentioned whether they were dealing with megalospheric or microspheric forms, or both. Haynes (1973) illustrated both microspheric and megalospheric forms, both of which range between 0.6 and 1.0 mm in length. From this it can be seen that there is considerable variation in size and it is not clear whether this can be used in species discrimination. Thus in the present study the Arabian Gulf specimens are left in the species E. scabra. The samples from Tarut Bay contain both megalospheric and microspheric forms, the former being much the commoner of the two.

This record, together with that of Lutze and Collins, indicate the cosmopolitan distribution of the genus, contrary to the opinion of Murray (1973) who gave its range as arctic to temperate.

Clavulina spp.

Two species of the genus are present in the area, but have been grouped together in the distribution data. 50 living and 440 dead specimens have been recorded, live specimens being found equally in sediment associated with seagrass and in bare sediment. It mainly occurs in the Shallow Subtidal area.

Clavulina angularis d'Orbigny

Plate 1, Fig. 7

Clavulina angularis d'Orbigny, 1826, Annls, Sci. Nat., Ser. 1, 7, p.268, Pl. 12, Fig. 7

The species is also recorded from Jeddah Bay, Red Sea (Bahafzallah 1975).

Clavulina pacifica Cushman

Plate 1, Fig. 8

Clavulina pacifica Cushman, 1924, Publs, Carnegie Inst., 21, p.22, Pl. 6, Figs 7-11.

This species is recorded from the Abu Dhabi region (Murray 1970b) and Jeddah Bay, Red Sea (Bahafzallah 1975).

Remarks: Normally these two species of Clavulina are easily separated, but occasionally specimens are found which seem to demonstrate gradation between the two. C. angularis has rounded chambers and typical C. pacifica has chambers which are triangular throughout; however, although typical C. pacifica occurs in Tarut Bay, other specimens have the last two chambers rounded as in C. angularis.

Suborder MILIOLINA

Delage & Hérouard, 1896

Cyclogyra planorbis (Schultze)

Plate 1, Fig. 9

Cornuspira planorbis Schultze, 1854, Organisms Polythal, p.40, Pl. 2, Fig.21.

5 living and 20 dead specimens were recorded from sample 38B from an area of extensive seagrass with coarse shelly sand in the Shallow Subtidal Zone.

This is recorded from the Abu Dhabi region (Murray 1970b), the Iranian side of the Gulf (Haake 1975), from offshore Kuwait (Anber 1974) and Jeddah Bay, Red Sea (Bahafzallah 1975).

Spiroloculina spp.

Two species of this genus are present and grouped together on the distribution charts.

Spiroloculina hadai Thalmann

Plate 1, Figs 10, 11

Spiroloculina hadai Thalmann, 1933, J. paleont., 7, p.354.

This is recorded from the Iranian side of the Gulf (Haake 1975).

Spiroloculina laevigata Cushman & Todd

Plate 1, Fig. 12

Spiroloculina laevigata Cushman & Todd, 1944, p.67, Pl. 9, Figs 26, 29. The Genus Spiroloculina and its species. Cushman Lab. foram. Res., Spec. Publ. 11: 1-82, Pls 1-9.

This is recorded from offshore Kuwait (Anber 1974) and from the Iranian side of the Gulf (Haake 1975).

Vertebralina striata d'Orbigny

Plate 2, Fig. 1

Vertebralina striata d'Orbigny, 1826, Annls, Sci. nat., Ser. 1, 7, p.283. Figured by Parker, Jones & Brady, 1871, Ann. Mag. Nat. His., Ser. 4, 8, Fig. 27.

270 living and 1220 dead specimens were recorded mostly from the Shallow Subtidal Zone; 70% of the living specimens came from vegetated areas. Living specimens are not encountered in the Intertidal Zone and are rare in the Deeper Subtidal. Dead specimens are recorded from all three zones.

This is recorded from the Abu Dhabi region (Murray 1970b) and from Jeddah Bay, Red Sea (Bahafzallah 1975).

Quinqueloculina spp.

Five species of Quinqueloculina have been differentiated but they are grouped together in the distribution data because of the difficulty in this differentiation.

Quinqueloculina cf. oblonga (Montagu)

Plate 2, Figs 2, 3

Vermiculum oblongum Montagu, 1803, Testacea Britannica, p.522, Pl. 14, Fig. 9.

This is also recorded from the Iranian side of the Gulf (Haake 1975), and from Jeddah Bay, Red Sea (Bahafzallah 1975).

Quinqueloculina elegans d'Orbigny

Plate 2, Figs 4, 5, 6, 7

Quinqueloculina elegans d'Orbigny, 1826, Ann. Sci. Nat., 1, 7, p.135.

This highly variable species is recorded from the Iranian Gulf coast (Haake 1975), and it is probable that the form illustrated by Murray (1966b) as "ribbed Quinqueloculina Type H" belongs here.

Quinqueloculina sp

Plate 2, Figs 8, 9

This is the form referred to by Murray (1966b) as Type B.

Quinqueloculina bidentata d'Orbigny

Plate 2, Figs 10, 11

Quinqueloculina bidentata d'Orbigny, 1839, Foraminiferes, In: Ramon de la Sagra, Histoire Physique et naturelle de l'Ile de Cuba, 8, p.197, Pl. 12, Figs 18-20.

This is also recorded from Jeddah Bay, Red Sea (Bahafzallah 1975).

Quinqueloculina sp.

Plate 2, Figs 12, 13

This is the form referred to by Murray (1966b) as Type E.

Massilina sp.

Plate 3, Fig. 1

235 living and 1710 dead specimens are recorded, 57% of the living from vegetated area, Shallow Subtidal.

Pseudomassilina sp.

Plate 3, Fig. 2

65 living and 215 dead specimens are recorded. Living specimens were found equally in bare sediment or associated with vegetation from the Subtidal Zone. Neither living nor dead specimens are recorded from the Intertidal Zone.

Miliolinella sp.

There are probably several species of this genus present. and these are grouped together in the distribution data. One species has been recognized and named from amongst these, M. subrotunda. 115 living and 455 dead specimens are recorded. 79% of the living are from vegetated sediment in the Shallow and Deeper Subtidal Zones. The dead have a wider distribution, occurring also in the Intertidal Zone.

Miliolinella subrotunda (Montagu)

Plate 3, Fig. 3

Vermiculum subrotundum Montagu, 1803, Testacea Britannica, p.251, figured by Walker and Boys, 1784, Testacea minuta rariora, Pl. 1, Fig. 4

The species is recorded from the Iranian side of the Gulf (Haake 1975) and from Jeddah Bay, Red Sea (Bahafzallah 1975).

Triloculina spp.

This is a group of species amongst which two species can be recognized but they are all plotted as one group in the distribution data.

Triloculina earlandi Cushman, Todd & Post

Plate 3, Figs 4, 5

Triloculina earlandi Cushman, Todd & Post, 1954, In: Recent foraminifera of the Marshall Islands: U.S. Geol. Survey, Prof. Paper 260.H, p.338, Pl. 85, Fig.3.

This is recorded from offshore Kuwait (Anber 1974).

Triloculina affinis d'Orbigny

Plate 3, Fig. 6

Triloculina affinis d'Orbigny, 1826, Annls, Sci. Nat., Ser. 1, 7, (2), p.299. Figured by Fornasini, 1905, Mem. R. Acad. Sci., Inst.Bologna, Ser 6, 2, p.59, Pl. 1, Figs 1a,b.

The species is recorded from the Iranian side of the Gulf (Haake 1975), from offshore Kuwait (Anber 1974) and from Jeddah Bay, Red Sea (Bahafzallah 1975).

Hauerina diversa Cushman

Plate 3, Fig. 7

Hauerina diversa Cushman, 1946, Contr. Cushman Lab. foramin. Res. 22, p.11, Pl. 2, Figs 16-19.

60 living and 200 dead specimens were recorded. Live

specimens occur equally in bare sediment and associated with vegetation. Neither living nor dead are encountered in the Intertidal Zone.

The species is recorded from Jeddah Bay, Red Sea (Bahafzallah 1975).

Articulina sp.

Plate 3, Fig. 8

40 living and 490 dead specimens are recorded. 63% of the living were found in samples from vegetated sediment. Neither living nor dead specimens are recorded from the Intertidal Zone.

The species is also recorded from Kohar Al Bazam of the Gulf (Murray 1966b) and the shelf of the Trucial coast (Murray 1966c).

Parrina bradyi (Millett)

Plate 3, Fig. 9

Nubecularia bradyi Millett, 1898, J. R. Microsc. Soc., (1), p.261, Pl. 5, Figs 6a-b.

200 living and 985 dead specimens have been recorded. Living specimens are encountered equally in samples from sediment and vegetated sediment. Both the living and dead have a wider distribution.

The species is also recorded from the Abu Dhabi region

(Murray 1970b), from the Iranian side of the Gulf (Haake 1975) and from Jeddah Bay, Red Sea (Bahafzallah 1975).

Peneroplis planatus (Fichtel & Moll)

Plate 3, Fig. 10

Nautilus planatus Fichtel & Moll, 1798, Testacea Microscopica, p.91, Pl. 16, Figs a-i.

This species is also recorded from the south western part of the Gulf (Murray 1965, 1970a, b), from offshore Kuwait (Anber 1974) and from Jeddah Bay, Red Sea (Bahafzallah 1975).

Peneroplis pertusus (Forskal)

Plate 3, Fig. 11

Nautilus pertusus Forskal, 1775, Descriptiones Animalum, Copenhagen. Figured by Brady, 1884, Rept, Voy. Challenger, Zoology, 9.

The species is also recorded from the Abu Dhabi region (Murray 1965, 1970a, b).

Remarks: P. planatus and P. pertusus differ slightly from each other. P. planatus is characterized by a large size and more flaring chambers.

Spirolina acicularis (Batsch)

Plate 4, Fig. 1

Nautilus (Lituus) acicularis Batsch, 1791, In: Testaceorum arenulae - marinae tabulae sex., Jena Univ. Press, p.3, 6,

Pl. 6, Figs 16a-b.

15 living and 455 dead specimens are recorded fromthe area. Living specimens occur equally on both bare sediment and vegetated sediment. Dead specimens are found mainly within the Intertidal and Shallow Subtidal Zones and are rare in the Deeper Subtidal.

The species is recorded from the south western part of the Gulf (Murray 1965b, 1970a, b) and Jeddah Bay, Red Sea (Bahafzallah 1975).

Spirolina arietina (Batsch)

Plate 4, Figs 2, 3, 4

Nautilus (Lituus) arietina, 1791, In: Testaceorum arenulae - marinae tabulae sex., Jena Univ. Press, p.4, Pl. 6, Fig. 15C.

The species is recorded from the south western part of the Gulf (Murray 1965, 1970a, b) and Jeddah Bay, Red Sea (Bahafzallah 1975).

Remarks: A normal specimen is illustrated on Plate 4, Fig. 2. Twinned specimens occur (Plate 4, Fig. 3 & 4) with two apertures; it is not clear whether such occurrences represent single individuals or two individuals fixed together. It seems more likely that the latter is the case.

Sorites marginalis (Lamarck)

Plate 4, Fig. 5

Orbulites marginalis Lamarck, 1816, Histoire naturelle des animaux sans vertebres, 2, p.196, No. 1

95 living and 335 dead specimens are recorded. Living specimens are found mainly from seagrass areas. The species has a wide distribution from the Intertidal Zone to the Deeper Subtidal Zone.

It is also recorded from the Abu Dhabi region (Murray 1965b, 1970a, b) and from Jeddah Bay, Red Sea (Bahafzallah 1975).

Suborder ROTALIINA

Delage & Hérouard, 1896

Nodosaria sp.

Plate 4, Fig. 6

5 living and 50 dead specimens are recorded. The living specimens occur in sample 23C from the Deeper Subtidal Zone. Both dead and living specimens are recorded from the Deeper Subtidal.

Lagena laevis (Montagu)

Plate 4, Fig. 7

Vermiculum laeve Montagu, 1803, In: Testacea Britannica, p. 524, Pl. 1, Fig. 9.

20 dead but no living specimens are recorded from the Deeper Subtidal Zone.

The species is recorded from offshore Kuwait (Anber 1974).

Brizalina spp.

Plate 4, Fig. 8

40 living and 440 dead specimens are recorded from the area. The species lives on bare sediment and seagrass areas in both the Shallow and Deeper Subtidal Zones. Neither living nor dead are encountered in the Intertidal Zone.

Bolivina lobata Brady

Plate 4, Fig. 9

Bolivina lobata Brady, 1881, Quart. J. Microscop. Soc., 21, 28. Figured by Brady, 1884, Rept. Voy. Challenger, Zoology, 9, Pl. 53 (22, 23).

20 living and 270 dead specimens are recorded from bare sediments of the Deeper Subtidal Zone.

The species is recorded from the shelf of the Trucial coast, Arabian Gulf (Murray 1966c).

Reussella spinulosa (Reuss)

Plate 4, Fig. 10

Vermeuilina spinulosa Reuss, 1850, Denkschr. K. Akad. Wiss., Wien, 1, p.374, Pl. 47, Fig. 12.

330 dead specimens but no living ones are recorded. These might have drifted in from deeper water.

Discorbina patelliformis Brady

Plate 4, Figs 11, 12

Discorbina patelliformis Brady, 1884, Rept. Voy. Challenger, Zoology, 9, 647, Pl. 88, Fig. 3a-c, Pl. 89, Fig. 1a-c.

The species is recorded from Khor Al Bazam (Murray 1966b) and from the Abu Dhabi region (Murray 1970b).

Rosalina spp.

350 living and 595 dead specimens are recorded from the area. 86% of the living are encountered in seagrass areas, mainly in the Shallow Subtidal Zone. The species is very often found clinging to shells or stones on the umbilical side. One species is identified as Rosalina globularis d'Orbigny 1826, Plate 5, Figs 1, 2, which is recorded from Kuwait (Anber 1974).

Murray (1965a) recorded a new species, Rosalina adhaerens, from the Abu Dhabi region which has not been found in the present study. He reviewed the wall structure of the genus, mentioning that Haynes (1956) had described the wall structure of some Rosalina species from the Palaeocene of England as granular, while other authors such as Reiss (1963) and Loeblich and Tappan (1964) stated that most species of Rosalina have a radial wall structure. Murray followed the latter interpretation, although he did not study thin-sections of the genus.

Spirillina vivipara Ehrenberg

Plate 5, Fig. 3

Spirillina vivipara Ehrenberg, 1843, Abh. Akad. Wiss. Berlin, (Jahrg 1841) pt. 1, pp.323, 422, Pl. 3, Sec. 7, Fig. 41.

5 living specimens are recorded from seagrass sample 14B and 10 dead from sample 34B and 11C. Both living and dead are found in shallow vegetated areas of the Subtidal Zone.

The species is recorded from the Iranian side of the Gulf (Lutze 1974), from offshore Kuwait (Anber 1974) and from Jeddah Bay, Red Sea (Bahafzallah 1975).

Ammonia beccarii (Linné)

Nautilus beccarii Linné, 1758, Systema Naturae, Ed. 10, Holmiae, Sweden, p.710, figured by Plancus 1739, Conch., Pl. 1, Fig. 1a-c.

The species is reported to have almost cosmopolitan distribution, but does show considerable variation. The specimens from Tarut Bay are variable with two distinct variants figured in Plate 5. The first of these (Figs 4, 5) has a prominent suture on the dorsal side with a prominent plug in the ventral side. The second variant (Figs 6, 7) tends to be smoother on the dorsal side and has a less developed plug on the ventral side. Both variants differ from the typical A. beccarii of western

Europe (Plate 5, Figs 8, 9). Murray (1970a,b) records the species as A. beccarii varieties; it is also recorded from the Iranian coast (Lutze 1974), Kuwait (Anber 1974) and Jeddah Bay (Bahafzallah 1975).

Elphidium aff. advenum(Cushman)

Plate 6, Fig. 1

Polystomella advena Cushman, 1922, Publs Carnegie Inst. 17, (311), p.56, Pl. 9, Figs 11-12.

The species is recorded from the Abu Dhabi region by Murray (1970b) who reported that his specimens differed from the typical E. advenum Cushman in possessing a well developed umbilical knob and in lacking a peripheral keel. The species is also recorded from the Iranian side of the Gulf (Lutze 1974), offshore Kuwait (Anber 1974) and from Jeddah Bay, Red Sea (Bahafzallah 1975).

Elphidium aff. discoidale (d'Orbigny)

Plate 6, Figs 2, 3

Polystomella discoidalis d'Orbigny, 1839, Foraminifères In: Ramon de la Sagra, Histoire Physique et naturelle de l'Ile de Cuba, 8, p.56, Pl. 6, Figs 23-24.

The species is recorded from the Abu Dhabi region by Murray (1970b). He found that in his specimens the umbilical bosses project less and are more globose than in the typical species. Similar forms were recorded from the Iranian side of the Gulf (Lutze 1974) and from

Jeddah Bay (Bahafzallah 1975) under the name of E. discoidale.

Elphidium crispum (Linne)

Plate 6, Figs 4, 5

Nautilus crispum Linne, 1758, Systema Naturae, Ed. 16, Holmiae, p.709, Figured by Plancus, 1739, Conch., Pl. 7, Figs 2d-f.

55 living and 675 dead specimens are recorded from the area. The living specimens are mainly found in bare sediment from the Shallow Subtidal Zone. Both living and dead specimens are recorded from the Intertidal, Shallow and Deeper Subtidal Zones.

The species if also recorded from the Abu Dhabi region (Murray 1970b) and from Jeddah Bay (Bahafzallah 1975).

Remarks: Specimens from Tarut Bay differ from typical European specimens (Plate 6, Fig. 5) in having a less prominent keel, less prominent sutures and in having a large distinct umbilical area.

Elphidium reticulosum Cushman

Plate 6, Fig. 6

Elphidium reticulosum Cushman, 1933, U.S. Nat. Museum Bull.,

The species is recorded from the Abu Dhabi region (Murray 1970b).

"Eponides" murrayi (Heron, Allen & Earland)

Plate 6, Figs 7, 8

Rotalia murrayi Heron, Allen & Earland, 1915, Trans. Zool. Soc. London, 20 (17), 721.

This species is recorded from the Abu Dhabi region (Murray 1970b).

Eponides repandus (Fichtel & Moll)

Plate 7, Figs 1, 2

Nautilus repandus Fichtel & Moll, 1798, Testacea microscopica, p. 35, Pl. 3, Figs a-d.

5 living and 5 dead specimens are recorded from sample 24C from a depth of 4 m from bare sediment. The species is recorded from Jeddah Bay, Red Sea (Bahafzallah 1975).

Cibicides sp.

Plate 7, Figs 3, 4

105 living and 535 dead specimens are recorded from the area. Neither living nor dead are recorded from the Intertidal Zone. 71% of the living are recorded from vegetated areas. Specimens are very often found clinging to stones and shells.

Cymbaloporella tabellaeformis (Brady)

Plate 7, Figs 5, 6

Cymbalopora tabellaeformis Brady, 1884, Rept. Voy. Challenger, Zool., 9, p.637, Pl. 102, Figs 15-18.

5 living and 40 dead specimens are recorded from the area. Live specimens come from the Shallow Subtidal Zone (sample 19B) attached to boulders in a seagrass area. Dead specimens arerrecorded from Shallow and Deeper Subtidal Zones but not from the Intertidal Zone.

The species is recorded from Jeddah Bay (Bahafzallah 1975).

Cymbaloporetta bradyi (Cushman)

Plate 7, Figs 7, 8

Cymbalopora bradyi Cushman, 1924, Publs Carnegie Inst., 21, (342), p.34, Pl. 10, Figs 2-4.

295 living and 1375 dead specimens are recorded from the area. 65% of living specimens are encountered in vegetated areas in the Shallow Subtidal Zone, but it is not found in the Intertidal Zone. Dead specimens have a wider distribution.

The species is recorded from Jeddah Bay, Red Sea (Bahafzallah 1975).

Acervulina inhaerens Schultze

Plate 7, Fig. 9

Acervulina inhaerens Schultze, 1854, Organismus Polythal, 1854, 68.

120 living and 730 dead specimens are recorded from the area. 99% of living specimens are recorded from seagrass areas in the Shallow Subtidal Zone, very often attached to shell debris. Dead specimens have a wider distribution, occurring in all three zones.

The species is also recorded from the Abu Dhabi region (Murray 1965b).

Nonion sp.

Plate 7, Fig. 10

330 living and 935 dead specimens are recorded from the area. 65% of the living specimens are found in bare sediment samples. The species is absent from the Intertidal Zone.

The test of specimens from Tarut Bay often display a green colour which might be due to the presence of symbiotic algae. Boltovsky and Wright (1976) reported the genus amongst those which have a symbiotic relationship with algae.

The species is recorded from Halat Al Bhrani region, Arabian Gulf (Murray 1966a).

SUMMARY AND CONCLUSIONS

The following points can be made from this study of the Foraminifera of Tarut Bay.

1. 109 out of 121 samples yielded Foraminifera, with a total population count of 37655 living and 142360 dead specimens.

2. The foraminiferal suborders occur in the following percentages: a) Living forms: Textulariina 6.3%, Miliolina 54.4% and Rotaliina 39.3%; b) Dead forms: Textulariina 3.1%, Miliolina 55.4% and Rotaliina 41.5%.

3. 14 taxa (Table 1) forming 92% of the living and 90% of the dead specimens have been considered to be common.

4. Although most of the taxa are found throughout Tarut Bay, the environment can be subdivided on the basis of relative abundance and the presence or absence of live populations of the 14 common taxa. Three zones can be recognized, the Intertidal, the Shallow Subtidal and the Deeper Subtidal.

5. The distribution of the common taxa has been plotted on maps. The level of their relative abundance ranges from $<3\%$, regarded as very rare, to $>50\%$,

regarded as dominant. It is not possible to draw a contoured distribution plot because of the patchiness of their distribution. This is caused by the various substrates existing in the area, in particular mobile and stabilized sediment and the different types of marine vegetation.

6. It is inferred that distribution of the dead fauna follows the same pattern as the living.

7. The fauna of the area can be divided into those living on the bare sediment and those living mainly in sediment associated with vegetation.

8. The distribution of the living forms within the area is mainly influenced by the type of substrate and to a less extent the depth of water.

9. Both living and dead populations are characterised by low diversity.

10. It is concluded that live/dead ratios do not reflect the rate of sedimentation in the area.

11. Transportation of the fauna after death if unlikely. Evidence can be drawn from the distribution patterns of the living and dead populations. The average of the total population per sample from vegetated areas

is 372 living and 1316 dead individuals, while bare sediment yields 327 living and 1299 dead.

12. The faunal distribution does not show a direct relationship to the grain size of the sediment. However, it is observed that coarse sediment is usually characterized by large sized Miliolids with thick shells and ornamented by agglutinated forms.

13. The Foraminifera of Tarut Bay display a great deal of morphological variations and integration between forms. This is particularly true of the Miliolids where it is difficult to differentiate species.

14. Aberrant forms have a very rare occurrence.

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Plate 1

Fig. 1, *Ammobaculites* sp.
Side view x 70

Fig. 2, *Textularia foliacea* (Heron, Allen & Earland)
Side view x 60

Fig. 3, *Textularia conica* (d'Orbigny)
Side view x 80

Fig. 4, *Bigenerina* sp?
Side view x 70

Figs 5, 6, *Eggerella scabra* (Williamson)
5 - Side view x 65
From the Firth of Clyde (Scotland)
6 - Side view x 130
From Tarut Bay

Fig. 7, *Clavulina angularis* (d'Orbigny)
Side view x 25

Fig. 8, *Clavulina pacifica* (Cushman)
Side view x 30

Fig. 9, *Cyclogyra planorbis* (Schultze)
Side view x 200

Figs 10, 11, *Spiroloculina hadai* (Thalmann)
10 - Side view x 60
11 - Side view x 80 (Aberrant growth)

Fig. 12, *Spiroloculina laevigata* (Cushman)
Side view x 48

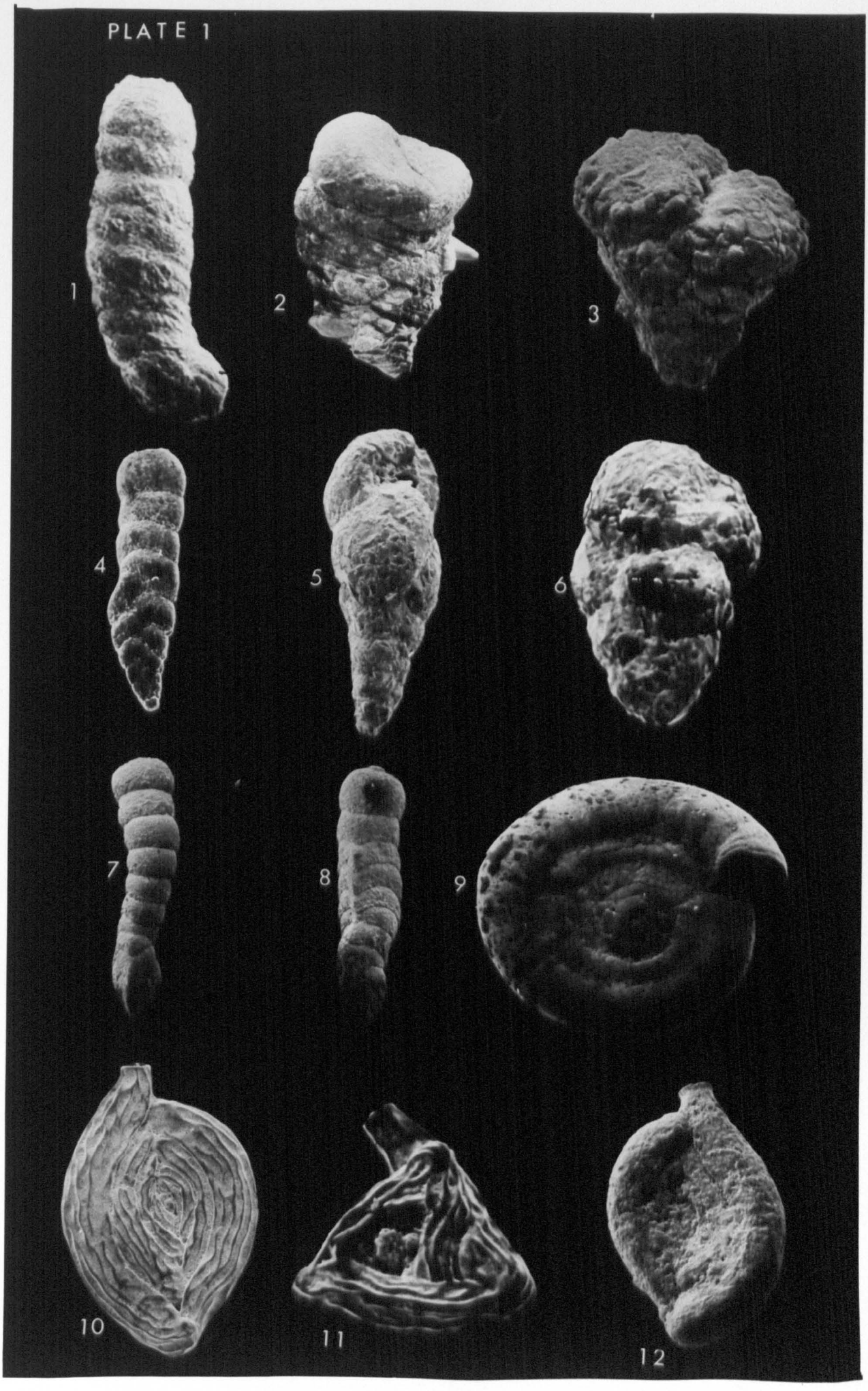
PLATE 1
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Plate 2

Fig. 1, Vertebralina striata (d'Orbigny)

Side view x 45

Figs 2, 3, Quinqueloculina cf. oblonga (Montagu)

2 - Side view x 45
3 - Side view x 65

Figs 4,5,6,7 Quinqueloculina elegans (d'Orbigny)

4 - Side view x 75
5 - Side view x 50
6 - Side view x 50
7 - Side view x 60

Figs 8, 9, Quinqueloculina sp. (Murray, B)

8 - Side view x 75
9 - Side view x 75

Figs 10, 11, Quinqueloculina bidentata (d'Orbigny)

10 - Side view x 75
11 - Side view x 60

Figs 12, 13, Quinqueloculina sp. (Murray, E)

12 - Side view x 65
13 - Side view x 40

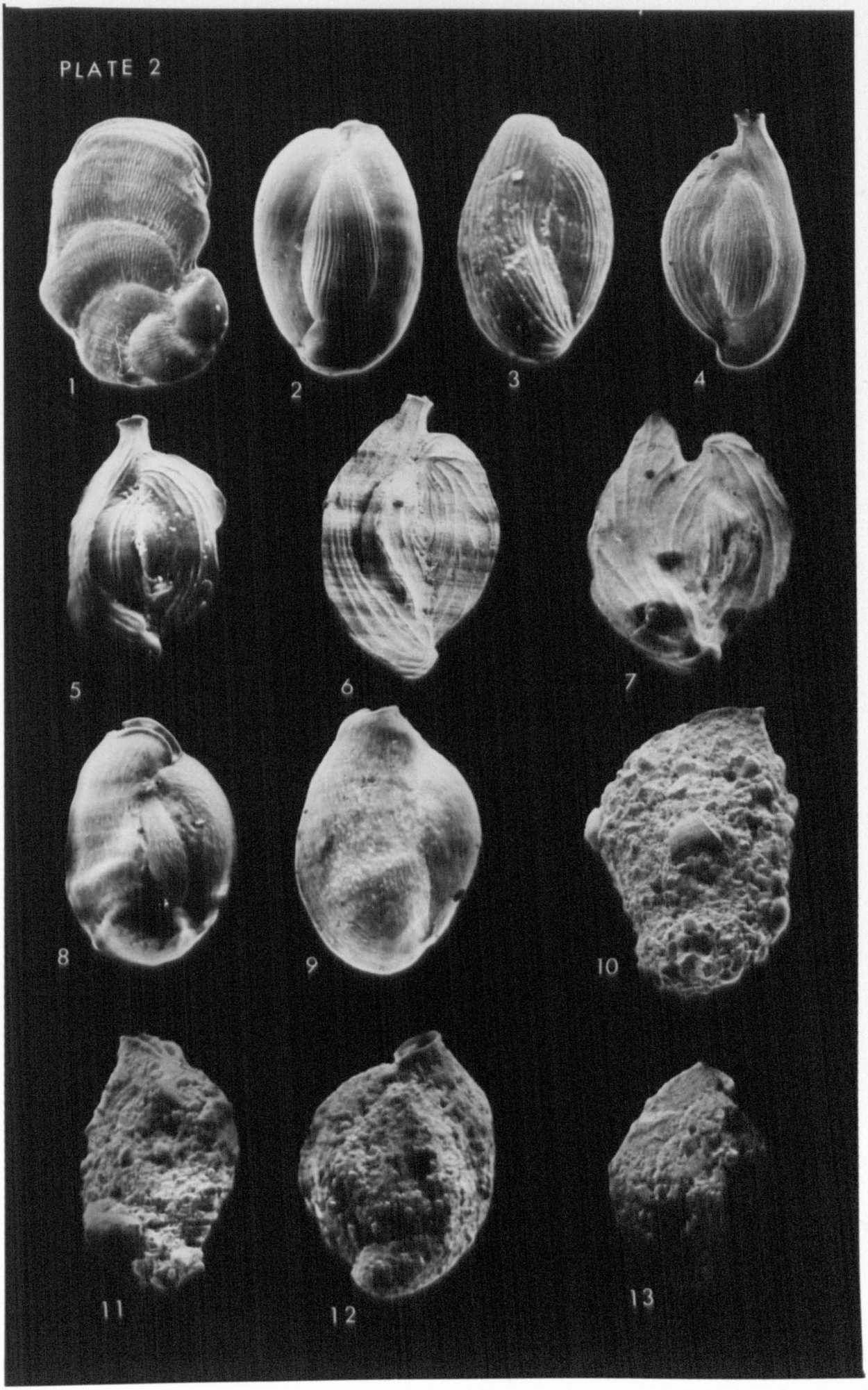
PLATE 2
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Plate 3

Fig. 1, *Massilina* sp.

Side view x 40

Fig. 2, *Pseudomassilina* sp.

Side view x 35

Fig. 3, *Miliolinella subrotunda* (Montagu)

Side view x 150

Figs 4, 5, *Triloculina earlandi* (Cushman, Todd & Post)

4 - Side view x 70
5 - Side view x 65

Fig. 6, *Triloculina affinis* (d'Orbigny)

Fig. 7, *Hauerina diversa* (Cushman)

Side view x 65

Fig. 8, *Articulina* sp.

Side view x 65

Fig. 9, *Parrina bradyi* (Millett)

General view x 85

Fig. 10, *Peneroplis planatus* (Fichtel & Moll)

General view x 42

Fig. 11, *Peneroplis pertusus* (Forskal)

General view x 55

PLATE 3

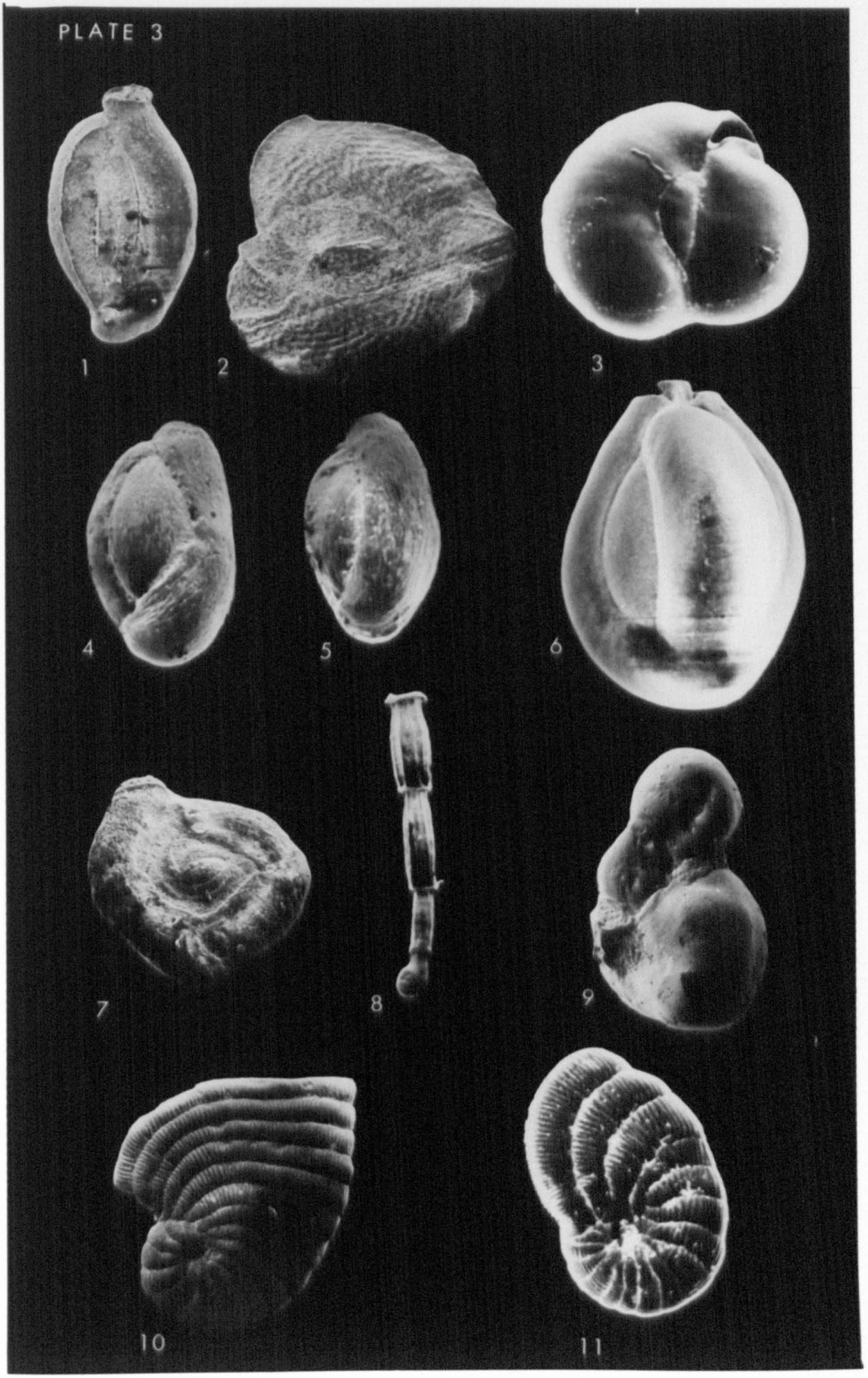

Plate 4

Fig. 1, *Spirolina acicularis* (Batsch)

Side view x 30

Figs 2, 3, 4, *Spirolina arietina* (Batsch)

2 - Side view x 25
3 - Side view x 70 (Aberrant growth)
4 - Side view x 50 (Aberrant growth)

Fig. 6, *Nodosaria* sp.

General view x 80

Fig. 7, *Lagena laevis* (Montagu)

General view x 95

Fig. 8, *Brizalina* sp.

Side view x 130

Fig. 9, *Bolivina lobata* (Brady)

Side view x 67

Fig. 10, *Reussella spinulosa* (Reuss)

General view x 110

Figs 11, 12, *Discorbina patelliformis* (Brady)

11 - Dorsal view x 150
12 - Ventral view x 200

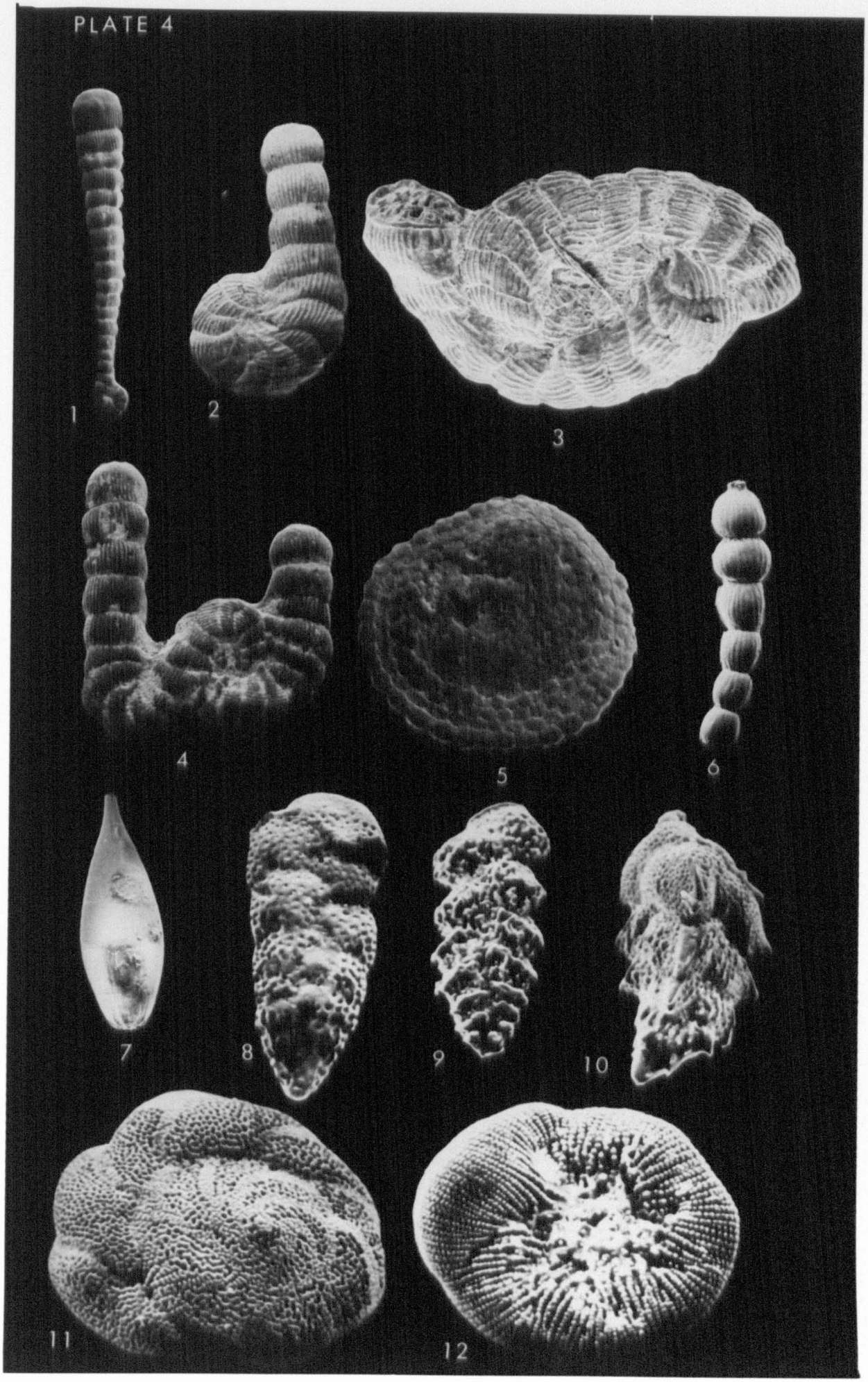
PLATE 4
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Plate 5

Figs 1, 2, *Rosalina globularis* (d'Orbigny)

1 - Dorsal view x 75
2 - Ventral view x 80

Fig. 3, *Spirillina vivipara* (Ehrenberg)

General view x 179

Figs 4,5,6,7, 8,9, *Ammonia beccarii* (Linne)

4 - Dorsal view x 90
5 - Ventral view x 120
6 - Dorsal view x 130
7 - Ventral view x 130
8 - Dorsal view x 65
9 - Ventral view x 65

(8 and 9 from the Firth of Clyde, Scotland)

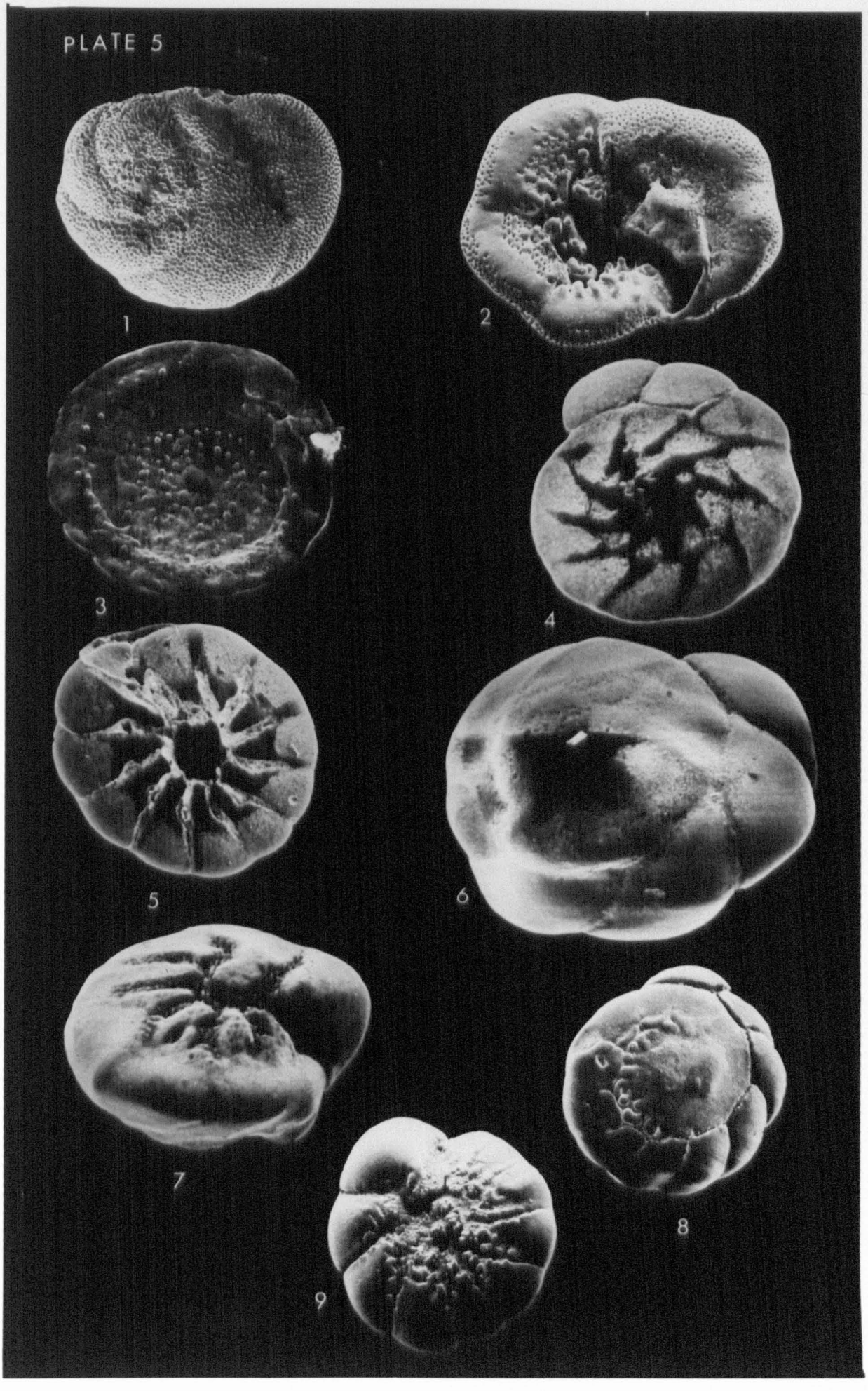
PLATE 5
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Plate 6

Fig. 1, *Elphidium* aff. *advenum* (Cushman)

General view x 160

Figs 2, 3, *Elphidium* aff. *discoidale* (d'Orbigny)

2 - General view x 130
3 - Side view x 130

Figs 4, 5, *Elphidium crispum* (Linne)

4 - Side view x 85
5 - Side view x 65

(From the Firth of Clyde)

Fig. 6, *Elphidium reticulosum* (Cushman)

Side view x 160

Figs 7, 8, *Eponides murrayi* (Heron, Allen & Earland)

7 - Dorsal view x 190
8 - Ventral view x 190

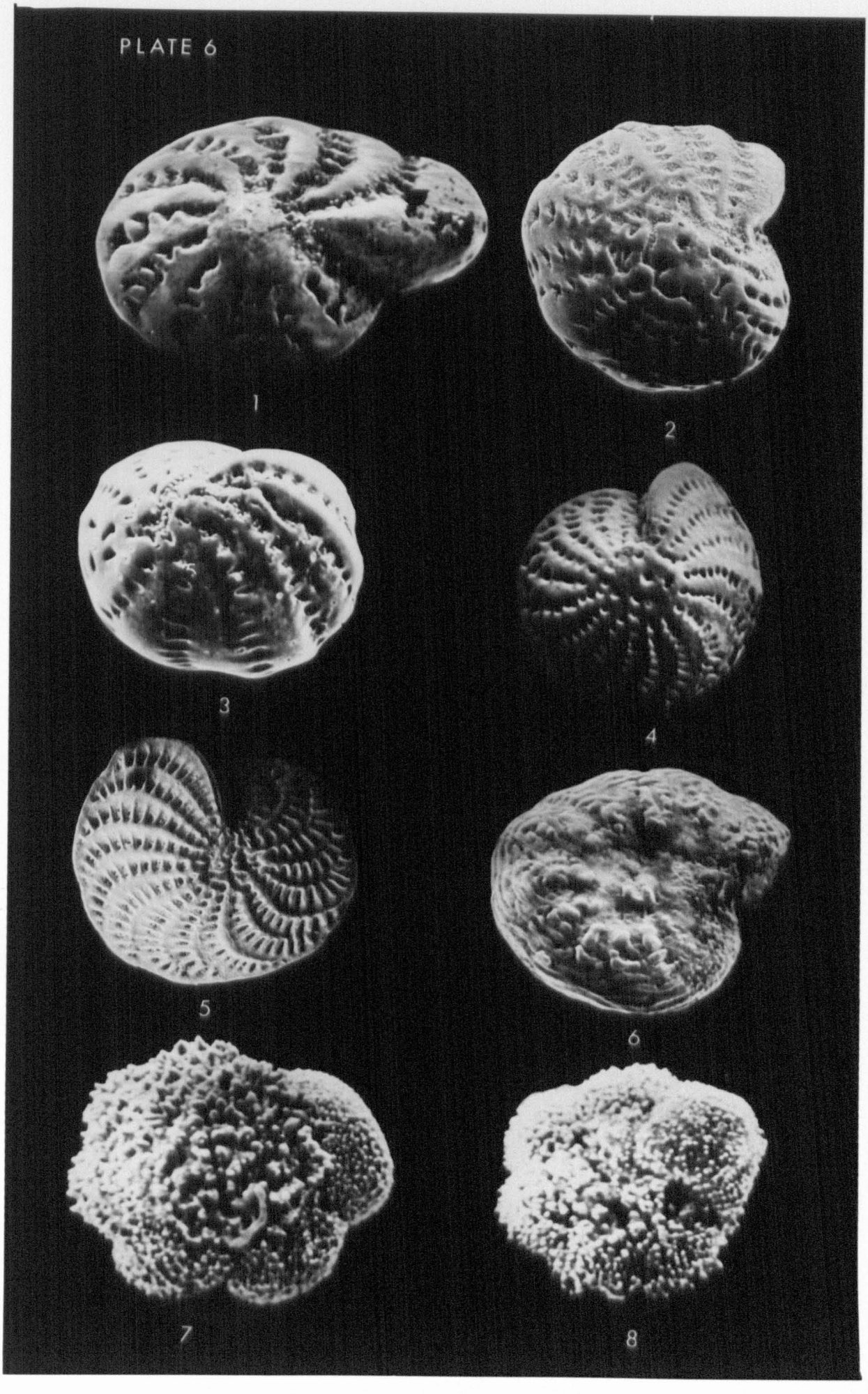
PLATE 6
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Plate 7

Figs 1, 2, *Eponides repandus* (Fichtel & Moll)

1 - Dorsal view x 55
2 - Ventral view x 75

Figs 3, 4, *Cibicides* sp.

3 - Dorsal view x 100
4 - Ventral view x 100

Figs 5, 6, *Cymbaloporetta tabellaeformis* (Brady)

5 - Dorsal view x 85
6 - Ventral view x 100

Figs 7, 8, *Cymbaloporetta bradyi* (Cushman)

7 - Dorsal view x 100
8 - Ventral view x 120

Fig. 9, *Acervulina inhaerens* (Schultze)

General view x 75

Fig. 10, *Nonion* sp.

Side view x 110

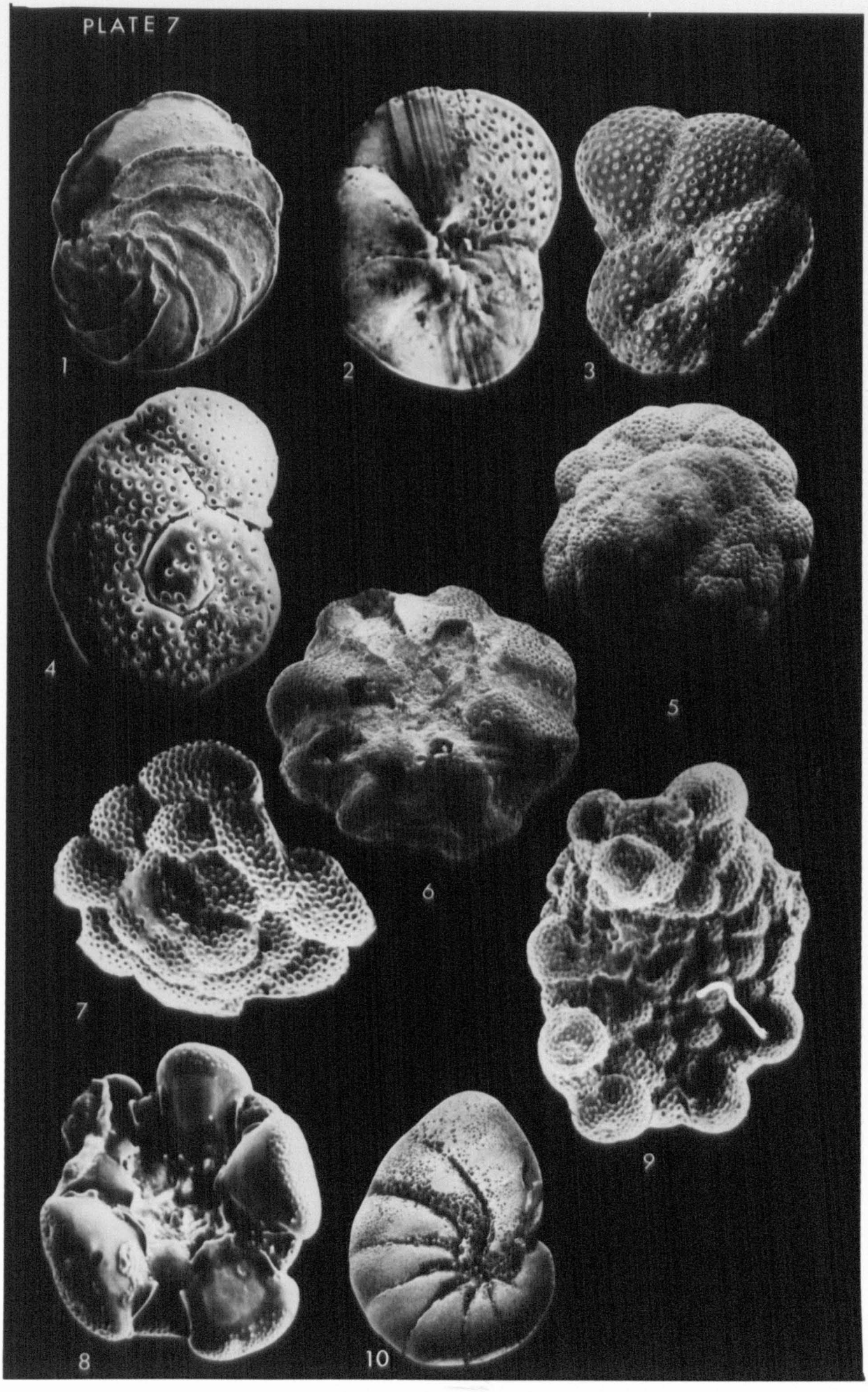
PLATE 7
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APPENDIX 1

Surface and Bottom temperature in the different sampling sites

Station Number	Surface temp. (^{o}C)	Bottom temp. (^{o}C)	Date of Measurements
1-B	25.4	26.3	
2-B	25.9	25.8	
3-B	25.9	26.3	
4-B	25.9	25.9	
5-B	25.9	26.1	
6-B	26	26.6	
7-B	26.2	27.9	
8-B	27.1	27.2	
9-B	26.1	27.5	
10-B	26.4	26.9	
11-B	27.3	26.7	
12-B	27.2	26.2	7/4/1979
13-B	28.1	26.7	
14-B	26.2	26.8	
15-B	26.5	26	
16-B	26.2	27.2	
17-B	26.2	27.3	
18-B	26.7	28.8	
19-B	26.6	26.4	
20-B	27.2	26.9	
21-B	27.2	27	
22-B	26.1	27.7	
23-B	26.2	27.2	
24-B	26.2	27.2	
Average	26.5	26.8	

Continued

Station Number	Surface temp. (°C)	Bottom temp. (°C)	Date of Measurements
1-C	23.9	23.8	
2-C	23.5	23.4	
3-C	23.9	23.6	
4-C	23.7	23.6	
5-C	23.9	23.6	
6-C	24.3	24.2	
7-C	24	24.2	
8-C	24.2	24.1	
9-C	24.5	24.3	9/4/1980
10-C	25	25	
11-C	25	25	
12-C	25	25	
13-C	25	25	
14-C	26	25.9	
15-C	25.8	25.8	
16-C	25.7	25.6	
17-C	25.1	24.9	
18-C	25.2	24.7	
19-C	26.6	24.6	
20-C	25	25.5	
21-C	24	24.1	
22-C	23.8	23.6	
23-C	23.9	23.7	
24-C	23.5	23.4	
25-C	23.6	23.4	
26-C	23.5	23.4	

Continued

Station Number	Surface temp. (^{o}C)	Bottom temp. (^{o}C)	Date of Measurements
27-C	23.7	23.4	
28-C	23.8	23.5	
29-C	23.6	23.4	
30-C	23.7	23.6	10/4/1980
31-C	24.1	24	
32-C	24.1	24	
33-C	24.4	24.1	
34-C	24.7	24.6	
35-C	24.8	24.7	
36-C	24.6	24.5	
37-C	24.5	24.4	
38-C	24.5	24.3	
39-C	24.5	24.4	
40-C	24.9	24.7	
41-C	25.2	25.1	
42-C	25.2	25.2	
Average	24.4	24.3	

APPENDIX 2

Showing the number of specimens of the LIVING population of each taxon for each sample

Sample No. Trip A	1	2	3	4	5	6	7	8	9
Suborder: Textulariina		5	15						
1. Ammobaculites sp.									
2. Textularia spp.									
3. Bigenerina sp.									
4. Eggerella scabra									
5. Clavulina spp.		5	15						
Suborder: Miliolina	115	200	350	265	320	120	95	380	420
6. Cyclogyra planorbis									
7. Spiroloculina spp.	10					10			
8. Vertebralina striata									
9. Quinqueloculina spp.	25	50	100	60	120	60	25	75	115
10. Massilina spp.									
11. Pseudomassilina sp.									
12. Miliolinella spp.									
13. Triloculina spp.	15			5	10		5		130
14. Hauerina diversa									
15. Articulina sp.									
16. Parrina bradyi	15				5				
17. Peneroplis planatus	50	80	150	90	80	50	40	150	75
18. Peneroplis pertusus			10						
19. Spirolina acicularis									
20. Spirolina arietina		70	96	110	105		25	155	100
21. Sorites marginalis									
Suborder: Rotaliina	380	260	175	170	350	200	80	250	260
22. Nodosaria sp.									
23. Lagena laevis									
24. Brizalina spp.									
25. Bolivina lobata									
26. Reussella spinulosa									
27. Discorbina patelliformis									
28. Rosalina spp.									
29. Spirillina vivipara									
30. Ammonia beccarii	150	140	75	100	150	65	50	150	150
31. Elphidium aff. advenum	120	110	100	70	150	55	15	100	110
32. E. aff. discoidale	10								
33. E. crispum									
34. E. reticulosum	100	5			50	80	15		
35. E. sp.		5							
36. E. spp.									
37. Eponides murrayi									
38. Eponides repandus									
39. Cibicides sp.									
40. Cymbaloporella tabellaeformis									
41. Cymbaloporetta bradyi									
42. Acervulina inhaerens									
43. Nonion sp.									
Totals	495	465	546	435	670	320	175	630	680
Number of species	9	8	7	6	8	6	7	5	6

Sample No. Trip B	1	2	3	4	5	6	7	8	9
Suborder: Textulariina	5	10	105	20	75	20			
1. Ammobaculites sp.									
2. Textularia spp.	5	10				20			
3. Bigenerina sp.									
4. Eggerella scabra			105	20	70				
5. Clavulina spp.									
Suborder: Miliolina	40	245	445	255	370	190	280	560	200
6. Cyclogyra planorbis									
7. Spiroloculina spp.	10	90	60	10	20	15	65	35	25
8. Vertebralina striata			5	10	5			15	5
9. Quinqueloculina spp.	15		110	55	120	100	100	205	125
10. Massilina spp.					10	15			
11. Pseudomassilina sp.			5					10	
12. Miliolinella spp.			30	5					
13. Triloculina spp.	10	50	25	5	65	55	50	95	15
14. Hauerina diversa			5	10					
15. Articulina sp.				5					
16. Parrina bradyi		5	15	15	20				
17. Peneroplis planatus		10	75	85	65		55	90	30
18. Peneroplis pertusus			15	5					
19. Spirolina acicularis						5	10		
20. Spirolina arietina	5	90	100	40	65			110	
21. Sorites marginalis				10					
Suborder: Rotaliina	10	10	650	90	55		160	390	265
22. Nodosaria sp.									
23. Lagena laevis									
24. Brizalina spp.								5	
25. Bolivina lobata									
26. Reussella spinulosa									
27. Discorbina patelliformis	5	5	100					10	
28. Rosalina spp.			200	5	5				5
29. Spirillina vivipara									
30. Ammonia beccarii	5	5		5			45	125	110
31. Elphidium aff. advenum				5	5		55	150	135
32. E. aff. discoidale							15	40	
33. E. crispum							5		
34. E. reticulosum			150	30	10		10	35	
35. E. sp.									
36. E. spp.								10	
37. Eponides murrayi			200		25		20		15
38. Eponides repandus									
39. Cibicides sp.				20	5				
40. Cymbaloporella tabellaeformis									
41. Cymbaloporetta bradyi			50	15	5		10	15	
42. Acervulina inhaerens			25	5					
43. Nonion sp.				5					
Totals	55	265	1200	365	500	210	440	950	465
Number of species	7	8	18	21	16	6	12	15	9

Sample No. Trip B	10	11	12	13	14	15	16	17	18
Suborder: Textulariina	5								5
1. Ammobaculites sp.									
2. Textularia spp.									
3. Bigenerina sp.									
4. Eggerella scabra	5								
5. Clavulina spp.									5
Suborder: Miliolina	225	150	195	160	175	110	185	150	265
6. Cyclogyra planorbis									
7. Spiroloculina spp.	5	60	40	25	70			5	10
8. Vertebralina striata	10		5				5		
9. Quinqueloculina spp.	165	90	125	75	105	110	90	35	120
10. Massilina spp.			20						
11. Pseudomassilina sp.									
12. Miliolinella spp.									
13. Triloculina spp.	40		5				75	5	5
14. Hauerina diversa									
15. Articulina sp.									
16. Parrina bradyi	5								
17. Peneroplis planatus							10	35	75
18. Peneroplis pertusus								20	
19. Spirolina acicularis									
20. Spirolina arietina							5	50	55
21. Sorites marginalis									
Suborder: Rotaliina	80	175	100	265	320	155	185	90	200
22. Nodosaria sp.									
23. Lagena laevis									
24. Brizalina spp.									
25. Bolivina lobata									
26. Reussella spinulosa									
27. Discorbina patelliformis			5		5				
28. Rosalina spp.									
29. Spirillina vivipara									
30. Ammonia beccarii	25	75	90	110	155	70	100	50	90
31. Elphidium aff. advenum	30	35	5	50	110	50	70	35	110
32. E. aff. discoidale				45	40		5		
33. E. crispum									
34. E. reticulosum	10	25		10			10		
35. E. sp.				15	5	5		5	5
36. E. spp.									
37. Eponides murrayi	15	40		35	5	15			
38. Eponides repandus									
39. Cibicides sp.									
40. Cymbaloporella tabellaeformis									
41. Cymbaloporetta bradyi									
42. Acervulina inhaerens									
43. Nonion sp.						15			5
Totals	310	325	295	365	495	265	370	240	470
Number of species	11	6	8	8	8	6	9	9	10

Sample No. Trip B	19	20	21	22	23	24	25	26	27
Suborder: Textulariina	5				5				
1. Ammobaculites sp.									
2. Textularia spp.									
3. Bigenerina sp.									
4. Eggerella scabra					5				
5. Clavulina spp.	5								
Suborder: Miliolina	170	380	365	410	260	240	225	145	245
6. Cyclogyra planorbis									
7. Spiroloculina spp.	36		10	30	10				
8. Vertebralina striata	5			5	10				
9. Quinqueloculina spp.	40	30	75	150	100	90	110	50	115
10. Massilina spp.									
11. Pseudomassilina sp.									
12. Miliolinella spp.									
13. Triloculina spp.	10	10		75	45	25			
14. Hauerina diversa									
15. Articulina sp.									
16. Parrina bradyi	5		5						
17. Peneroplis planatus	40	160	150	65	50	30	25	20	30
18. Peneroplis pertusus		30	25	5	10	5			
19. Spirolina acicularis									
20. Spirolina arietina	35	150	100	70	45	90	90	75	160
21. Sorites marginalis				10					
Suborder: Rotaliina	30	30	80	335	170	220	160	300	175
22. Nodosaria sp.									
23. Lagena laevis									
24. Brizalina spp.									
25. Bolivina lobata									
26. Reussella spinulosa									
27. Discorbina patelliformis				5	5	5			
28. Rosalina spp.									
29. Spirillina vivipara									
30. Ammonia beccarii	5	10	40	150	90	120	110	150	105
31. Elphidium aff. advenum		20	40	125	70	75	50	100	60
32. E. aff. discoidale								20	
33. E. crispum									
34. E. reticulosum						10			
35. E. sp.								30	10
36. E. spp.									
37. Eponides murrayi	5			50	5	10			
38. Eponides repandus									
39. Cibicides sp.									
40. Cymbaloporella tabellaeformis	5								
41. Cymbaloporetta bradyi	10			5					
42. Acervulina inhaerens	5								
43. Nonion sp.									
Totals	205	410	445	745	435	460	385	445	420
Number of species	12	7	8	13	12	10	5	7	6

Sample No. Trip B	28	29	30	31	32	33	34	35	36
Suborder: Textulariina				5			10		5
1. Ammobaculites sp.									
2. Textularia spp.				5					
3. Bigenerina sp.							5		
4. Eggerella scabra							5		
5. Clavulina spp.									5
Suborder: Miliolina	370	240	320	255	270	250	345	420	280
6. Cyclogyra planorbis									
7. Spiroloculina spp.		20	60	35	70	15	40	55	50
8. Vertebralina striata			5				20		5
9. Quinqueloculina spp.	150	110	90	60	60	105	60	90	50
10. Massilina spp.					5			45	5
11. Pseudomassilina sp.									
12. Miliolinella spp.									
13. Triloculina spp.	55	20	65	50	25	40	30	60	50
14. Hauerina diversa									
15. Articulina sp.									
16. Parrina bradyi	5		5		5		5	5	5
17. Peneroplis planatus	40	30	35	55	40	40	25	45	30
18. Peneroplis pertusus	5	10	5	5	25	30	15	20	25
19. Spirolina acicularis									
20. Spirolina arietina	110	50	55	50	40	15	150	100	60
21. Sorites marginalis	5					5			
Suborder: Rotaliina	240	140	35	20	65	70	105	0	15
22. Nodosaria sp.									
23. Lagena laevis									
24. Brizalina spp.									
25. Bolivina lobata									
26. Reussella spinulosa									
27. Discorbina patelliformis							30		5
28. Rosalina spp.									
29. Spirillina vivipara									
30. Ammonia beccarii	150	115	25	5	30	40	20		10
31. Elphidium aff. advenum	75	26	10	10	20	20	10		
32. E. aff. discoidale									
33. E. crispum									
34. E. reticulosum	15				5	5	35		
35. E. sp.									
36. E. spp.									
37. Eponides murrayi			5		10	5			
38. Eponides repandus									
39. Cibicides sp.									
40. Cymbaloporella tabellaeformis									
41. Cymbaloporetta bradyi			5				5		
42. Acervulina inhaerens									
43. Nonion sp.				5			5		
Totals	610	380	355	280	335	320	460	420	300
Number of species	10	8	12	10	12	11	16	8	12

Sample No. Trip B	38	39	40	41	42	43	44	45	46
Suborder: Textulariina	15		15				5		
1. Ammobaculites sp.									
2. Textularia spp.							5		
3. Bigenerina sp.			5						
4. Eggerella scabra	10		5						
5. Clavulina spp.	5		5						
Suborder: Miliolina	240	300	660	95	20	70	100	60	5
6. Cyclogyra planorbis	5								
7. Spiroloculina spp.	30	50	25	20	5	30	40	10	5
8. Vertebralina striata			20						
9. Quinqueloculina spp.	55	75	200	10	15	35	50	30	
10. Massilina spp.	10	10	5						
11. Pseudomassilina sp.									
12. Miliolinella spp.			10						
13. Triloculina spp.	30	40	200	5		5	10	15	
14. Hauerina diversa			15						
15. Articulina sp.		5	5						
16. Parrina bradyi									
17. Peneroplis planatus	45	50	90	25				5	
18. Peneroplis pertusus	40	15	40	15					
19. Spirolina acicularis									
20. Spirolina arietina	15	55	50	20					
21. Sorites marginalis	10								
Suborder: Rotaliina	80	25	465	35	60	35	45	65	165
22. Nodosaria sp.									
23. Lagena laevis									
24. Brizalina spp.									
25. Bolivina lobata							5		
26. Reussella spinulosa									
27. Discorbina patelliformis			260		5				
28. Rosalina spp.									
29. Spirillina vivipara									
30. Ammonia beccarii	20	10	25	5	10	20	10	50	110
31. Elphidium aff. advenum	10	15		5	15	15	15	10	40
32. E. aff. discoidale									
33. E. crispum									
34. E. reticulosum	40		260	25	5		10	5	5
35. E. sp.									
36. E. spp.									
37. Eponides murrayi	10		20		25		5		10
38. Eponides repandus									
39. Cibicides sp.									
40. Cymbaloporella tabellaeformis									
41. Cymbaloporetta bradyi			20						
42. Acervulina inhaerens									
43. Nonion sp.									
Totals	335	325	1140	130	80	105	150	125	170
Number of species	15	10	19	9	7	5	9	7	5

Sample No. Trip B	47	48	49	50	51	52	53	54	55
Suborder: Textulariina									
1. Ammobaculites sp.									
2. Textularia spp.									
3. Bigenerina sp.									
4. Eggerella scabra									
5. Clavulina spp.									
Suborder: Miliolina	0	25	55	20	25	10	0	125	25
6. Cyclogyra planorbis									
7. Spiroloculina spp.								40	
8. Vertebralina striata									
9. Quinqueloculina spp.		10	30	20	15	10		50	15
10. Massilina spp.									
11. Pseudomassilina sp.									
12. Miliolinella spp.									
13. Triloculina spp.		5	25	-	10			25	
14. Hauerina diversa									
15. Articulina sp.									
16. Parrina bradyi									
17. Peneroplis planatus								5	
18. Peneroplis pertusus								5	
19. Spirolina acicularis									
20. Spirolina arietina		10							10
21. Sorites marginalis									
Suborder: Rotaliina	15	0	50	300	60	45	80	485	105
22. Nodosaria sp.									
23. Lagena laevis									
24. Brizalina spp.									
25. Bolivina lobata									
26. Reussella spinulosa									
27. Discorbina patelliformis				10		5			
28. Rosalina spp.			10						
29. Spirillina vivipara									
30. Ammonia beccarii	5		25	150	30	25	60	150	75
31. Elphidium aff. advenum	10		15	100	5	5	10	125	20
32. E. aff. discoidale								50	
33. E. crispum				10	10	10	5	135	
34. E. reticulosum								15	10
35. E. sp.									
36. E. spp.									
37. Eponides murrayi				30	15		15		
38. Eponides repandus									
39. Cibicides sp.									
40. Cymbaloporella tabellaeformis									
41. Cymbaloporetta bradyi									
42. Acervulina inhaerens									
43. Nonion sp.								10	
Totals	15	25	105	320	85	55	80	610	130
Number of species	2	3	5	6	5	5	4	11	5

Sample No. Trip B	56	57	58	59	60	61	62	63	64
Suborder: Textulariina							5		
1. Ammobaculites sp.									
2. Textularia spp.									
3. Bigenerina sp.									
4. Eggerella scabra									
5. Clavulina spp.							5		
Suborder: Miliolina	145	80	35	50	65	305	145	80	35
6. Cyclogyra planorbis									
7. Spiroloculina spp.	25	10				5	5		
8. Vertebralina striata									
9. Quinqueloculina spp.	70	25	10	35	55	60	40	30	5
10. Massilina spp.									
11. Pseudomassilina spp.									
12. Miliolinella spp.									
13. Triloculina spp.	15	10	15	5		10	5		
14. Hauerina diversa									
15. Articulina sp.									
16. Parrina bradyi									
17. Peneroplis planatus	5	25	5	10	5	200	40	10	20
18. Peneroplis pertusus		5	5		5				5
19. Spirolina acicularis									
20. Spirolina arietina	30	15				25	50	40	
21. Sorites marginalis						5	5		5
Suborder: Rotaliina	340	330	255	240	270	370	110	230	15
22. Nodosaria sp.									
23. Lagena laevis									
24. Brizalina spp.									
25. Bolivina lobata									
26. Reussella spinulosa									
27. Discorbina patelliformis			20	5					
28. Rosalina spp.									
29. Spirillina vivipara									
30. Ammonia beccarii	150	200	150	200	100	150	75	150	5
31. Elphidium aff. advenum	75	25	50		60	75	25	40	
32. E. aff. discoidale	50	55		5	40	50			
33. E. crispum						20	10		
34. E. reticulosum	20	25	10		10				
35. E. sp.	15	15	25	25	55	75		40	
36. E. spp.									
37. Eponides murrayi	30	10			5				5
38. Eponides repandus									
39. Cibicides sp.									
40. Cymbaloporella tabellaeformis									
41. Cymbaloporetta bradyi				5					
42. Acervulina inhaerens									
43. Nonion sp.									5
Totals	485	410	295	290	335	675	260	310	50
Number of species	11	12	9	8	9	11	10	6	7

Sample No. Trip B	65	66	70						
Suborder: Textulariina	5	20	10						
1. Ammobaculites sp.	5	20	10						
2. Textularia spp.									
3. Bagenerina sp.									
4. Eggerella scabra									
5. Clavulina spp.									
Suborder: Miliolina	30	10	10						
6. Cyclogyra planorbis									
7. Spiroloculina spp.									
8. Vertebralina striata									
9. Quinqueloculina spp.	5		10						
10. Massilina spp.									
11. Pseudomassilina sp.									
12. Miliolinella spp.									
13. Triloculina spp.									
14. Hauerina diversa									
15. Articulina sp.									
16. Parrina bradyi									
17. Peneroplis planatus	25	10							
18. Peneroplis pertusus									
19. Spirolina acicularis									
20. Spirolina arietina									
21. Sorites marginalis									
Suborder: Rotaliina	170	190	130						
22. Nodosaria sp.									
23. Lagena laevis									
24. Brizalina spp.									
25. Bolivina lobata									
26. Reussella spinulosa									
27. Discorbina patelliformis									
28. Rosalina spp.									
29. Spirillina vivipara									
30. Ammonia beccarii	75	100	95						
31. Elphidium aff. advenum	10		15						
32. E. aff. discoidale	15		10						
33. E. crispum									
34. E. reticulosum									
35. E. sp.	5	15							
36. E. spp.	65	75	10						
37. Eponides murrayi									
38. Eponides repandus									
39. Cibicides sp.									
40. Cymbaloporella tabellaeformis									
41. Cymbaloporetta bradyi									
42. Acervulina inhaerens									
43. Nonion sp.									
Totals	105	220	150						
Number of species	8	5	6						

Sample No. Trip C	1	2	3	4	6	7	8	9	11
Suborder: Textulariina		15	30	15	20	10	30	10	
1. Ammobaculites sp.									
2. Textularia spp.		15	5	15			5	5	
3. Bigenerina sp.									
4. Eggerella scabra			25		20	10	25	5	
5. Clavulina spp.									
Suborder: Miliolina	60	200	245	275	110	55	235	80	140
6. Cyclogyra planorbis									
7. Spiroloculina spp.	10	40	50	10	50		15		15
8. Vertebralina striata					5		25	10	
9. Quinqueloculina spp.	50	120	100	125	20	40	100	60	70
10. Massilina spp.				55			10		
11. Pseudomassilina sp.									
12. Miliolinella spp.									
13. Triloculina spp.		40	95	75	5	15	50	5	20
14. Hauerina diversa									
15. Articulina sp.									
16. Parrina bradyi									
17. Peneroplis planatus				10	10		25	5	10
18. Peneroplis pertusus					5		5		10
19. Spirolina acicularis									
20. Spirolina arietina					5		5		15
21. Sorites marginalis					10				
Suborder: Rotaliina	290	40	90	15	50	40	225	120	145
22. Nodosaria sp.									
23. Lagena laevis									
24. Brizalina spp.			5		10				15
25. Bolivina lobata									5
26. Reussella spinulosa									
27. Discorbina patelliformis		10			5				
28. Rosalina spp.									20
29. Spirillina vivipara									
30. Ammonia beccarii	150	25	75		10	20	50	10	30
31. Elphidium aff. advenum	40		5		10	15		10	20
32. E. aff. discoidale	15								
33. E. crispum									
34. E. reticulosum	10				5		10	20	5
35. E. sp.	10								
36. E. spp.									
37. Eponides murrayi	15	5			10		50	25	35
38. Eponides repandus									
39. Cibicides sp.				10			40		
40. Cymbaloporella tabellaeformis									
41. Cymbaloporetta bradyi				5			25	25	15
42. Acervulina inhaerens					5		50	30	
43. Nonion sp.	5		5						
Totals	350	225	365	365	180	105	490	210	285
Number of species	9	7	9	8	15	6	16	12	14

Sample No. Trip C	12	13	14	15	16	17	18	19	20
Suborder: Textulariina			5	15	5		6	25	
1. Ammobaculites sp.									
2. Textularia spp.			5						
3. Bigenerina sp.								10	
4. Eggerella scabra				15	5		5	25	
5. Clavulina spp.									
Suborder: Miliolina	55	190	435	145	250	250	100	125	120
6. Cyclogyra planorbis									
7. Spiroloculina spp.		5	25	5	10	55	25	25	10
8. Vertebralina striata		5	20	25	5	5			
9. Quinqueloculina spp.	40	100	250	50	140	75	75	70	50
10. Massilina spp.			10					5	
11. Pseudomassilina sp.									
12. Miliolinella spp.			15			15			5
13. Triloculina spp.	15	55	20	30	10	45		5	40
14. Hauerina diversa								5	
15. Articulina sp.								5	
16. Parrina bradyi			10					5	5
17. Peneroplis planatus		15	10	20	25	40			5
18. Peneroplis pertusus		10	5			5			
19. Spirolina acicularis									
20. Spirolina arietina			10	10	60	10		5	5
21. Sorites marginalis				5					
Suborder: Rotaliina	15	15	120	70	170	110	240	45	75
22. Nodosaria sp.									
23. Lagena laevis									
24. Brizalina spp.									
25. Bolivina lobata									
26. Reussella spinulosa									
27. Discorbina patelliformis				20					
28. Rosalina spp.		5		5		5			10
29. Spirillina vivipara			5						
30. Ammonia beccarii		5	25	25	100	55	200		
31. Elphidium aff. advenum		5	20		60	50	15		
32. E. aff. discoidale									
33. E. crispum	15		5						
34. E. reticulosum			25	15	10		15		
35. E. sp.									
36. E. spp.									
37. Eponides murrayi			40				10	20	50
38. Eponides repandus									
39. Cibicides sp.									5
40. Cymbaloporella tabellaeformis									
41. Cymbaloporetta bradyi				5				25	
42. Acervulina inhaerens									
43. Nonion sp.									10
Totals	70	205	560	230	425	360	345	195	195
Number of species	3	9	17	13	10	11	7	12	11

Sample No. Trip C	22	23	24	26	27	28	29	30	31
Suborder: Textulariina	5	85	10	30	35	10	25	40	120
1. Ammobaculites sp.									
2. Textularia spp.	5	80	10	30	35	10	25	15	55
3. Bigenerina sp.									5
4. Eggerella scabra		5						25	60
5. Clavulina spp.									
Suborder: Miliolina	135	215	125	85	95	70	155	155	200
6. Cyclogyra planorbis									
7. Spiroloculina spp.		65	10			15	30	50	60
8. Vertebralina striata		5	15						
9. Quinqueloculina spp.	50	70	35	20	50	10	50	50	30
10. Massilina spp.		5							
11. Pseudomassilina sp.		30				5			
12. Miliolinella spp.	20		5		5				
13. Triloculina spp.		20	5	40	40	30	60	45	70
14. Hauerina diversa		10	10	5					
15. Articulina sp.				5					
16. Parrina bradyi	25	10	5						
17. Peneroplis planatus	25		25	5					
18. Peneroplis pertusus	15		15	5					
19. Spirolina acicularis									
20. Spirolina arietina						10	15	10	40
21. Sorites marginalis				5					
Suborder: Rotaliina	70	35	55	10	20	35	25	95	75
22. Nodosaria sp.		5							
23. Lagena laevis									
24. Brizalina spp.								5	
25. Bolivina lobata							5	5	
26. Reussella spinulosa									
27. Discorbina patelliformis						15		75	
28. Rosalina spp.	50	10	15	5					
29. Spirillina vivipara									
30. Ammonia beccarii									
31. Elphidium aff. advenum								10	
32. E. aff. discoidale									
33. E. crispum									
34. E. reticulosum									
35. E. sp.									
36. E. spp.									
37. Eponides murrayi		10			5	10			
38. Eponides repandus			5						
39. Cibicides sp.			10						
40. Cymbaloporella tabellaeformis									
41. Cymbaloporetta bradyi	20	10	25		10	10			
42. Acervulina inhaerens									
43. Nonion sp.				5	5		20		75
Totals	210	335	190	125	150	115	205	290	395
Number of species	8	14	14	10	7	9	7	10	8

Sample No. Trip C	32	33	34	35	36	37	38	39	40
Suborder: Textulariina	10	230	170	80	280	60	125	75	275
1. Ammobaculites sp.									
2. Textularia spp.	10	30	10	5	30	5	25	25	25
3. Bigenerina sp.									
4. Eggerella scabra		200	160	75	250	55	100	50	250
5. Clavulina spp.									
Suborder: Miliolina	115	160	275	35	285	105	105	220	200
6. Cyclogyra planorbis									
7. Spiroloculina spp.	40	50	50		50	10	20	15	25
8. Vertebralina striata									
9. Quinqueloculina spp.	50	75	100	20	100	60	55	30	55
10. Massilina spp.			5		5		5	5	5
11. Pseudomassilina sp.					5		5	5	
12. Miliolinella spp.								5	
13. Triloculina spp.	25	20	100	15	100	30	20	40	55
14. Hauerina diversa									
15. Articulina sp.			5		5				5
16. Parrina bradyi		5	5		5				5
17. Peneroplis planatus			5		5	5		10	10
18. Peneroplis pertusus			5					5	5
19. Spirolina acicularis									
20. Spirolina arietina		10			5			100	30
21. Sorites marginalis					5			5	5
Suborder: Rotaliina	60	40	5	0	25	10	10	5	30
22. Nodosaria sp.									
23. Lagena laevis									
24. Brizalina spp.									
25. Bolivina lobata									
26. Reussella spinulosa									
27. Discorbina patelliformis								5	
28. Rosalina spp.									
29. Spirillina vivipara									
30. Ammonia beccarii	10	10							
31. Elphidium aff. advenum									
32. E. aff. discoidale									
33. E. crispum									
34. E. reticulosum									
35. E. sp.									
36. E. spp.		10							
37. Eponides murrayi					25				30
38. Eponides repandus									
39. Cibicides sp.		10	5						
40. Cymbaloporella tabellaeformis									
41. Cymbaloporetta bradyi									
42. Acervulina inhaerens									
43. Nonion sp.	50	10				10	10		
Totals	185	430	450	115	590	175	240	300	505
Number of species	6	11	11	4	13	7	8	13	13

Sample No. Trip C	41	42							
Suborder: Textulariina	150	10							
1. Ammobaculites sp.									
2. Textularia spp.	75								
3. Bigenerina sp.									
4. Eggerella scabra	75	10							
5. Clavulina spp.									
Suborder: Miliolina	155	105							
6. Cyclogyra planorbis									
7. Spiroloculina spp.	20	10							
8. Vertebralina striata									
9. Quinqueloculina spp.	25	25							
10. Massilina spp.									
11. Pseudomassilina sp.									
12. Miliolinella spp.									
13. Triloculina spp.	35	10							
14. Hauerina diversa									
15. Articulina sp.									
16. Parrina bradyi									
17. Peneroplis planatus	10	15							
18. Peneroplis pertusus	5	5							
19. Spirolina acicularis									
20. Spirolina arietina	55	40							
21. Sorites marginalis	5								
Suborder: Rotaliina	30	10							
22. Nodosaria sp.									
23. Lagena laevis									
24. Brizalina spp.									
25. Bolivina lobata									
26. Brussella spinulosa									
27. Discorbina patelliformis									
28. Rosalina spp.									
29. Spirillina vivipara									
30. Ammonia beccarii									
31. Elphidium aff. advenum									
32. E. aff. discoidale									
33. E. crispum									
34. E. reticulosum									
35. E. sp.									
36. E. spp.									
37. Eponides murrayi	30	10							
38. Eponides repandus									
39. Cibicides sp.									
40. Cymbaloporella tabellaeformis									
41. Cymbaloporetta bradyi									
42. Acervulina inhaerens									
43. Nonion sp.									
Totals	335	125							
Number of species	11	8							

APPENDIX 3

Showing the number of specimens of the DEAD population of each taxon for each sample

Sample No. Trip A	1	2	3	4	5	6	7	8	9
Suborder: Textulariina	10	50	75	5	5	5	20	0	0
1. Ammobaculites sp.									
2. Textularia spp.									
3. Bigenerina sp.									
4. Eggerella scabra									
5. Clavulina spp.	10	50	75	5	5	5	20	0	0
Suborder: Miliolina	590	800	825	820	755	455	625	790	946
6. Cyclogyra planorbis									
7. Spiroloculina spp.	20	10	5	10		45	25	10	10
8. Vertebralina striata						5	15		
9. Quinqueloculina spp.	250	250	250	250	250	250	250	250	250
10. Massilina spp.			15		15				
11. Pseudomassilina sp.									
12. Miliolinella spp.	5				25				
13. Triloculina spp.	60	15	25	25	25		45	10	250
14. Hauerina diversa									
15. Articulina sp.									
16. Parrina bradyi	35	5	5	10	15	5	10	10	10
17. Peneroplis planatus	200	250	250	250	175	150	150	250	140
18. Peneroplis pertusus	5	15	25	25			30		30
19. Spirolina acicularis	10								
20. Spirolina arietina	5	250	250	250	250		100	250	250
21. Sorites marginalis		5						10	
Suborder: Rotaliina	850	625	530	515	575	755	310	500	515
22. Nodosaria sp.									
23. Lagena laevis									
24. Brizalina spp.						5			
25. Bolivina lobata									
26. Reussella spinulosa									
27. Discorbina patelliformis									
28. Rosalina spp.									
29. Spirillina vivipara									
30. Ammonia beccarii	250	250	250	250	250	250	150	250	250
31. Elphidium aff. advenum	250	250	250	250	250	250	85	250	250
32. E. aff. discoidale	50	30	5	15	25				
33. E. crispum									
34. E. reticulosum	250	45	25		50	250	50		15
35. E. sp.	30	45							
36. E. spp.	20								
37. Eponides murrayi							25		
38. Eponides repandus									
39. Cibicides sp.									
40. Cymbaloporella tabellaeformis									
41. Cymbaloporetta bradyi		5							
42. Acervulina inhaerens									
43. Nonion sp.									
Totals	1450	1475	1430	1340	1335	1215	955	1290	1455
Number of species	16	15	13	11	12	10	13	9	10

Sample No. Trip B	1	2	3	4	5	6	7	8	9
Suborder: Textulariina	30	45	5	5	35	60	20	0	20
1. Ammobaculites sp.									
2. Textularia spp.	30	45			15				5
3. Bigenerina sp.									
4. Eggerella scabra			5	5	10	50	5		5
5. Clavulina spp.					10	10	15		10
Suborder: Miliolina	935	585	840	825	680	485	885	1120	500
6. Cyclogyra planorbis									
7. Spiroloculina spp.	110	110	110	75	105	5	165	75	45
8. Vertebralina striata			25	30	15	5	15	10	25
9. Quinqueloculina spp.	250	165	250	250	250	250	250	250	250
10. Massilina spp.				15	20	5	50		15
11. Pseudomassilina sp.	5		15						
12. Miliolinella spp.			50	30	10			15	5
13. Triloculina spp.	260	260	55		55	205	250	250	40
14. Hauerina diversa			15	30					10
15. Articulina sp.			10	20					5
16. Parrina bradyi	10	10	45	45	20		10	15	5
17. Peneroplis planatus	160	20	100	200	40		120	250	40
18. Peneroplis pertusus	10		30	55					
19. Spirolina acicularis						15	20	250	50
20. Spirolina arietina	250	80	125	60	165				
21. Sorites marginalis			10	15			5	5	10
Suborder: Rotaliina	65	60	320	345	60	0	680	1025	690
22. Nodosaria sp.									
23. Lagena laevis									
24. Brizalina spp.				5					5
25. Bolivina lobata				5					
26. Reussella spinulosa				5			5	5	5
27. Discorbina patelliformis			50	30	5		25	55	50
28. Rosalina spp.			50		5			15	15
29. Spirillina vivipara									
30. Ammonia beccarii	35	30		5	5		135	250	250
31. Elphidium aff. advenum	25	10		15	10		250	250	250
32. E. aff. discoidale							90	210	
33. E. crispum							25	15	
34. E. reticulosum			40	150	10		50	90	
35. E. sp.				5					
36. E. spp.								60	
37. Eponides murrayi			125		10		55	55	90
38. Eponides repandus									
39. Cibicides sp.			50	35	5				15
40. Cymbaloporella tabellaeformis				5					
41. Cymbaloporetta bradyi	5	10		50	5		35	15	
42. Acervulina inhaerens		10	5	25	5		10	5	
43. Nonion sp.				10					10
Totals	1030	690	1165	1175	775	545	1585	2145	1210
Number of species	12	11	20	26	21	8	21	21	24

Sample No. Trip B	10	11	12	13	14	15	16	17	18
Suborder: Textulariina	0	0	5	0	0	0	5	10	5
1. Ammobaculites sp.									
2. Textularia spp.			5						
3. Bigenerina sp.									
4. Eggerella scabra									
5. Clavulina spp.							5	10	5
Suborder: Miliolina	420	500	550	385	470	360	475	690	720
6. Cyclogyra planorbis								5	
7. Spiroloculina spp.	20	250	250	90	200	90	25	80	10
8. Vertebralina striata					20	10	15	10	
9. Quinqueloculina spp.	250	250	250	250	250	250	250	250	250
10. Massilina spp.	15		35					10	10
11. Pseudomassilina sp.									
12. Miliolinella spp.								20	10
13. Triloculina spp.	80		15				110	55	20
14. Hauerina diversa									
15. Articulina sp.				25					
16. Parrina bradyi	15			5		5	5	10	5
17. Peneroplis planatus	15			10		5	50	110	220
18. Peneroplis pertusus				5			15	30	40
19. Spirolina acicularis	25								5
20. Spirolina arietina							5	100	150
21. Sorites marginalis								10	
Suborder: Rotaliina	200	1035	270	995	910	860	640	505	675
22. Nodosaria sp.									
23. Lagena laevis									
24. Brizalina spp.		10		5		5		5	
25. Bolivina lobata									
26. Reussella spinulosa		5							
27. Discorbina patelliformis	5	65	5	25	25	40		15	
28. Rosalina spp.									
29. Spirillina vivipara									
30. Ammonia beccarii	50	250	250	250	250	250	250	220	250
31. Elphidium aff. advenum		250	15	250	250	250	250	200	250
32. E. aff. discoidale	100			250	250	50	45		25
33. E. crispum									
34. E. reticulosum	20	130		65	25	45	20	20	90
35. E. sp.				60	30	40	25		25
36. E. spp.									
37. Eponides murrayi	25	250		90	80	135	20	30	
38. Eponides repandus									
39. Cibicides sp.									
40. Cymbaloporella tabellaeformis									
41. Cymbaloporetta bradyi		10					15	5	10
42. Acervulina inhaerens									
43. Nonion sp.		65				45	15	10	25
Totals	620	1535	825	1380	1380	1220	1120	1205	1400
Number of species	12	11	8	14	16	14	17	21	18

Sample No. Trip B	19	20	21	22	23	24	25	26	27
Suborder: Textulariina	35	5	0	0	0	0	0	0	0
1. Ammobaculites sp.									
2. Textularia spp.	10								
3. Bigenerina sp.									
4. Eggerella scabra									
5. Clavulina spp.	25	5							
Suborder: Miliolina	725	920	905	945	680	680	535	525	555
6. Cyclogyra planorbis									
7. Spiroloculina spp.	170	15	10	160	50	20	5	5	5
8. Vertebralina striata	40	5		25	30				
9. Quinqueloculina spp.	250	250	250	250	250	250	250	250	250
10. Massilina spp.	30								
11. Pseudomassilina sp.									
12. Miliolinella spp.									
13. Triloculina spp.	30	30	25	200	115	100			
14. Hauerina diversa	5								
15. Articulina sp.									
16. Parrina bradyi	20	5	30						
17. Peneroplis planatus	75	250	250	110	100	55			45
18. Peneroplis pertusus	45	115	90	30	25	20	30	20	5
19. Spirolina acicularis						5			
20. Spirolina arietina	60	250	250	150	100	225	250	250	250
21. Sorites marginalis				20	10	5			
Suborder: Rotaliina	95	125	310	795	605	645	470	610	530
22. Nodosaria sp.									
23. Lagena laevis									
24. Brizalina spp.									
25. Bolivina lobata									
26. Reussella spinulosa									
27. Discorbina patelliformis				35	20	25			
28. Rosalina spp.									
29. Spirillina vivipara									
30. Ammonia beccarii	5	20	120	250	250	250	250	250	250
31. Elphidium aff. advenum	10	100	180	250	250	250	150	250	250
32. E. aff. discoidale						20		30	
33. E. crispum	5								
34. E. reticulosum	25				35	30	25		
35. E. sp.						15	35	70	20
36. E. spp.									
37. Eponides murrayi	30		5	210	35	40			
38. Eponides repandus									
39. Cibicides sp.				10					
40. Cymbaloporella tabellaeformis									
41. Cymbaloporetta bradyi	5	5	5	40	15	15	10	10	10
42. Acervulina inhaerens									
43. Nonion sp.	15								
Totals	855	1050	1215	1740	1285	1325	1005	1135	1085
Number of species	19	12	9	14	14	16	9	9	9

Sample No. Trip B	28	29	30	31	32	33	34	35	36
Suborder: Textulariina	0	0	5	20	5	15	45	5	5
1. Ammobaculites sp.									
2. Textularia spp.			5	10	5		10		5
3. Bigenerina sp.						10	15		
4. Eggerella scabra							10		
5. Clavulina spp.				10		5	10		
Suborder: Miliolina	715	680	980	865	1185	1245	1130	1195	1075
6. Cyclogyra planorbis									
7. Spiroloculina spp.	15	90	250	165	250	250	295	250	250
8. Vertebralina striata	5	25	15	15	40	30	50	40	15
9. Quinqueloculina spp.	250	250	250	250	250	250	250	250	200
10. Massilina spp.					20			45	45
11. Pseudomassilina sp.			5						
12. Miliolinella spp.									
13. Triloculina spp.	110	70	250	250	205	225	250	200	150
14. Hauerina diversa									
15. Articulina sp.			5	10			20		15
16. Parrina bradyi	20		20	20	20	20	15	30	25
17. Peneroplis planatus	70	90	50	90	100	200	70	75	100
18. Peneroplis pertusus	30	5	40	25	100	140	50	50	75
19. Spirolina acicularis			5	15		5		5	
20. Spirolina arietina	200	150	90	25	200	105	200	250	200
21. Sorites marginalis	15					20			
Suborder: Rotaliina	590	460	410	375	495	635	265	180	125
22. Nodosaria sp.									
23. Lagena laevis									
24. Brizalina spp.			5						
25. Bolivina lobata									
26. Reussella spinulosa			5						
27. Discorbina patelliformis			50		15	20	50	25	15
28. Rosalina spp.									
29. Spirillina vivipara							5		
30. Ammonia beccarii	250	250	150	225	200	250	60	45	60
31. Elphidium aff. advenum	250	150	90	60	130	250	50	25	10
32. E. aff. discoidale									
33. E. crispum		55		10		15			
34. E. reticulosum	50		5	15	25	25	15	25	10
35. E. sp.						5			
36. E. spp.									
37. Eponides murrayi			65	50	125	50	35	50	30
38. Eponides repandus									
39. Cibicides sp.									
40. Cymbaloporella tabellaeformis									
41. Cymbaloporetta bradyi	35	5	15			15	20	10	
42. Acervulina inhaerens	5		5			5			
43. Nonion sp.			20	15			30		
Totals	1305	1140	1395	1260	1685	1895	1440	1380	1205
Number of species	14	11	22	18	15	21	21	16	16

Sample No. Trip B	38	39	40	41	42	43	44	45	46
Suborder: Textulariina	35	5	0	25	5	0	125	25	10
1. Ammobaculites sp.									
2. Textularia spp.	10	5		15			25	10	
3. Bigenerina sp.									
4. Eggerella scabra	15						100	10	10
5. Clavulina spp.	10			10	5			5	
Suborder: Miliolina	1295	1160	450	1120	550	675	755	970	710
6. Cyclogyra planorbis									
7. Spiroloculina spp.	250	250	55	200	250	250	250	250	250
8. Vertebralina striata	25	5	20	20			5		10
9. Quinqueloculina spp.	250	250	150	250	250	250	250	250	250
10. Massilina spp.	50	35	15						
11. Pseudomassilina sp.									
12. Miliolinella spp.			20						
13. Triloculina spp.	150	200	65	180		150	200	200	200
14. Hauerina diversa			5						
15. Articulina sp.	10	10							
16. Parrina bradyi	5			15					
17. Peneroplis planatus	250	150	55	200	40		10	40	
18. Peneroplis pertusus	200	50	30	115			5		
19. Spirolina acicularis									
20. Spirolina arietina	100	200	35	125	10	25	35	225	
21. Sorites marginalis	5	10		15				5	
Suborder: Rotaliina	280	135	25	325	850	560	595	550	700
22. Nodosaria sp.									
23. Lagena laevis									
24. Brizalina spp.									
25. Bolivina lobata							10		15
26. Reussella spinulosa							25	5	
27. Discorbina patelliformis	25	5			100		20		20
28. Rosalina spp.									
29. Spirillina vivipara									
30. Ammonia beccarii	50	60	5	75	200	250	200	250	250
31. Elphidium aff. advenum	105	60	20	125	250	250	250	175	250
32. E. aff. discoidale									
33. E. crispum									
34. E. reticulosum	40			75	50	30	40	20	50
35. E. sp.									
36. E. spp.									
37. Eponides murrayi	50	10		50	250	30	50	100	110
38. Eponides repandus									
39. Cibicides sp.									
40. Cymbaloporella tabellaeformis									
41. Cymbaloporetta bradyi	10								5
42. Acervulina inhaerens									
43. Nonion sp.									
Totals	1610	1360	475	1470	1405	1235	1475	1545	1420
Number of species	20	15	12	15	10	8	16	14	12

Sample No. Trip B	47	48	49	50	51	52	53	54	55
Suborder: Textulariina	0	10	0	5	5	5	0	5	0
1. Ammobaculites sp.									
2. Textularia spp.									
3. Bigenerina sp.					5	5			
4. Eggerella scabra								5	
5. Clavulina spp.		10		5					
Suborder: Miliolina	750	690	535	625	625	525	520	835	770
6. Cyclogyra planorbis									
7. Spiroloculina spp.	250	30	10	60	90	50	65	250	90
8. Vertebralina striata					5	25	5	5	
9. Quinqueloculina spp.	250	250	250	250	250	250	250	250	250
10. Massilina spp.				5				10	
11. Pseudomassilina sp.									
12. Miliolinella spp.									
13. Triloculina spp.	250	200	250	250	250	200	100	250	150
14. Hauerina diversa									
15. Articulina sp.									
16. Parrina bradyi				5	30			5	5
17. Peneroplis planatus		10						40	
18. Peneroplis pertusus								5	25
19. Spirolina acicularis			25	10					
20. Spirolina arietina		200		45				20	250
21. Sorites marginalis									
Suborder: Rotaliina	240	95	230	885	855	875	870	1010	395
22. Nodosaria sp.									
23. Lagena laevis									
24. Brizalina spp.					5	5			
25. Bolivina lobata									
26. Reussella spinulosa									
27. Discorbina patelliformis				10	50	75	50		
28. Rosalina spp.			5						
29. Spirillina vivipara									
30. Ammonia beccarii	150	90	150	250	250	250	250	250	200
31. Elphidium aff. advenum	75		35	250	200	225	200	250	120
32. E. aff. discoidale								180	20
33. E. crispum		5							
34. E. reticulosum			15	120	100	65	90	250	10
35. E. sp.							15	50	40
36. E. spp.									
37. Eponides murrayi	15		25	250	250	250	250		5
38. Eponides repandus									
39. Cibicides sp.									
40. Cymbaloporella tabellaeformis									
41. Cymbaloporetta bradyi									
42. Acervulina inhaerens									
43. Nonion sp.				5		5	15	30	
Totals	990	795	765	1515	1485	1405	1290	1850	1165
Number of species	6	8	9	13	12	12	10	16	12

Sample No. Trip B	56	57	58	59	60	61	62	63	64
Suborder: Textulariina	0	5	0	0	0	0	15	0	25
1. Ammobaculites sp.									
2. Textularia spp.									
3. Bigenerina sp.									
4. Eggerella scabra									25
5. Clavulina spp.		5					15		
Suborder: Miliolina	550	545	510	645	725	710	800	490	930
6. Cyclogyra planorbis									
7. Spiroloculina spp.	75	50	15	15	100	20	50		250
8. Vertebralina striata	5		5		20	5			30
9. Quinqueloculina spp.	250	250	250	250	250	250	250	250	250
10. Massilina spp.									
11. Pseudomassilina sp.									
12. Miliolinella spp.									
13. Triloculina spp.	45	100	150	150	100	55	40	5	250
14. Hauerina diversa									
15. Articulina sp.									
16. Parrina bradyi	10		5		10	15	10		
17. Peneroplis planatus	90	90	60	170	90	250	175		75
18. Peneroplis pertusus		35	25	45			10	35	40
19. Spirolina acicularis									
20. Spirolina arietina	75	20			150	100	250	200	15
21. Sorites marginalis				15	5	15	15		20
Suborder: Rotaliina	1130	805	670	740	1125	1045	625	440	875
22. Nodosaria sp.									
23. Lagena laevis									
24. Brizalina spp.	10				5				10
25. Bolivina lobata									
26. Reussella spinulosa									25
27. Discorbina patelliformis	46	10	30	10	5			5	50
28. Rosalina spp.									
29. Spirillina vivipara									
30. Ammonia beccarii	250	250	250	250	250	250	250	250	250
31. Elphidium aff. advenum	200	150	15	100	250	250	250	150	250
32. E. aff. discoidale	250	250	200	105	250	250	15	10	
33. E. crispum						100	50		
34. E. reticulosum	160	40	25	50	75	20	10	20	
35. E. sp.	65	75	150	200	250	175	20		
36. E. spp.									
37. Eponides murrayi	135	5			40		20	5	230
38. Eponides repandus									
39. Cibicides sp.									
40. Cymbaloporella tabellaeformis									
41. Cymbaloporetta bradyi				25			10		10
42. Acervulina inhaerens									
43. Nonion sp.	20	25							30
Totals	1680	1355	1180	1385	1850	1755	1440	930	1830
Number of species	16	15	13	13	16	14	17	10	17

Sample No. Trip B	65	66	70						
Suborder: Textulariina	30	55	10						
1. Ammobaculites sp.	25	50	10						
2. Textularia spp.									
3. Bigenerina sp.									
4. Eggerella scabra									
5. Clavulina spp.	5	5							
Suborder: Miliolina	505	505	430						
6. Cyclogyra planorbis									
7. Spiroloculina spp.			60						
8. Vertebralina striata	5	5							
9. Quinqueloculina spp.	250	250	250						
10. Massilina spp.									
11. Pseudomassilina sp.									
12. Miliolinella spp.									
13. Triloculina spp.			100						
14. Hauerina diversa									
15. Articulina sp.									
16. Parrina bradyi									
17. Peneroplis planatus	250	250							
18. Peneroplis pertusus			20						
19. Spirolina acicularis									
20. Spirolina arietina									
21. Sorites marginalis									
Suborder: Rotaliina	1150	1125	1050						
22. Nodosaria sp.									
23. Lagena laevis									
24. Brizalina spp.									
25. Bolivina lobata									
26. Reussella spinulosa									
27. Discorbina patelliformis									
28. Rosalina spp.									
29. Spirillina vivipara									
30. Ammonia beccarii	250	250	250						
31. Elphidium aff. advenum	150	175	250						
32. E. aff. discoidale	250	250	250						
33. E. crispum									
34. E. reticulosum									
35. E. sp.	250	200	50						
36. E. spp.	250	250	250						
37. Eponides murrayi									
38. Eponides repandus									
39. Cibicides sp.									
40. Cymbaloporella tabellaeformis									
41. Cymbaloporetta bradyi									
42. Acervulina inhaerens									
43. Nonion sp.									
Totals	1685	1685	1490						
Number of species	10	10	10						

Sample No. Trip C	1	2	3	4	6	7	8	9	11
Suborder: Textulariina	0	30	40	20	5	70	45	46	15
1. Ammobaculites sp.									
2. Textularia spp.		30	30	15		65	35	25	15
3. Bigenerina sp.									
4. Eggerella scabra			10				10	15	
5. Clavulina spp.				5	5	5			
Suborder: Miliolina	405	730	635	605	720	880	870	460	500
6. Cyclogyra planorbis							5		
7. Spiroloculina spp.	155	225	115	5	250	250	35	20	25
8. Vertebralina striata		5			40	25	65	10	10
9. Quinqueloculina spp.	250	250	250	250	250	250	250	250	250
10. Massilina spp.			10	100	15		40	5	
11. Pseudomassilina sp.									
12. Miliolinella spp.			10						
13. Triloculina spp.		250	250	250	25	150	250	105	70
14. Hauerina diversa							15	5	5
15. Articulina sp.							10	10	10
16. Parrina bradyi							15	15	10
17. Peneroplis planatus					75	105	120	40	55
18. Peneroplis pertusus					30	100	50		20
19. Spirolina acicularis									
20. Spirolina arietina					30				40
21. Sorites marginalis					5		15		5
Suborder: Rotaliina	1110	475	400	10	1150	440	1355	1085	610
22. Nodosaria sp.									
23. Lagena laevis									
24. Brizalina spp.	20				30		25	30	5
25. Bolivina lobata							15	15	
26. Reussella spinulosa							15		5
27. Discorbina patelliformis	40	15			100		25	20	5
28. Rosalina spp.							25	50	40
29. Spirillina vivipara									5
30. Ammonia beccarii	250	250	250		250	250	250	250	200
31. Elphidium aff. advenum	250	90	80		250		50	150	100
32. E. aff. discoidale	250								
33. E. crispum						150	50		25
34. E. reticulosum	110	50	15		250		50	110	80
35. E. sp.	40								
36. E. spp.									
37. Eponides murrayi	130	60	50		250		200	250	100
38. Eponides repandus									
39. Cibicides sp.							200		
40. Cymbaloporella tabellaeformis									
41. Cymbaloporetta bradyi		10	5	10	20		200	100	30
42. Acervulina inhaerens						40	250	110	15
43. Nonion sp.	20								
Totals	1515	1235	1075	635	1875	1390	2270	1585	1125
Number of species	11	11	12	7	17	11	27	21	24

Sample No. Trip C	12	13	14	15	16	17	18	19	20
Suborder: Textulariina	30	10	10	0	10	25	15	60	10
1. Ammobaculites sp.									
2. Textularia spp.	5	5	10		10	25			5
3. Bigenerina sp.								40	
4. Eggerella scabra							15	5	5
5. Clavulina spp.	25	5						15	
Suborder: Miliolina	275	610	840	720	735	1125	515	625	690
6. Cyclogyra planorbis				5			5		
7. Spiroloculina spp.	10	15	100	25	50	250	150	240	50
8. Vertebralina striata	5	55	55	80	5	25	20		40
9. Quinqueloculina spp.	200	250	250	250	250	250	250	250	200
10. Massilina spp.		15			5	20	20	50	
11. Pseudomassilina sp.		5						5	
12. Miliolinella spp.				40		35			
13. Triloculina spp.	40	135	200	125	40	250	60	50	250
14. Hauerina diversa		5	10					15	
15. Articulina sp.			5						10
16. Parrina bradyi	5		30	15	10			10	30
17. Peneroplis planatus	5	80	110	110	105	200	10	5	75
18. Peneroplis pertusus		25	15	15	20	25			10
19. Spirolina acicularis									
20. Spirolina arietina	10	25	65	40	250	80			20
21. Sorites marginalis				15					5
Suborder: Rotaliina	45	140	810	795	620	700	1465	260	610
22. Nodosaria sp.									
23. Lagena laevis									
24. Brizalina spp.			5	35	5		15		30
25. Bolivina lobata									30
26. Reussella spinulosa						5			
27. Discorbina patelliformis			5	120		30	100		
28. Rosalina spp.		10	10	25	25	25			100
29. Spirillina vivipara									
30. Ammonia beccarii	20	25	250	170	250	250	250	5	5
31. Elphidium aff. advenum			60	250	250	250	260		
32. E. aff. discoidale							250		
33. E. crispum	20	30	50					25	
34. E. reticulosum		25	125	75	40	75	250		40
35. E. sp.							100		
36. E. spp.									
37. Eponides murrayi		30	250	80		50	250	120	250
38. Eponides repandus									
39. Cibicides sp.			10	15	10			25	40
40. Cymbaloporella tabellaeformis	5		15						
41. Cymbaloporetta bradyi		20	25	25		10		70	60
42. Acervulina inhaerens			5			5		15	40
43. Nonion sp.									15
Totals	350	760	1660	1515	1365	1850	1995	945	1310
Number of species	12	18	23	20	16	19	16	17	22

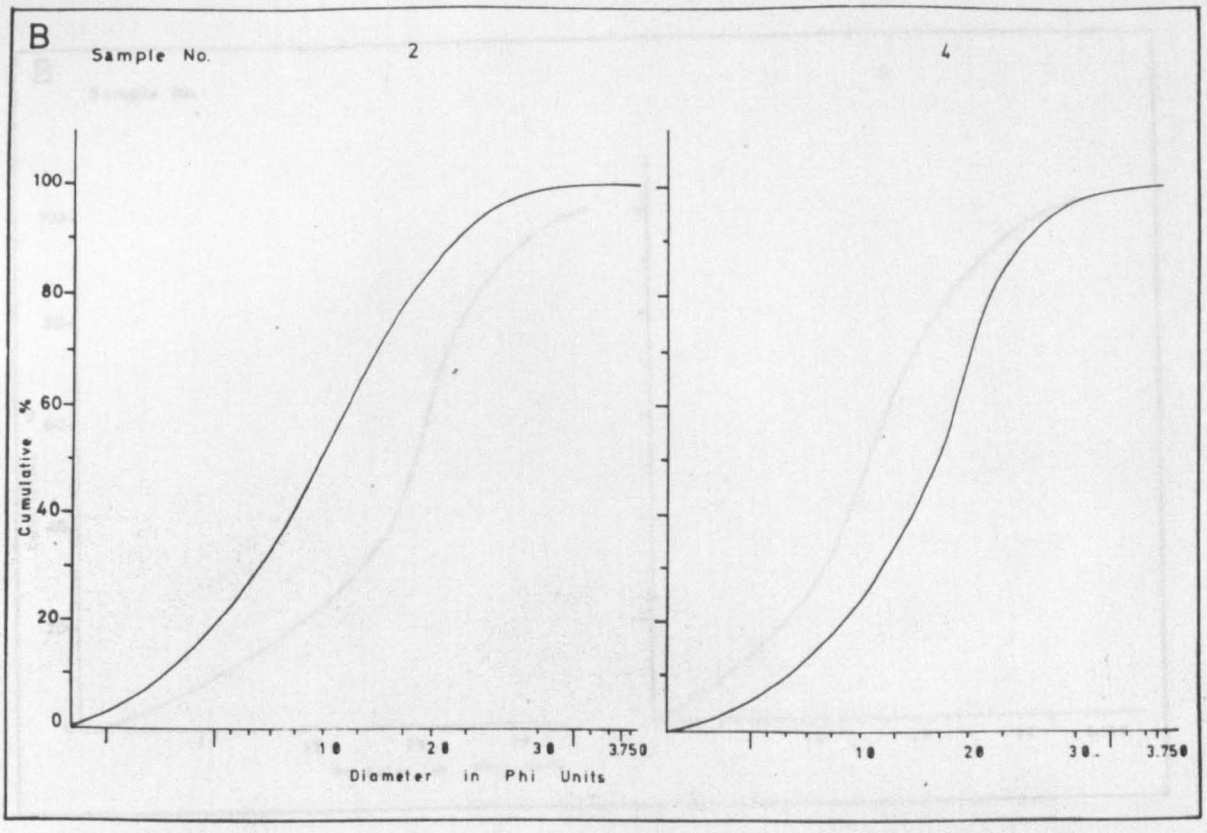
Sample No. Trip C	22	23	24	26	27	28	29	30	31
Suborder: Textulariina	20	95	45	115	155	40	110	110	265
1. Ammobaculites sp.									
2. Textularia spp.	20	80	40	115	155	40	110	60	225
3. Bigenerina sp.									5
4. Eggerella scabra		15	5					50	35
5. Clavulina spp.									
Suborder: Miliolina	135	505	320	405	610	410	575	780	780
6. Cyclogyra planorbis									
7. Spiroloculina spp.	5	60	25	10	30	55	100	250	250
8. Vertebralina striata	5	10	10	5	15				
9. Quinqueloculina spp.	25	200	80	100	225	80	100	200	115
10. Massilina spp.		25	10		5				
11. Pseudomassilina sp.		25		5	5	10	5	5	10
12. Miliolinella spp.		35	10	30	25	25	15		
13. Triloculina spp.	25	70	35	105	200	150	250	150	250
14. Hauerina diversa	10		10	25	5	15			
15. Articulina sp.		40		25	5	15	15	20	10
16. Parrina bradyi	5	15	15	5	25	10			
17. Peneroplis planatus	50	20	90	60	45	15	5	5	
18. Peneroplis pertusus	10		30	25		15	5		20
19. Spirolina acicularis									
20. Spirolina arietina		5	5	10	25	20	80	150	125
21. Sorites marginalis									
Suborder: Rotaliina	40	250	45	175	340	215	275	490	205
22. Nodosaria sp.		15				5	5		5
23. Lagena laevis									5
24. Brizalina spp.					10	10	30	40	5
25. Bolivina lobata				5			35	40	10
26. Reussella spinulosa		10			5	10	40	90	5
27. Discorbina patelliformis				5		40		125	
28. Rosalina spp.		40	5	20	30	40	25		
29. Spirillina vivipara									
30. Ammonia beccarii	15		10	25	20		10	15	15
31. Elphidium aff. advenum								200	
32. E. aff. discoidale									
33. E. crispum	5	20	5		15				
34. E. reticulosum		15			25				
35. E. sp.									
36. E. spp.									
37. Eponides murrayi	5	55		50	90	50	40	30	
38. Eponides repandus			5						
39. Cibicides sp.	5	15		5	15				
40. Cymbaloporella tabellaeformis					15				
41. Cymbaloporetta bradyi		55	5	30	75	60	20	20	10
42. Acervulina inhaerens	10	5	5	15	15		30		
43. Nonion sp.		20	10	20	25		40		150
Totals	195	850	410	695	1105	665	960	1380	1250
Number of species	14	23	20	22	25	19	20	17	18

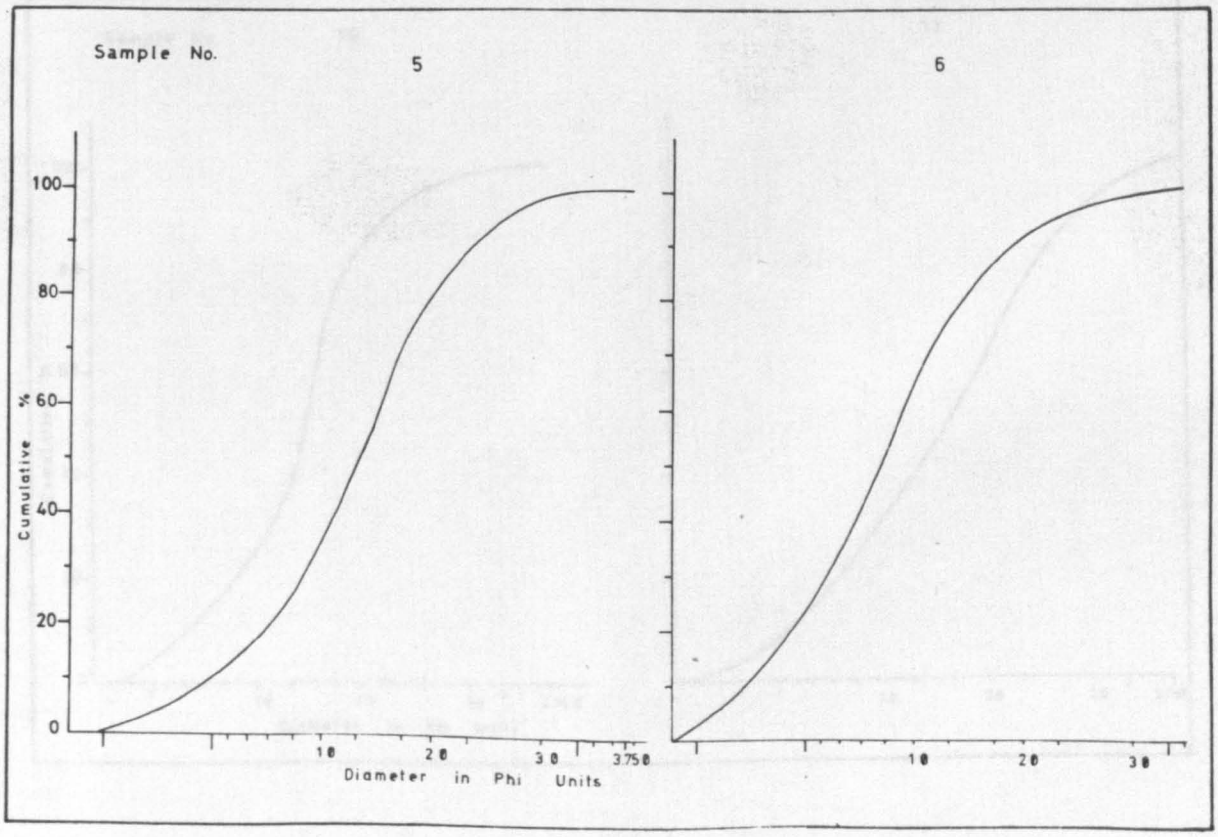
Sample No. Trip C	32	33	34	35	36	37	38	39	40
Suborder: Textulariina	145	455	110	50	95	220	305	210	365
1. Ammobaculites sp.									
2. Textularia spp.	110	200	100	40	80	65	150	175	100
3. Bagenerina sp.	5	5							10
4. Eggerella scabra	30	250	10	10	15	150	150	35	250
5. Clavulina spp.						5	5		5
Suborder: Miliolina	620	795	770	715	755	555	775	895	860
6. Cyclogyra planorbis									
7. Spiroloculina spp.	225	250	225	120	150	165	110	90	100
8. Vertebralina striata								5	
9. Quinqueloculina spp.	200	250	150	250	250	215	250	150	150
10. Massilina spp.			25	30	15		50	30	15
11. Pseudomassilina sp.		10	25	5	15		15	10	10
12. Miliolinella spp.			15					25	
13. Triloculina spp.	150	150	225	250	250	90	250	250	250
14. Hauerina diversa				5					10
15. Articulina sp.	15	25	20		10	20	15	30	30
16. Parrina bradyi			30		15	10	10	15	10
17. Peneroplis planatus	10	10	25	35	15	20	20	15	65
18. Peneroplis pertusus					5	10	10	10	60
19. Spirolina acicularis	10						5		
20. Spirolina arietina	10	100	30	20	25	25	40	250	150
21. Sorites marginalis					5			15	10
Suborder: Rotaliina	635	730	95	165	140	95	0	120	255
22. Nodosaria sp.		5	5						5
23. Lagena laevis	15								
24. Brizalina spp.		30	10						20
25. Bolivina lobata	40	35						5	10
26. Reussella spinulosa	40	35			15			10	10
27. Discorbina patelliformis	10							15	
28. Rosalina spp.	10								
29. Spirillina vivipara									
30. Ammonia beccarii	200	250						10	
31. Elphidium aff. advenum			15						
32. E. aff. discoidale									
33. E. crispum									
34. E. reticulosum									
35. E. sp.									
36. E. spp.	150	150				40		10	
37. Eponides murrayi	25	50	45	90	100	50		25	175
38. Eponides repandus									
39. Cibicides sp.	15		10					10	15
40. Cymbaloporella tabellaeformis									
41. Cymbaloporetta bradyi	20	25			10				5
42. Acervulina inhaerens			10	15	15	5		25	15
43. Nonion sp.	110	150						10	10
Totals	1460	1980	975	870	990	870	1080	1225	1480
Number of species	21	19	18	12	17	14	14	24	25

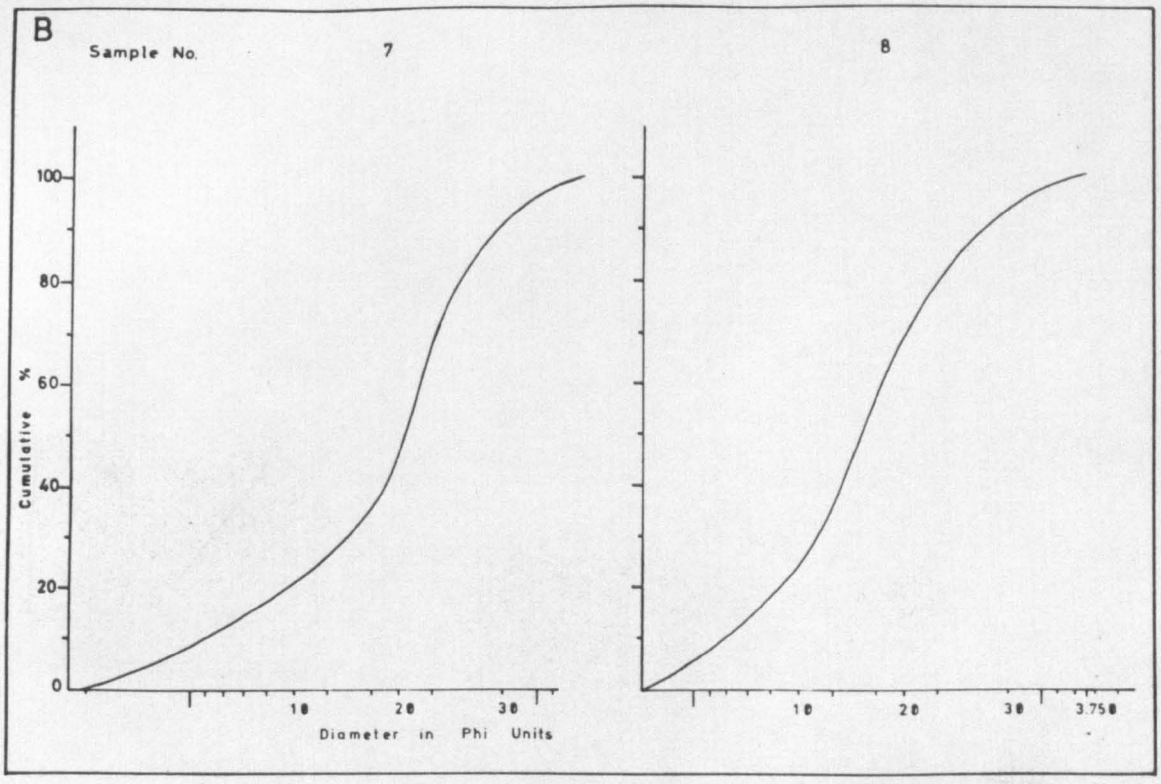
Sample No. Trip C	41	42							
Suborder: Textulariina	70	15							
1. Ammobaculites sp.									
2. Textularia spp.	25	15							
3. Bėgenerina sp.	20								
4. Eggerella scabra	25								
5. Clavulina spp.									
Suborder: Miliolina	940	580							
6. Cyclogyra planorbis									
7. Spiroloculina spp.	130	80							
8. Vertebralina striata	15								
9. Quinqueloculina spp.	200	125							
10. Massilina spp.	15								
11. Pseudomassilina sp.	25								
12. Miliolinella spp.		10							
13. Triloculina spp.	250	60							
14. Hauerina diversa									
15. Articulina sp.	10								
16. Parrina bradyi	15	15							
17. Peneroplis planatus	75	65							
18. Peneroplis pertusus	15	25							
19. Spirolina acicularis									
20. Spirolina arietina	175	200							
21. Sorites marginalis	15								
Suborder: Rotaliina	240	205							
22. Nodosaria sp.	5								
23. Lagena laevis									
24. Brizalina spp.		5							
25. Bolivina lobata									
26. Reussella spinulosa	10	10							
27. Discorbina patelliformis	10	10							
28. Rosalina spp.	25								
29. Spirillina vivipara									
30. Ammonia beccarii	5	5							
31. Elphidium aff. advenum		25							
32. E. aff. discoidale									
33. E. crispum									
34. E. reticulosum		25							
35. E. sp.									
36. E. spp.									
37. Eponides murrayi	130	100							
38. Eponides repandus									
39. Cibicides sp.	15	15							
40. Cymbaloporella tabellaeformis									
41. Cymbaloporetta bradyi	15	10							
42. Acervulina inhaerens	20								
43. Nonion sp.	5								
Totals	1250	800							
Number of species	25	18							

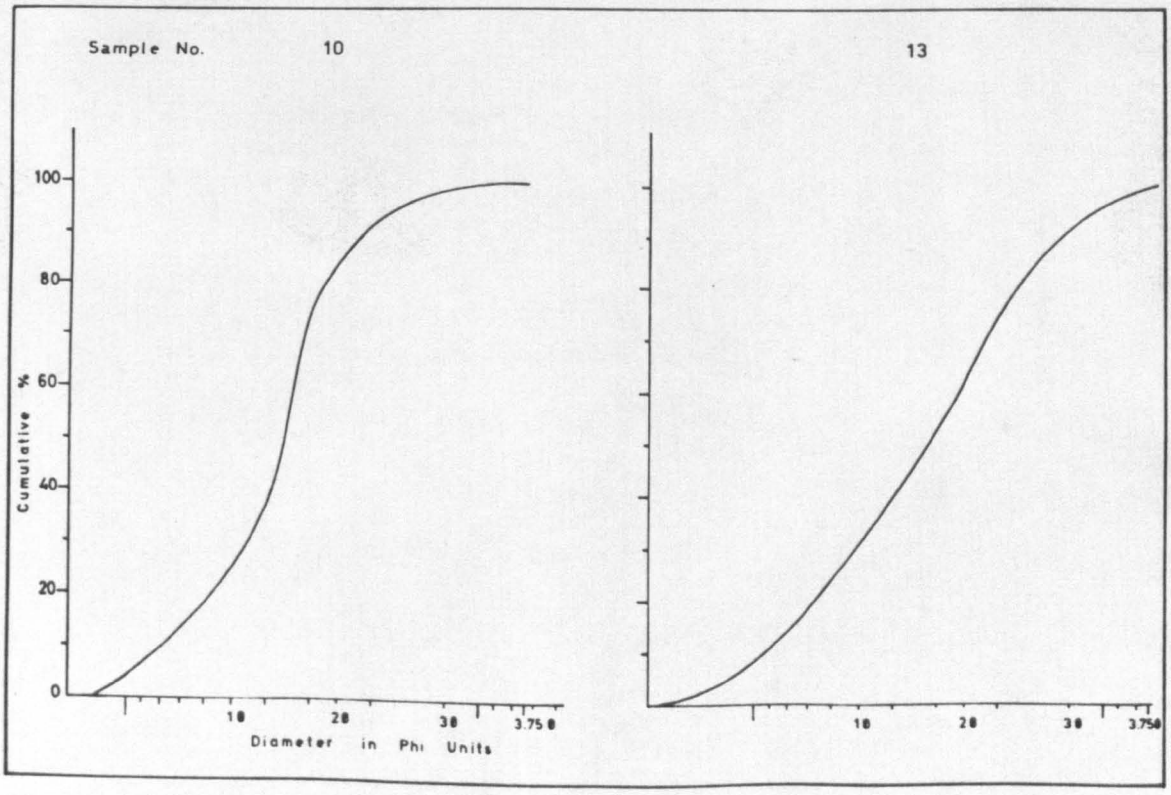
EXPLANATION OF APPENDIX 4

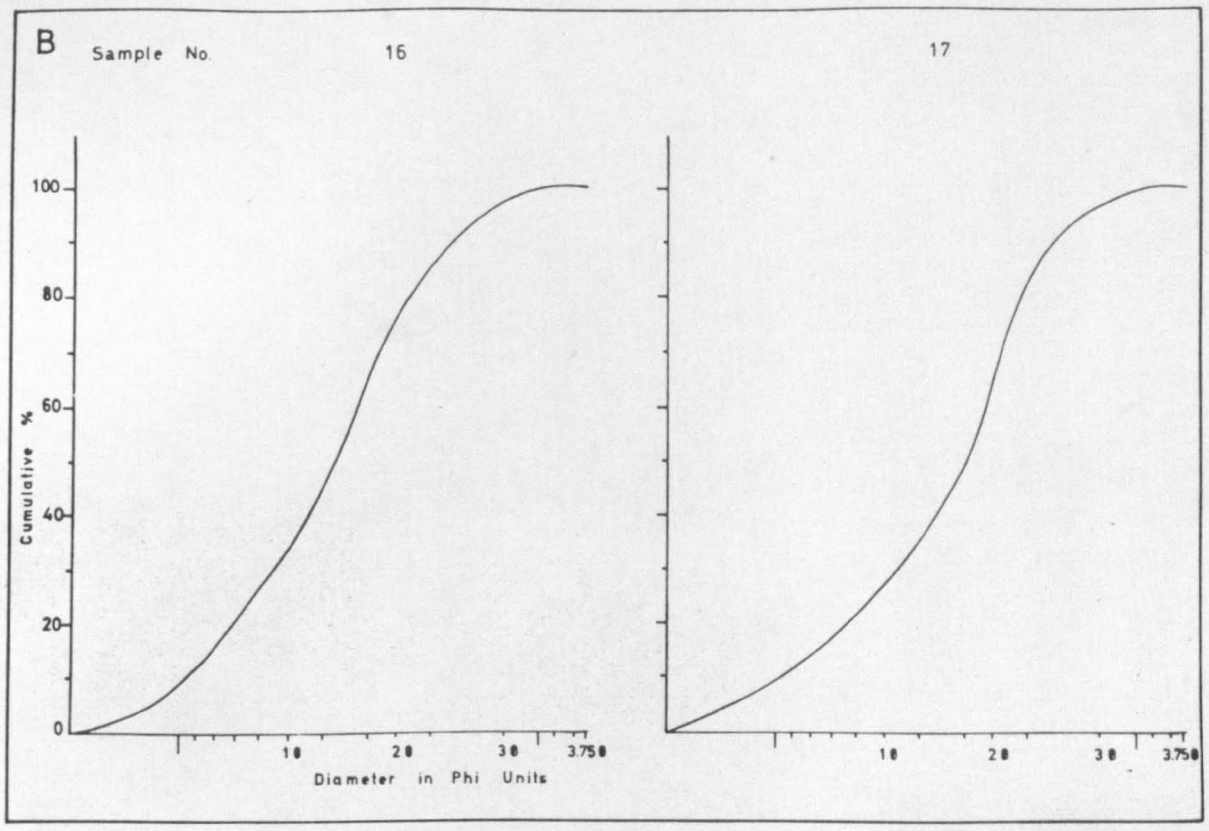
Cumulative frequency curves for some representative samples to examine the grain size of the sediment. The aim of this work was to determine whether there is any relationship between the faunal distribution and grain size and if grain size has any effect on the living/dead ratio.

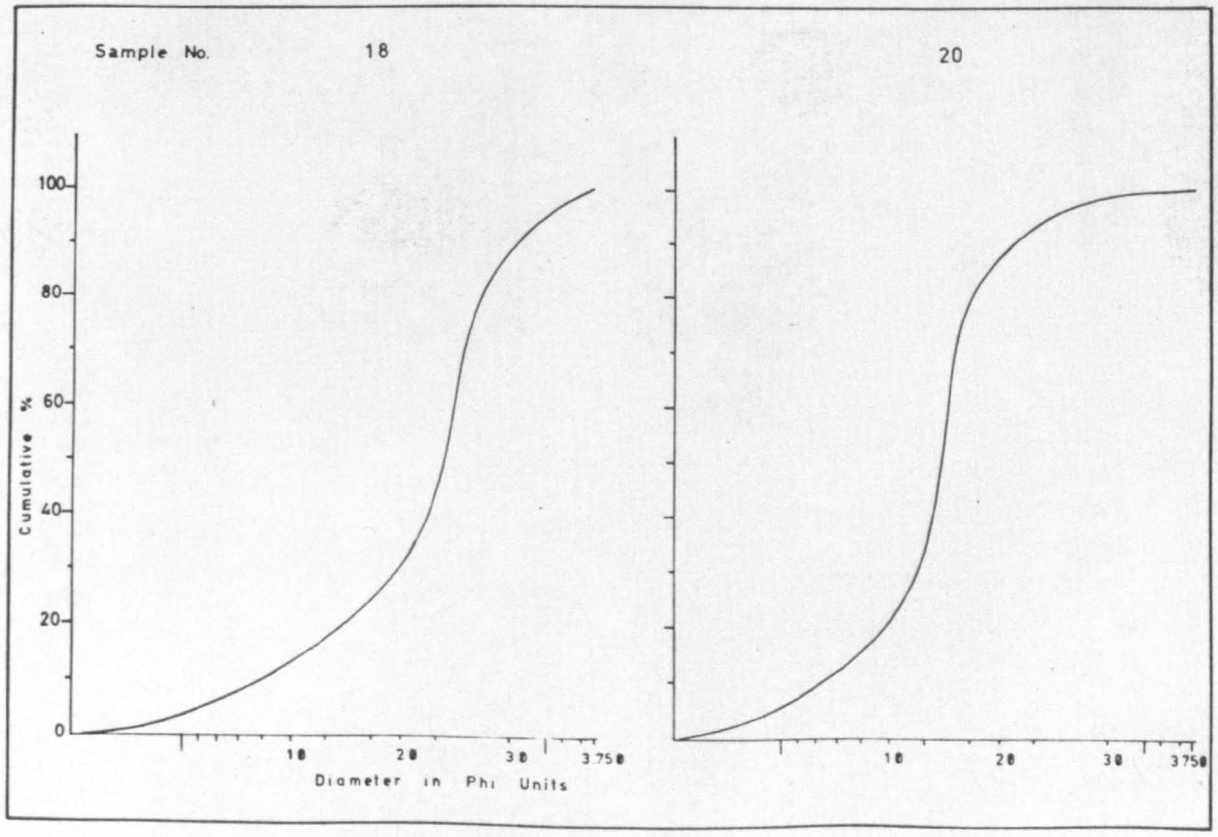

B
Sample No.
2
4
100
80
60
40
20
0
Cumulative %
1 0
2 0
3 0
3.750
Diameter in Phi Units
1 0
2 0
3 0.
3.750

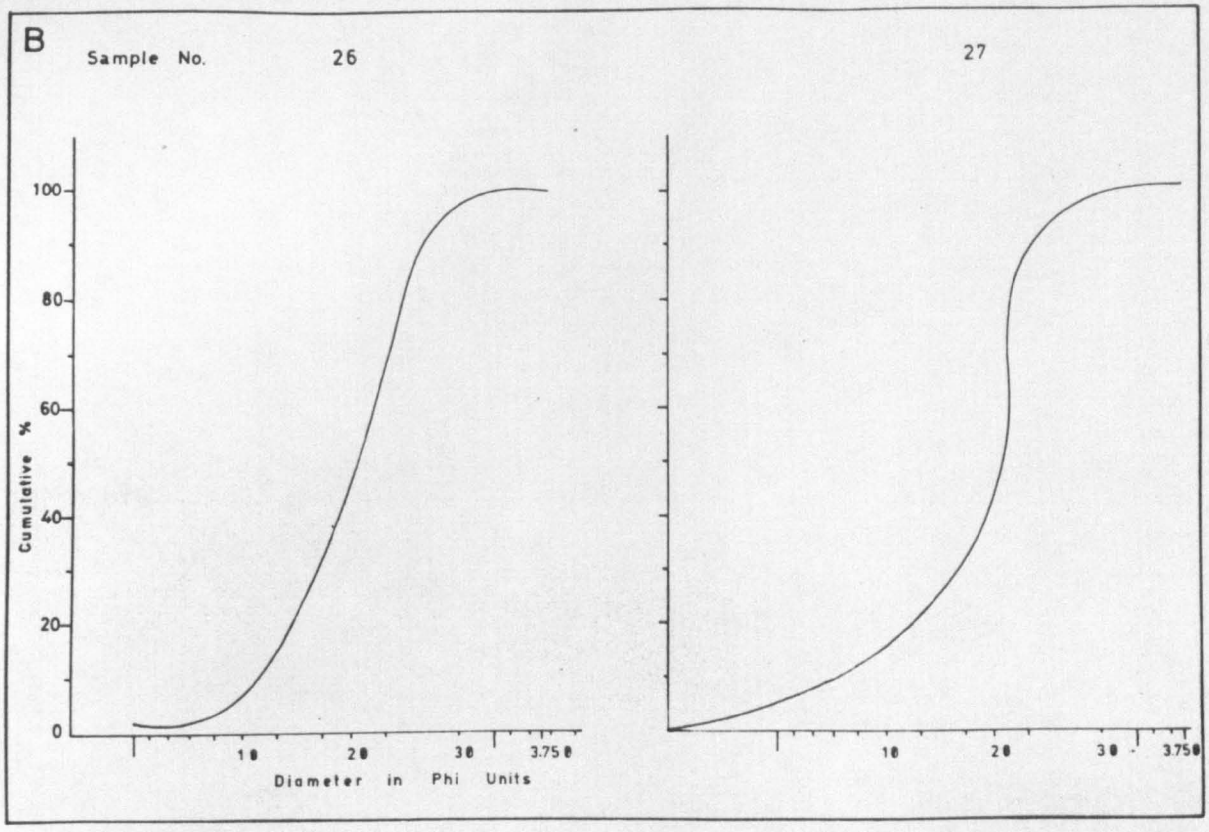

Sample No.
5
6
100
80
60
40
20
0
Cumulative %
1 0
2 0
3 0
3.750
Diameter in Phi Units
1 0
2 0
3 0

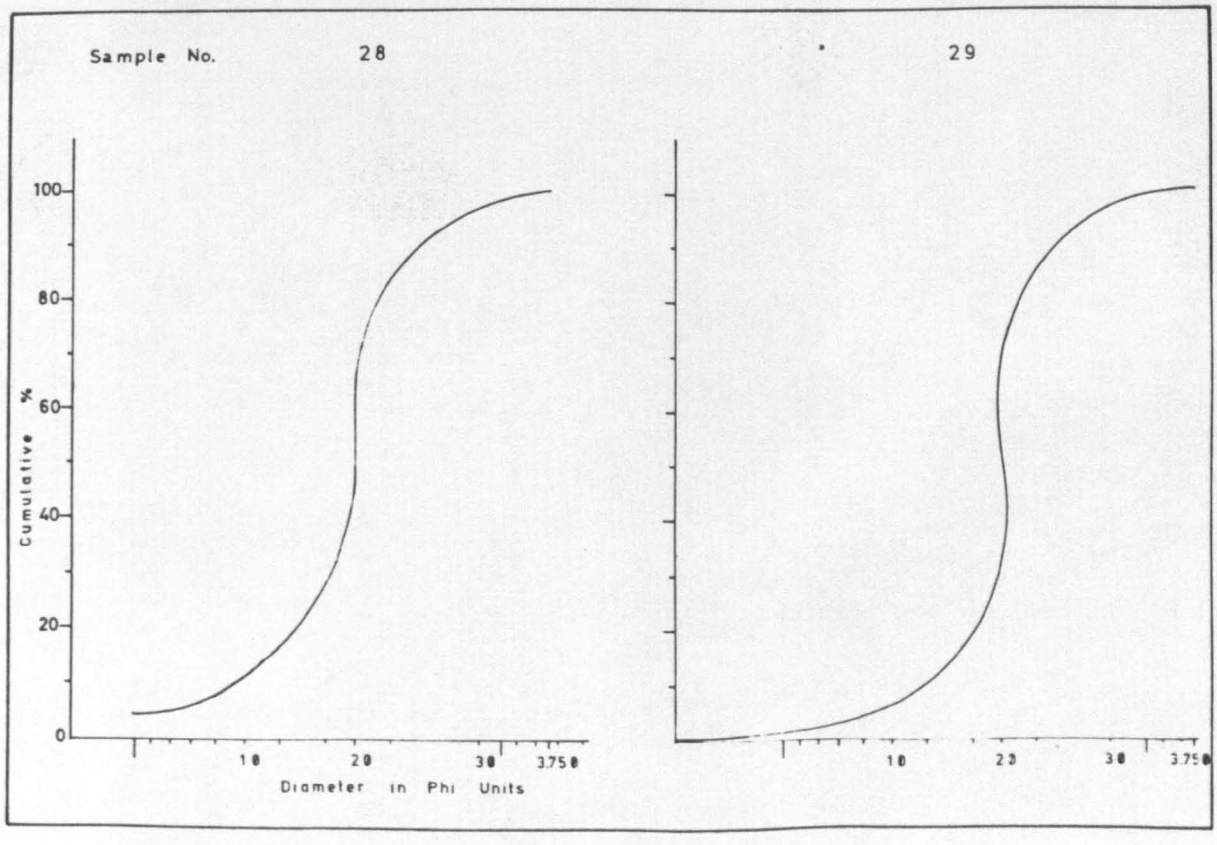

B
Sample No. 7
8
100
80
60
40
20
0
Cumulative %
1.0
2.0
3.0
3.750
Diameter in Phi Units

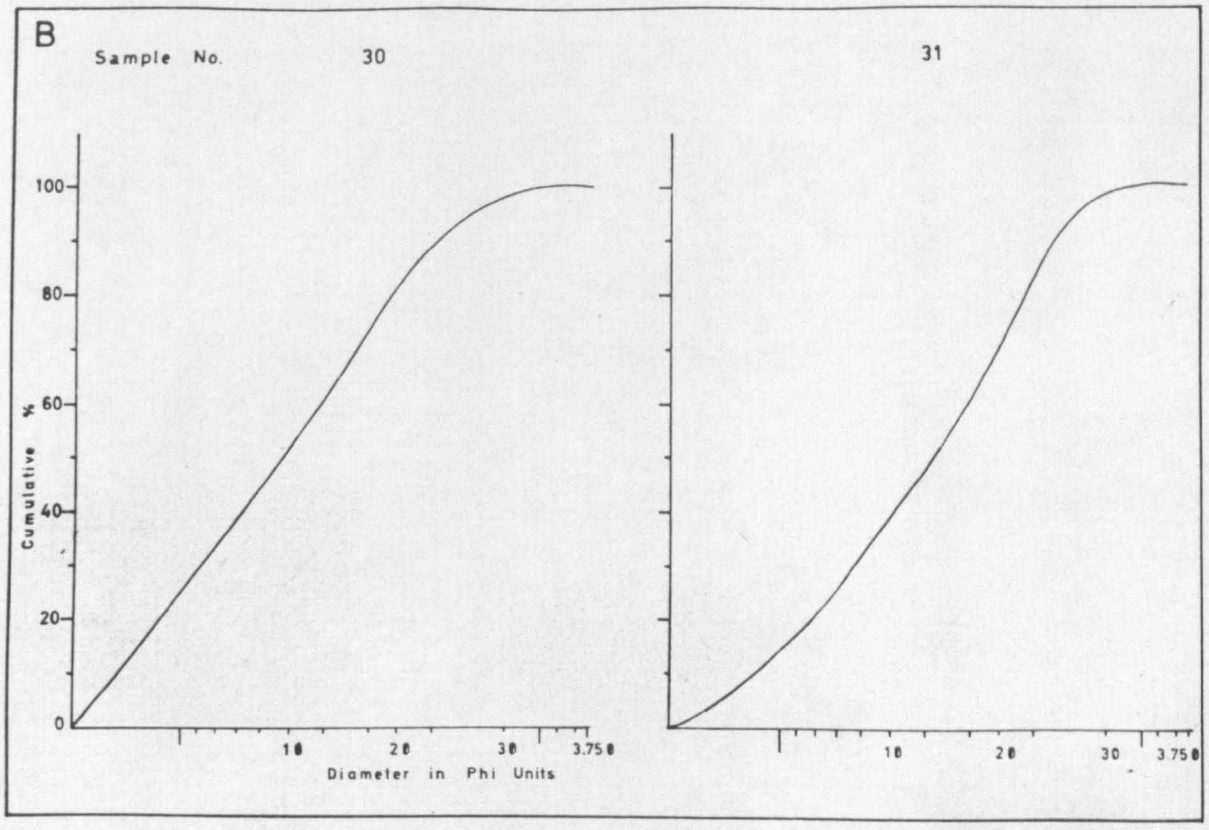

Sample No. 10
13
100
80
60
40
20
0
Cumulative %
1.0
2.0
3.0
3.750
Diameter in Phi Units

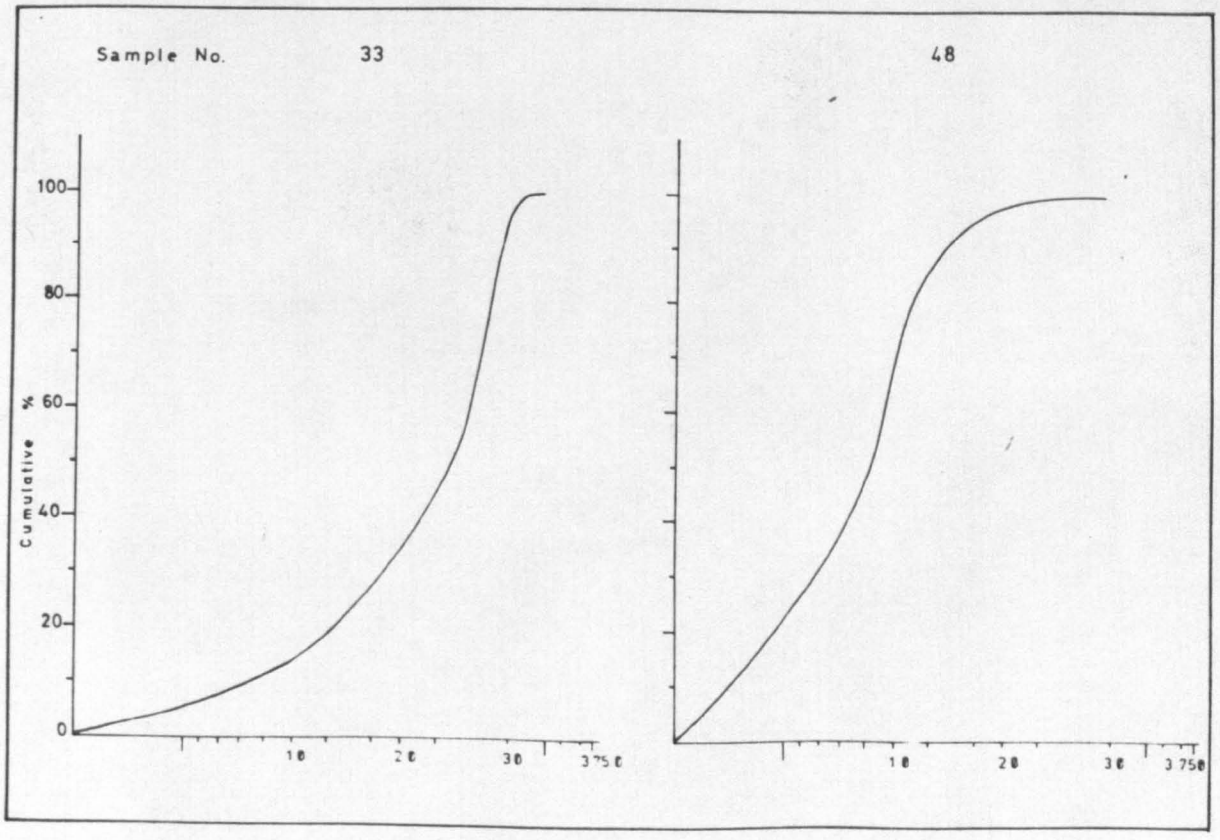

B
Sample No.
16
17
100
80
60
40
20
0
Cumulative %
1Ø
2Ø
3Ø
3.75Ø
Diameter in Phi Units

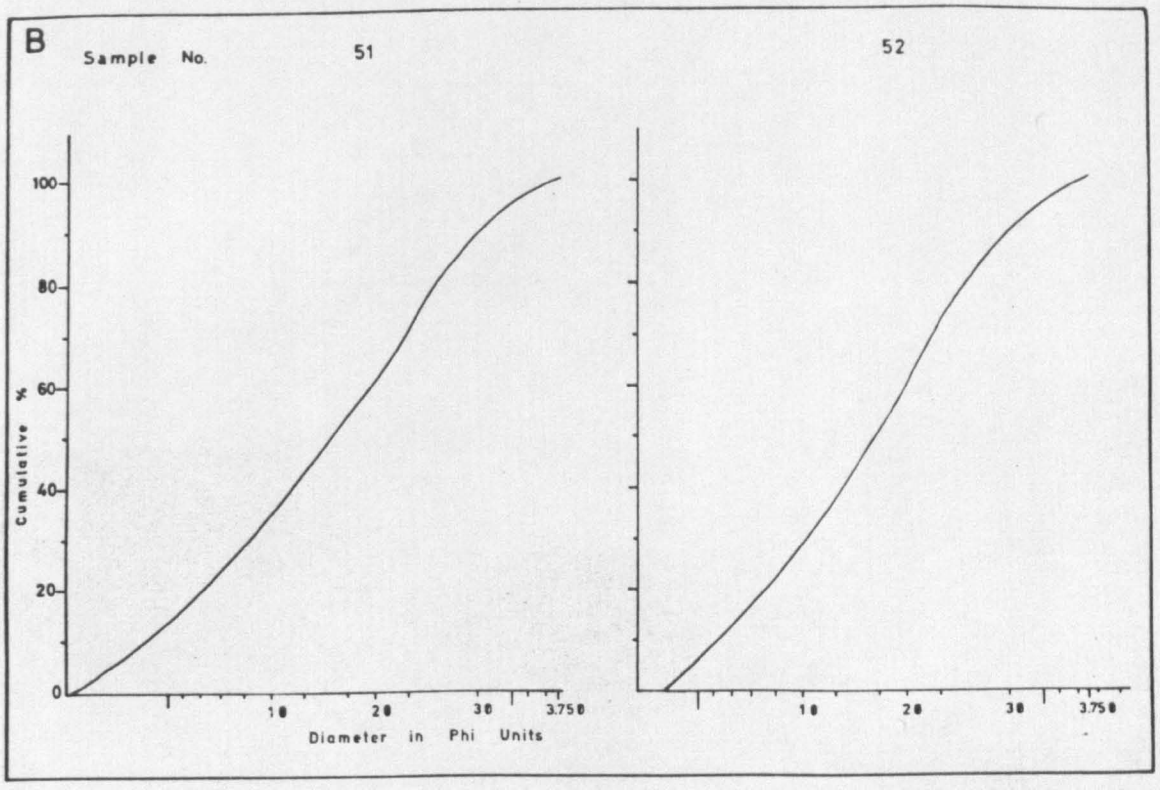

Sample No.
18
20
100
80
60
40
20
0
Cumulative %
1Ø
2Ø
3Ø
3.75Ø
Diameter in Phi Units

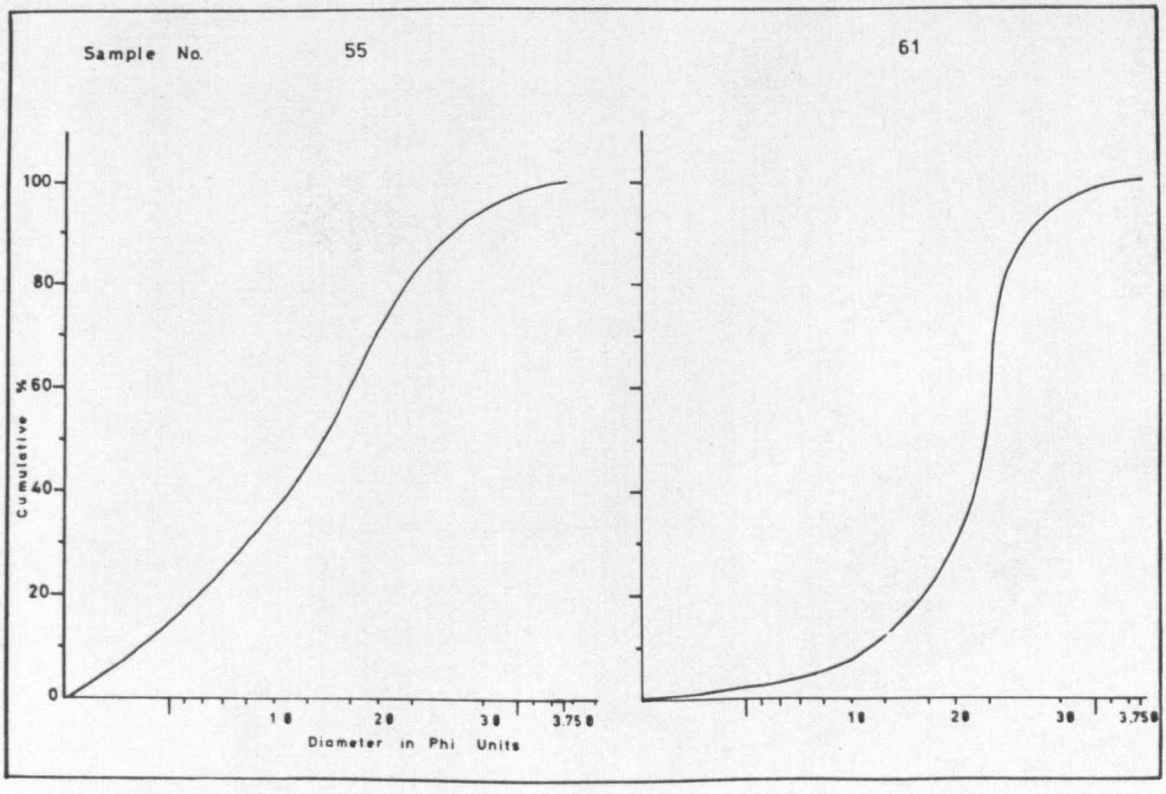

B
Sample No. 26
27
Cumulative %
100
80
60
40
20
0
1.0
2.0
3.0
3.750
Diameter in Phi Units

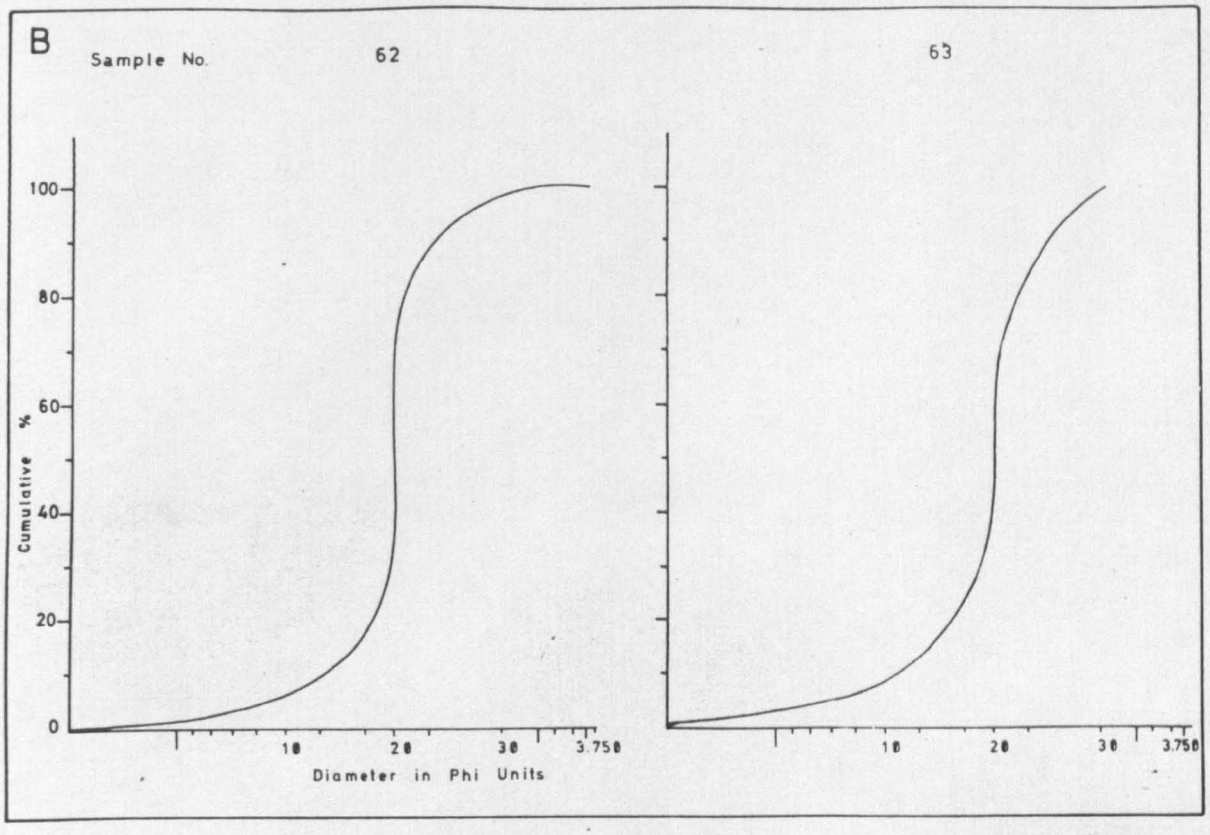

Sample No. 28
29
Cumulative %
100
80
60
40
20
0
1.0
2.0
3.0
3.750
Diameter in Phi Units

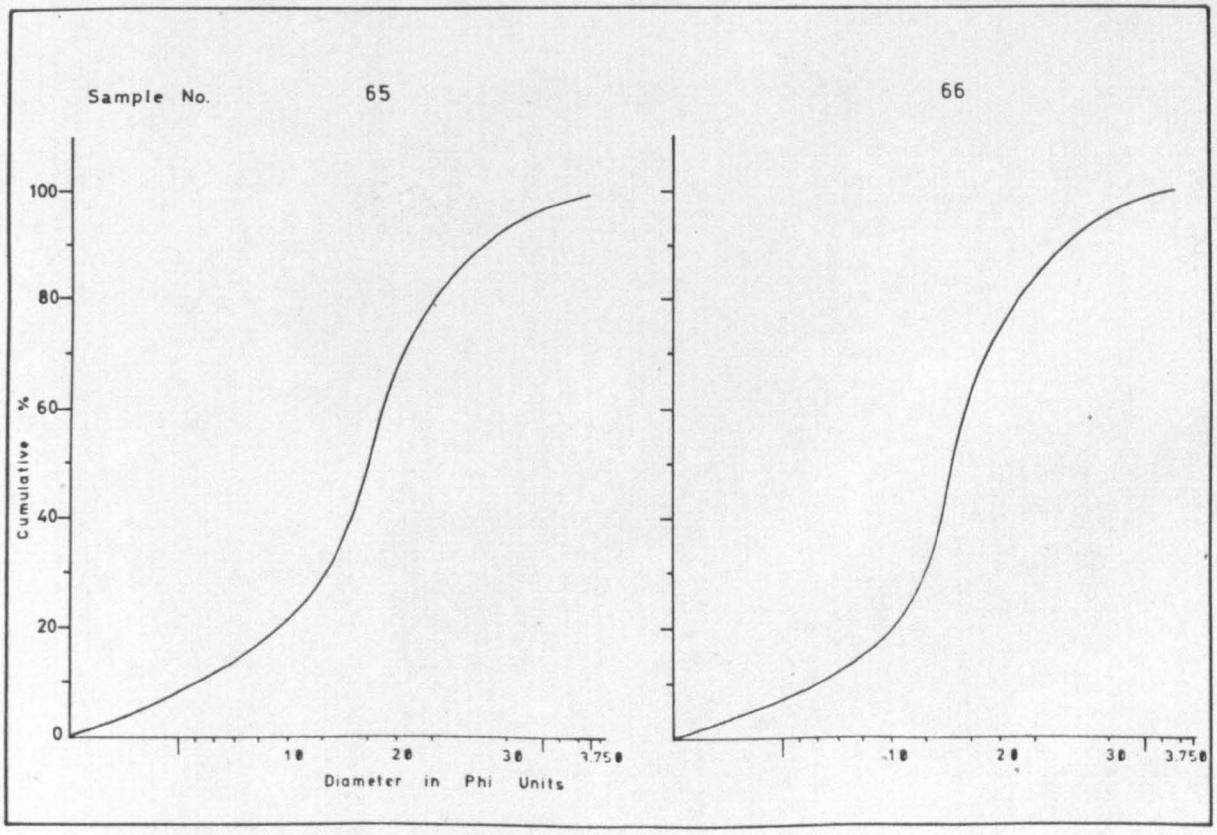

B
Sample No. 30
31
100
80
60
40
20
0
Cumulative %
10
20
30
3.750
Diameter in Phi Units

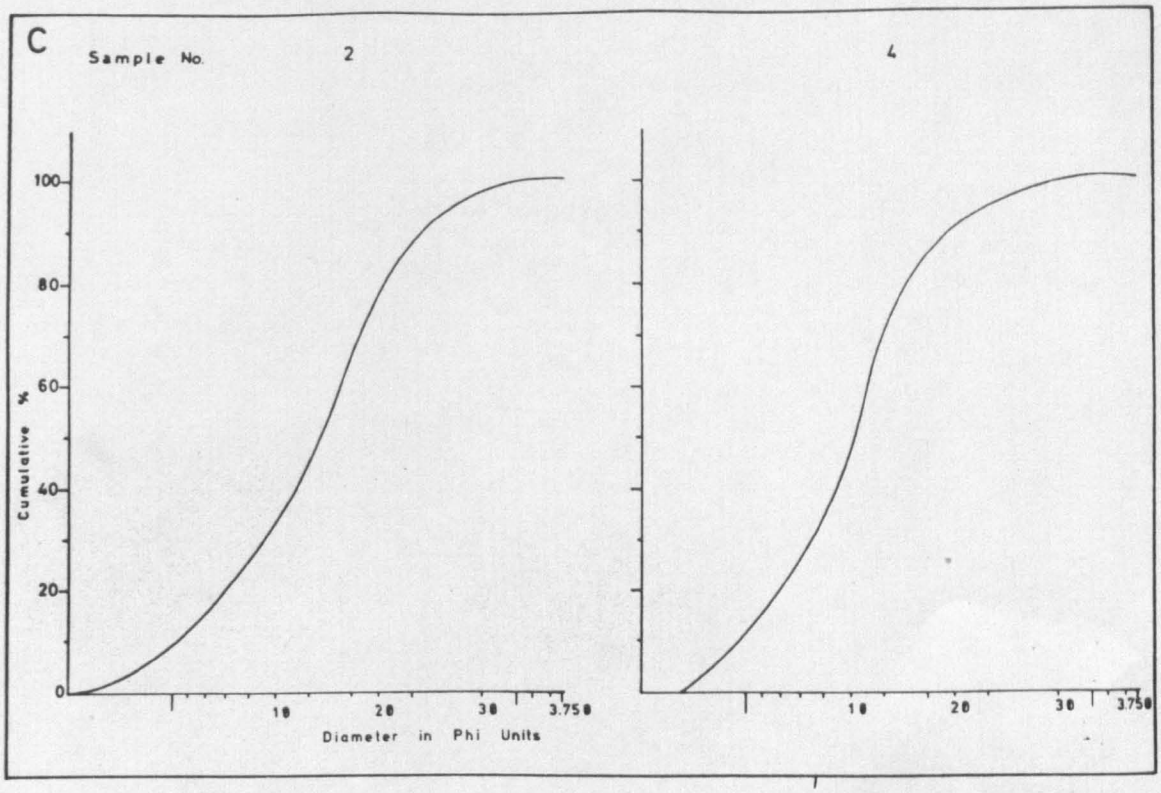

Sample No. 33
48
100
80
60
40
20
0
Cumulative %
10
20
30
3.750

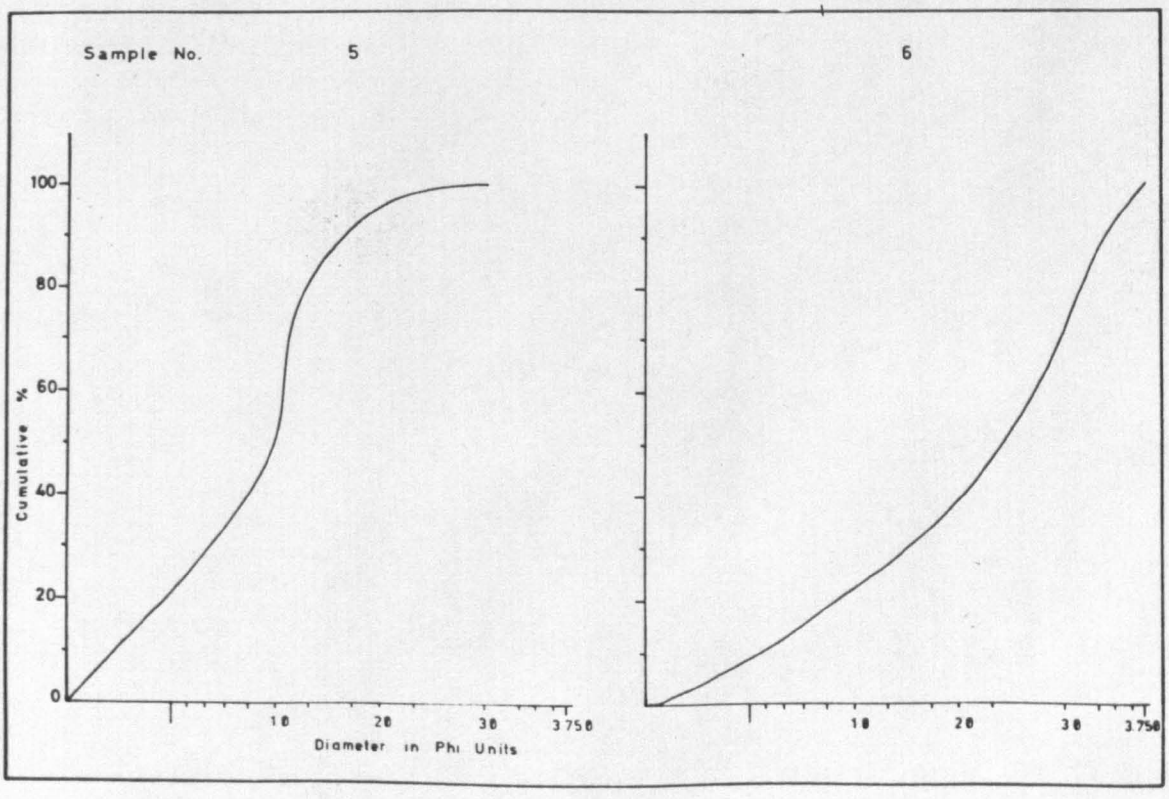

B
Sample No.
51
52
100
80
60
40
20
0
Cumulative %
1.0
2.0
3.0
3.750
Diameter in Phi Units

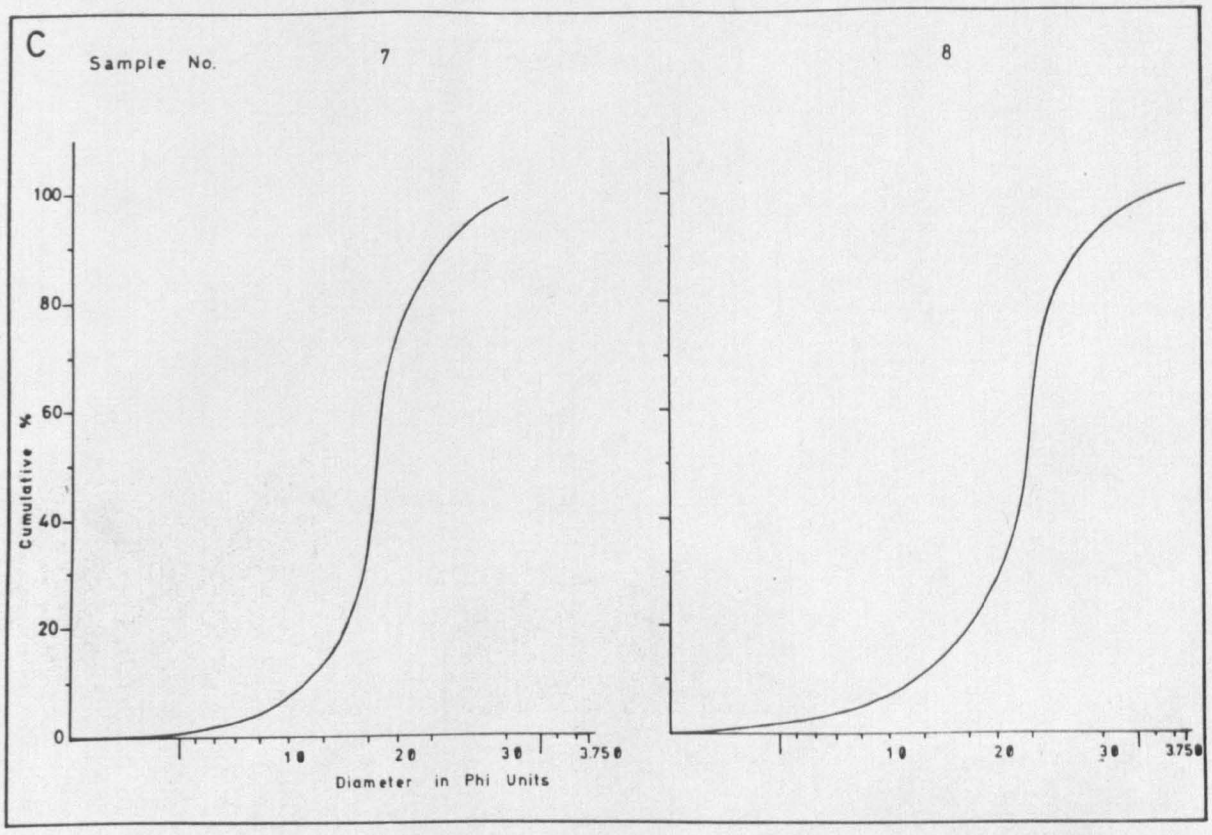

Sample No.
55
61
100
80
60
40
20
0
Cumulative %
1.0
2.0
3.0
3.750
Diameter in Phi Units

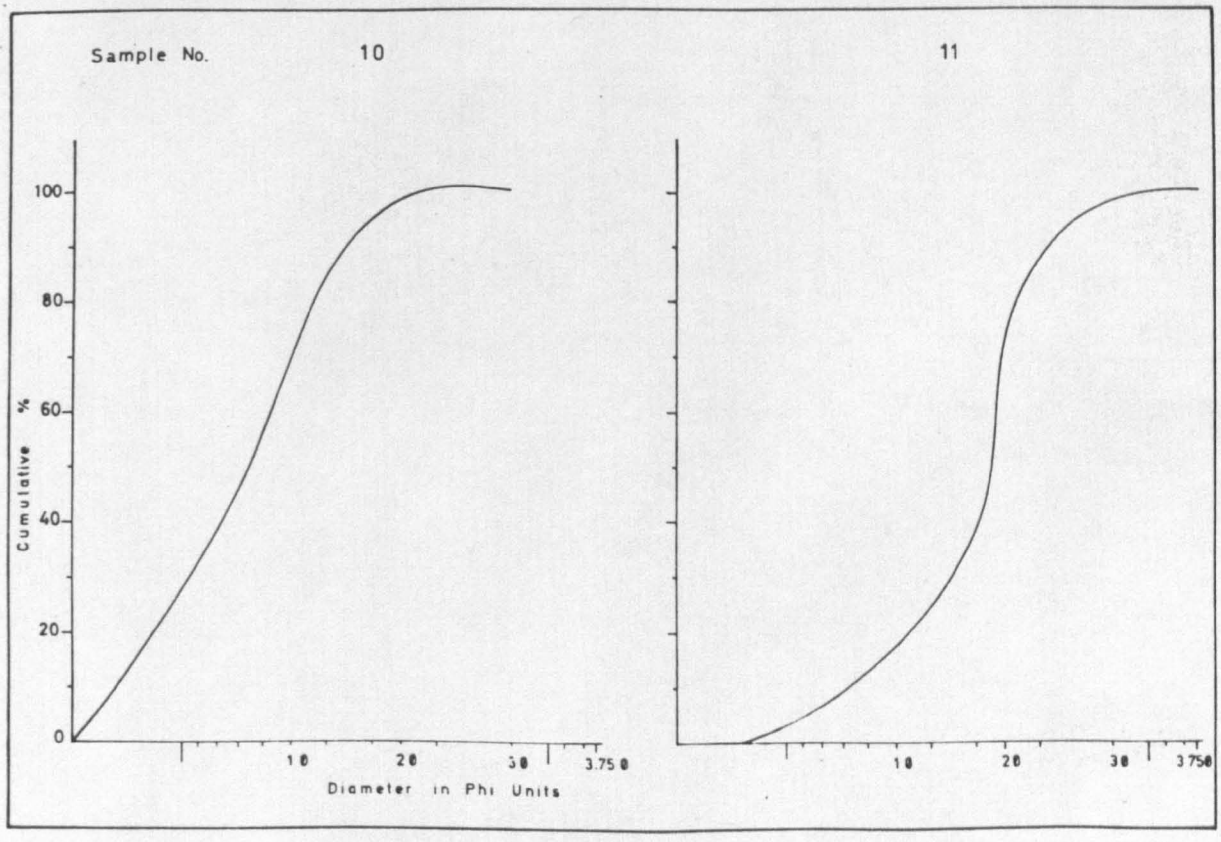

B
Sample No.
62
63
100
80
60
40
20
0
Cumulative %
1Ø
2Ø
3Ø
3.75Ø
Diameter in Phi Units

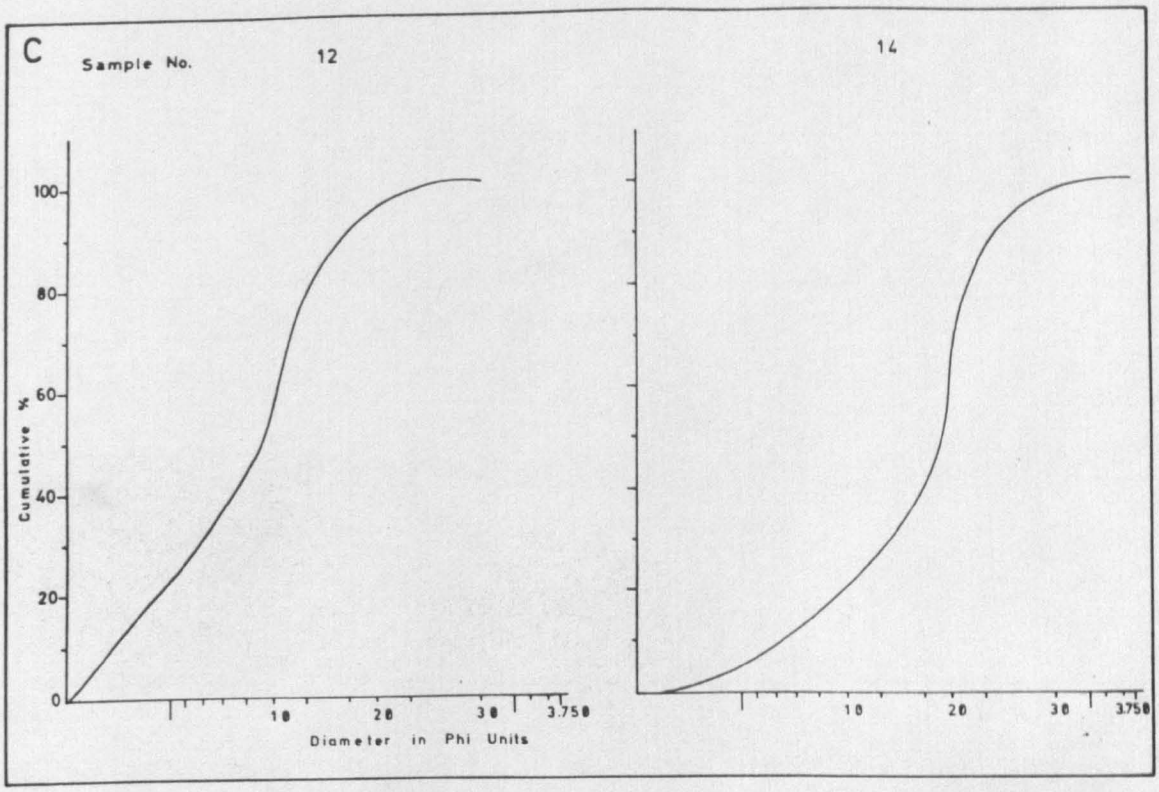

Sample No.
65
66
100
80
60
40
20
0
Cumulative %
1Ø
2Ø
3Ø
3.75Ø
Diameter in Phi Units

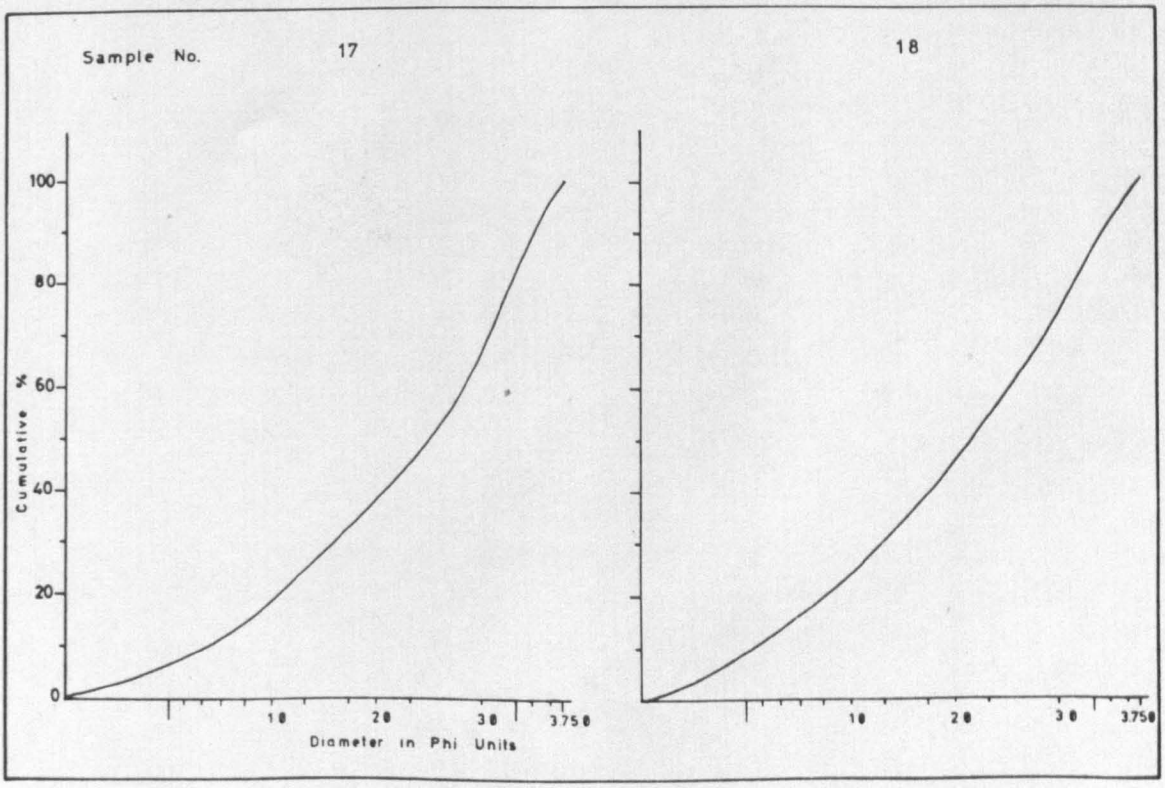

C
Sample No. 2
4
100
80
60
40
20
0
Cumulative %
1Ø
2Ø
3Ø
3.75Ø
Diameter in Phi Units

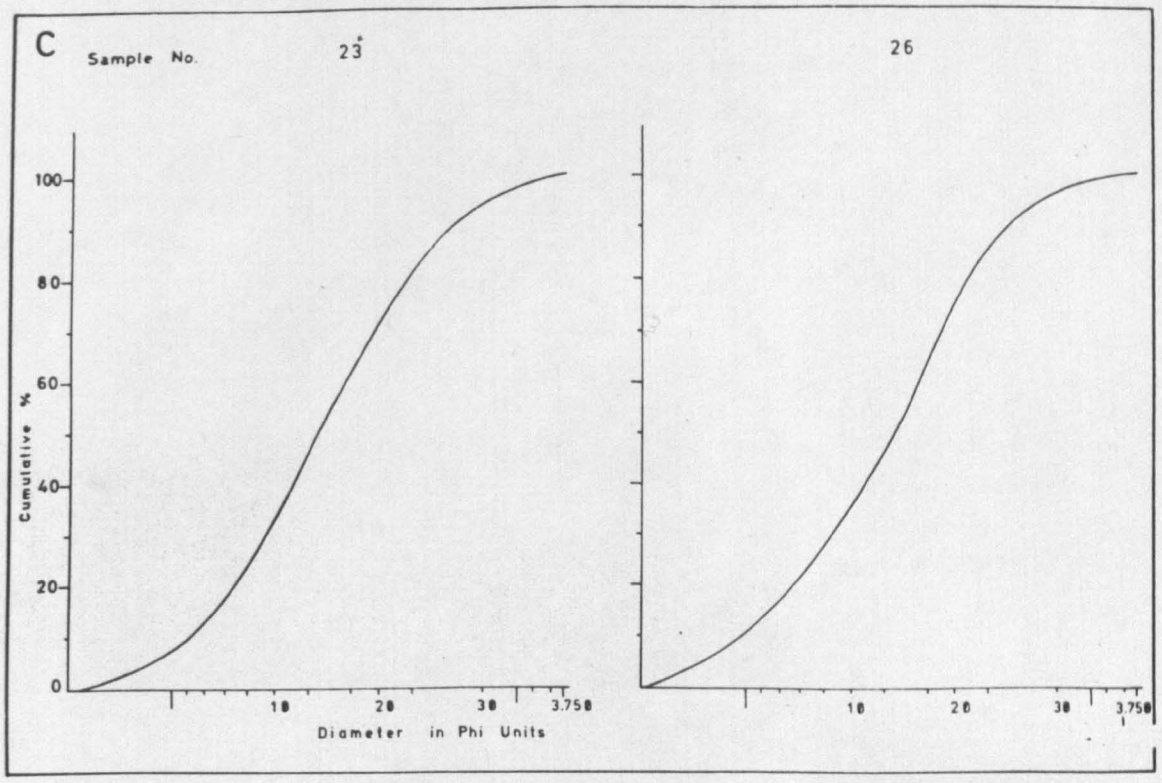

Sample No. 5
6
100
80
60
40
20
0
Cumulative %
1Ø
2Ø
3Ø
3.75Ø
Diameter in Phi Units

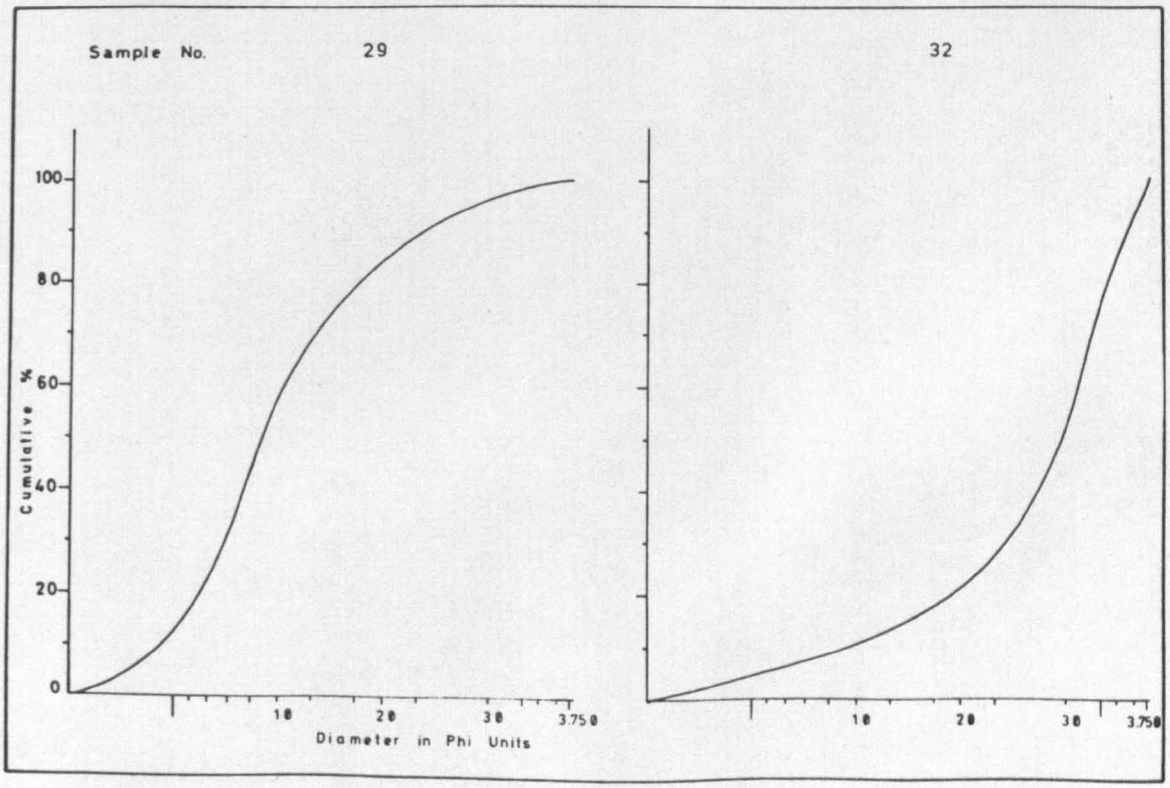

C
Sample No.
7
8
100
80
60
40
20
0
Cumulative %
10
20
30
3.750
Diameter in Phi Units

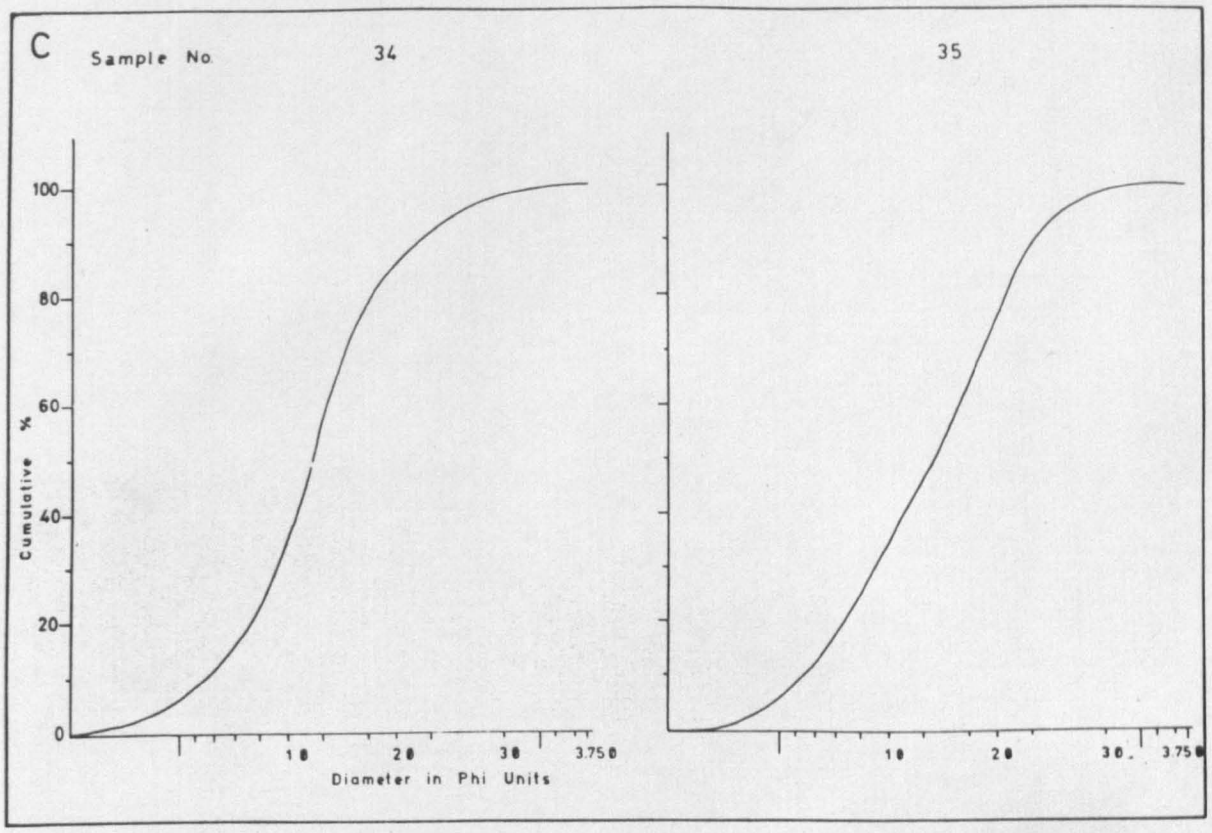

Sample No.
10
11
100
80
60
40
20
0
Cumulative %
10
20
30
3.750
Diameter in Phi Units

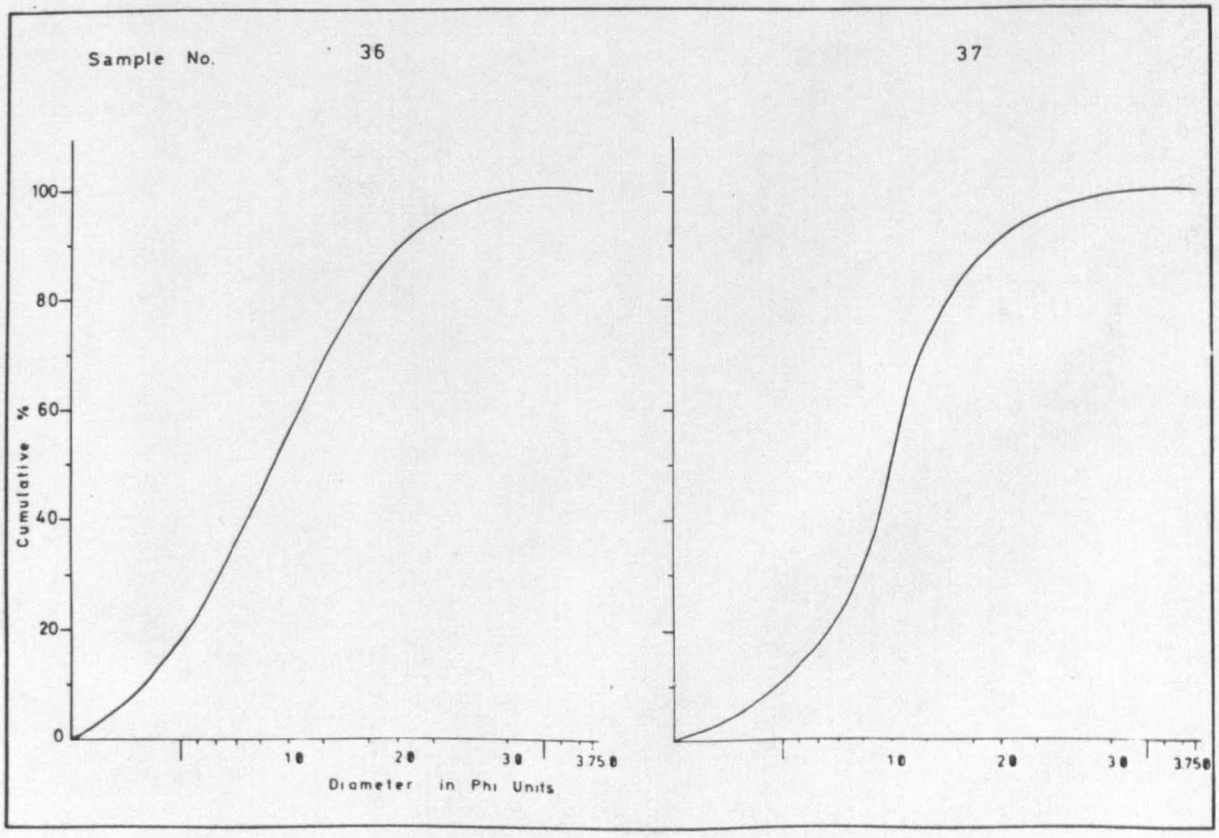

C
Sample No.
12
14
100
80
60
40
20
0
Cumulative %
10
20
30
3.750
Diameter in Phi Units


Sample No.
17
18
100
80
60
40
20
0
Cumulative %
10
20
30
3.750
Diameter in Phi Units


C
Sample No.
23
26
100
80
60
40
20
0
Cumulative %
10
20
30
3.750
Diameter in Phi Units


Sample No.
29
32
100
80
60
40
20
0
Cumulative %
10
20
30
3.750
Diameter in Phi Units


C
Sample No.
34
35
100
80
60
40
20
0
Cumulative %
10
20
30
3.750
Diameter in Phi Units


Sample No.
36
37
100
80
60
40
20
0
Cumulative %
10
20
30
3.750
Diameter in Phi Units

C