

BENTHIC FORAMINIFERA FROM THE ORANGE-LUDERITZ SHELF

SOUTHERN AFRICAN CONTINENTAL MARGIN

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requirements for the degree of  
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## ABSTRACT

An investigation of the benthic foraminifera in the surficial sediments of the continental shelf and upper slope off the Orange River mouth and the Namib Desert was undertaken as an adjunct to sedimentological and geophysical investigations being conducted by members of the Joint Geological Survey/University of Cape Town Marine Geoscience Group. 117 species in 65 genera of benthic foraminifera are described and illustrated, and five bathymetric zones are distinguished on the basis of faunal differences. A cluster analysis yielded clusters which correlated well with the three deeper bathymetric zones, but were ambiguous in the two shallower zones. Fauna interpreted as relict or reworked were present at a number of stations and were distinguished on the basis of glauconite or phosphorite infillings, anomalous distributions, and tests which are worn, battered, and partially dissolved.

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## CHAPTER 1. INTRODUCTION

1.1 General statement

The continental shelf and upper slope off southwestern Africa is under investigation by members of the Joint Geological Survey/University of Cape Town Marine Geoscience Unit. General morphologic and geochemical studies were completed by Birch (1975), Rogers (1977), and Bremner (1978). The present study, undertaken independently, is intended to supplement the above work and is concerned with the continental shelf and upper slope between the latitudes 25°S and 30°S, the area previously studied by Rogers.

1.2 Purpose of study

This area is of importance to the micropaleontologist for a number of reasons. First, the Orange River, one of the major rivers of the continent, discharges low salinity water and terrigenous sediment into the region causing localized environmental fluctuations. Second, the continental shelf is unusually wide (225 km) in the southern part of the area, and anomalously deep (400 m to 500 m) throughout most of the region. Finally, the prevailing coastal winds generate intense oceanic upwelling, with its attendant environmental consequences.

The purpose of the present study is to investigate the benthic foraminifera of the surficial sediments, establish the types present, their distribution, and the factors determining this distribution.

1.3 Previous investigations

Work on foraminifera from the South African continental margin has been sparse, the earliest being that of H.B. Brady (1884). Two 'Challenger' stations are located off southern Africa: station 142 at 150 fathoms off the Cape of Good Hope, and station 142a at 15 to 20 fathoms off Simon's Bay. Both stations yielded a characteristic cool water fauna which Brady compared with North Atlantic samples.

Since the 'Challenger' expedition, foraminifera from eastern and southern African areas have been studied by Heron-Allen and Earland (1915, Kerimba Islands off northern Mozambique), Braga (1965, Mozambique coast), and Albani (1965, a sample from off Salisbury Island, Durban Bay).

McMillan (1974) studied the foraminifera in nine samples from the Agulhas Bank. He isolated 115 species in 57 genera and established three major depth zonations.

On the western margin, studies have been undertaken in the Gulf of Guinea by Le Calvez (1963) and Boltovskoy (1968). Siesser (1973) did a paleoclimatic study of eight cores recovered off Cape Town, and later correlated pore densities in Globoquadrina dutertrei with temperature curves in the cores (Siesser, 1974). In 1976, Siesser consolidated data collected on 168 rock samples recovered from various localities off the South African coast and gave a comprehensive list of samples, age assignments, and types of fossils used in the determinations. Several of the rock samples were taken from the area under consideration in the present study.

Finally, a series of six M.Sc. theses written by students from the University College of London dealt with foraminifera from traverses off the west coast. One, by Magdy H. Girgis (1979) covered a traverse of five samples off Chamais Bay in the present study area. Girgis isolated 77 species and divided the area into four zones on the basis of faunal differences.

#### 1.4 Materials and methods

The samples used for the present study, with the exception of the material from the Tripp Sea Mount, were all recovered during cruises of the University of Cape Town Research Vessel Thomas B. Davie between February, 1971 and May, 1974, using a modified van Veen grab. The Tripp Sea Mount sample was recovered by H.M.S. Hecla in 1966. Table 1 lists the samples used, location, water depths, and date of sampling. The samples were stored in airtight tubs, and sub-samples washed through a nest of three sieves: 355 $\mu$ , 180 $\mu$ , and 63 $\mu$ . Each fraction was dried before examination. In order to determine if agglutinated specimens were disintegrating in the drying process, a number of samples were examined before and after drying with no appreciable difference in foraminiferal content. Foraminifera were picked and identified from each fraction separately in order that smaller species and juveniles were not overlooked. A minimum of 300 individuals in each fraction was counted. Sixty-five samples were examined in this way, and of these, 58 contained benthic foraminifera and were used in the analysis of the fauna. As no samples had been preserved and stained for protoplasm, the assemblages were all treated as thanatocoenoses.

TABLE 1. SAMPLE LOCATIONS

<u>STATION</u>	<u>LAT.</u> S.	<u>LONG.</u> E.	<u>DEPTH</u> M.	<u>DIST.</u> N.M.	<u>DATE</u>
2744	29 42.0	16 54.0	110	8.0	23: 2:71
2753	29 47.0	15 50.0	191	63.6	24: 2:71
2848	29 37.0	14 2.0	1495	131.5	13: 5:71
2852	29 38.0	14 44.0	420	186.5	13: 5:71
2854	29 38.0	15 5.0	280	92.7	13: 5:71
2856	29 38.0	15 26.0	194	77.1	14: 5:71
2868	29 27.0	16 41.0	122	14.0	14: 5:71
2873	29 28.0	15 45.0	178	58.1	15: 5:71
2893	29 17.0	15 48.0	178	49.8	17: 5:71
2900	29 6.2	16 44.8	68	3.1	17: 5:71
2903	29 7.0	16 23.0	135	19.0	17: 5:71
2905	29 7.0	16 13.0	148	25.4	17: 5:71
2918	29 6.0	14 10.0	984	185.5	18: 5:71
2922	28 55.0	14 46.0	190	74.5	18: 5:71
2924	28 54.0	15 10.0	158	59.2	18: 5:71
2932	28 56.3	16 39.7	34	1.9	19: 5:71
2957	28 37.0	15 56.0	122	15.2	21: 5:71
2958	28 37.0	16 8.0	100	10.0	21: 5:71
2959	28 37.0	16 19.0	19	3.7	21: 5:71
2964	28 41.2	16 29.0	19	1.6	21: 5:71
2965	28 38.6	16 26.7	12	.9	21: 5:71
2966	28 37.0	16 23.4	16	1.3	21: 5:71
2971	28 26.0	15 24.0	162	30.7	21: 5:71
2978	28 24.0	14 12.0	736	81.4	22: 5:71
2994	28 7.0	15 34.0	109	10.8	23: 5:71
2999	28 7.0	14 31.0	280	59.3	12: 5:71
3015	27 47.0	14 57.0	195	30.9	24: 5:71
3016	27 47.0	14 48.0	360	38.0	24: 5:71
3020	27 38.8	14 7.2	1258	65.3	24: 5:71
3132	27 37.0	15 18.2	118	9.0	19:11:71
3139	27 27.0	15 19.0	92	3.2	19:11:71
3146	27 28.0	14 30.0	352	38.6	19:11:71
3166	27 7.0	15 7.6	123	6.6	20:11:71
3198	26 47.0	14 21.0	350	39.3	22:11:71
3202	26 47.0	13 37.0	900	78.2	22:11:71
3205	26 37.0	13 33.0	995	77.0	22:11:71
3207	26 37.0	13 55.0	418	62.5	22:11:71
3209	26 37.0	14 16.0	352	41.1	23:11:71
3224	25 8.0	13 52.0	215	51.9	26:11:71
3225	25 7.0	13 36.0	530	66.9	26:11:71
3257	25 11.0	14 8.0	300	42.8	28:11:71
3260	26 5.0	14 37.0	180	17.2	29:11:71
3264	26 3.0	14 54.0	51	3.7	29:11:71
3271	26 27.0	14 47.0	153	12.0	29:11:71
3354	28 38.0	13 54.0	1780	101.1	11: 5:72
3356	26 23.0	13 7.0	1430	98.4	12: 5:72
3374	25 53.8	14 9.0	254	37.8	13: 5:72
3375	25 53.0	13 57.0	326	47.7	13: 5:72
3383	25 36.2	13 45.5	335	58.6	13: 5:72
3398	25 15.5	14 37.0	87	11.0	14: 5:72
3400	25 16.0	14 13.0	182	31.9	14: 5:72
3406	25 20.0	13 6.0	1530	92.5	14: 5:72
3635	28 56.0	16 26.2	117	9.5	29:11:72
3639	28 48.2	16 26.2	50	7.2	29:11:72

Tripp Sea Mount -- data unknown

RS 45 Orange River - marshland east of mouth at bar

RS 48 Orange River - marshland 1 mile upriver of mouth

BS 103 Elizabeth Bay beach sample

## CHAPTER II. DESCRIPTION OF THE STUDY AREA

2.1 Morphology

The continental shelf in the study area is widest (230 km) in the south near the Tripp Sea Mount, narrows to 90 km off Chamais Bay, and widens again to 130 km off Luderitz (Fig. 1). This shelf has been noted by Shepard (1963) to be one of the deepest in the world. In the southern section, off the Buffels River, the shelf break lies at 480 m and rises northward to 210 m. Off Chamais Bay it deepens again to 490 m and continues at depths between 400 m and 500 m as far north as Saddle Hill. From there, it rises rapidly to a depth of 275 m off Sylvia Hill. Where the shelf break is deep, an inner shelf break separates the middle and outer shelves (Rogers, 1977).

Rogers recognized four main morphologic zones in the area. The deepest is the upper slope, which has a low gradient (average  $1.2^\circ$ ) and a number of slumps. The Tripp Sea Mount lies in this zone, rising from a depth of -1000 m to a peak at -152 m. In the middle of the zone, the Chamais slump extends for a distance of 220 km and is 30 km wide. It is steepest off Chamais Bay.

The outer shelf extends from the shelf break to the landward edge of the Orange Banks. On these banks, the outer shelf is often shallower than the middle shelf (approx. 150 m). Rogers (1977) notes that the occurrence of coralline algae in some of the rock dredged from the Banks indicates deposition within the euphotic zone, though the lack of terrigenous components suggests deposition far from the coast. Northwards, between Spencer Bay and Sylvia Hill, an extensive deposit of residual sand rich in pelletal phosphorite was sampled on the outer shelf.

Rogers (1977) delimits the middle shelf by defining the outer and inner shelves either side of it. The outer shelf in the south extends from the shelf break to the landward edge of the Orange Banks. In the north, its landward boundary is the inner shelf break. The inner shelf is defined as the zone beside the coast underlain by 'acoustic basement', which is assumed to be Precambrian. Northwest of Luderitz, the middle shelf is dominated by the bench-like elevation termed the Luderitz Bank (Rogers, 1977). This bank is the site of a rich deposit of glauconitic sand.

As previously noted, Rogers (1977) defined the inner shelf as the zone underlain by Precambrian rocks beside the coast. The variable lithology of the bedrock is reflected in the bathymetric style of the inner shelf. The Recent delta of the Orange River buries the Precambrian bedrock and attains a maximum thickness of approximately 60 m. The pro-delta pinches out at a depth of 120 m over the middle shelf. Deltaic sediments disappear 95 km north of the Orange River mouth and extend 380 km southwards to St. Helena Bay.

West of the Orange River mouth lies a feature which was interpreted as a delta of the Orange River formed during the Würm glaciation (Rogers, 1977). Differences

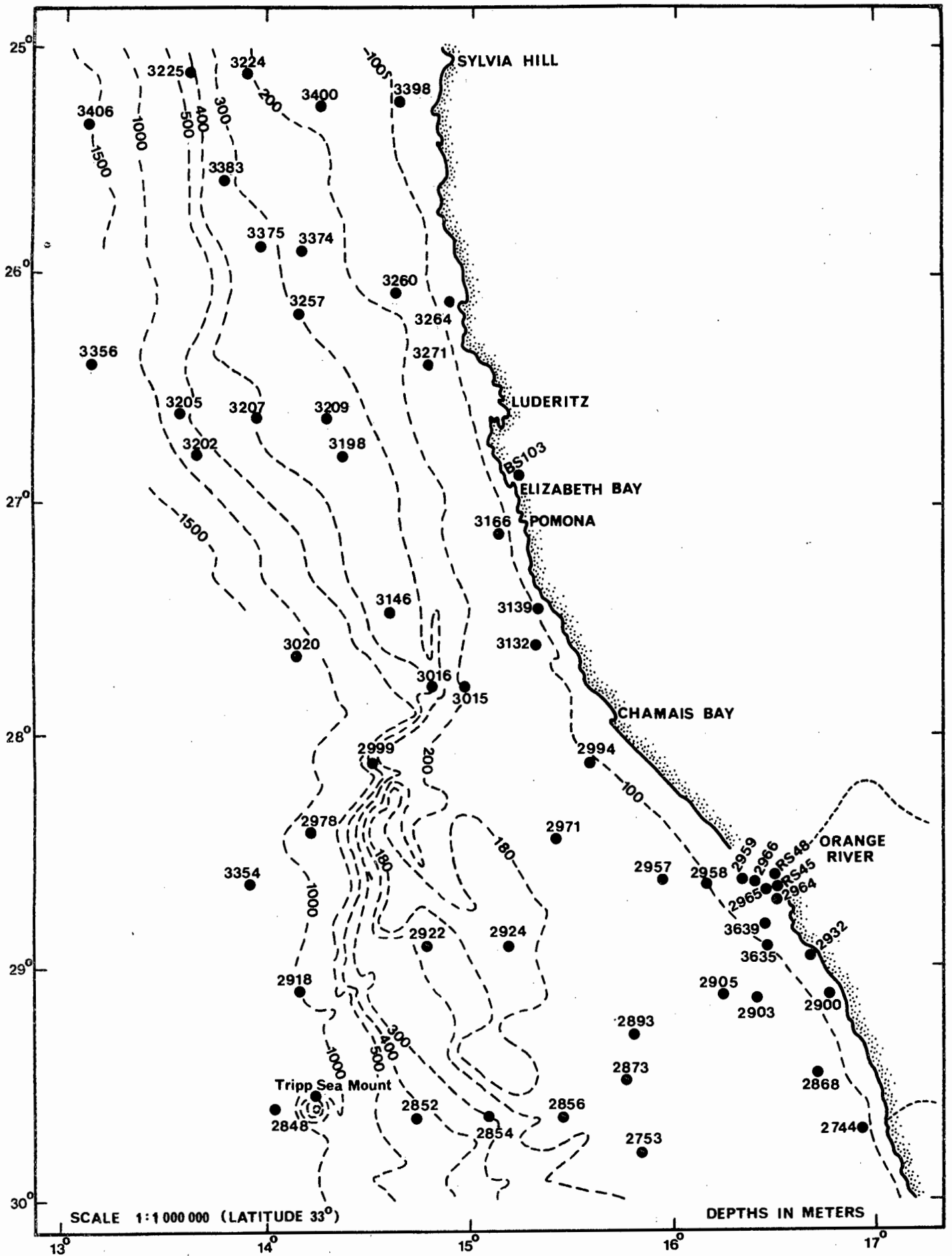


Figure 1. Bathymetry and sample locations

in depth between analogous features of the Recent and drowned deltas indicate a lowering of sea level of 110 m. In addition, two gravel beaches were discovered in the vicinity of the 75 m and 100 m contours between the Orange River mouth and Pomona. Assuming these are contemporaneous with the drowned delta, this evidence is in agreement with world-wide evidence for a lowering of sea level of 100 to 120 m during the Würm glaciation approximately 17 000 years B.P. (Butzer, 1971; Flint, 1971; Shackleton and Opdyke, 1973; in Rogers, 1977).

## 2.2 Sediments

Rogers subdivided the unconsolidated sediments of the study area into four types: 1) residual sediments reworked from bedrock, including glauconite and phosphorite; 2) relict sediments from Pleistocene regressions; 3) Recent terrigenous sediments; 4) Recent biogenic sediments, the bulk of which is composed of calcium carbonate and organic matter.

Recent terrigenous sands dominate the offshore sediments along the entire coastline within this area. These are flanked by Recent terrigenous muds north and south of the Orange River. Most of the shelf off the Orange River is covered with foraminiferal sediments; sands dominate the outer shelf, with muds occurring on both the middle shelf and upper slope. Northward, the foraminiferal muds of the upper slope merge with the glauconitic and phosphoritic sands of the middle and outer shelf.

## 2.3 Hydrography

The hydrography of the region is presently under investigation, and a detailed examination is not warranted in this study; however, a general description of conditions is necessary to an understanding of the environmental conditions affecting the types and distributions of the foraminifera. The major hydrographic features are the Benguela current system, and extensive nearshore upwelling.

The north-setting Benguela Current is a sluggish (0.5 to 1 knot) system operating over the shelf from Cape Point to latitude 23°S where it turns westward. It is separated from the warmer, steadier north-setting Trade Wind Drift by the Offshore Divergence, a zone which generally follows the shelf break. In naming the Benguela Current, Hart & Currie (1960) define it as the "region of cool upwelled coastal water along the south-west coast of Africa". Bang (1971) defines it as that area east of the Offshore Divergence within which oceanic processes are dominated by short-term atmospheric interactions. The overall trend of surface temperatures (Fig. 2) with colder water nearest the coast, is characteristic of active upwelling.

Beneath the Benguela occurs a south-setting oxygen deficient zone termed the DeDecker Current, an off-shoot of the oxygen-poor Angola Current. It can be several hundred meters thick, but thins toward the Orange River and continues southward in a narrow coastal belt. It thus forms a 1800 km stretch of minimal oxygen values, rising from 500 m to 300 m and reaches the vicinity of the shore south of the Orange River. It has been suggested that off Saldanha Bay and St. Helena Bay this oxygen

depleted zone is the cause of mass mortalities among diverse organisms (De Decker, 1970). The lowest oxygen values occur within a narrow temperature range (8.9°C to 9.6°C) (De Decker, 1970). The temperature range widens as the oxygen value increases. The salinity is only slightly lower than normal (34.65<sup>0</sup>/∞ to 34.75<sup>0</sup>/∞) in the areas of the oxygen minima.

The most notable hydrographic feature of the area is the extensive upwelling which occurs from Cape Point northward. The primary cause is the southerly coastal winds operating the length of the coast, affecting the area to approximately 36 km offshore. These winds, with the Coriolis effect, impart a net westward movement of the surface water which is replaced by cold, nutrient-rich water. This inflow of cold water is well illustrated by temperature curves which indicate inshore temperatures as low as 8°C to 10°C. Bang's temperature curves of Feb., 1966 (Fig. 3) show no indications of active upwelling, but Hart & Currie (1960) show two phases in their temperature and salinity curves (Fig. 4&5). Survey I (March, 1950) demonstrates a "quiescent phase subsequent to upwelling", while Survey II (October, 1950) shows a "phase of active upwelling". The upwelling along the west coast is best developed off Luderitz and just south of the Kunene River. Elsewhere the winds are less constant and upwelling is subject to seasonal fluctuations.

The records of the Department of Sea Fisheries give an indication of the prevailing temperatures and salinities in the study area. These are recorded at intervals from the surface to within a few meters of the bottom. Generally, temperatures near the bottom of inshore stations range from 9°C to 10°C, with surface temperatures as high as 20°C. At deeper stations, the temperature drops to just over 3°C. Salinities are normal, varying between 34<sup>0</sup>/∞ and 36<sup>0</sup>/∞. The Orange River estuary, however, shows extreme variation. Brown (1959) measured the salinity at low water springs and high water springs and found it to be 6.33<sup>0</sup>/∞ just off the bar at the river mouth at low tide, and 34.7<sup>0</sup>/∞ on the upstream side of the bar at high tide. These conditions have a profound influence on the fauna of the area.

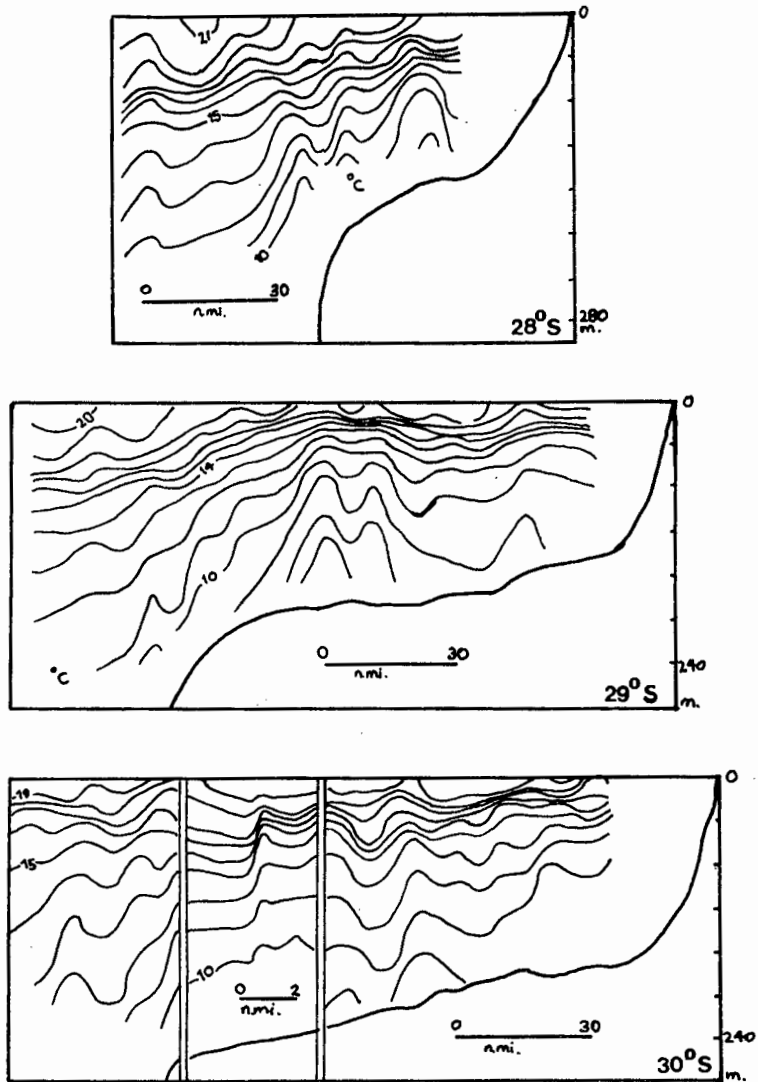


Figure 3. Temperature curves for February, 1966 (after Bang, 1971)

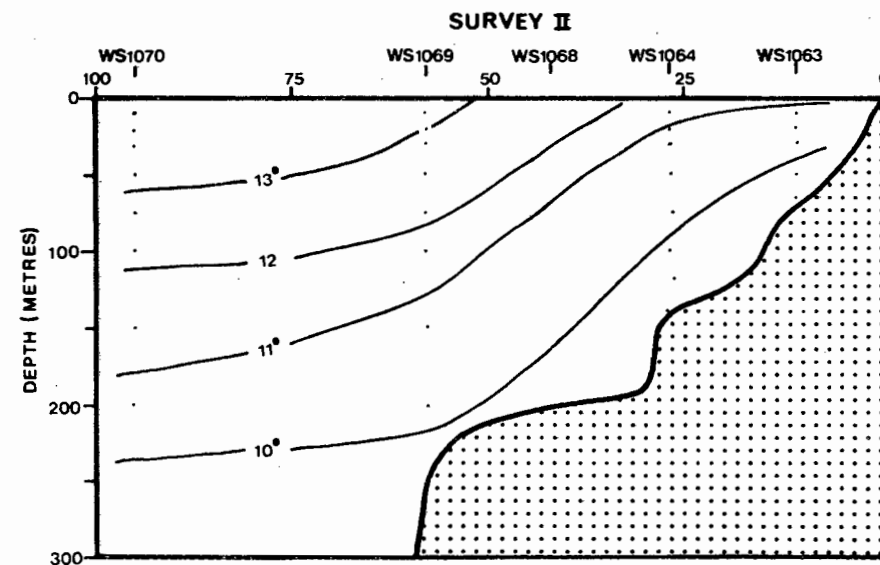
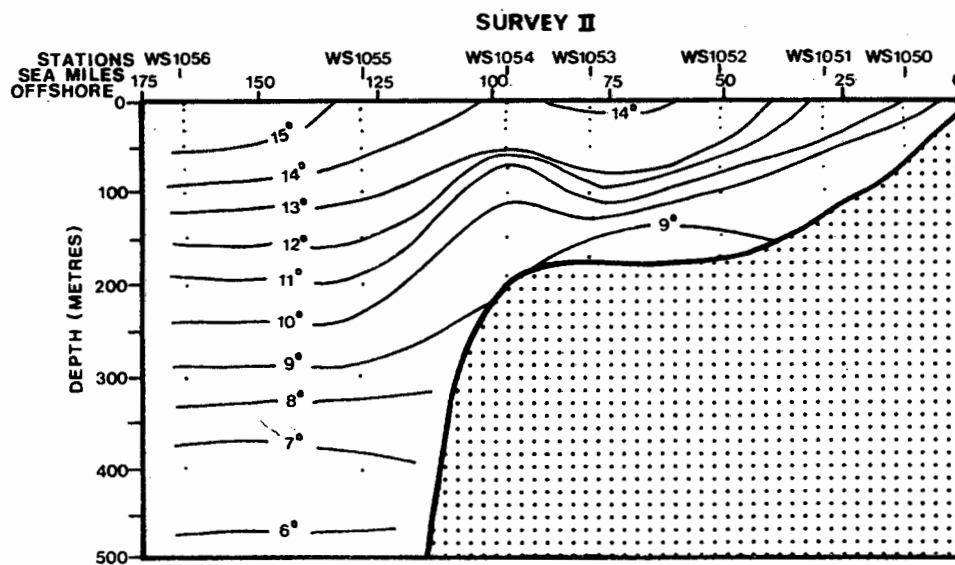
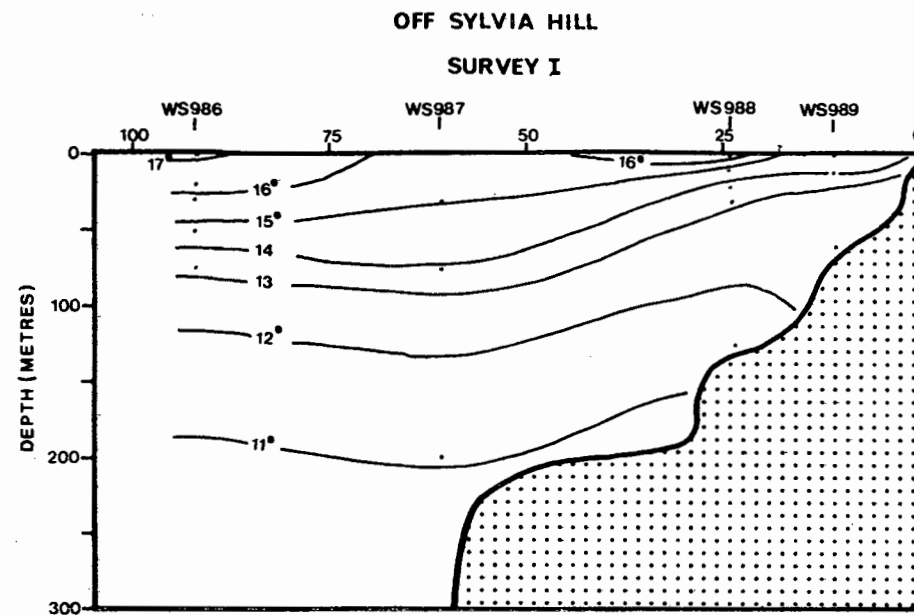
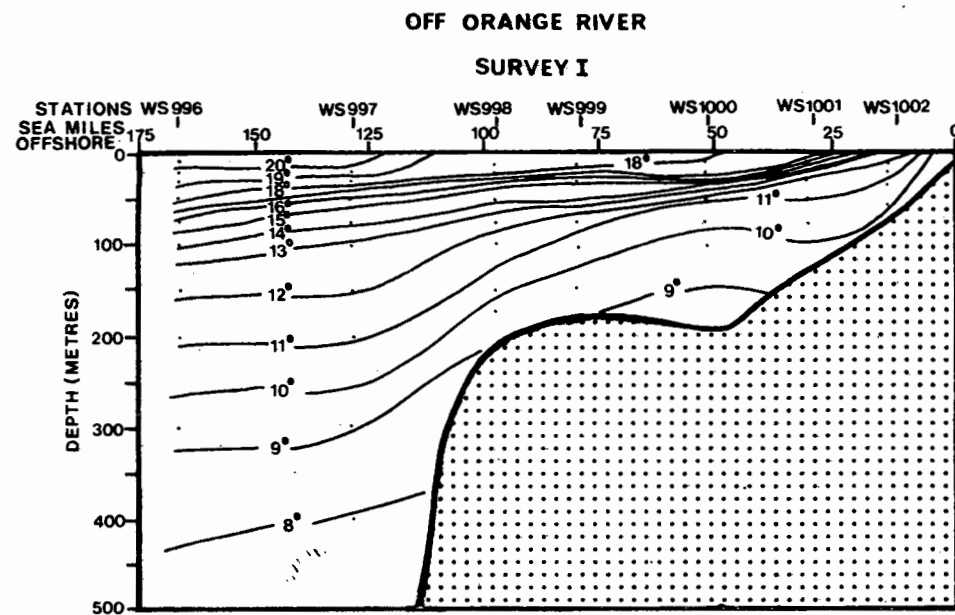


Figure 4. Temperature curves for March, 1950 (Survey I) and September-October, 1950 (Survey II). No upwelling is shown in Survey I; Survey II indicates a phase of active upwelling. (After Hart & Currie, 1960)

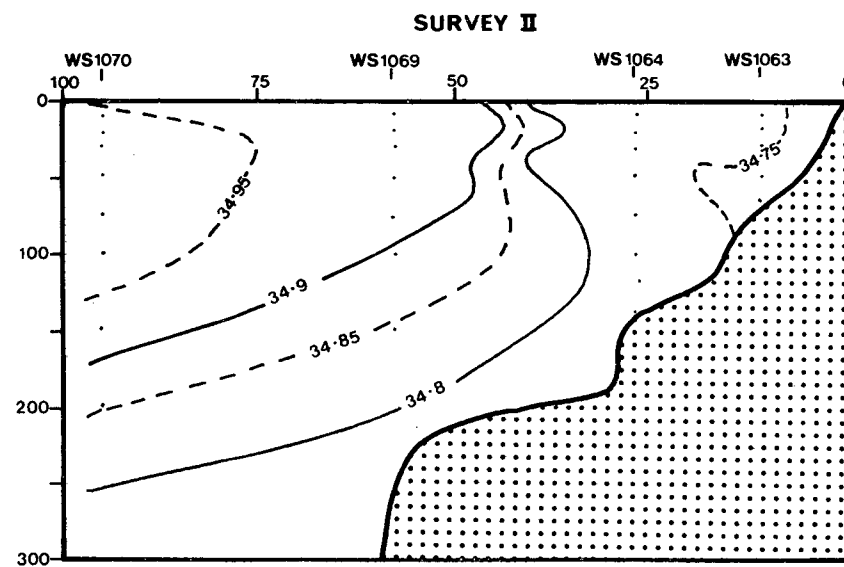
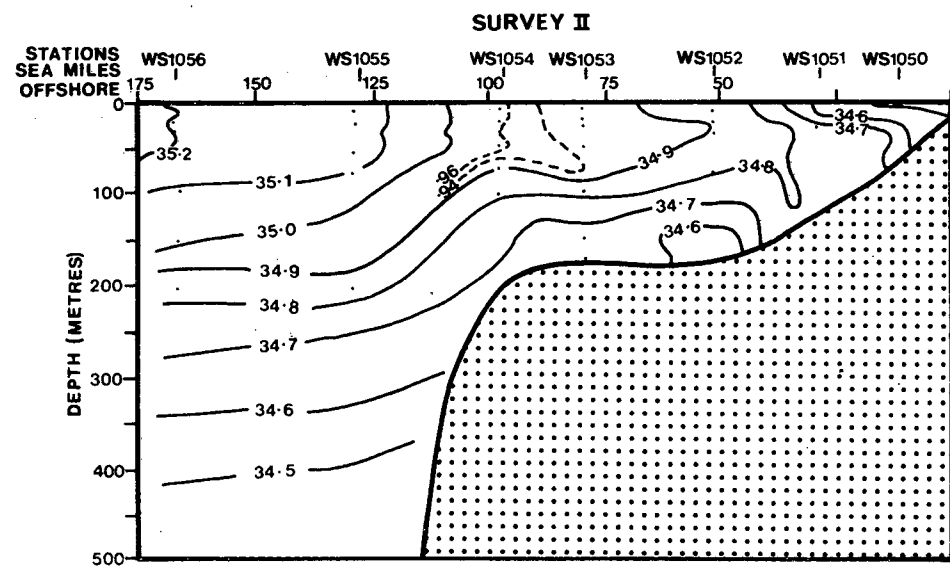
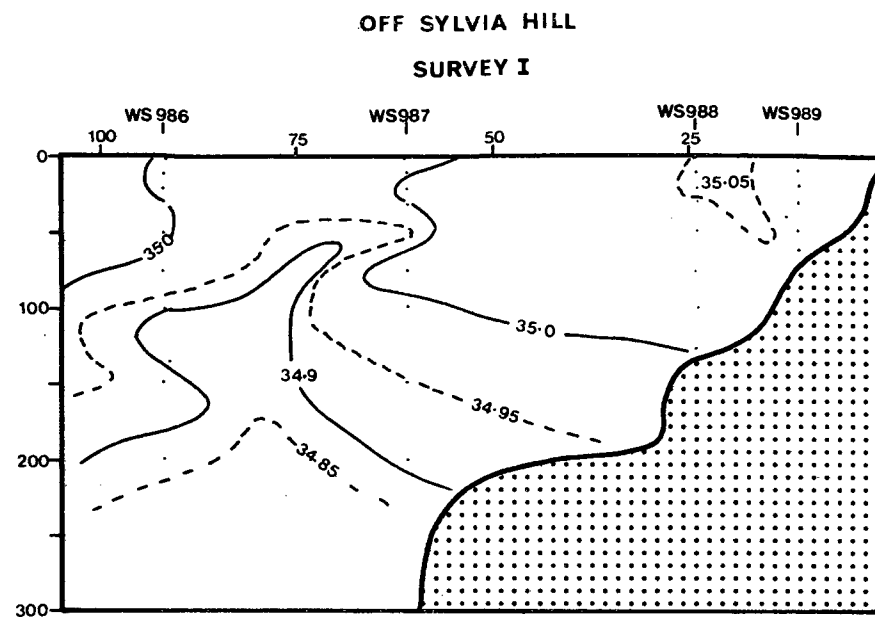
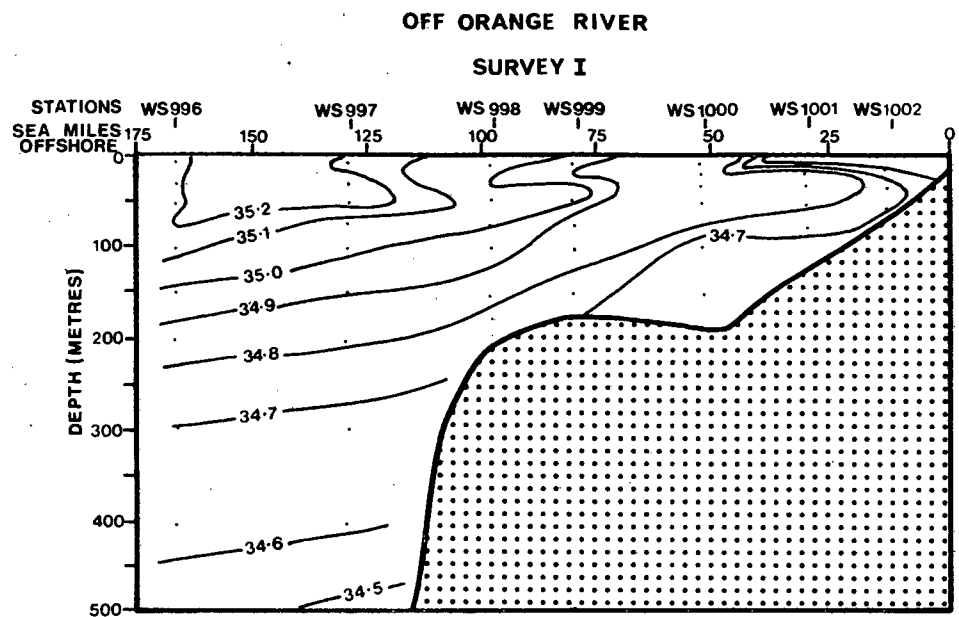


Figure 5. Salinity curves for March, 1950 (Survey I) and September-October, 1950 (Survey II). (After Hart & Currie, 1960)

## CHAPTER III. FORAMINIFERAL DISTRIBUTION

3.1 General Statement

Many diverse, but interrelated factors influence the distribution of benthic foraminifera. Those such as temperature, depth, and salinity have been extensively studied, whereas others such as nutrients, currents and tides, oxygen levels, and substrate have been given less attention. All will be briefly discussed in the context of the present study. Most information regarding the various factors is drawn from Boltovskoy and Wright (1976) and Murray (1973).

3.2 Temperature

Zoogeographic studies generally produce zonations based on faunas characterized by different temperature ranges. Foraminifera lend themselves well to such studies because their diversity and abundance are sensitive to changes in the environment. Boltovskoy and Wright (1976) have prepared a map of biogeographic zones of the world based on studies of littoral foraminifera (Fig. 6). They have delineated three major regions characterized by the types of foraminifera present. These are: areas of warm water fauna; temperate water fauna; and cold water fauna. This delineation cannot, however, be confidently extended to deeper waters; knowledge of the faunas is insufficient, and the deeper oceans are fairly monotonous in their environmental conditions and faunas. The present study area falls within the temperate faunal region as described by Boltovskoy and Wright (1976), though in deeper areas, bottom temperatures fall as low as 3°C. A number of the genera present in this area are recognized by Murray (1973) as cold to temperate water dwellers, among them Brizalina, Bulimina spp., Cassidulina, Uvigerina, Bolivina spp., Eggerella, Eponides spp., Fissurina, Gyroidina, Karreriella, Martinotiella, Nonion, and Pullenia. These are generally moderate to deep water dwellers.

The influence of temperature, however, extends to other features such as growth rate, reproduction, and morphology. Bradshaw's (1957) study of Streblus beccarii var. tepida indicated growth stops in that species below 10°C and above 30° to 35°C; reproduction takes place between 20°C and 30°C. Laboratory studies on other species indicate a similar pattern, each species having a fairly narrow range for growth and reproduction, but with the ability to survive in a much broader temperature range. It is obvious, therefore, that temperature greatly influences the species present in an area, particularly in shallow waters, and may help determine abundance through its effect on reproduction.

3.3 Salinity

Foraminifera display a wide range of tolerance to varying salinity; values within a range of 30<sup>o</sup>/oo to 40<sup>o</sup>/oo have little effect on the foraminiferal populations. Many species which survive wide fluctuations in salinity, however, reproduce only within a much narrower range. Salinity variations may also affect test morphology,

120

0

120

60

60

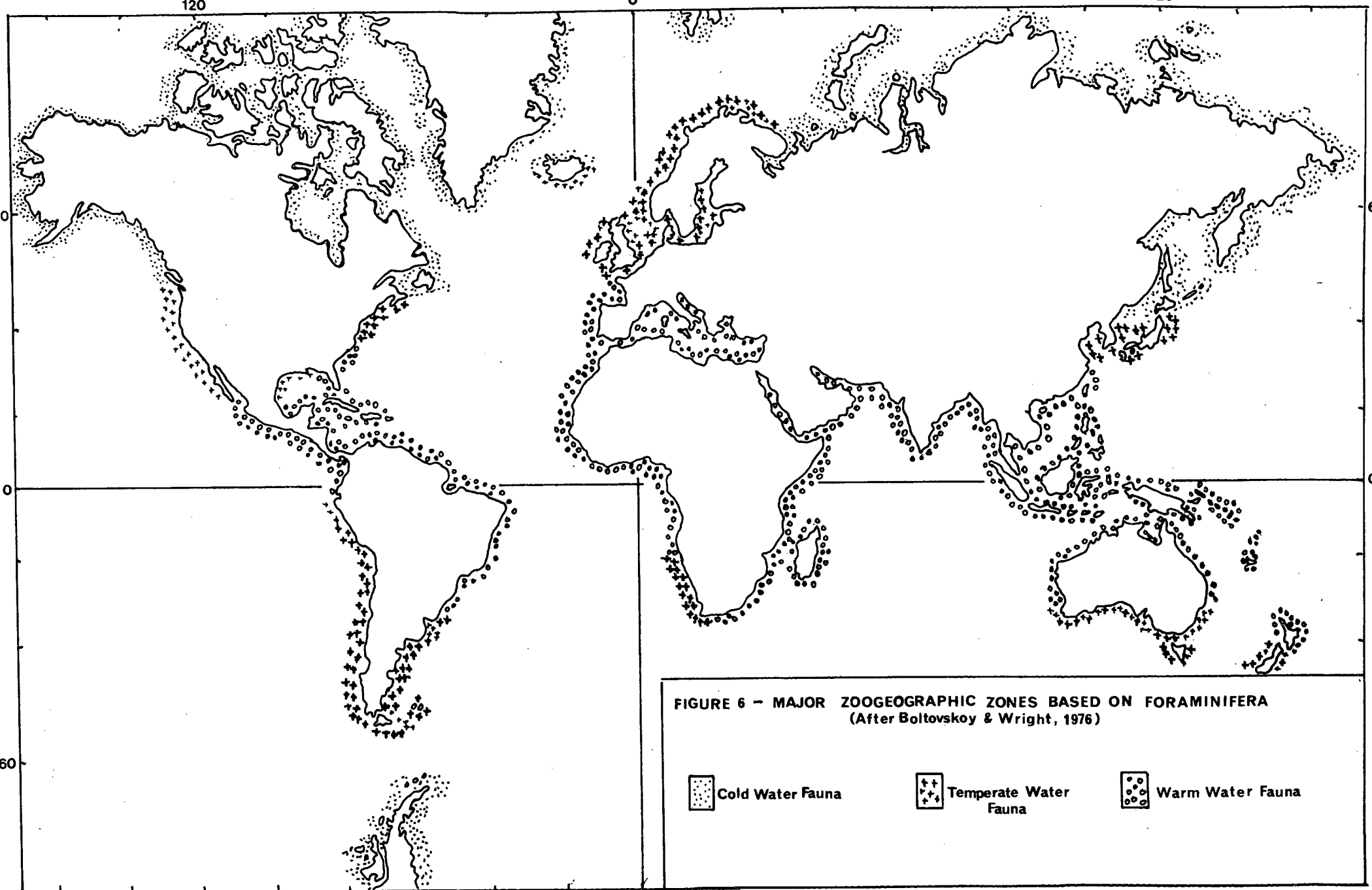
0

0




60

120

0



**FIGURE 6 - MAJOR ZOOGEOGRAPHIC ZONES BASED ON FORAMINIFERA**  
(After Boltovskoy & Wright, 1976)

 Cold Water Fauna	 Temperate Water Fauna	 Warm Water Fauna
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as studies on Ammonia beccarii have suggested. Specimens of A. beccarii taken from an area in the Black Sea where salinity ranged between  $16^{\circ}/\text{oo}$  and  $22^{\circ}/\text{oo}$  displayed fewer chambers, were smoother, and lacked ornamentation and umbilical plugs (Fursenkou, 1959, in Boltovskoy and Wright, 1976).

Except at the Orange River Mouth, salinities in this area are normal ( $\sim 35^{\circ}/\text{oo}$ ), and the fauna is correspondingly a normal marine fauna. The nearshore samples, and particularly those from the Orange River mouth contained a foraminiferal population with known tolerance to salinity fluctuations. The Orange River samples contained only two species, Ammonia beccarii and Elphidium gunteri. Both of these are common in low salinity environments in many parts of the world. In addition, A. beccarii showed morphologic features which may have been influenced by the low salinity; it was generally much smaller in the Orange River samples than elsewhere, and showed very little excavation in the umbilicus, though most specimens had umbilical plugs.

#### 3.4 Depth

The influence of depth on foraminiferal distribution is difficult to assess because many other influential factors such as pressure, light, temperature, oxygen content, and calcium carbonate solubility vary with depth. Numerous authors, however, have demonstrated that the composition of a fauna varies with depth and many benthic species have the same upper depth limit in various parts of the world, despite diverse temperatures. Conversely, many species are found at diverse depths. These would appear to be primarily affected by the physio-chemical characteristics of the overlying water mass, and two water masses with the same characteristics may occur at different depths. Various morphologic and distributional characteristics, however, indicate depth, with its related parameters, does have a direct effect on some foraminifera. For example, Elphidium is always found in shallow water, and Bolivina habitually occurs in a given depth range regardless of other environmental features.

When foraminifera live in an area outside their optimum depth range, morphologic alterations may occur. In the present study area this was noted in a few cases. Cibicides lobatulus in the deeper samples, and particularly from the Tripp Sea Mount became more spreading, slightly flattened, and developed more deeply depressed sutures. Cassidulina carinata developed a more prominent carina as depth increased. The tendency for C. carinata to change the configuration of its keel and aperture was also noted by Eade (1967) in samples from New Zealand. The character of the uvigerinids changed from costate to hispid in the deeper samples, a tendency which has also been noticed in many parts of the world. A complete bathymetric zonation of the study area is given in section 3.9.

#### 3.5 Nutrients

The supply of nutrients in an area has an obvious effect on the foraminiferal population. A variety of phytoplankton serve as nutrients, as do algae, seaweed,

bacteria, small echinoderms, copepods, and nematodes. Too little nutrition affects foraminiferal chamber growth, causing chambers to become shorter and smaller. Seasonal variation in nutrition affects abundance as well as morphology.

In the study area, the supply of nutrients is apparently excellent, due primarily to the upwelling of water rich in phosphorous and nitrogen. Fig. 7 shows the distribution of microplankton found by Hart & Currie (1960). In both surveys, the richest concentrations are found in the area off Sylvia Hill. The lack of rich plankton off the Orange River in Survey I was attributed to intense grazing, and in Survey II to the plankton not yet having become established after the recent upwelling. A study of the living population over a period of time would be necessary to assess seasonal fluctuations in the nutrient supply.

### 3.6 Oxygen level

A lowered oxygen content can affect foraminifera but, except in the case of a totally anoxic environment, is apparently not a limiting factor in their existence. Generally, the number of benthic foraminifera tends to decrease with lowered oxygen content; however, Bolivina and its close relatives Brizalina and Suggrunda appear to be enhanced by a decrease in oxygen. Morphologic alterations take place in areas of low oxygen concentration, but even these are not clear, as some authors noted species to be well-developed whereas others found them to be poorer. In the present study area it would again be necessary to sample the standing crop over a period of time, especially when the DeDecker current is operating strongly to determine what effect, if any, there is on the benthic foraminifera.

### 3.7 Currents and tides

Currents and tides within an area can affect the distribution of both living and dead foraminifera in a number of ways. Dead tests generally behave as sediment grains of the hydrodynamic equivalent, although decaying protoplasm within may produce gases which result in increased buoyancy. Thus, tests of benthic foraminifera have been found in plankton tows, and their distribution after death may be quite different than in life, particularly in areas where strong currents are active. Living foraminifera may be affected if water movement is strong enough to break up the reticulation of their pseudopodia, thus transporting them as sediment grains. Additionally, currents and tides transport nutrients and water masses thereby helping to establish the environmental conditions, and can also bring about morphologic changes, such as the reinforcing of tests in high energy areas.

In the present study area, there has probably been some transport of dead tests, however a study of the living population is necessary to establish the extent of such transport. Off the Orange River mouth it is clear that the inflow of water affects the foraminiferal population. Samples taken near the mouth were uniformly poor in foraminifera and high in organic detritus. It is probable that a combination of factors such as high energy and lowered salinity is responsible for the paucity of foraminifera.

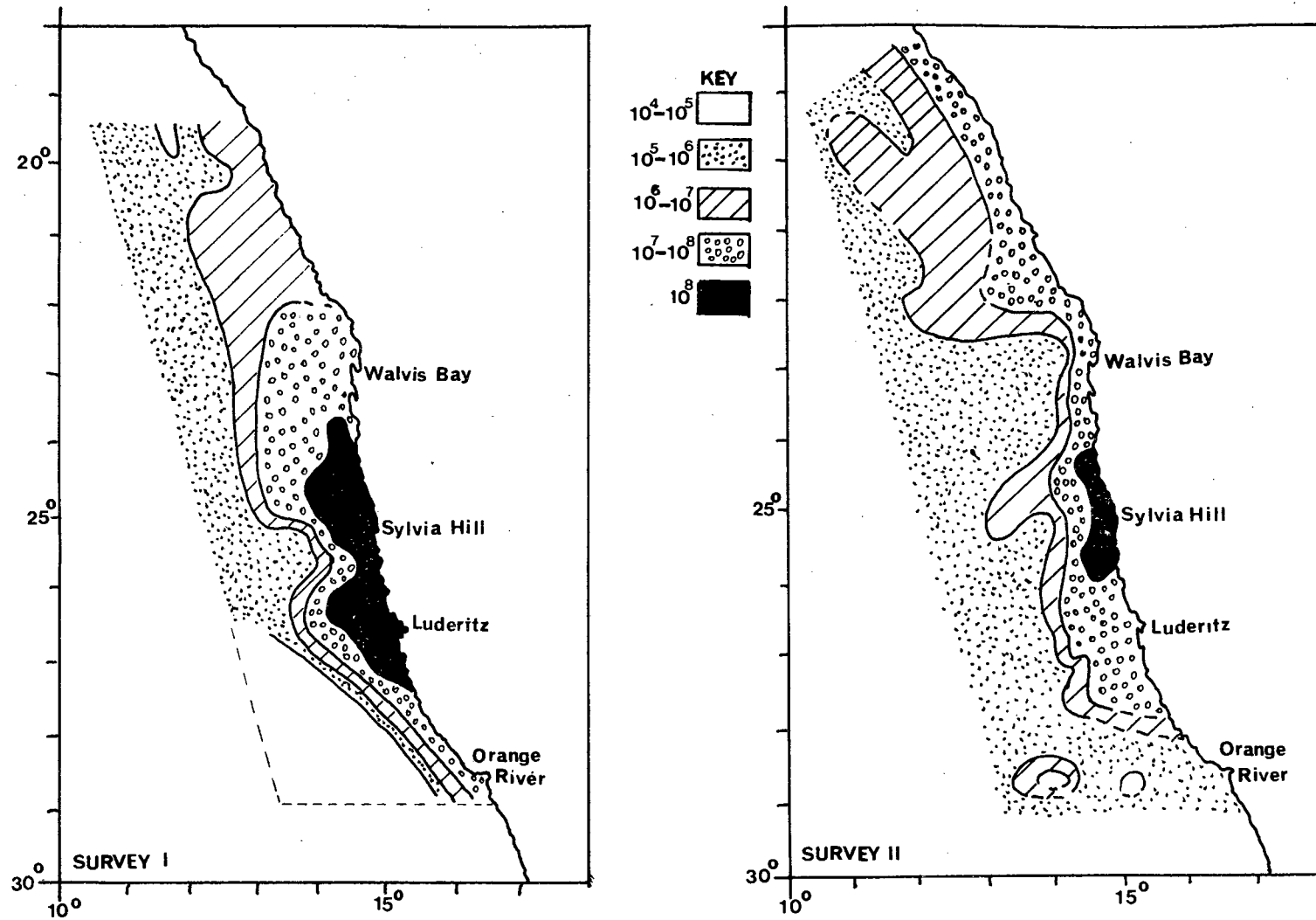


Figure 7. Distribution of microplankton, estimated total per net haul. Survey I, March, 1950; Survey II, September-October, 1950. (After Hart & Currie, 1960)

### 3.8 Substrate

Of all the factors influencing the distribution of benthic foraminifera, substrate is probably the most controversial. Large bodies of evidence have been presented indicating substrate type exerts great influence over the foraminiferal distribution. Equally large bodies of evidence indicate there is no correlation at all. If a substrate preference does exist, it is possibly due to grain size or sediment cohesion, as a non-cohesive sediment may tear the protoplasm apart, and a coarse grain size may restrict movement.

Rogers' (1977) lithofacies map (Fig. 8) provides an excellent basis for comparison between substrate type and foraminiferal distribution in the study area, although it must be remembered that these are distributions of dead tests only. Figures 9-20 show the relationships between substrate types and the distribution of 12 selected species.

Ammobaculites americanus (Fig. 9) occurs at 28 stations of which 20 have <25% mud; it occurs abundantly only twice in stations with >25% mud, both off the Orange River mouth.

Bolivina subspinescens (Fig. 10) occurs at 12 stations, 10 of which are in areas of >25% mud or >75% mud. It may avoid areas of very low mud content as indicated by its absence in outer shelf stations in the south.

Brizalina spathulatus (Fig. 11) occurs in all sediment types in the area.

Cassidulina carinata (Fig. 12) occurs in all sediment types and is abundant in all sediments, though most often in sandy sediments of both terrigenous and biogenic origin.

Cibicides lobatulus (Fig. 13) occurs abundantly only on the Tripp Sea Mount, but 13 of the 21 stations in which it occurs are located in sediments comprised primarily of terrigenous sand.

Elphidium advenum (Fig. 14) is common or abundant in a line of stations in just over 100 m of water, but is never abundant in stations with >75% mud, even when these stations fall near the 100m contour.

Florilus boueanum (Fig. 15) is restricted in its bathymetric range, but occurs in all sediment types within that range.

Hoeglundina elegans (Fig. 16) occurs in all sediment types, but most often in biogenic sands and muds.

Quinqueloculina agglutinans (Fig. 17) occurs in all sediments, though only once in >75% mud.

Textularia millettii (Fig. 18) occurs in biogenic muds and sands.

T. saggitula (Fig. 19) is present in all sediment types except where mud content is >75%.

Uvigerina peregrina (Fig. 20) occurs in all sediment types and is abundant in most. It appears to avoid glauconitic and phosphoritic sediments, as its concentrations in these sediments are very low despite being in its bathymetric zone of abundance.

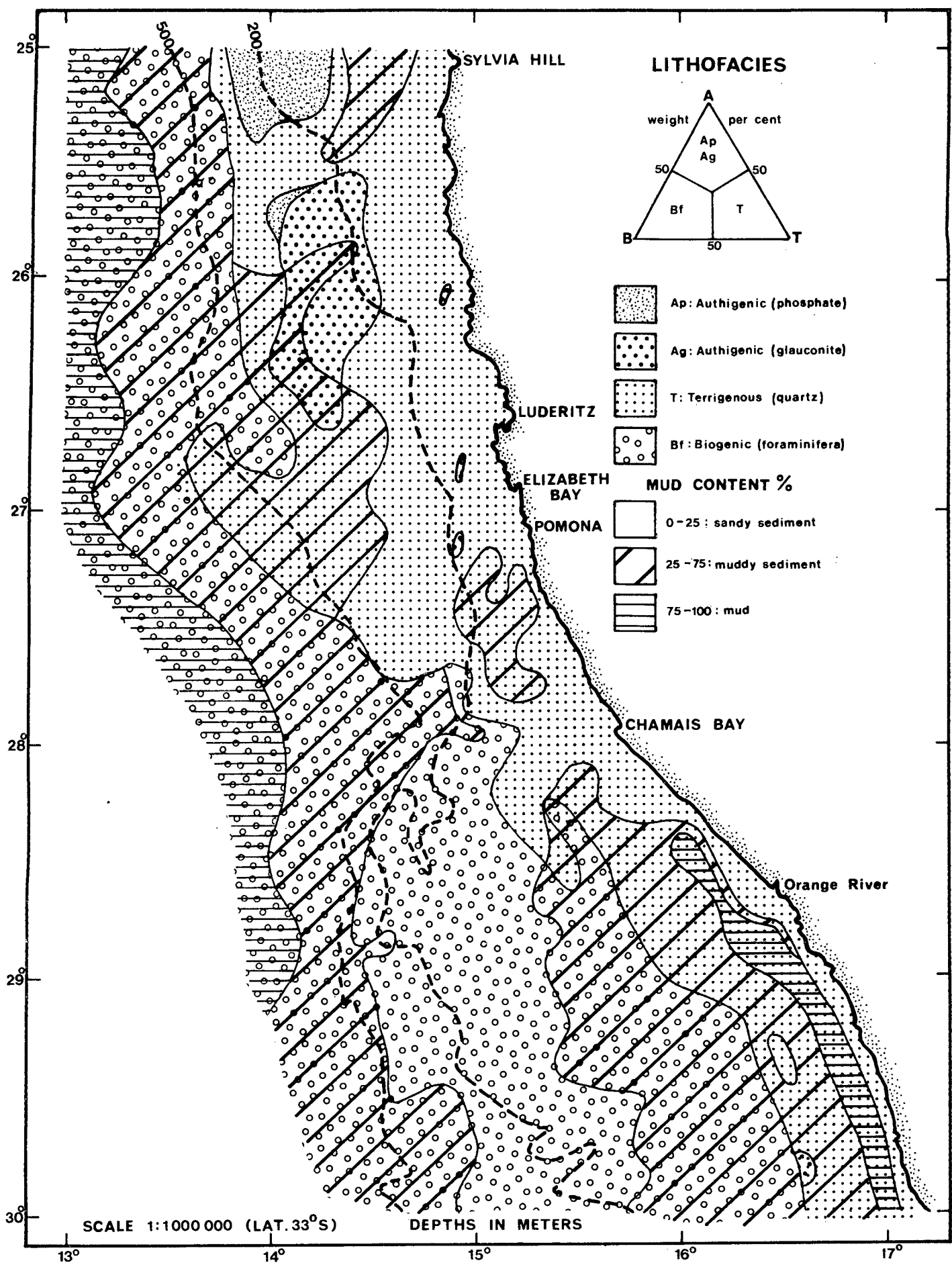


Figure 8. Lithofacies (after Rogers, 1977)

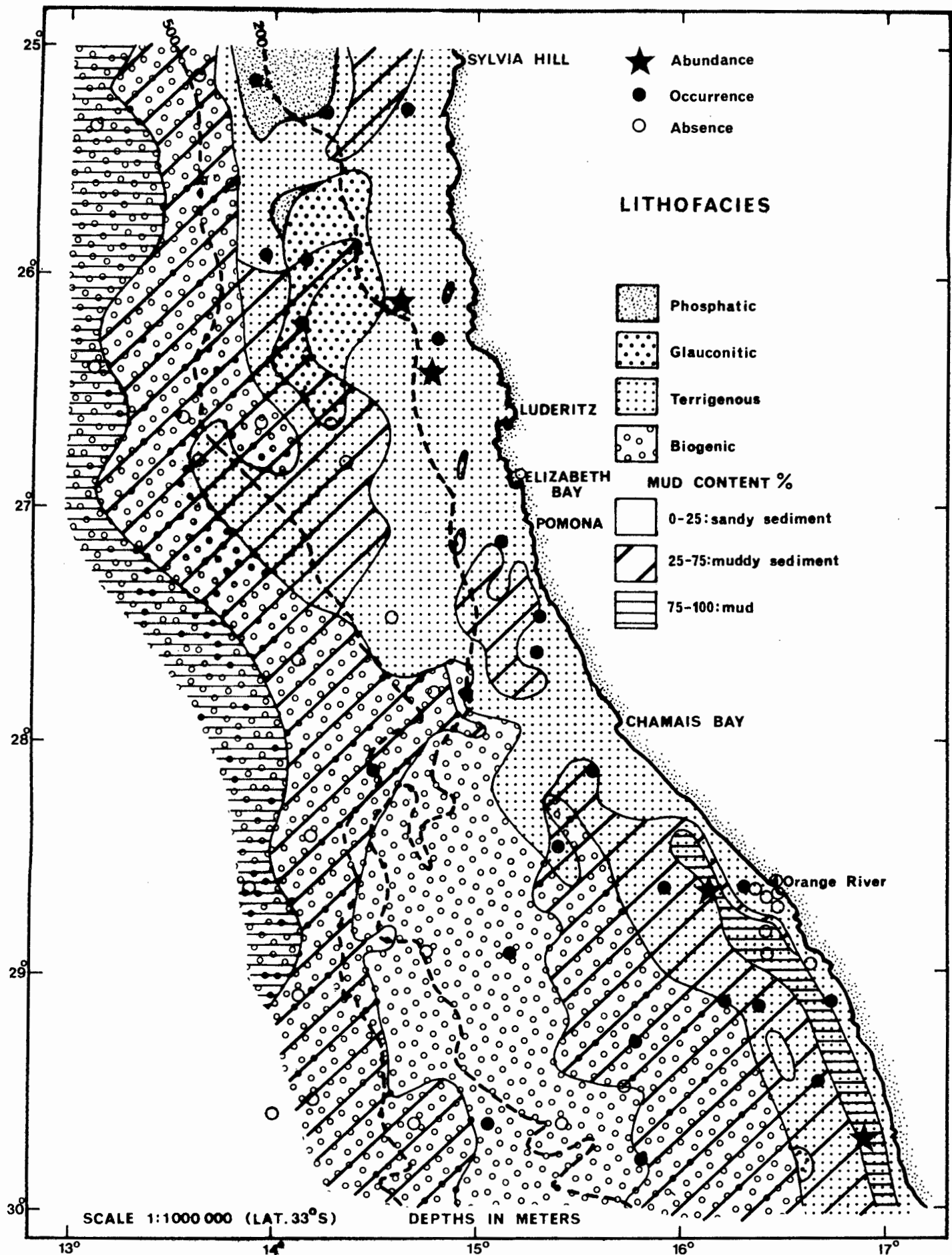


Figure 9. Distribution of *Ammobaculites americanus*

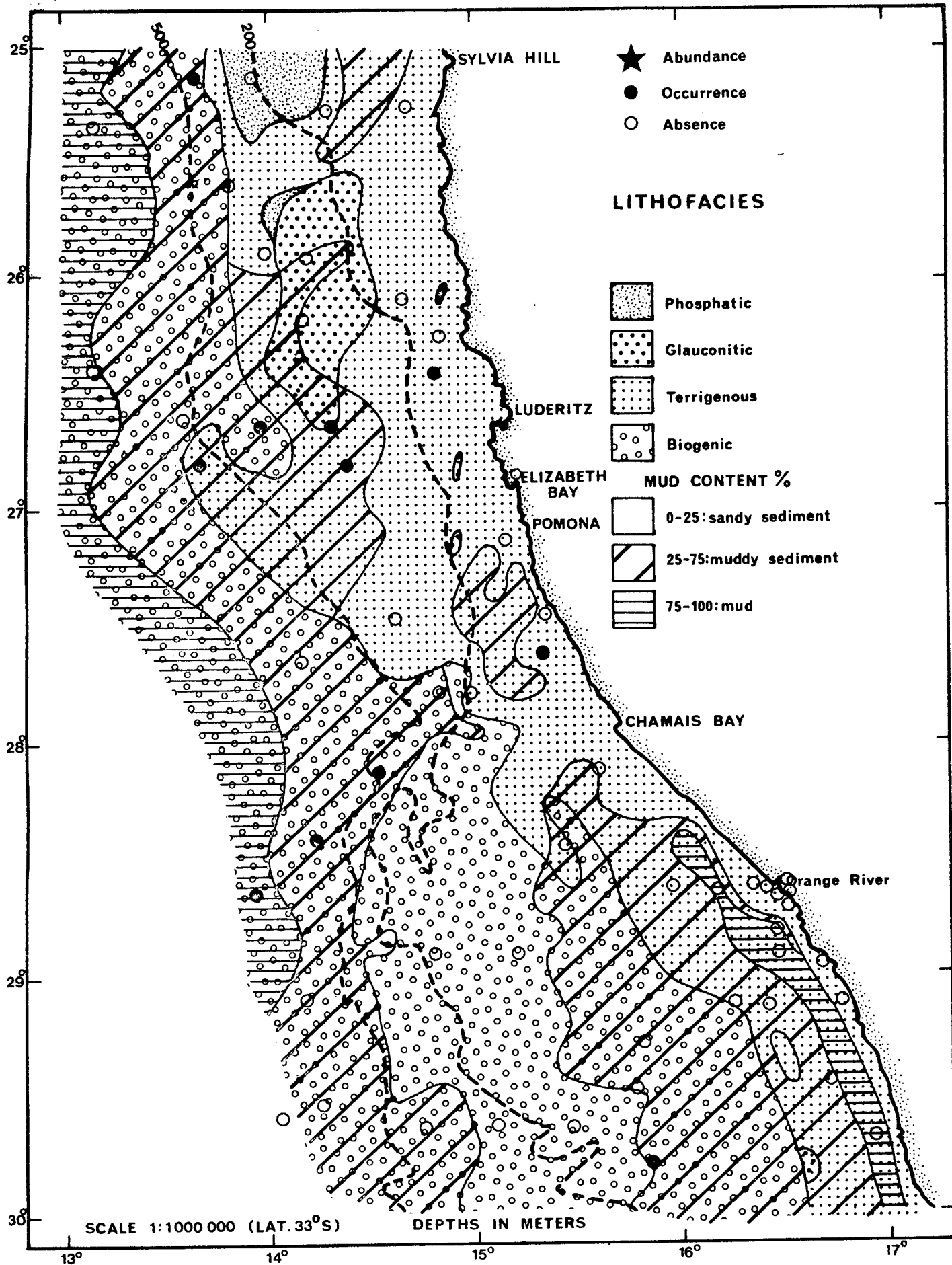


Figure 10. Distribution of *Bolivina subspinescens*

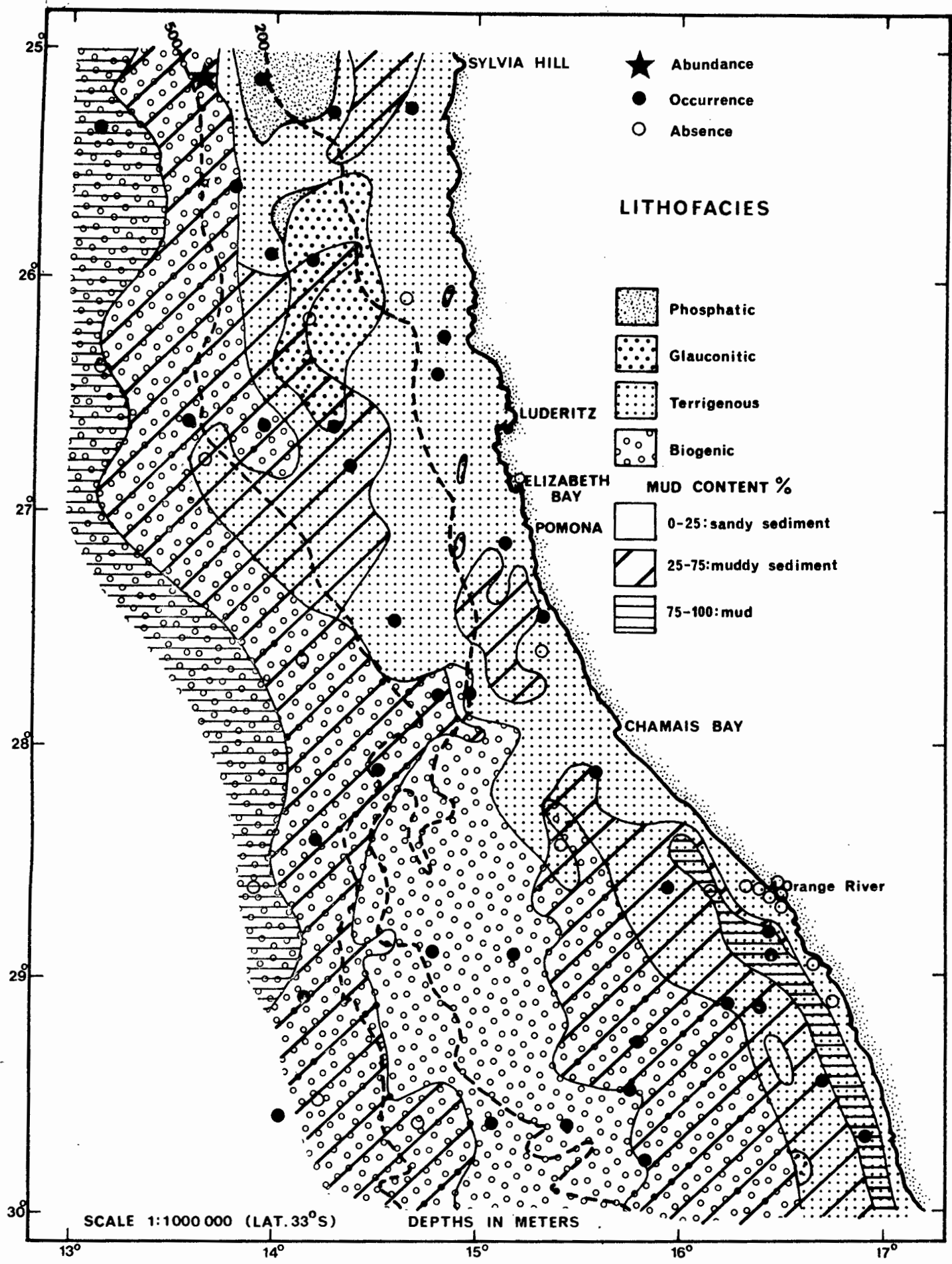


Figure 11. Distribution of *Brizalina spathulatus*

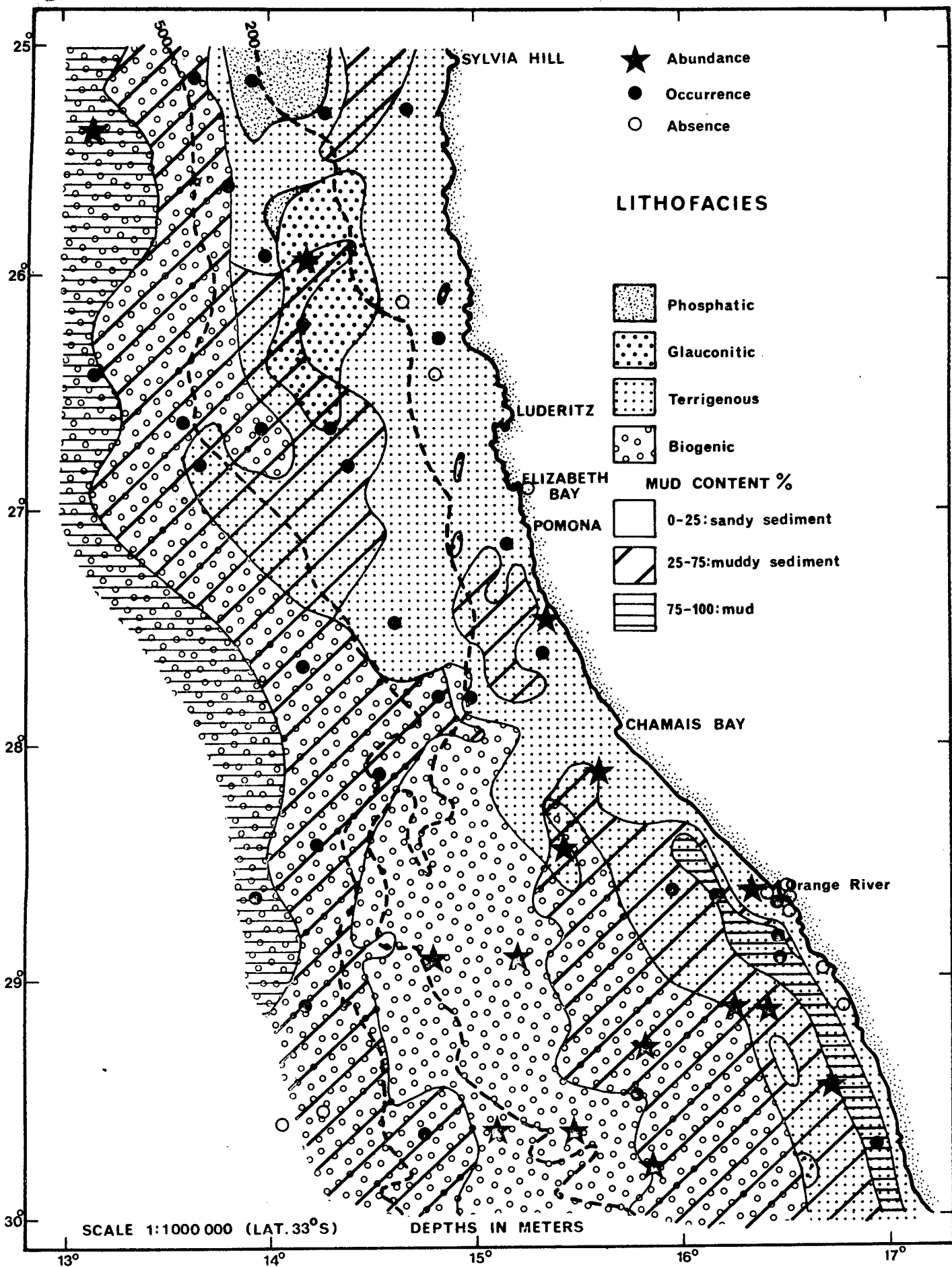


Figure 12. Distribution of *Cassidulina carinata*

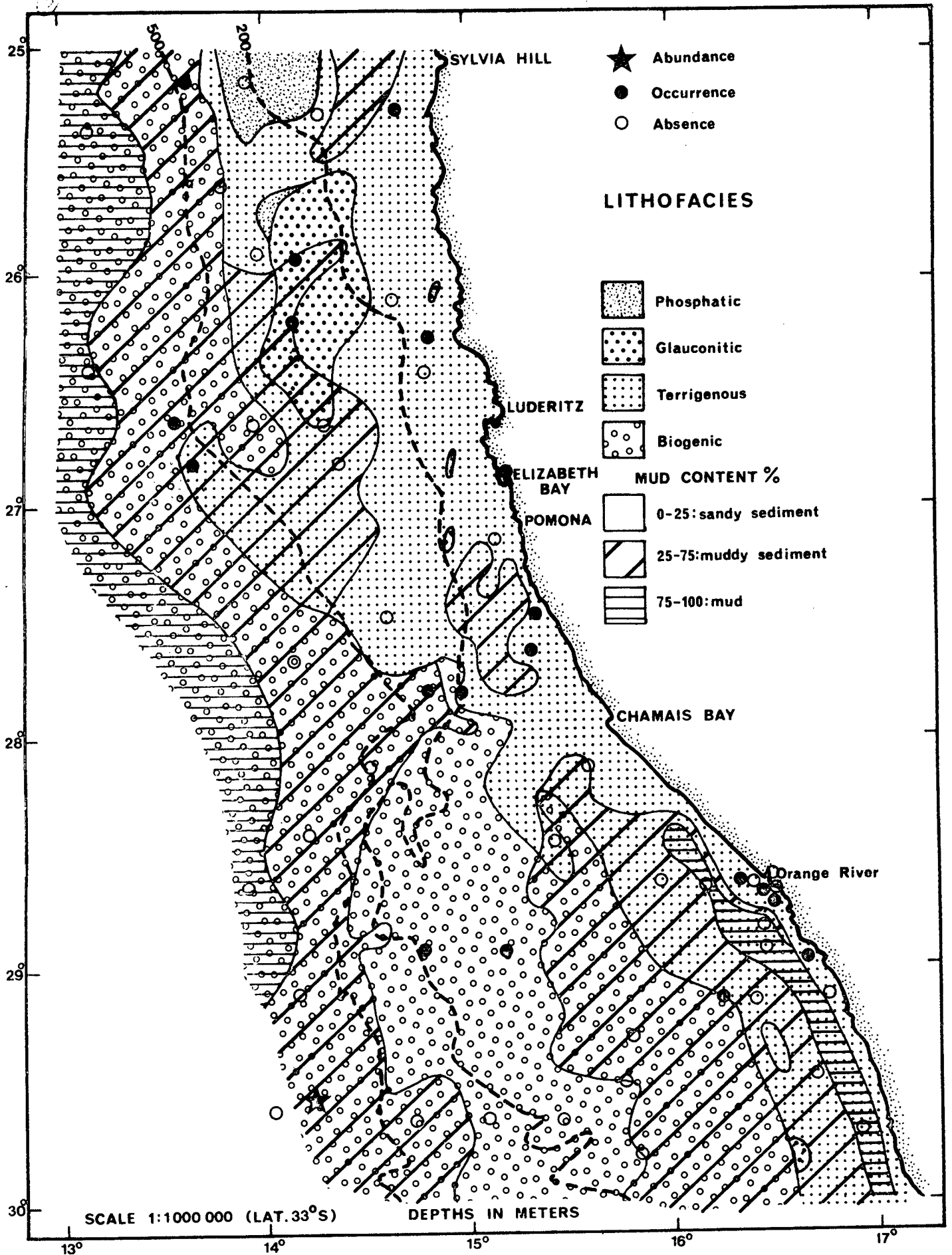


Figure 13. Distribution of *Cibicides lobatulus*

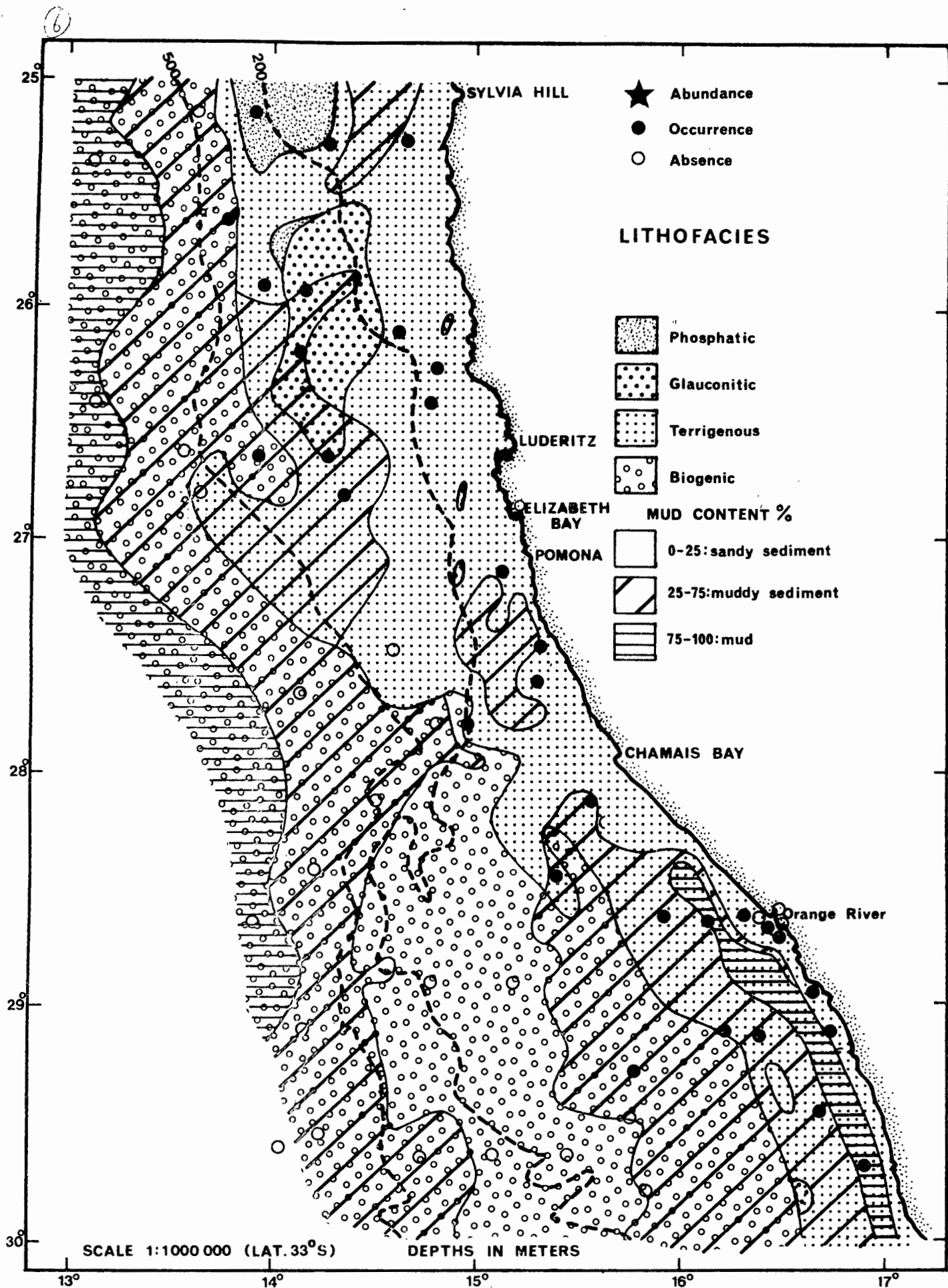


Figure 14. Distribution of *Elphidium advenum*

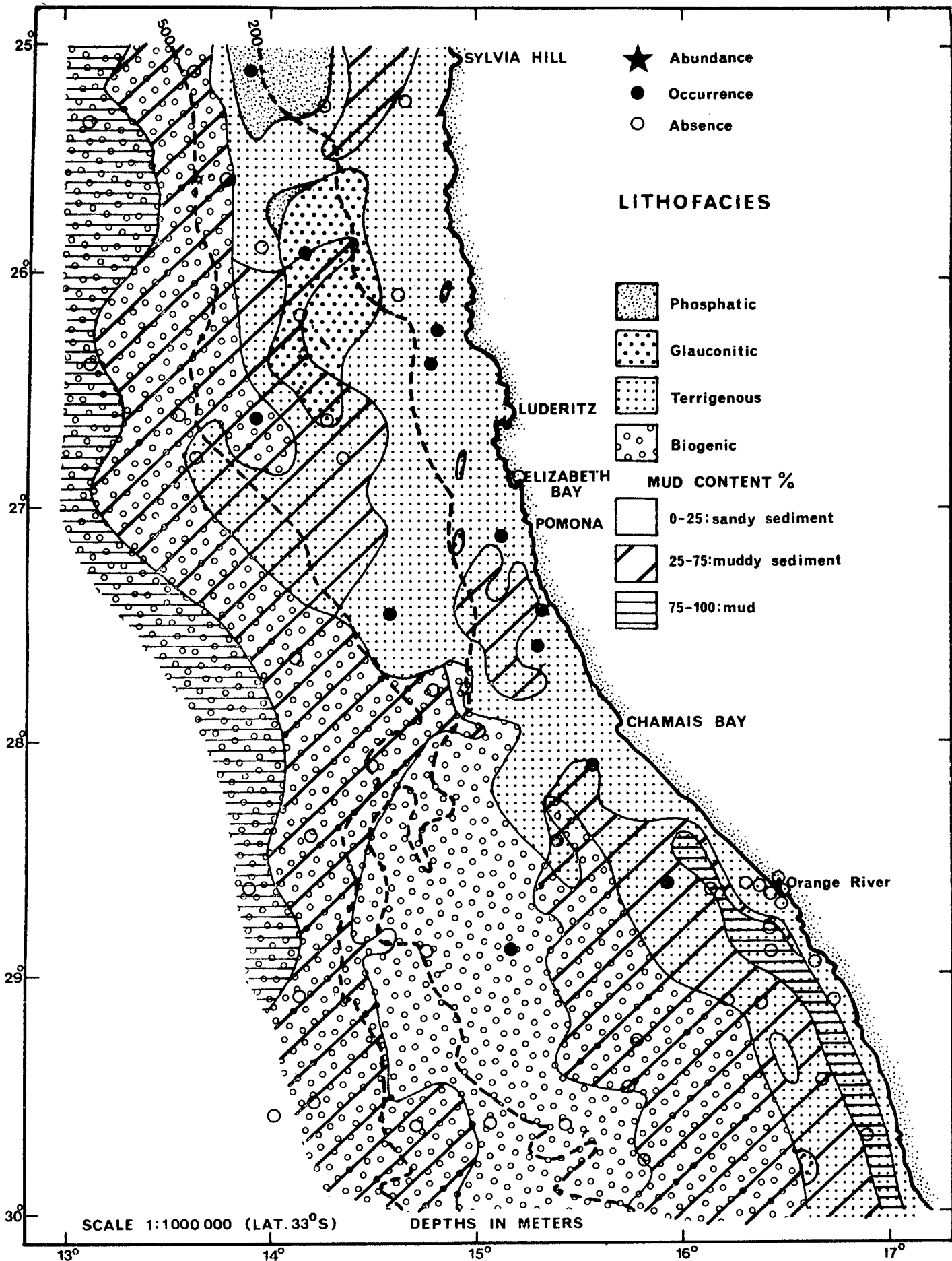


Figure 15. Distribution of *Florilus boueanum*

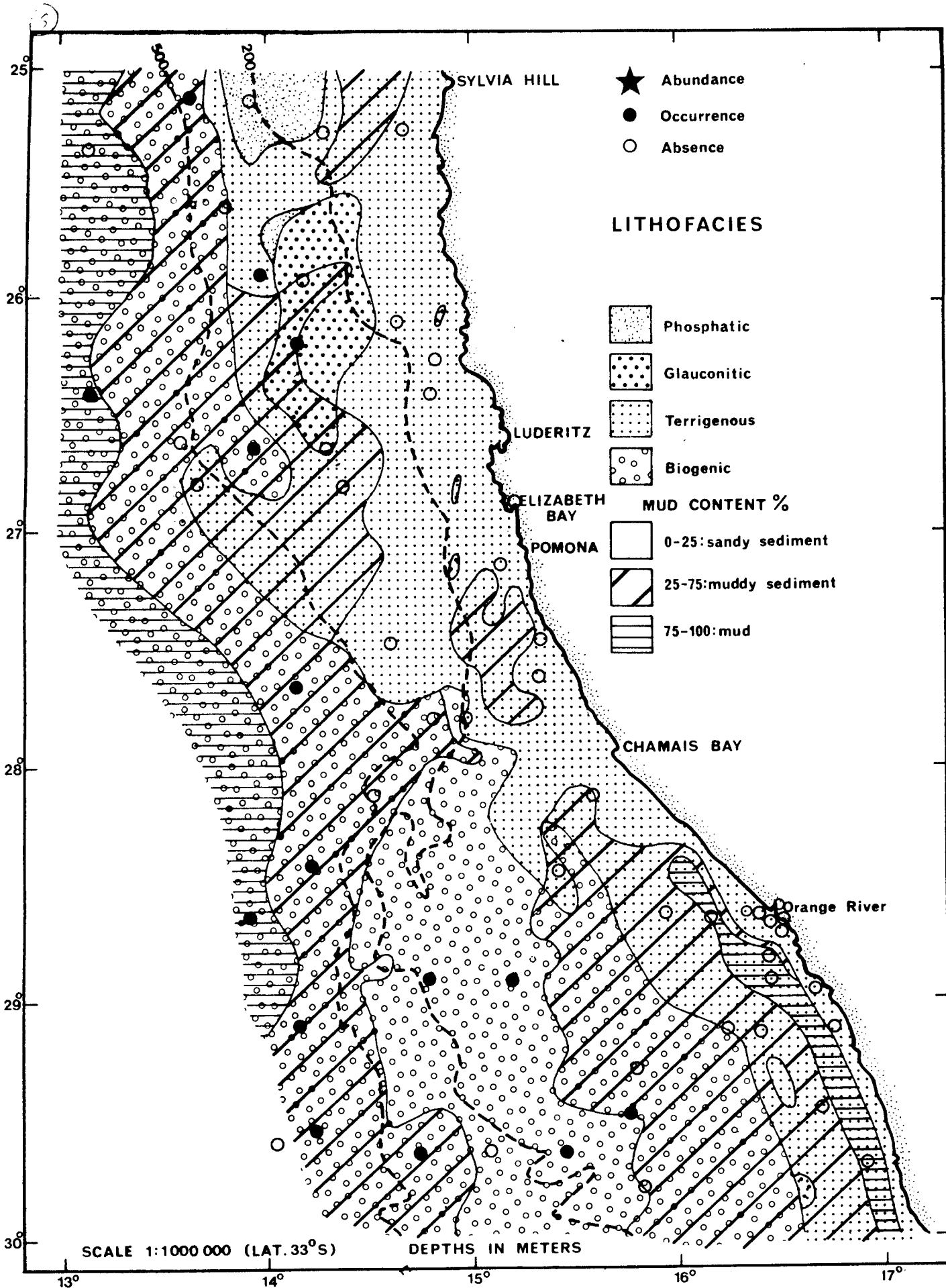


Figure 16. Distribution of *Hoeglundina elegans*

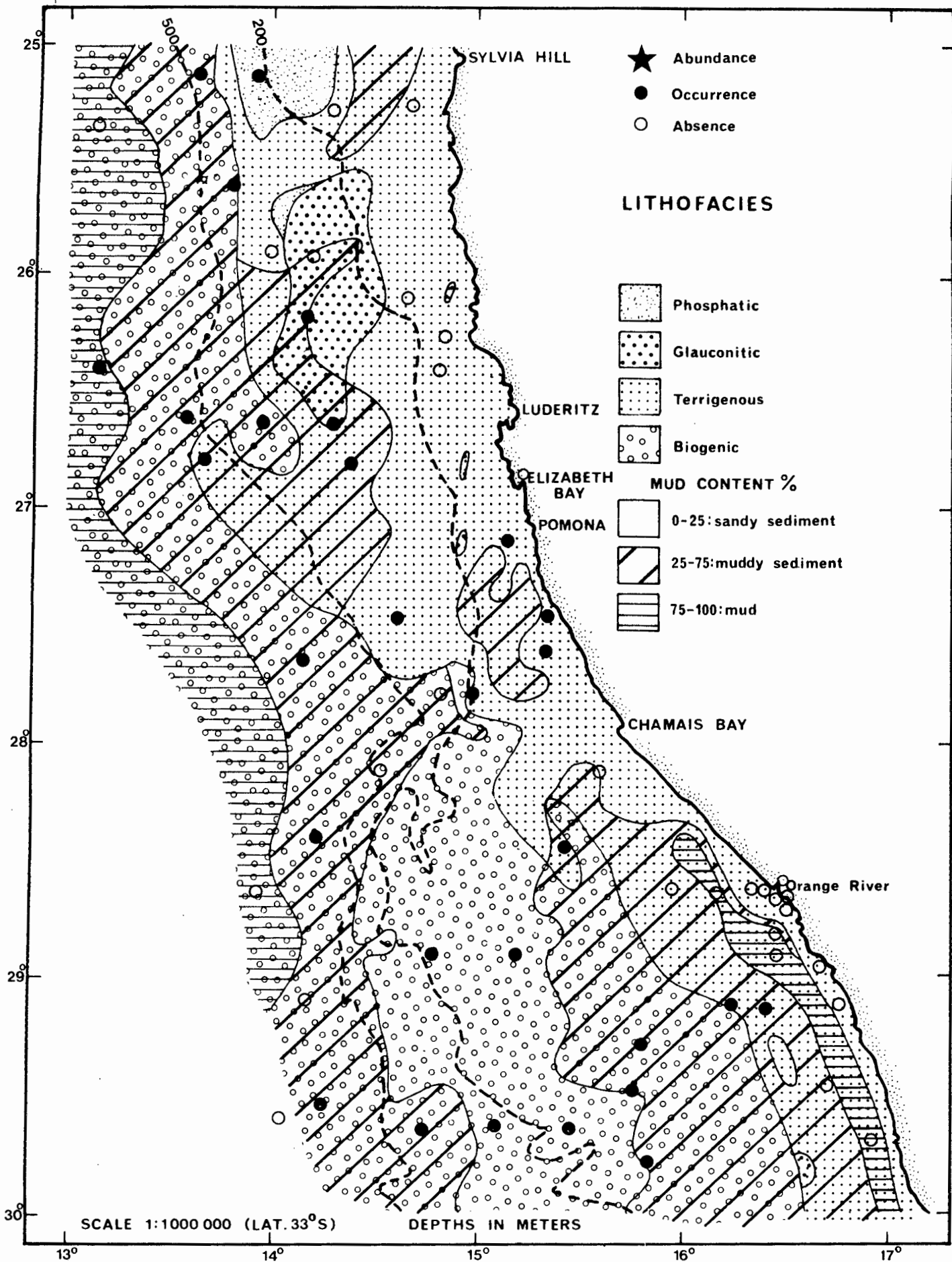


Figure 17. Distribution of *Quinqueloculina agglutinans*

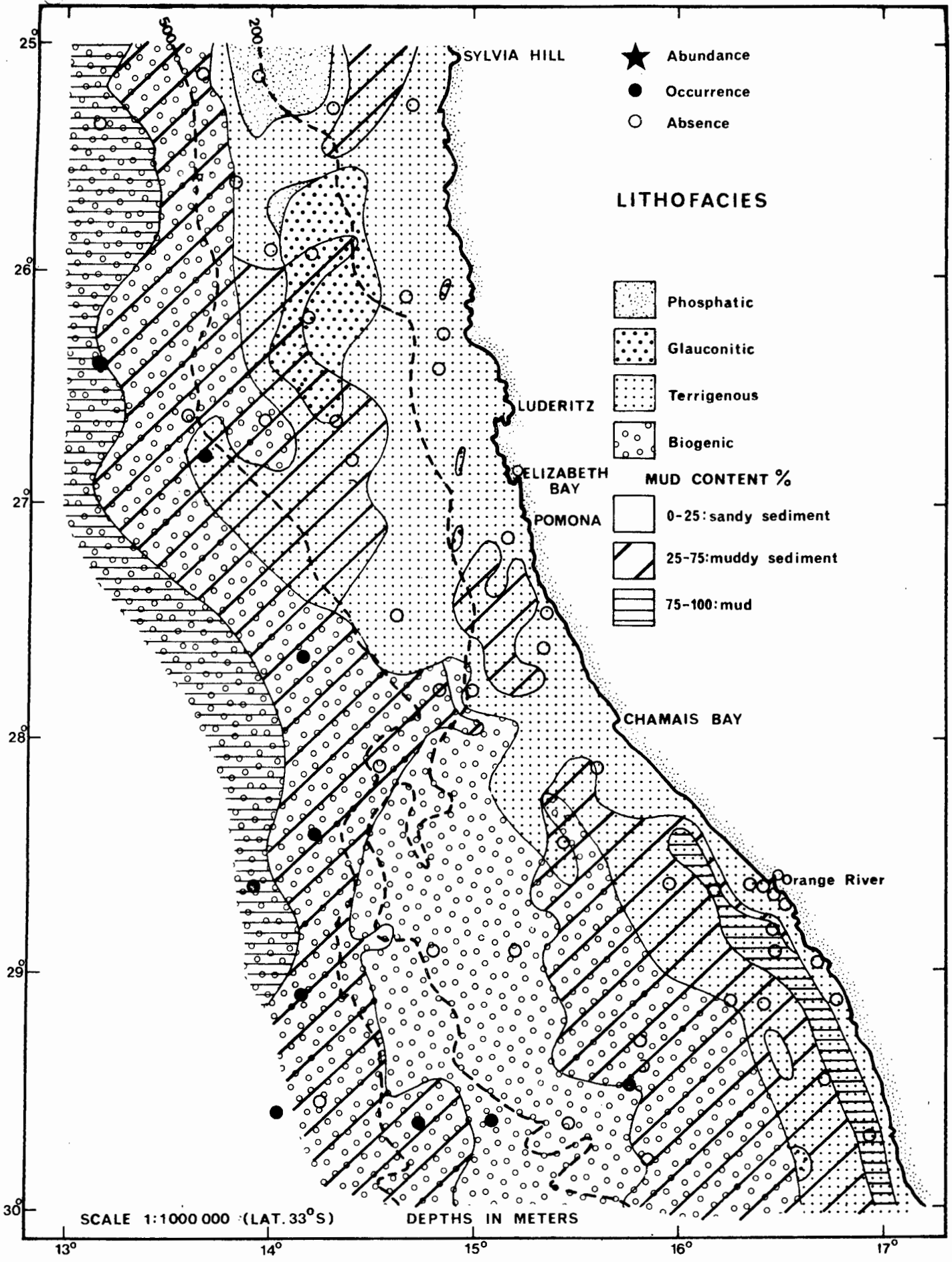


Figure 18. Distribution of *Textularia millettii*

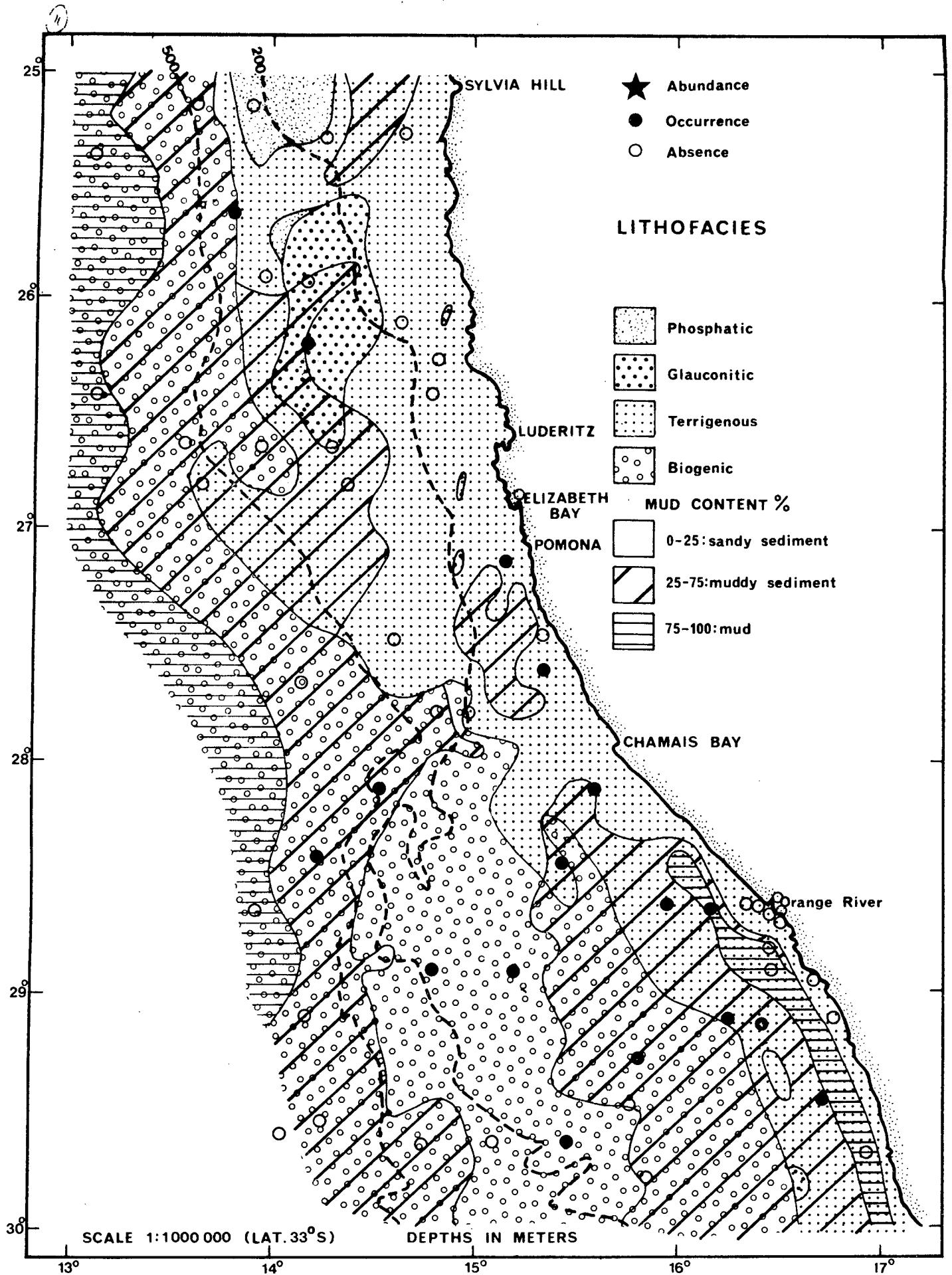


Figure 19. Distribution of *Textularia sagittula*

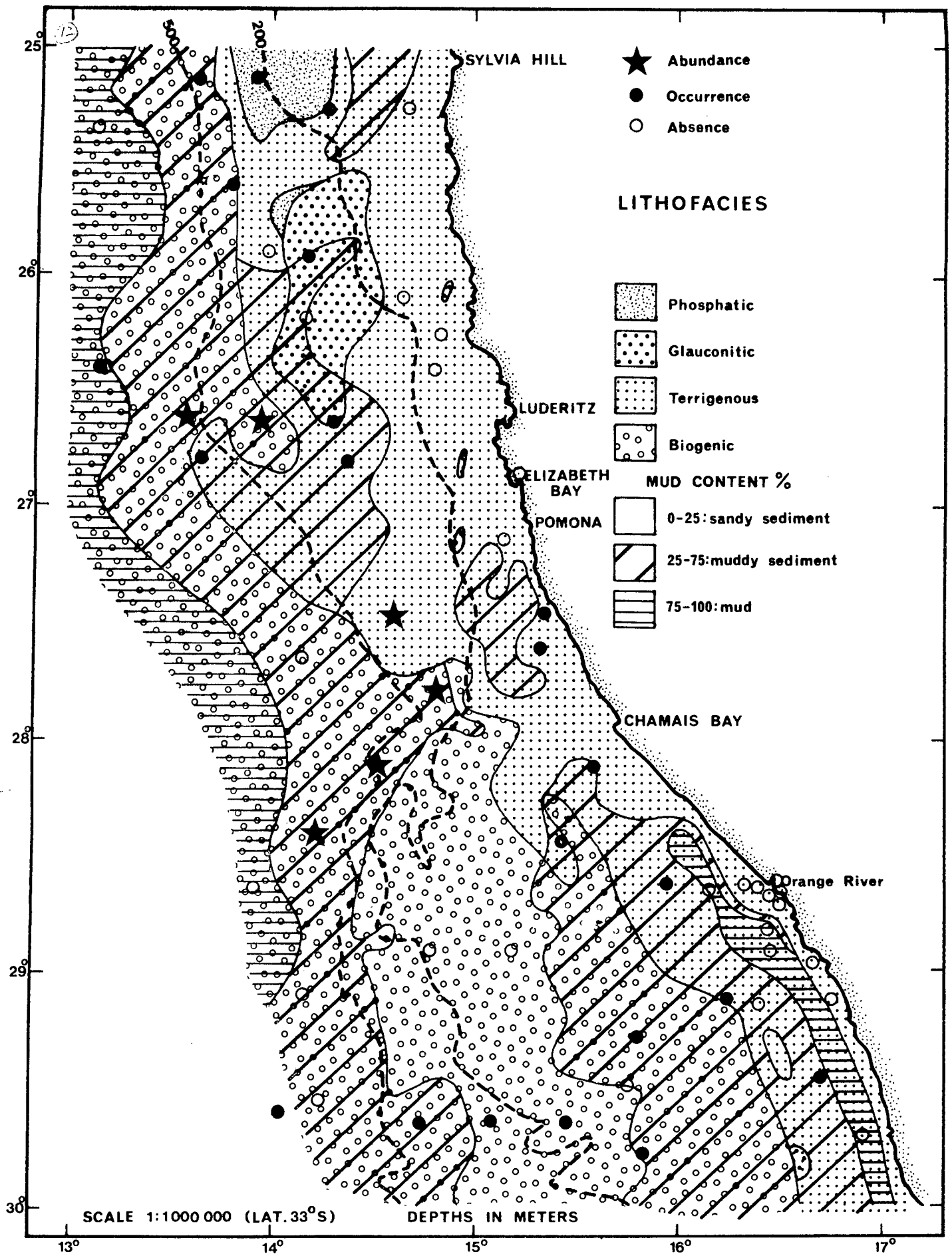


Figure 20. Distribution of *Uvigerina peregrina*

It is evident from the preceding that a number of species apparently exhibit some substrate preference, though it must be remembered that these are distributions of dead tests only. The two dominant agglutinate species, Ammobaculites americanus and Textularia sagittula are both widely distributed, but both appear to avoid very muddy sediments. Closer examination of the distribution of A. americanus (see Table 2) reveals a less clear-cut preference. For example, at station 2958, with 47% sand, it constitutes 50% of the population, and at station 2868, with only 22% sand, it constitutes 14% of the population. Textularia sagittula, on the other hand, appears only three times at stations with less than 50% sand, and two of these stations are at the deep end of its bathymetric range. The preference for biogenic sediments show by T. millettii is undoubtedly due to its deep-water habitat. Elphidium advenum shows a striking preference by its marked decrease in abundance in samples with high mud content in its preferred bathymetric range, as does Uvigerina peregrina in its avoidance of glauconitic and phosphoritic sediments. Except in the deeper samples, Cibicides lobatulus tends to occur in very sandy sediments, though this may be due to its preference for a higher energy environment traversed by currents and tides. The other species are inconclusive in their substrate preferences, and a long term examination of the living population would be necessary to establish any substrate preference and its relationship to other environmental parameters.

### 3.9 Bathymetric zonation

The fauna in the study area is dominated by 18 species which comprise 79.7% of the total fauna. The relative contributions of these species is shown in figure 21.

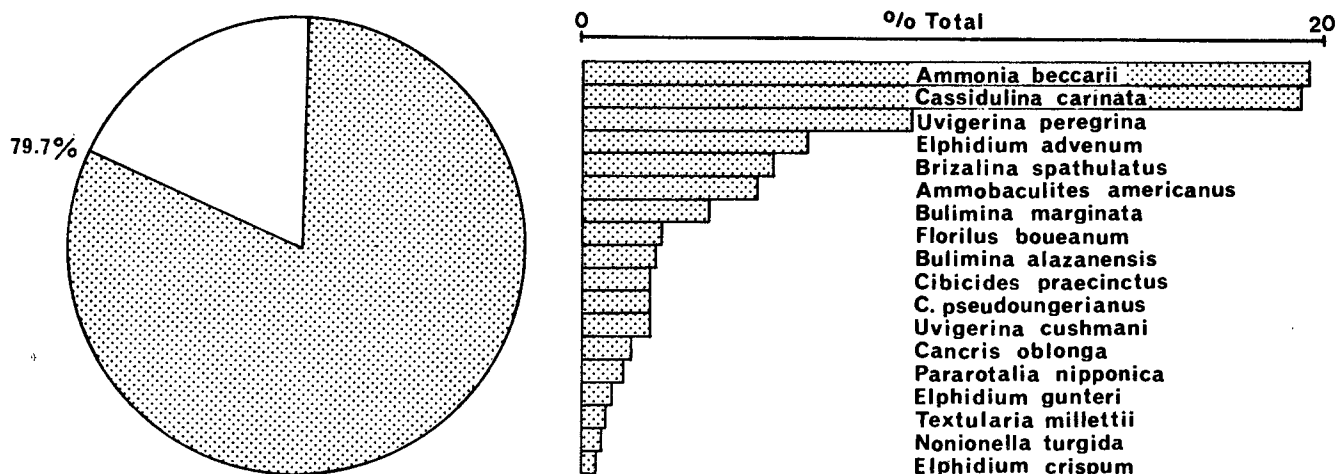


Fig. 21 Composition of faunal assemblage throughout study area

Many other species, though only rare or frequent (1-4.9%) are distinctive and characteristic of the various faunal zone. These are discussed separately within each



Table 3. Dominant and supporting species in each zone. Dominant species are those comprising 20% or more of the population. Supporting species are those considered typical or diagnostic of the zone

	Zone 1 0-34m 99 individuals/gm	Zone 2 34-162m 372 individuals/gm	Zone 3 162-326m 1161 individuals/gm	Zone 4 326-736 903 individuals/gm	Zone 5 736-1780m 416 individuals/gm
Dominant Species	<u>Ammonia beccarii</u> (25%)  <u>Elphidium</u> spp. (46%)	<u>Ammonia beccarii</u> (27%)  <u>Cassidulina carinata</u> (22%)	<u>Cassidulina carinata</u> (26%)  ( <u>Ammonia beccarii</u> ) (20%)	<u>Uvigerina</u> spp. (23%)	
Supporting Species	<u>Pararotalia nipponica</u>	<u>Elphidium advenum</u>  <u>Ammobaculites americanus</u>  <u>Florilus boueanum</u>	<u>Brizalina spathulatus</u>  <u>Bulimina</u> spp.  <u>Uvigerina</u> spp.	<u>Brizalina spathulatus</u>  <u>Cassidulina carinata</u>  <u>Cancris oblonga</u>  <u>Bulimina marginata</u>	<u>Bulimina</u> spp.  <u>Cibicides pseudoungerianus</u>  <u>Uvigerina</u> spp.

# FORAMINIFERAL ZONES

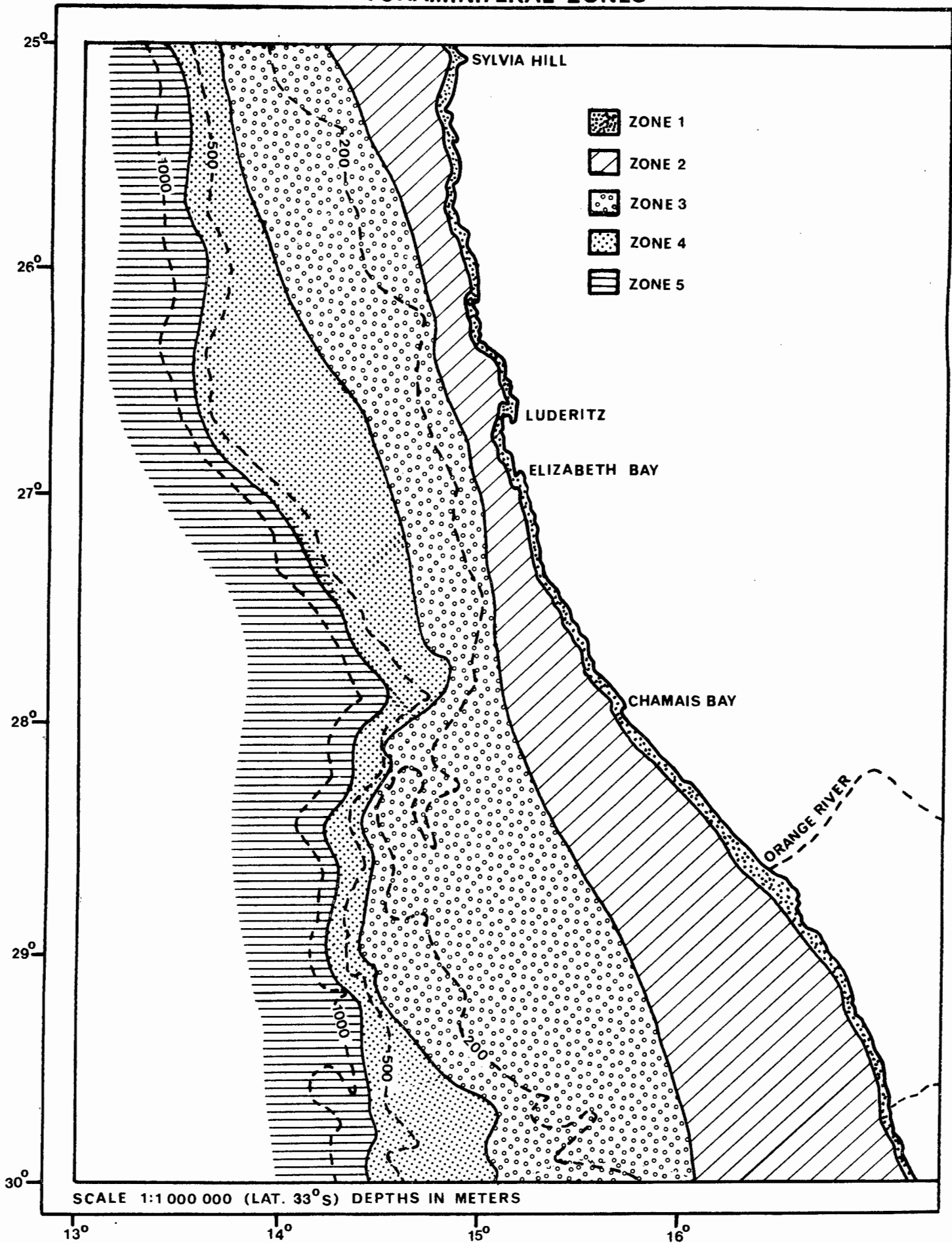


Figure 22. Foraminiferal zones

zone. The distribution of each species found in the area is given in Table 2. Five bathymetric zones have been distinguished on the basis of differences in the dominant species or groups of species. In Zones 1-3, a dominant species is one which constitutes 20% or more of the total population in the zone; in Zones 4 & 5 no single species constitutes 20% of the fauna, and the zonation is based on genera and groups of genera. Table 3 summarizes the dominant and supporting genera in each zone. The five bathymetric zones are shown in figure 22. A rough indication of population diversity is given by the average number of species per sample in each zone. Abundance is given as the average number of individuals per gram of dry sediment.

Zone 1. This zone, extending from 0 to 34 m is notable primarily for its paucity of foraminifera, which is to be expected in a shallow nearshore area with its less stable environment. The fauna is dominated by Ammonia beccarii, Pararotalia cf nipponica, and Elphidium gunteri. The last is confined to the two river samples and is the dominant species in RS45, from the bar at the mouth of the Orange River. It is a common inhabitant of nearshore and brackish water environments (Boltovskoy & Wright, 1976). Both Pararotalia and Ammonia beccarii are well-known nearshore dwellers capable of withstanding extremes of temperature and salinity. Elphidium advenum appears frequently in some samples, and Cibicides lobatulus, though rare in this zone, is noteworthy because it is an attached form with a preference for vegetation and areas traversed by currents. The beach sample, taken at Elizabeth Bay, contained abundant Elphidium crispum, Ammonia beccarii, and Pararotalia cf nipponica, and rare Cibicides lobatulus. Although a number of foraminifera are known to survive desiccation and live at the water's edge, these are not among them, and it is safe to assume they were transported there, either by wind or wave action. The average number of species per sample in zone one is 5.6, and the population averages 99 individuals per gram.

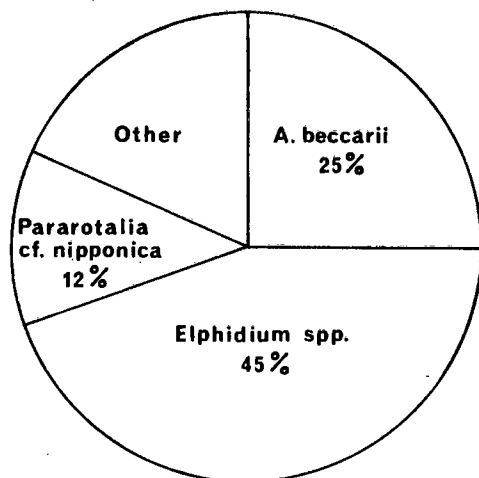


Fig. 23. Composition of faunal assemblage in Zone 1

Zone 2 (34 to 162 m) is dominated by an assemblage consisting of Ammonia beccarii, Elphidium advenum, Cassidulina carinata and Ammobaculites americanus. The last-

mentioned species appeared rarely in zone 1, but is prominent in the middle of this zone and becomes sparser in the deeper samples. C. carinata becomes dominant in the middle of the zone and continues throughout. A number of other species are noteworthy, particularly Florilus boueanum, which is diagnostic of this zone, appearing in significant numbers in 9 samples between 92 m and 123 m. Planulina ariminensis is a distinctive component of the samples in this zone, though not in large numbers. In addition, a number of species which become prominent in deeper zones make their appearances, particularly Brizalina spathulatus, the buliminids (especially Bulimina marginata), and the uvigerinids (especially U. peregrina), which is a frequent component of several samples. The average number of species per sample is 12.7. There are 372 individuals per gram.

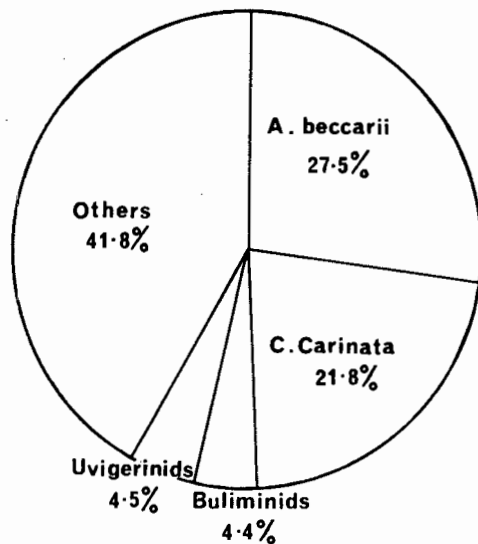


Fig.24. Composition of fauna in Zone 2

Station 2924, from the Orange Banks, falls bathymetrically into this zone, though geographically it is well within zone 3. The faunal assemblage at this station is mixed, but generally shows an affinity to the deeper zone, with A. americanus and A. beccarii very rare, E. advenum is absent, and C. carinata being abundant. Conversely, the buliminids are very rare, as are U. peregrina and Hyalinea balthica. Hoeglundina elegans is absent.

Zone 3 (162 to 326 m) continues to have C. carinata as the dominant member, but the assemblage here includes B. spathulatus, the buliminids, especially B. alazanensis and B. marginata, Cibicides wuellerstorfi, Hoeglundina elegans, Uvigerina cushmani, and U. peregrina. A curious feature is the persistence of Ammonia beccarii as a major contributor to the assemblage. This will be discussed in the section on relict and re-worked faunas. Cibicides wuellerstorfi first appeared in zone 1, but is a frequent constituent of several samples in this zone. Hoeglundina elegans, a species typical of globigerinid oozes and deeper waters is also frequent at several stations. Both of these species continue to the deeper zones, but are most prominent in this zone.

In addition to the characteristic assemblage, this zone marks the disappearance

of Ammobaculites americanus and the appearance of Cibicides pseudoungerianus, which becomes prominent in deeper samples. The dentalinas, though rare in number, appear consistently in this zone, as do Hyalinea balthica and Uvigerina canariensis. The average number of individuals per sample in zone 3 is 23, and abundance is 1161 individuals per gram.

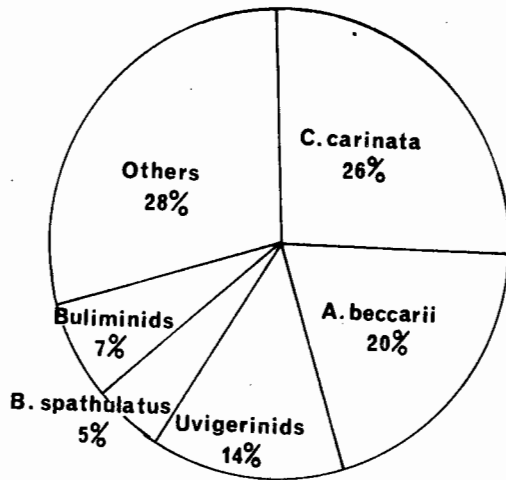


Fig. 25. Composition of fauna in Zone 3.

Zone 4 (335 to 736 m) is dominated by an assemblage consisting of Brizalina spathulatus, Bulimina marginata, Uvigerina peregrina, and Cancris oblonga. Cassidulina carinata is still present, but with diminished prominence. In addition, several deeper water species appear consistently in the area, including Gyroidina orbicularis, Praeglobobulimina spinescens, and Sphaeroidina bulloides. Several textulariids also make rare but consistent appearances, including Karrerriella bradyi, Martinottiella communis, and Textularia millettii. As is to be expected in the deeper, more stable environment, the number of species increases, with an average of 30 species per sample in this zone. Abundance decreases slightly from zone 3, with an average of 903 individuals per gram.

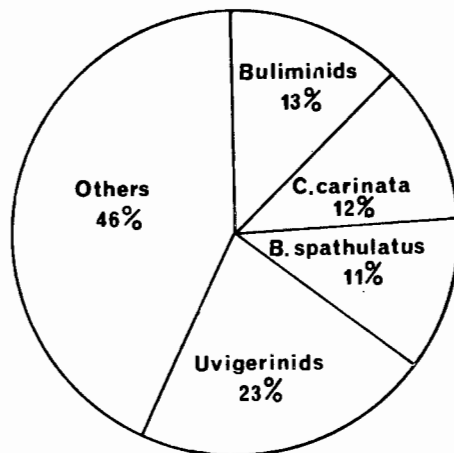


Fig. 26. Composition of fauna in Zone 4.

Table 4. Comparison of depth zonations proposed by various authors. (Taken partially from Boltovskoy & Wright, 1976)

	Parker, 1958 E. Mediterranean	Phleger, 1960 Various	Phleger, 1965 E. Pacific	Murray, 1973 Various	McMillan, 1974 Agulhas Bank	This Study
100	50	20-30 50	25 35 55	25 80	90	34
	143-205	70-125	75-85 120 180 340	180 350	180 210	162
500	500-700		550			326
1000	1,000- 1300	1000				736
1500						
2000		2000				

Zone 5 (-736 to -1780 m) is characterized by an assemblage of buliminids and Cibicides pseudoungerianus. Brizalina spathulatus becomes rare and C. carinata decreases further in importance. A number of other species are persistent in this zone, among them Gyroidina orbicularis, the lagenids, Nonion affine, Pullenia subcarinata, Sphaeroidina bulloides, and Uvigerina proboscidea. The textulariids of the previous zone remain rare but persistent. The average number of species per sample is 31. The number of individuals per gram is 416.

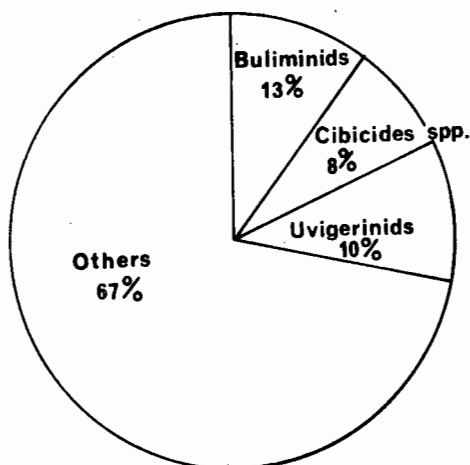


Fig. 27. Composition of fauna in Zone 5.

The preceding discussion indicates that in the present study area, as in other parts of the world, the fauna exhibits a distinct change with depth. Table 4 compares the depth zonations of various authors with those of this study.

The shallower zones in this area are characterized by a smaller, less diverse population than the deeper zones, undoubtedly due to the more stable environmental conditions in the deeper waters. Zone 3 (162 to 326 m) corresponds to the middle and outer shelf in this area, and shows the greatest abundance of benthic foraminifera, though the population is more diverse in zones 4 and 5. The greater abundance of zone 3 suggests optimum conditions for growth and reproduction in that area. The drop in abundance in the two deeper zones may be due to the vastly increased number of planktic foraminifera.

### 3.10 Cluster Analysis

To supplement the zonation previously discussed, a cluster analysis was performed on the data using a program supplied by Dr. John Field of the Zoology Department of the University of Cape Town. In the field of foraminiferal research, this technique has been used by a number of workers. Among the first were Mello and Buzas (1968) who used samples from the Gulf of Mexico which had previously been studied and zoned by Phleger (1956). They found the cluster analysis yielded results which compared favourably with those of Phleger, and felt the method to be a useful empirical tool. It has subsequently been used in a number of studies to aid in the delineation of faunal zones. A full description of this technique is not given in this paper,

however, those who wish may refer to Clifford and Stephenson (1975) or Sokal and Sneath (1963) for a complete discussion.

The program used in this study utilizes an abundance-weighted Bray-Curtis similarity measure to produce the similarity matrix comparing all the samples in the area, that is, a Q-mode analysis. The program provides for the data to be run with or without a log transformation ( $\log(n+1)$ ) before the similarity indices are calculated. As a test, the program was run both ways on the data, and the resulting dendrograms are shown in Figures 28 and 29. The dendrogram produced from the untransformed data is less compact than that produced from the transformed data. A significant similarity level of 32 on the transformed dendrogram yields five major clusters which, when mapped, compare well with the zonation in zones 3-5, but are distinctly different in zones 1 and 2 (Fig. 30). The samples falling within the first two zones include the beach sample, the two river samples, and the samples off the Orange River mouth. The first three of these contained foraminiferal assemblages which were distinct from all other samples in the study area. The samples off the Orange River mouth contained a very sparse fauna. As the dendrogram indicates, all of these cluster at a relatively low similarity level. The program utilized in this study also provides for a multi-dimensional scaling of the data, and the two-dimensional plot of this is shown in figure 31. This is a two-dimensional representation of the positions of each point in n-dimensional space, and gives a clearer indication of the relationships between members of each group as well as the relationships between the groups themselves. Groups 3,4, and 5, from the deeper, more stable environments, lie close to each other, while zone 2 is close to the others, but zone 1 lies widely separated, and is obviously quite distinct from the others. The same similarity level (32) on the untransformed data yielded nine clusters; a drop in the chosen similarity level yielded one very large cluster with several smaller clusters. When mapped, these clusters were meaningless.

The choice of a significant similarity level is arbitrary, and as pointed out by Mello and Buzas (1968) pre-supposes a meaningful relationship over the sampled area. In the case of non-transformed data, any such relationship is undoubtedly confused by 'noise' from such factors as the high number of very rare species, and high concentrations of relict and re-worked fauna. The log-transformed data yields a more meaningful clustering by filtering out some of this 'noise'. It must be pointed out, however, that a log-transformation is not considered ideal for percentage data (Field, pers. comm.): the recommended transformation is an arc-sine transformation, however this was not available in this program. Mello and Buzas (1968) feel there is no compelling reason in choosing a single level of demarcation in a non-taxonomic analysis, and point out that Kaesler (1966) states it may be best in bio-facies analysis to avoid drawing lines and simply let the dendrogram speak for itself, as a representation of similarity.

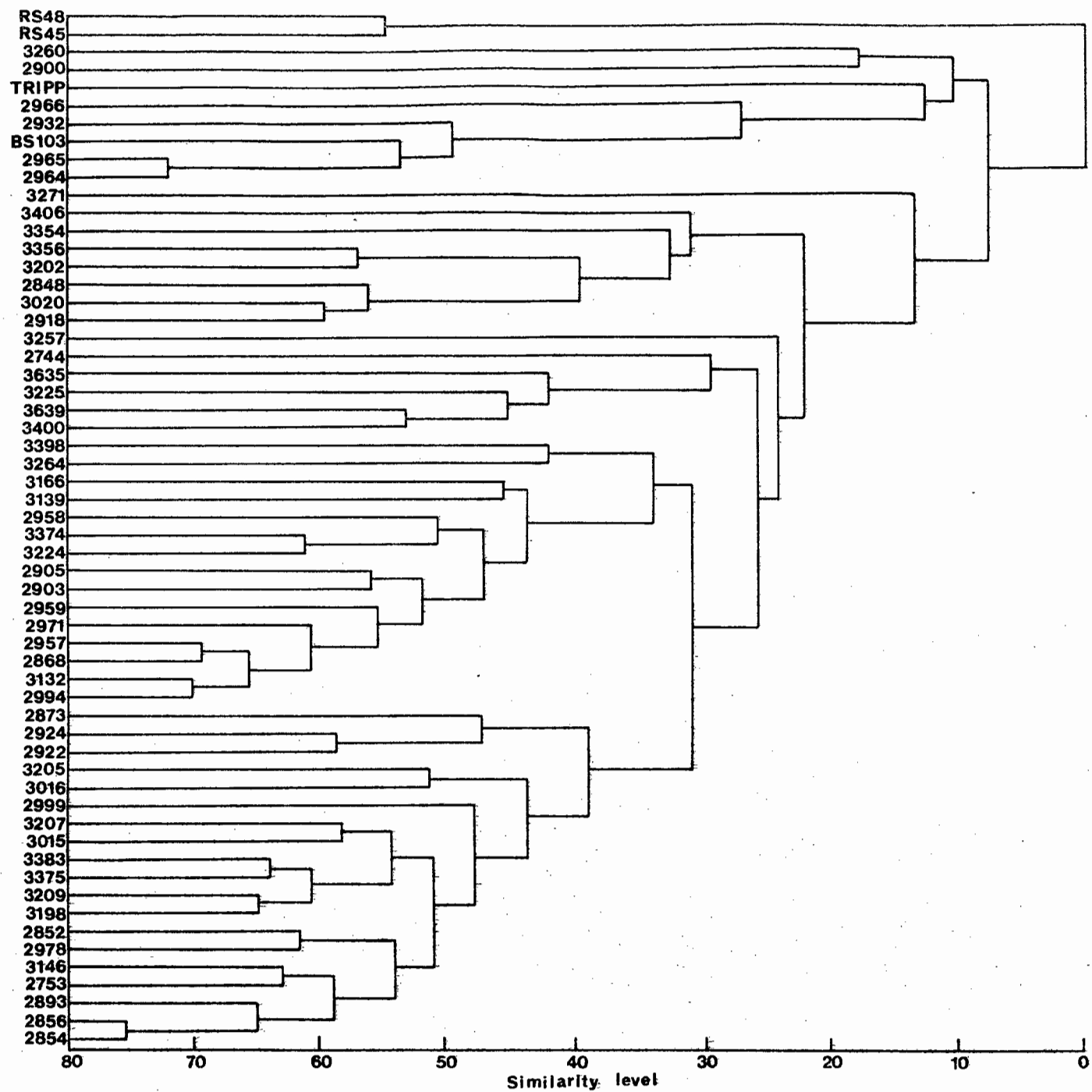


Figure 28. Log-transformed dendrogram of Q-mode cluster analysis

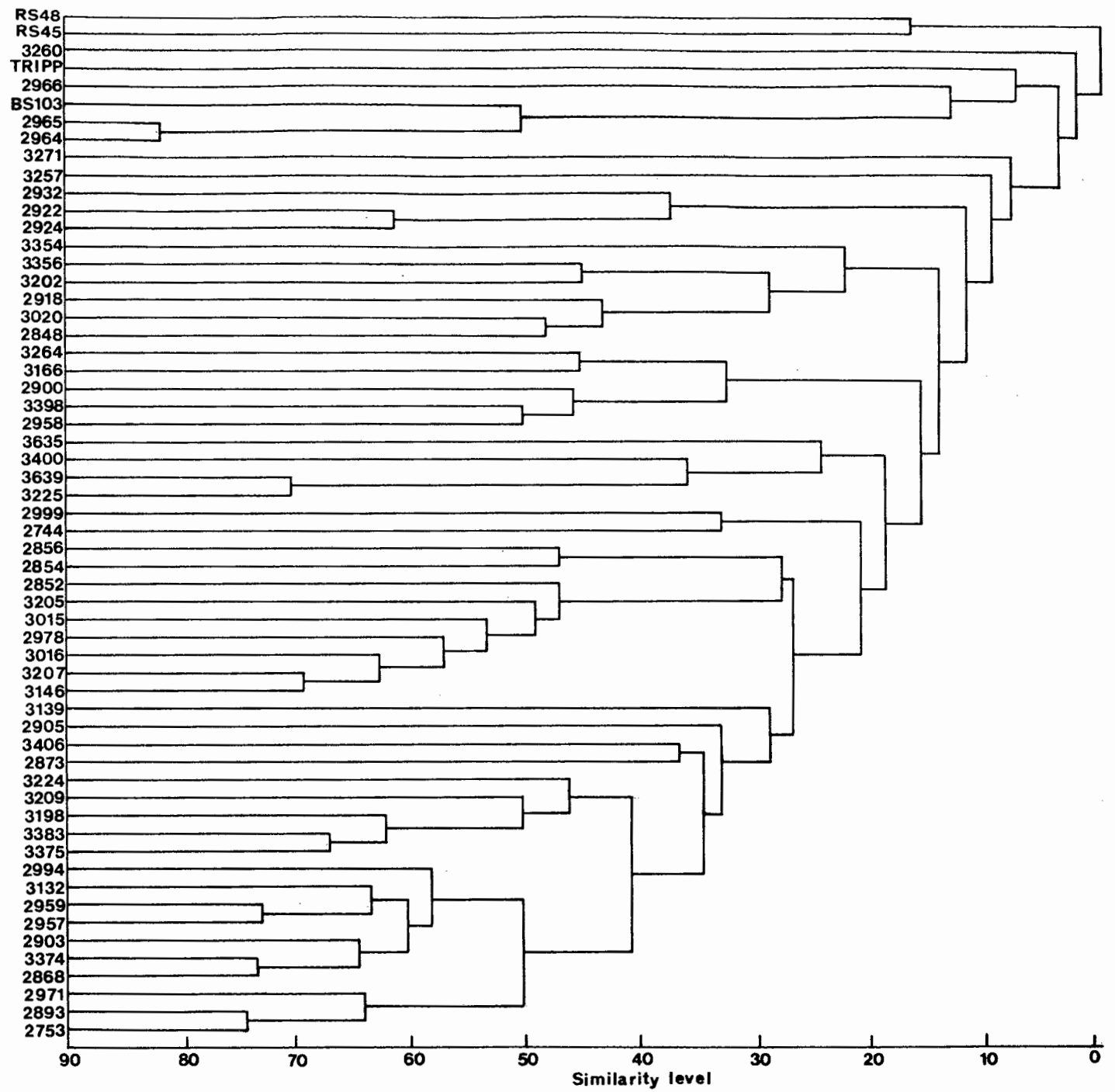


Figure 29. Untransformed dendrogram of Q-mode cluster analysis

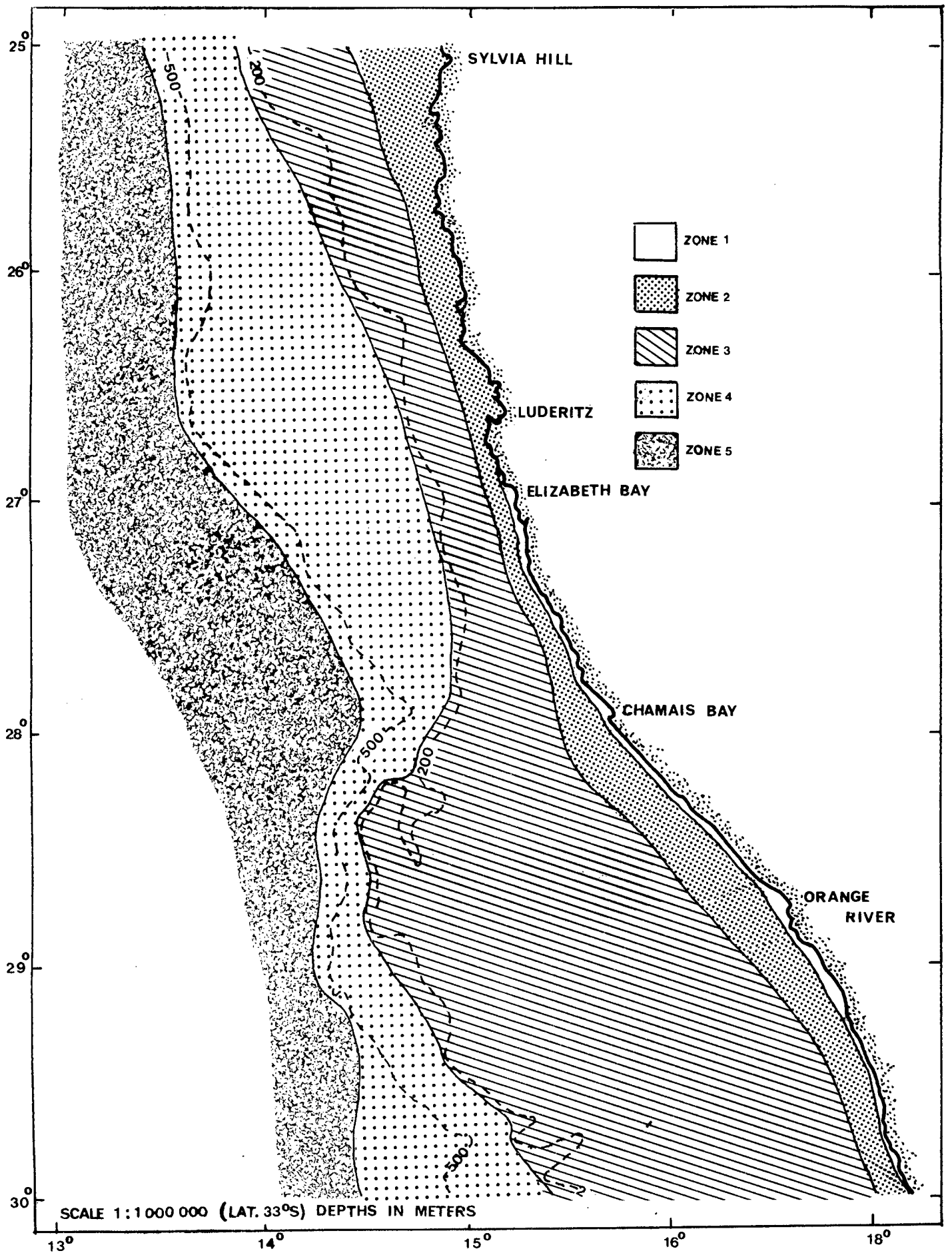


Figure 30. Foraminiferal zones as defined by log-transformed cluster analysis and multi-dimensional scaling

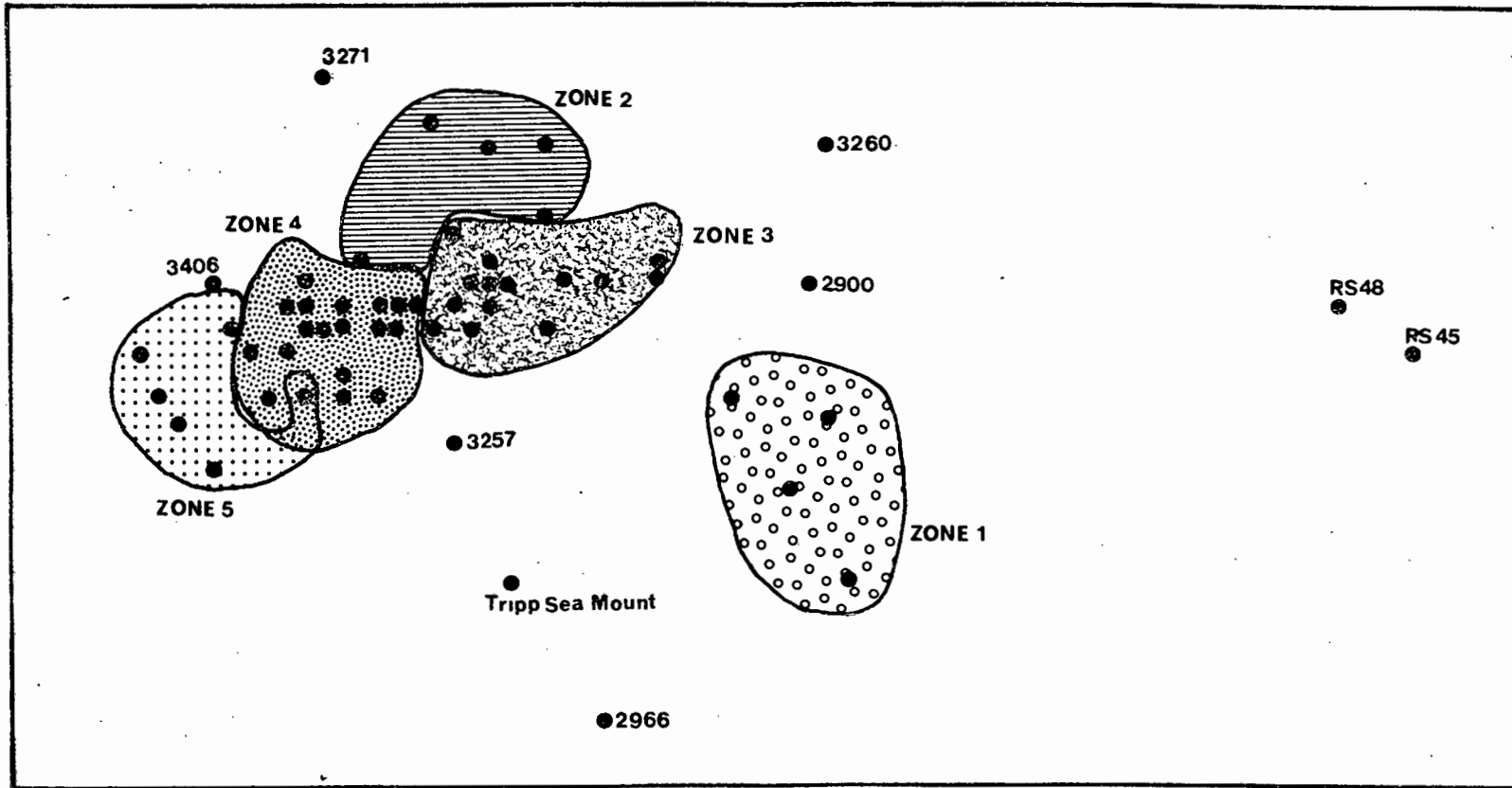


Figure 31. Multi-dimensional scaling (two-dimensional plot) of log-transformed data

Fig 31

### 3.11 Relict and Re-worked Faunas

A number of stations yielded assemblages which have been interpreted as relict or re-worked. The basis for the distinction of such fauna are three-fold, although all are circumstantial, because no fossil species were encountered. The most direct evidence of re-working of the fauna is the glauconite and phosphorite infillings found in specimens at seven stations. The second criterion, used as an indication of relict faunas, is the anomalous distribution of shallow-water species such as Ammonia beccarii. Finally, a tenuous and subjective feature is the 'old aspect' of specimens in 12 samples. Table 5 lists the stations at which infilled and 'old' specimens were recovered.

Several areas were found by Rogers (1977) to be rich in residual glauconite and phosphorite. The southernmost glauconitic area extends from Hondeklip Bay in the south to Port Nolloth. Further north, four deposits contain more than 5% glauconite: three on the Walvis shelf, and one on the Orange shelf. Phosphorites also occur throughout the area, but the richest deposits are north of the Lüderitz Bank, where phosphorite values are as high as 26.4%. The samples containing foraminifera with phosphorite and glauconite infillings fall within the areas of high concentration of these minerals. It is therefore reasonable to assume that the foraminifera containing infillings are derived from the same source. The southern glauconite belt was attributed by Birch (1975) to rock outcrops presumed by Dingle (1973) to be Cretaceous and Paleogene. A possible source-rock for the northern deposit was recovered off Chamais Bay and dated as post-middle Miocene. The phosphorite source is possibly pelletal-phosphorite bedrock (Rogers, 1977). The source rocks for both glauconite and phosphorite are still under investigation. Birch (pers. comm.) states that more than one episode of glauconitization is now suspected, and that the infillings in the foraminifera are certainly not Recent. The species most often found containing infillings are Ammonia beccarii, Elphidium advenum, Pararotalia cf nipponica, Uvigerina peregrina, Praeglobobulimina spinescens, Pseudonodosaria torrida and Cassidulina carinata.

The anomalous distribution of shallow water species was discussed briefly in the section on distribution of the fauna. The most striking occurrence is that of Ammonia beccarii, a species which normally resides at depths less than 50 m and is considered to have an extreme depth limit of 110 m to 120 m. In this area, it occurs in high concentrations in water as deep as 380 m. The same is true for Elphidium advenum, which is generally found living in warm nearshore waters, lagoons and estuaries, (Boltovskoy and Wright, 1976). Both of these species were found with glauconite infillings at some stations, which accounts for part of the distribution anomaly, but in other samples they are numerous and without infillings. Assuming, however, a sea-level drop of approximately 100 m in the Würm glaciation, these deeper stations would be within the depth ranges of both of these species. It is therefore

TABLE 5. Stations containing 'old' and infilled fauna

Glauconite or phosphorite infillings

<u>Station</u>	<u>Depth(m)</u>	<u>%</u>	<u>Dominant infilled species</u>
2905	148	12	<u>Ammonia beccarii</u>
3016	360	2	<u>Praeglobobulimina spinescens</u>
3146	352	1	<u>Planulina ariminensis</u>
3202	900	1	<u>Pseudonodosaria torrida</u>
3205	995	2	<u>Hyalinea balthica</u>
3375	326	4	<u>Elphidium advenum</u>
3400	182	3	<u>Ammonia beccarii</u>

Specimens with 'old aspect'

<u>Station</u>	<u>Depth(m)</u>	<u>%</u>	<u>Dominant 'old' species</u>
2873	178	9	<u>Cibicides praecinctus</u>
2903	135	15	<u>Cassidulina carinata</u>
2918	984	1	<u>Cibicides pseudoungerianus</u>
2922	190	9	<u>Cibicides pseudoungerianus</u>
2924	158	5	<u>Ammonia beccarii</u>
2958	100	12	<u>Ammonia beccarii</u>
3015	195	4	<u>Elphidium advenum</u>
3016	360	8	<u>Uvigerina peregrina</u>
3225	530	3	<u>Ammonia beccarii</u>
3257	98	4	<u>Ammonia beccarii</u>
3375	326	16	<u>Ammonia beccarii</u>
Tripp Sea Mount		5	<u>Anomalina colligera</u>

hypothesized that these are relict from that regression.

The lat criterion for denoting a fauna which may be relict or re-worked is somewhat vague and certainly subjective. To denote an individual or assemblage as having an 'old aspect' requires a certain degree of familiarity with the material and must be applied with great caution. The features used in assigning specimens to this category are marked breakage and abrasions of tests, obliteration of surface features and ornamentation, evidence of solution, opacity, and encrustation with consolidated sediments. All of these may be caused by many factors: breakage, abrasion and obliteration by transport of various types, solution by low  $\text{CaCO}_3$  in the water, opacity may occur within hours in a low pH environment (Murray, 1960), and encrustation in the normal accumulation of sediments. This category is therefore treated with circumspection and no single feature was considered sufficient evidence on its own. Four of the samples which yielded specimens in this category are among those containing rock samples or semi-consolidated sediments and for which Rogers (1977) obtained dates. These are:

- Sample 2922 -- Lower to middle Miocene (considered middle Miocene by Siesser)
- Sample 3015 -- Tertiary
- Sample 3257 -- Miocene (considered by Siesser to be upper Miocene to Pliocene)
- Sample 3375 -- Upper Pliocene to lower Pleistocene

It is not unreasonable to assume that many specimens found in the unconsolidated sediments of these samples have been re-worked from older strata. Sources for re-worked fauna, if indeed they are such, are not known for the remaining eight samples. The two specimens of Peneroplis found at station 2873, however, are undoubtedly older than Recent. They are worn and their surface ornamentation has nearly disappeared, but more important, Peneroplis is a tropical species, extant in shallow waters, indicating these two specimens may be remnants of a larger warm water assemblage. Other species which may in some cases be part of a re-worked fauna are Cibicides pseudoungerianus, C. praecinctus, C. wuellerstorfi, Hoeglundina elegans, Bulimina sp., Lenticulina cf occidentalis, Cassidulina carinata, and Uvigerina cushmani.

#### CONCLUSIONS

The foraminiferal fauna of this study area is characteristic of shelf seas of normal salinity as defined by Murray (1973) and demonstrated in a triangular plot (Fig. 32). The rotaliids are strongly dominant, with the textulariids and miliolids assuming a minor role. One hundred seventeen species in sixty-six genera of benthic foraminifera are present in this area, whereas on the east coast, McMillan (1979) encountered only 86 species in 44 genera. McMillan, however, was working over a much narrower range of depths and with fewer samples, and it must be assumed that further sampling on the east coast would yield a similar diversity in the fauna. In terms of the abundance of the fauna, the two areas are similar, with

the east coast slightly poorer in foraminifera than the west. The relative abundance within the study area itself indicates the foraminifera to be considerably more abundant in the northern samples than in the south. Drawing a line at the latitude of Elizabeth Bay (lat. 27°S), and calculating the average abundance of samples north and south of this line, it is found that the northern samples contain an average of 828 individuals per gram of sediment and the southern samples contain an average of 614 individuals per gram. This is consistent with the microplankton data of Hart and Currie (1960) in which it is evident that the greatest concentrations of microplankton are off Luderitz and Sylvia Hill (Fig. 7). It has been shown that upwelling is best developed in the northern part of the area, suggesting that the benthic fauna reacts similarly to the planktic fauna in an area of upwelling.

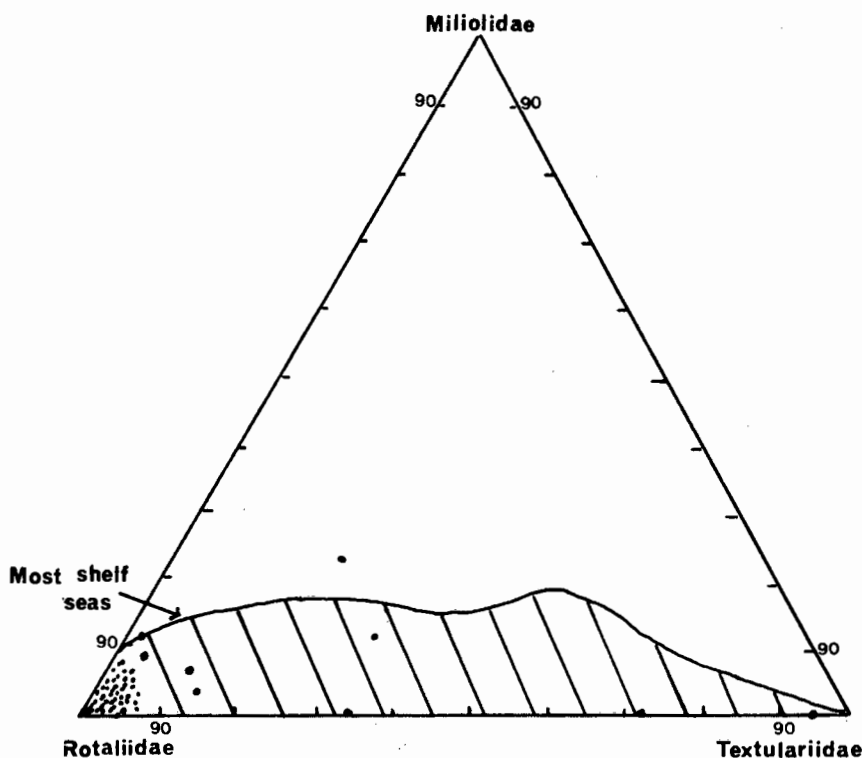


Fig. 32. Triangular plot of faunal composition of stations.

Well-defined changes in the fauna are evident as the sample locations deepen, giving rise to the five previously discussed bathymetric zones. The cluster analysis of the data supported the zonation, although a number of stations did not fit into any of the clusters. These unclustered samples contained faunal assemblages which were high in rare species or which showed unusual associations of species. These unusual associations are probably due to reworking of older strata or to the presence of relict sediments at those stations. No significant latitudinal changes were detected in the fauna, and it is apparent that within this study area, depth (with its attendant parameters) is the primary factor governing the distribution of the foraminiferal population.

## CHAPTER IV. SYSTEMATIC PALEONTOLOGY

The species encountered in the study are listed systematically within this section. Included for each species is a list of synonymies and at least two references which were used in the identification of the species. 117 species were separated for classification. Of these, 95 were identified to species level; the names of the remaining 22 are accompanied by sp or cf. The classification system used is that of Loeblich and Tappan, 1964. No detailed species descriptions are included as these are readily available in the references; however, notes on distribution and species variation within the study area are included. All species are illustrated, and distribution by depth is shown graphically for a number of species.

ORDER: FORAMINIFERA Eichwald, 1830  
 SUB-ORDER: TEXTULARIINA Delage and Herouard, 1896  
 SUPERFAMILY: LITUOLACEA deBlainville, 1825  
 FAMILY: HORMOSINIDAE Haeckel, 1894  
 SUBFAMILY: HORMOSININAE Haeckel, 1894  
 GENUS: SULCOPHAX Rhumbler, 1931

Sulcophax sp.

Plate 1, Fig. 10

Remarks: Four specimens which are referred to Sulcophax were recovered from two stations: one at station 2954 (19 m) and three at station 2994 (109 m). They are coarsely agglutinate and finely tapering, with highly inflated final chambers. Loeblich and Tappan (1964) indicate this genus is common to Antarctic and North American waters.

FAMILY: LITUOLIDAE de Blainville, 1825  
 SUBFAMILY: HAPLOPHRAGMOIDINAE Mayne, 1952  
 GENUS: HAPLOPHRAGMOIDES Cushman, 1910

Haplophragmoides canariensis (d'Orbigny, 1826)

Plate 1, Fig. 6

Haplophragmium canariensis - Brady, 1884, p.310, pl.35, figs. 1-5.

Haplophragmoides canariensis - Cushman, 1920, p.38, pl.8, fig. 1.

Haplophragmoides canariensis - Todd and Bronniman, 1957, p.22, pl.1, fig. 27.

Remarks: Five specimens of H. canariensis were recovered from station 2903 at a depth of 135 m. They closely resemble the illustrations of the above authors.

Distribution: Brady (1884) states this species has a world-wide distribution, and in the South Atlantic it has been found in depths ranging from 13 to 1900 fathoms.

Todd and Bronniman (1957) record it as abundant in the tidal zone of their Mangrove 11 fauna. Heron-Allen and Earland (1915) found it widely distributed in their New Zealand and Antarctic samples and noted its extraordinary variability, with a general tendency to increase in size further south.

GENUS: CRIBROSTOMOIDES Cushman, 1910

Cribrostomoides subglobosum (G.O. Sars, 1868)

Plate 1, Fig. 2

Haplophragmium latidorsatum Bornemann - Brady, 1884, p.307, pl.34, figs.7,8,10.

Haplophragmium subglobosum G.O. Sars - Cushman, 1920, p.45, pl.8, fig.5.

Cribrostomoides subglobosum G.O. Sars - Loeblich & Tappan, 1964, p.225, pl.136, fig.1,2.

Three specimens closely resembling those illustrated by the above authors were recovered from three samples. Depths of the samples are 109, 191 and 195 m.

Distribution: Brady (1884) recovered this species from north of Juan Fernandez Island (1375 fm), two stations in the West Indies (both 390 fm) and from one station off Fiji (210 fm).

SUBFAMILY: LITUOLINAE de Blainville, 1825

GENUS: AMMOBACULITES Cushman, 1910

Ammobaculites americanus Cushman, 1910

Plate 1, Fig. 1

Haplophragmium fontinense Terquem - Brady, 1884, p.305, pl.34, Figs.1-4.

Ammobaculites americanus - Cushman, 1910, p.117.

Remarks: This distinctive species occurs persistently throughout the area in depths ranging from 51 m to 362 m and is very abundant (as high as 94%) at several stations. The specimens from this area correspond with Cushman's description, and also closely resemble cotypes examined in the United States National Museum. The cotypes display the same concavity, compressed test and lack of development of uncoiled chambers. All specimens are coarsely agglutinate, and the species is not highly variable in this area.

Distribution: Cushman described this species from 772 fms. off the west coast of Mexico. Brady found it at 1900 fm in the South Atlantic.

FAMILY: TEXTULARIIDAE Ehrenberg, 1838

SUBFAMILY: TEXTULARIINAE Ehrenberg, 1838

GENUS: TEXTULARIA Defrance, 1824

Textularia agglutinans (d'Orbigny, 1839)

Plate 1, Fig. 11

Textularia agglutinans - Brady, 1884, p.363, pl.43, figs.1-3.

Textularia agglutinans - Todd & Bronniman, 1957, p.24, pl.2, fig.13.

Remarks: Three specimens which appear identical with T. agglutinans were recovered from the Tripp Sea Mount. All were damaged, but exhibited the finely tapered, compressed early chambers and rapidly inflating latter chambers of this species.

Distribution: This is an extremely widespread species geographically and bathymetrically. Bagg (1908) states it occurs "at all depths and in every ocean", and in the Albatross samples it occurs at five stations with depths from 104 to 1342 fms. Brady (1884) recorded it from 100 to 150 fms in the South Atlantic, 435 fms off Bermuda, and 70 to 100 fms off the Shetland Islands. Todd and Bronniman (1957) noted it as common in their offshore zone in the Gulf of Paria.

Textularia cf goesii (Cushman, 1911)

Plate 1, Fig. 12

Remarks: Twenty-five specimens which compare well with T. goesii as illustrated by Brady (1884), Boltovskoy (1978), and Cushman (1911) were recovered from two stations: 2873 (178 m) and 2924 (158 m). The specimens are closest to Boltovskoy's illustration, having a more compressed test and less distinct sutures than those in Brady's illustrations.

Textularia millettii (Cushman, 1911)

Plate 2, Fig. 1

Textularia millettii - Cushman, 1911, p.13, figs.18,19,Textularia millettii - Boltovskoy, 1978, p.170, pl.7, figs.49,50.

This distinctive species occurs at 10 stations with depths ranging from 178 to 1780 m. It is best developed in the deeper samples and at station 3020 (1258 m) it comprises 28% of the population. Most specimens are fairly finely agglutinate, and whitish in color, apparently from the calcareous particles it appears to prefer in test building.

Distribution: Boltovskoy (1978) noted T. millettii as a rare constituent of a number of samples on the Ninetyeast Ridge, ranging from Lower Miocene through Quaternary. Cushman (1911) found the species at four North Pacific stations at depths of 323, 737, 859, and 891 fathoms.

Textularia sagittula Defrance, 1824

Plate 2, Fig. 2

Textularia sagittula Defrance - Brady, 1884, p.361, pl.42, figs.17,18.Textularia sagittula Defrance - Cushman, 1923, p.6.

Remarks: Occurring at nineteen stations, T. sagittula Defrance is the most persistent species of its genus. McMillan (1974) noted it to be the most common agglutinate species in his Agulhas Bank samples, and in terms of number of stations, the same is true in this area. It does not, however, achieve the level of abundance of Ammobaculites americanus, and always constitutes less than 15% of the population. It ranges from 19 to 735 m in depth, but occurs primarily in samples between 100 and 194 m. This species exhibits considerable variation in the study area. While maintaining an extremely angular periphery, there is a large degree of variety in the amount of inflation of the final chambers. Many specimens also exhibit less distinct sutures with very little depression and a nearly entire periphery, rather than a lobulate one. All specimens are finely agglutinate; some are smoothly finished.

Distribution: Brady (1884) notes T. sagittula to be cosmopolitan, with a preference for shallow water. Bagg (1908) also states it is cosmopolitan with known depths of 2700 fm, though preferring shallow water. He recorded it from four stations with depths ranging from 275 to 1544 fm. McMillan (1974) noted its greatest abundance to be over the middle part of the shelf, which corresponds with its distribution on the west coast.

FAMILY: ATAXOPHRAGMIIDAE Schwager, 1877

SUBFAMILY: VERNEUILININAE Cushman, 1911

GENUS: GAUDRYINA d'Orbigny, 1839

Gaudryina sp.

Plate 1, Fig. 5

A single specimen of Gaudryina was recovered from the Tripp Sea Mount. It resembles G. stavensis Bandy, but more specimens and investigation are necessary for a positive identification.

SUBFAMILY: GLOBOTEXTULARIINAE Cushman, 1927

GENUS: EGGERELLA Cushman, 1933

Eggerella bradyi Cushman, 1911

Plate 1, Fig. 3

Verneuilina pygmaea Egger - Brady, 1884, p.385, pl.47, figs.4-7.

Verneuilina bradyi - Cushman, 1911, p.54.

Cushman, 1922, p.59, pl.11, fig.1.

Eggerella bradyi Cushman - Barker, 1960, p.96, pl.47, figs.4-7.

Remarks: Six specimens of E. bradyi were recovered from two stations at depths of 1258 and 1780 m. Most were of moderate size (180 $\mu$  to 355 $\mu$ ) and had smooth, very finely agglutinate surface. The low arched aperture was bordered by a thickened lip in all specimens.

Distribution: Brady (1884) recorded this species from samples in the South Pacific at 1825 fm and the West Indies at 450 fm. Cushman (1922) notes it as characteristic of globigerinid oozes, widely distributed in deeper waters of all oceans.

Eggerella propinqua (Brady, 1884)

Plate 1, Fig. 4

Verneuilina propinqua - Brady, 1884, p.387, pl.47, figs.8-12.

Eggerella propinqua Brady - Cushman, 1937, p.53.

Remarks: Occurring at four stations with depths ranging from 736 to 1495 m,

E. propinqua is a minor constituent (always less than 1%) of the deep-water sediments in this area. It is more coarsely agglutinate than E. bradyi, and generally less inflated in the final chambers.

Distribution: Brady (1884) records it from the Atlantic off Africa at 1750 fm and the North Pacific at 2050 fm. Heron-Allen and Earland (1915) found it as a rare constituent of their Antarctic fauna.

GENUS: KARRERIELLA Cushman, 1933

Karrerrella bradyi Cushman, 1922

Plate 1, Fig. 7

Gaudryina pupoides H.B. Brady - Brady, 1884, p.379, pl.46, figs.1-4.

Gaudryina bradyi - Cushman, 1922, p.74, pl.12, fig.8.

Karrerrella bradyi Cushman - Phleger & Parker, 1951, p.6, pl.3, fig.4.

Remarks: This species occurs as a rare constituent (less than 1%) at ten stations ranging from 280 to 1495 m. Although rare, it displays a certain amount of variability, particularly in the number of chambers and the degree of inflation of the chambers. The final two chambers are always inflated, and the aperture always

displays a prominent lip. The early triserial stage is often indistinct.

Distribution: Brady (1884) found this species to be common in deep water, noting it from 350 to 2350 fms in the South Atlantic. Phleger and Parker (1951), reported it as widespread in the Atlantic, at depths greater than 300 m.

Karreriella sp.

Plate 1, Fig. 8

Thirteen specimens which have been referred to Karreriella were recovered from station 3205 (995 m). Many specimens were damaged, particularly at the apertural end. The test is robust, nearly circular in section, and the final chambers inflate very rapidly, appearing to overlap somewhat. It is coarsely agglutinate, but the sutures on the biserial section are distinct, while those of the triserial portion are less so. The aperture is nearly terminal, and is surrounded by a prominent lip.

SUBFAMILY: VALVULININAE Berthelin, 1880

GENUS: MARTINOTIELLA Cushman, 1933

Martinottiella communis (d'Orbigny, 1826)

Plate 1, Fig. 9

Clavulina communis d'Orbigny - Brady, 1884, p.394, pl.48, figs.3,4,6,7,8.

Clavulina communis - Cushman, 1922, p.34, pl.16, figs.4,5.

Martinottiella communis d'Orbigny - Barker, 1960, p.98, pl.48, figs.3,4,6,7,8.

Remarks: This species occurs at ten stations with depths ranging from 350 to 1780 m. It always constitutes less than 5% of the population. It is not highly variable except in size. It is always coarsely agglutinate and light brown in color, regardless of the character of the substrate.

Distribution: Brady (1884) recorded the species from the South Atlantic and from 390 fm in the West Indies. Cushman (1922) noted that the best specimens in the west Atlantic were from four stations off the eastern United States in depths of 129 to 478 fm. Hayward and Buzas (1979) found it as a rare constituent of thanatopes B,C, and D in the Early Miocene of New Zealand and the north Tasman Sea. (See Table 6).

SUBORDER MILIOLINA Delage and Herouard, 1896

SUPERFAMILY: MILIOLACEA Ehrenberg, 1839

FAMILY: NUBECULARIIDAE Jones, 1875

SUBFAMILY: SPIROLOCULININAE Wiesner, 1920

GENUS: SPIROLOCULINA D'Orbigny, 1826

Spiroloculina cf limbata d'Orbigny, 1826

Plate 3, Fig. 1

Two specimens which appear similar to S. limbata occur at two stations: 2753 (191 m) and 2978 (736 m). They possess the same concave profile, extremely angular

Table 6. Summary of thanatotopes of Northern New Zealand and the North Tasman Sea, Hayward and Buzas, 1979

	Thanatotope A	Thanatotope B	Thanatotope C	Thanatotope D	Thanatotope E	Thanatotope F
Inferred Depth	Shallow, warm water	~50 - 200m	200 - 1000m	150 - 2000m	2000 - 4000m	50 - 100m
Four most common species	<u>Amphistegina madagascariensis</u>	<u>Cibicidiodes temperatus</u>	<u>Gyroidina zealandica</u>	<u>Cassidulina laevigata</u>	<u>Globocassidulina subglobosa</u>	<u>Quinqueloculina angulostriata</u>
	<u>Miogypsina intermedia</u>	<u>Cibicides mediocris</u>	<u>Euuvigerina miozea</u>	<u>Bolivina finlayi</u>	<u>Epistominella exigua</u>	<u>Quinqueloculina seminula</u>
	<u>Cibicides notocenicus</u>	<u>Amphistegina madagascariensis</u>	<u>Astrononion stelligerum</u>	<u>Cibicides vortex</u>	<u>Bolivina genariensis</u>	<u>Bulimina pupula</u>
	<u>Cibicides mediocris</u>	<u>Cibicides vortex</u>	<u>Lenticulina cf nitida</u>	<u>Globocassidulina subglobosa</u>	<u>Oridorsalis tenera</u>	<u>Quinqueloculina plana</u>

chambers, and square periphery illustrated by Brady (1884) and Cushman (1929), but display a short apertural neck not evident in those illustrations.

FAMILY: MILIOLIDAE Ehrenberg, 1839

SUBFAMILY: QUINQUELOCULININAE Cushman, 1917

GENUS: QUINQUELOCULINA d'Orbigny, 1826

Quinqueloculina agglutinans d'Orbigny, 1839

Plate 2, Fig. 8

Miliolina agglutinans d'Orbigny - Brady, 1884, p.180, pl.8, figs.6,7.

Quinqueloculina agglutinans d'Orbigny - Cushman, 1929, p.2, pl.1, fig. 1.

Remarks: This is one of the most widespread and persistent species in this area, occurring at 28 stations with depths ranging from 92 m to 1430 m. It reaches maximum development between 162 and 420 m, where in many samples it constitutes up to 15% of the assemblage. It displays considerable variation in size and in the apertural area. No specimens exhibited a serrate aperture, though many individuals had a bifid tooth. A few displayed a pronounced apertural neck. In general the specimens are coarsely agglutinate, though a few smaller individuals were finer.

Distribution: This is a widely distributed species generally found in shallow waters. Brady (1884) reported it from 18 to 25 fm off the Admiralty Islands and 2435 fm off Ireland. Todd and Bronniman (1957) report it as rare in their nearshore zone and common in the off-shore zone in the Gulf of Paria. Hedley, et al (1965) found it in 87 m off the west coast of North Island, New Zealand.

Quinqueloculina cf horrida (Cushman, 1929)

Plate 2, Fig. 9

A single specimen recovered from the Tripp Sea Mount resembled Q. horrida Cushman as described and illustrated by Bock (1970). It is distinct from Q. agglutinans in having a slender, less inflated test and a very pronounced apertural neck. Q. horrida is generally a shallow water species, however, the fauna of the Tripp Sea Mount is mixed, including species which show a preference for inner and mid-shelf depths as well as those which prefer deeper waters. It is possible, however, that this is an extreme variation of Q. agglutinans.

Quinqueloculina cf lamarckiana d'Orbigny, 1826

Plate 2, Fig. 10

Two specimens of Quinqueloculina resembling those illustrated by Brady (1884) as Miliolina venusta and later referred to Q. lamarckiana (Barker, 1960) were recovered from two stations: 2848 (1495 m) and 2924 (158 m). They also compared with the illustrations of Todd and Bronniman (1957). Both specimens were damaged, but still exhibit the slender profile and angular chambers of this species.

Quinqueloculina seminulum (Linné, 1767)

Plate 2, Fig. 11

Miliolina seminulum Linné - Brady, 1884, p.157, pl.5, fig.6.Quinqueloculina seminulum Linné - Cushman, 1929, p.24, pl.1, fig.5.

Remarks: This species occurs at seven stations in depths ranging from 19 to 254 m where it always constitutes less than 5% of the population, but attains maximum development in those stations shallower than 100 m. In most cases, the test is damaged, either by abrasion or solution, but considerable variation among individuals is still evident. This is primarily in size and shape of the final chamber which varies from broadly rounded to almost triangular. When the aperture is entire, a simple tooth is present.

Distribution: This is a cosmopolitan species which Brady (1884) recorded from shallow pools and depths down to 3000 m. McMillan (1974) found well-preserved specimens from 64 m and some in a poorer state in deeper water on the Agulhas Bank. Todd and Bronniman (1957) noted it as abundant in the nearshore zone and common in the offshore zone in the Gulf of Paria.

GENUS: PYRGO Defrance, 1824

Pyrgo lucernula (Schwager, 1866)

Plate 2, Fig. 5

Biloculina bulloides d'Orbigny - Brady, 1884, p.142, pl.2, figs.5,6.Pyrgo lucernula Schwager - Barker, 1960, p.4.

Remarks: One specimen of P. lucernula occurred at station 2848 in 1495 m of water. It appears identical to the specimens illustrated by Brady (1884) and by McMillan (1974).

Distribution: This is a deep-water species found in the North and South Atlantic and off the Cape of Good Hope by Brady. It was also reported in New Zealand and South Polar waters by Heron-Allen and Earland (1915) who found it to attain maximum dimensions "in deeper waters".

Pyrgo murrhyna (Schwager, 1866)

Plate 2, Fig. 6

Biloculina depressa d'Orbigny v. murrhyna Schwager - Brady, 1884, p.146, pl.2, figs.10,11.Pyrgo murrhyna Schwager - Cushman, 1929, p.71, pl.19, figs.6,7.

Remarks: This species occurs as less than 5% of the population at seven stations, the shallowest 736 m. It appears identical to Brady's (1884) illustrations, particularly figure 11, rather than the elongate test of figure 10. It displays the wide keel and bifid tooth characteristic of the species.

Distribution: This species is widely distributed in cold, deep waters. Brady (1884) noted it from 1850 fm in the North Pacific, and 1900 fm in the South Atlantic.

Parker (1957) reported it from eight samples in the Mohole drilling. Heron-Allen and Earland (1915) recorded it in their New Zealand and Antarctic samples and found it reached maximum development in New Zealand waters and became less robust and sparser in their Antarctic samples.

Pyrgo serrata (L.W. Bailey, 1862)

Plate 2, Fig. 7

Biloculina depressa d'Orbigny v. serrata Bailey - Brady, 1884, p.146, pl.3, fig.3.

B. serrata Bailey - Cushman, 1917, p.16.

Pyrgo serrata Bailey - Cushman, 1929, p.73.

Remarks: Sixteen specimens of P. serrata were recovered from station 2918 at a depth of 984 m. Many specimens were damaged, but others were sufficient for identification of this distinctive species.

Distribution: This is another species typical of cool deep waters. Brady (1884) recorded it from 1100 fm off New Zealand. Parker (1964) found it in two samples from the Mohole drilling and Boltovskoy (1978) noted it as a rare constituent of one sample from the Ninetyeast Ridge.

GENUS: SIGMOILINA Schlumberger, 1887

Sigmoilina(?) tenuis (Czjzek, 1847)

Plate 2, Fig. 12

Spiroloculina tenuis Czjzek - Brady, 1884, p.152, pl.10, figs.7-11.

Sigmoilina tenuis Czjzek + Todd & Bronniman, 1957, p.17, pl.4, fig.3.

Remarks: This graceful species occurs at 21 stations with depths ranging from 122 to 1530 m. It always constitutes less than 5% of the fauna and does not favor any particular depth zone. The individuals do not vary greatly, and are always small. Following the example of Cushman (1929), Todd and Bronniman (1957), Parker (1964), and Phleger and Parker (1951), this species has been placed in Sigmoilina. Barker (1960), however, points out that Wiesner placed Planispirina sigmoidea Brady, the genotype of Sigmoilina in Nummuloculina, necessitating a new generic name for tenuis. Loeblich and Tappan (1964) reinstated P. sigmoidea as genotype for Sigmoilina, therefore tenuis should remain in Sigmoilina.

Distribution: This is a very widely distributed species found, according to Bagg (1907) in all great oceans. Bagg also states its depth ranges from a few meters down to 2750 fm. Brady (1884) noted that the best specimens come from moderate depths. Parker (1964) found it in ten samples from the Mohole drilling, and Todd and Bronniman (1957) recorded it as common in the offshore zone of the Gulf of Paria.

GENUS: SIGMOILOPSIS Finlay, 1947

Sigmoilopsis schlumbergeri (Silvestri, 1904)

Plate 2, Fig. 13

Planispirina celata Costa - Brady, 1884, p.197, pl.8, figs.1-4.

Sigmoilina schlumbergeri Silvestri - Cushman, 1929, p.49, pl.11, figs.1-3.

Sigmoilopsis schlumbergeri Silvestri - Barker, 1960, p.16, pl.8, figs.1-4.

Remarks: This species occurs as less than 5% of the total fauna at four stations with depths ranging from 984 to 1780 m. It is generally fairly coarsely agglutinate, with somewhat indistinct sutures and short apertural neck. There is little variation among individuals.

Distribution: This is a fairly widespread species. Brady (1884) states it is most common between 300 and 1500 fms. Hayward and Buzas (1979) found it as a rare constituent of thanatotores D and E, which are considered to be upper to lower bathyal (See Table 6). Boltovskoy (1978) reports it as a rare constituent in all samples from the Ninetyeast Ridge.

SUBFAMILY: MILIOLINELLINAE Vella, 1957

GENUS: MILIOLINELLA Wiesner, 1931

Miliolinella circularis (Bornemann, 1855)

Plate 2, Fig. 3

Triloculina circularis Bornemann - Cushman, 1929, p.58, pl.13, figs.6,7, pl.14, figs.1, 2.

Miliolinella circularis Bornemann - McMillan, 1974, p.41, pl.3, fig.6.

Remarks: This robust miliolid occurs only in the Tripp Sea Mount sample in which five specimens were found. It appears to be identical to those illustrated by Cushman (1929) and McMillan (1974).

Distribution: McMillan (1974) found this species in varying numbers in samples from the middle and outer shelf on the Agulhas Bank. Cushman (1929) found it to be common in shallow water in tropical, sub-tropical, and temperate areas. He noted the cold water forms to be less constant in their characters.

FAMILY: SORITIDAE Ehrenberg, 1839

SUBFAMILY: PENEROPLINAE, Schultze, 1854

GENUS: PENEROPLIS de Montfort, 1808

Peneroplis sp.

Plate 2, Fig. 4

Remarks: Two specimens of Peneroplis were recovered from station 2873 at a depth of 178 m. Both were heavily worn, but it is evident that this is a closely compressed form of this genus. Boltovskoy and Wright (1976) indicate this to be a warm water genus, typically found in the nearshore zone and inner shelf (0 - 70 m). Dihdkov'sky (in Boltovskoy & Wright, 1976) suggested that the more tightly coiled forms of Peneroplis are characteristic of agitated rather than quiet waters. In the section on relict and reworked faunas, it is suggested that these specimens have been re-

worked from an unknown source. The genus is not typical of the prevailing climatic conditions in this area, and the condition of the tests infer reworking.

SUBORDER: ROTALIINA Delage and Hérouard, 1896

SUPERFAMILY: NODOSARIACEA Ehrenberg, 1838

FAMILY: NODOSARIIDAE Ehrenberg, 1838

SUBFAMILY: NODOSARIINAE Ehrenberg, 1838

GENUS: NODOSARIA Lamarck, 1812.

Nodosaria radricula (Linné, 1758)

Plate 8, Fig. 10

Nodosaria radricula Linné - Brady, 1884, p.495, p.61, figs.28-31.

Nodosaria radricula Cushman, 1923, p.73.

Nodosaria radricula McMillan, 1974, p.44.

Remarks: This species constitutes less than 5% of the fauna at nine stations ranging from 158 to 984 m depth. Specimens from this area appear identical to those figured by Brady. Little variation was noted in the species; some individuals, however, exhibited a greater degree of overlap of the chambers than the majority of the specimens. Generally, the specimens were undamaged with distinct, depressed sutures and inflated final chambers.

Distribution: Brady (1884) recorded it as widely distributed in the South Atlantic in depths down to 2350 fms. McMillan (1974) found four specimens in the Agulhas Bank samples. Heron-Allen and Earland (1915) noted it as inconspicuous in their New Zealand fauna.

GENUS: DENTALINA Risso, 1826

Dentalina emaciata (Reuss, 1851)

Plate 6, Fig. 3

Nodosaria consobrina d'Orbigny v. emaciata Reuss - Brady, 1884, p.502, pl.62, figs.25,26.

Nodosaria consobrina d'Orbigny Cushman, 1923, p.78, pl.13, figs.5,6.

Dentalina emaciata Reuss - Hedly, et al, 1965, p.18, pl.6, fig.18.

D. emaciata Reuss - Albani, 1968, p.75, pl.10, fig.7.

Remarks: Specimens of Dentalina which appear similar to those illustrated by the above authors were found at three stations. In the two shallow stations (109 and 119 m) only one specimen was recovered per station, but at station 3205 (995 m) 38 specimens were found. There is considerable controversy over the taxonomy of the species; Barker (1960) indicates that Brady's figures should be placed in D. subemaciata Parr, and is probably a variety of that species. Hedly, et al (1965) feel, however, that it is difficult to distinguish D. subemaciata Parr from D. emaciata and have retained the latter designation; this name has been used for the specimens found in this area.

Distribution: Brady (1884) indicates the species lives at depths from 290 to 725 fms in the North Atlantic and was found off the Cape of Good Hope at 150 fms. Hedly,

et al (1965) recorded it from 87 m off the west coast of North Island, New Zealand.

Dentalina filiformis (d'Orbigny, 1826)

Plate 6, Fig. 4

Nodosaria filiformis d'Orbigny - Brady, 1884, p.500, pl.63, figs.3-5.

Nodosaria filiformis Cushman, 1923, p.76, pl.14.

Dentalina filiformis d'Orbigny - Barker, 1960, p.132, pl.63, figs.3-5.

Remarks: This species occurs at nine stations ranging from 158 to 1430 m, but is always rare. The individuals in this area are most similar to Brady's figure 3. Distribution: Brady (1884) recorded the species from 435 fms off Bermuda and from Prince Edward Island in the South Pacific. Heron-Allen and Earland (1915) noted it in their samples off New Zealand and in the deep water just south, remarking that at one station it attained a remarkable size.

Dentalina cf nummulina (Gümbel, 1868)

Plate 6, Fig. 5

This species comprises less than 5% of the population in eleven samples ranging in depth between -98 and -360 m. There is little variation in the individuals, and they appear very similar to those illustrated by Todd (1970). The test tapers only slightly, and displays a spine on the initial chamber. Sutures are distinct; costae are robust and numerous.

Dentalina subsoluta (Cushman 1923)

Plate 6, Fig. 7

Nodosaria soluta Reuss - Brady, 1884, p.503, pl.62, figs.13-16.

N. subsoluta - Cushman, 1923, p.74, pl.13.

Dentalina subsoluta Cushman - Barker, 1960, p.130, pl.62, figs.13-16.

Remarks: Fourteen specimens of Dentalina which appear identical to Brady's and Cushman's figures occurred at station 2848 at a depth of 1495 m.

Distribution: Brady (1884) reported the species from the West Indies in 390 fms and northwest of Ireland in 630 fms. Cushman (1923) found it to be common throughout the Atlantic at moderate to great depths.

Dentalina sp. (?)

Plate 6, Fig. 6

Three specimens of a species similar to those illustrated by Brady (1884) as Nodosaria pauperata were found at stations with depths of 178, 335, and 1495 m. Brady's N. pauperata was transferred to Stilostomella on the basis of its apertural neck with phialine lip (Barker, 1960). All specimens from this area had the apertural end broken, though one appeared to have an apertural neck and would therefore be placed in the genus Stilostomella. None of the specimens displayed a basal spine.

GENUS: LAGENA Walker & Jacob, 1758

Lagena gracillima (Seguenza, 1862)

Plate 7, Fig. 16

Lagena gracillima Seguenza - Brady, 1884, p.456, pl.55, figs.19-28.

Lagena gracillima Seguenza - Cushman, 1923, p.23, pl.4, fig.5.

Remarks: This species occurs at eight stations with depths ranging from 51 to 1530 m, and is never more than a rare constituent of the assemblage. It is very distinctive, but shows great variability in the amount of inflation of the test and in the length of the neck and spine. Heron-Allen and Earland (1915) noted the tendency to a very long neck in one Antarctic station.

Distribution: Brady (1884) lists this species from a number of localities in the Pacific ranging from 25 to 1100 fms. Heron-Allen and Earland (1915) also recorded a wide distribution in their samples. Cushman (1923) found most of this species occurred off the northeast United States and in two samples off Florida.

Lagena cf hispida (Reuss, 1858)

Plate 7, Fig. 17

A single specimen of Lagena which appears similar to L. hispida Reuss was recovered from station 3202 at a depth of 900 m.

Lagena laevis Montague

Plate 8, Figs. 1,2

Lagena semistriata Williamson - Brady, 1884, p.460, pl.57, figs.14,16,17,?18.

Lagena laevis Montague - Barker, 1960, p.118, pl.57, figs.14,16,17.

Remarks: Specimens of Lagena which have been referred to L. laevis Montague were recovered from five stations at depths of 19, 51, 418, 900, and 995 m. They vary somewhat, particularly in the amount of elongation of the test and the prominence of the costae at the lower end, but certainly fall within the broad limits of the species as illustrated by Brady. They were placed in this species rather than within L. crenata Parker and Jones on the basis of the more rounded initial end of the test.

Distribution: Brady (1884) noted L. laevis from several locations in the Pacific at depths ranging from 37 to 155 fms, and east of the Shetland Islands at 155 fms. Heron-Allen and Earland (1915) noted it to be fairly general in their New Zealand and Antarctic samples and quite variable. Their deep water specimens sometimes bore very long necks.

Lagena sulcata Walker and Jacob, 1798

Plate 8, Fig. 3

Lagena sulcata Walker & Jacob - Brady, 1884, p.462, pl.57, figs.23,26,33,34, pl.58, figs.4,17,18.

Lagena sulcata Walker & Jacob - Cushman, 1923, p.57, pl.11, fig.1.

Remarks: Occurring at 17 stations in depths ranging from 51 to 1530 m, this is the most widespread representative of its genus. It is always a rare constituent, (less than 1% of the population) but appears to be more consistent in shallow to moderately deep waters. It displays a considerable amount of variation, primarily in the number of costae and in their prominence. This does not seem to be dependent upon environment, as specimens with costae quite different from one another occur at the same stations.

Distribution: Brady (1884) described the species from the Pacific at two stations, one in 2425 fms and the other in 20 to 60 fms. Cushman (1923) noted it to be rare in the western Atlantic. He pointed out that the numerous other records of it may be due to the wide variation in form attributed to the species. Heron-Allen and Earland (1915) recorded a wide distribution for it in their New Zealand and Antarctic samples, also noting extensive variability in the costae and the width of the neck.

GENUS: LENTICULINA Lamarck, 1804

Lenticulina cf altifrons (Parr, 1950)

Plate 8, Fig. 5

A single specimen resembling those figured by Brady (1884) as Cristellaria acuti-auricularis was recovered at station 2978 at a depth of 736 m. Brady's figures have been referred to L. altifrons Parr (Barker, 1960).

Lenticulina cf calcar (Linné 1767)

Plate 8, Fig. 6

One specimen of Lenticulina which appears very similar to Brady's (1884) and Cushman's (1923) illustrations of Cristellaria calcar Linné was found at station 2922 at a depth of 190 m. The specimen was damaged, but shows the characteristic oblique, straight sutures with a single peripheral spine at each chamber.

Lenticulina cf occidentalis v. novangliae (Cushman, 1923)

Plate 8, Fig. 7

Specimens which are similar to those described by Cushman (1923) under the above name are found at six stations with depths ranging from -178 to -1780 m. The specimens are worn, often damaged, but display the broad, thin keel and large prominent aperture typical of the species. Cushman noted the species to be abundant in the western Atlantic at depths between 82 fms and 1731 fms.

Lenticulina cf peregrina (Schwager 1866)

Plate 8, Fig. 8

A single specimen of Lenticulina which appears very similar to L. peregrina Schwager as illustrated by Brady (1884), Cushman (1923) and McMillan (1974) occurred at station 2959 at a depth of 19 m.

Lenticulina Group D

## Plate 8, Fig. 9

A group of Lenticulina occurred as rare constituents at 11 stations with depths ranging from 12 to 1430 m. They have been grouped together on the basis of gross characteristics: all possess a large, robust test with distinct sutures, usually straight and slightly oblique. Most display a prominent boss of clear material and a carina which varies in width. The outline of the test is generally circular.

GENUS: ORTHOMORPHINA Stainforth, 1952

Orthomorphina scalaris (Batsch, 1791)

## Plate 9, Fig. 3

Nodosaria scalaris Batsch - Brady, 1884, p.510, pl.63, figs.28-31.

Amphicoryna scalaris Batsch - Barker, 1960, p.134, pl.63, figs.28-31.

Orthomorphina scalaris Batsch - Boltovskoy, 1978, p.163, pl.5, fig.27,28.

Remarks: This species occurs at 12 stations ranging from 158 to 736 m. At all stations it was a very rare (less than 1% of the population) constituent. It is a distinctive species and not highly variable in this area. Considerable confusion surrounds the taxonomy of this species. Originally called Nautilus by Batsch, it was placed in Nodosaria by Brady (1884) and Cushman (1923), then referred to Lagenonodosaria by Bandy (1956). Barker (1960), and Albani (1968) placed it in Amphicoryna but Boltovskoy (1978) refers to it as Orthomorphina. No specimens in this area display the compressed chambers and oblique sutures characteristic of the initial chambers of Amphicoryna, and all display the short neck with slightly flaring lip of Orthomorphina. It was therefore decided to follow Boltovskoy's practice and place the species in Orthomorphina.

Distribution: This is a widely recorded species and references to it are numerous. Brady (1884) recorded it from west of Ireland and from 95 to 100 fms off the Philippines. Albani (1968) found it frequently in the middle zone of his Port Hacking area. Boltovskoy (1978) also found it frequently in his lower and middle Miocene sequence of the Ninetyeast Ridge.

Orthomorphina(?) separans (Brady, 1884)

## Plate 9, Fig. 4

Nodosaria scalaris Batsch v. separans - Brady, 1884, p.510, pl.64, figs.16-19.

Nodosaria scalaris Batsch v. separans - Cushman, 1923, p.82.

Amphicoryna separans Brady - Barker, 1960, p.136, pl.64, figs.16-19.

Remarks: A single specimen was found at station 2918 at a depth of 984 m. This has been referred tentatively to Orthomorphina for the same reasons given for O. scalaris.

GENUS: PSEUDONODOSARIA Boomgaard, 1949

Pseudonodosaria torrida (Cushman, 1923)

Plate 9, Fig. 10

Nodosaria (Glandulina) laevigata d'Orbigny - Brady, 1884, p.490, pl.61, figs.20-22.

Nodosaria (Glandulina) laevigata d'Orbigny v. torrida - Cushman, 1923, p.65, pl.12, fig.10.

Pseudonodosaria torrida Cushman - Bock, 1970, p.42, pl.15, fig.13.

Remarks: This species appears at 14 stations ranging in depth from 98 to 1430 m.

It is always a rare constituent (less than 5%) of the faunal assemblage. It is not highly variable; most specimens are slightly elongate and possess a single spine on the initial chamber. Barker (1960) notes that this species belongs in the genus Pseudoglandulina which he stated was placed in Rectoglandulina. This is a synonym of Pseudonodosaria Boomgaard, the genus accepted by Loeblich and Tappan (1964).

Both Bock (1970) and Boltovskoy (1978) have placed this species in Pseudonodosaria.

Distribution: Brady (1884) records it from the West Indies in 390 fms, though notes it is cosmopolitan and occurs at various depths. Cushman (1923) notes its occurrence in the warmer parts of the west Atlantic at depths of 227 to 478 fms.

GENUS: SARACENARIA Defrance in de Blainville, 1824

Saracenaria italica (Defrance, 1824)

Plate 10, Fig. 3

Cristellaria italica Defrance - Brady, 1884, p.544, pl.68, figs.17,18,20-23.

Cristellaria italica Cushman, 1923, p.125, pl.35, figs.2,5-7.

Saracenaria italica Defrance - Barker, p.144, pl.68, figs.17,18,20-23.

Remarks: This species occurs as a rare constituent at five stations ranging from 158 to 280 m in depth. The specimens agree well with those illustrated by Brady (1884) and Cushman (1923). Although originally placed in Cristellaria, it is the genotype of Saracenaria (Loeblich and Tappan, 1964).

Distribution: This is a fairly widespread species. Brady (1884) and Cushman (1923) both have numerous records at moderate depths. McMillan (1974) recorded it from stations on the middle and outer shelf.

SUBFAMILY: OOLININAE Loeblich and Tappan, 1961

GENUS: OOLINA d'Orbigny, 1839

Oolina hexagona (Williamson 1848)

Plate 8, Fig. 15

Lagena hexagona Siddall - Brady, 1884, p.472, pl.58, figs.32,33.

L. hexagona Williamson - Cushman, 1923, p.24, pl.4, fig.6.

Oolina hexagona Williamson - Barker, 1960, p.120, pl.58, figs.32,33.

Remarks: A number of specimens which have been referred to this species were found at five stations ranging from 51 to 1780 m in depth. Although occurring in small numbers at all stations, the species is best developed in the shallow water samples. Considerable variation occurs in the surface pattern of the individuals; in most specimens the reticulation is randomly aligned, with very deep pitting and thick 'walls' separating the pits. Most individuals exhibit a short apertural neck.

Distribution: Brady (1884) recorded it from 40 fms off the Honolulu Reefs and 2425 fms in the South Pacific. Cushman (1923) points out there are numerous records of it in the British Isles. Todd and Low (1967) reported two specimens from the Gulf of Alaska at depths of 95 and 100 m.

GENUS: FISSURINA Reuss, 1850

Fissurina cf annectens (Burrows and Holland)

Plate 7, Fig. 1

Four specimens of Fissurina resembling Brady's (1884) illustrations of F. annectens were found at two stations. Barker points out that the taxonomy of this species has been confused; it was assigned to Lagena quadricostulata Reuss by Brady, to L. annectens by Burrows and Holland, L. fasciata Egger by Millett, and L. quadricostulata v. sexcostulata by Silvestri.

Fissurina laevigata (Reuss, 1849)

Plate 7, Fig. 2

Lagena laevigata Reuss - Brady, 1884, p.473, pl.114, fig.8.

Lagena laevigata Reuss - Cushman, 1923, p.28, pl.5, figs.1,2.

Fissurina laevigata Reuss - Barker, 1960, p.236, pl.114, fig.8.

Remarks: This species is the most persistent of its genus, appearing as a rare (less than 5%) component of the fauna at 22 stations with depths ranging from 19 to 1780 m. It is best developed at depths greater than 200 m and in samples with a high diversity. It shows little variation throughout the area.

Distribution: Cushman (1923) notes this species to be abundant about the British Isles. Hayward and Buzas (1979) found it to be a rare constituent of thanatotope D and extremely rare in thanatotopes B,C, and E of northern New Zealand and the North Tasman Sea (Table 6).

Fissurina cf radiata (Seguenza, 1859)

Plate 7, Fig. 3

Five specimens of this beautiful species occurred at two stations: 2978 and 3354. All of the specimens were damaged, but they appear close to Brady's (1884) illustrations.

SUPERFAMILY: BULIMINACEA Jones 1875

FAMILY: TURRILINIDAE Cushman, 1927

SUBFAMILY: TURRILININAE Cushman, 1927

GENUS: BULIMINELLA Cushman, 1911

Buliminella elegantissima (d'Orbigny, 1839)

Plate 4, Fig. 12

Bulimina elegantissima d'Orbigny - Brady, 1884, p.402, pl.50, figs.20-22.

Buliminella elegantissima d'Orbigny - Cushman, 1911, p.89.

Buliminella elegantissima Todd & Bronniman, 1957, p.32, pl.8, figs.1,2.

Remarks: This beautiful and distinctive species occurs as a rare constituent of the fauna at two stations in depths of 87 and 182 m. The specimens found in this area appear identical to those illustrated by the above authors.

Distribution: Brady (1884) recorded this species from the Falkland Islands in 6 fms. Todd and Bronniman (1957) found it to be abundant in their nearshore zone in the Gulf of Paria.

FAMILY: SPHAEROIDINIDAE Cushman, 1927

GENUS: SPHAEROIDINA d'Orbigny, 1826.

Sphaeroidina bulloides d'Orbigny, 1826

Plate 10, Fig. 5

Sphaeroidina bulloides d'Orbigny - Cushman, 1924, p.36, pl.7, figs.1-6.

Sphaeroidina bulloides Boltovskoy, 1978, p.169, pl.7, fig.11.

Remarks: This is a persistent species, occurring at 22 stations with a depth range of 109 to 1780 m. It displays a slight preference for the deeper stations. The specimens throughout this area are remarkably uniform and appear very close to Cushman's illustrations.

Distribution: This is a widely distributed species, both bathymetrically and geographically. Brady (1884) found it at 1400 fms in the South Atlantic, 675 fms off Pernambuco, and 420 fms off Tahiti, Bagg (1908) recorded it from four Albatross stations with depths ranging from 572 to 1398 fms. Parker (1964) noted it in eight stations in the Mohole drilling samples. McMillan (1974) recovered six specimens at two deep water stations on the Agulhas Bank, and Boltovskoy (1978) found it as a rare component at four stations from the Ninetyeast Ridge.

FAMILY: BOLIVINITIDAE Cushman, 1927.

GENUS: BOLIVINITA Cushman, 1927

Bolivinita sp.

Plate 3, Fig. 11

Six specimens of this distinctive species were recovered from a depth of 1780 m.

They display the rectangular cross-section typical of this genus and are flattened or concave on the broad sides. The four axial costae at the angles of the test are not strongly developed or are obscured by the general roughness of the surface, as are the sutures. The aperture appears to be a basal arch, but was damaged in all specimens, therefore lip and toothplate were indistinguishable.

Distribution: Loeblich and Tappan (1964) have retained Bolivinita as a separate genus because of its more restricted and therefore useful stratigraphic range (Miocene to Recent). They indicate the genus has a wide distribution throughout the Atlantic and Pacific.

GENUS: BOLIVINA d'Orbigny, 1839

Bolivina globulosa (Cushman, 1933)

Plate 3, Fig. 8

Bolivina globulosa Cushman, 1933, p.80, pl.8, fig.9.

Bolivina globulosa Boltovskoy, 1978, p.152, pl.1, fig.19.

Remarks: This species is the most persistent of its genus in this area, occurring at 12 stations with depths ranging from 182 to 1780 m. Except at station 3205, the specimens are fresh and unaltered, but with some variation in the amount of inflation of the chambers. The smaller, presumably juvenile specimens have less inflated chambers and a less rounded, though not angular, periphery. Chambers of the larger specimens are more inflated with a broadly rounded periphery, particularly in the last few chambers.

Distribution: Parker (1964) found this species in one sample from the Mohole Drilling. Boltovskoy noted that this species appears frequently at the middle Miocene/upper Miocene boundary and throughout the younger sequence on the Ninetyeast Ridge.

Bolivina subspinescens (Cushman, 1922)

Plate 3, Fig. 9

Bolivina textilarioides Reuss, Brady, 1884, p.419, pl.52, figs.24,25.

Bolivina subspinescens - Cushman, 1922, p.48, pl.7, fig.8.

Remarks: This species has a wide distribution, ranging from 118 to 1780 m, but is a rare constituent (less than 5% of the population) at all stations. It is not highly variable, though some individuals show more pronounced spines than others. It always appears translucent and unaltered.

Distribution: Brady described B. textilarioides Reuss from the eastern Atlantic in 183 fms. Cushman's (1922) B. subspinescens is apparently the same species (Barker, 1960) and the type was taken from 1060 fms off the northeastern United States. Cushman (1922) quotes that the species has also been recorded from the Gulf of Mexico and the Caribbean.

Bolivina sp.

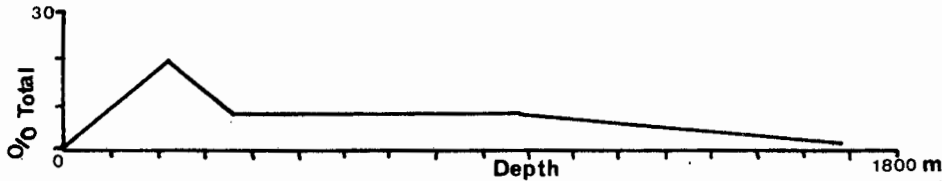
Plate 3, Fig. 10

Five specimens of Bolivina recovered from three stations with depths of 984, 1495, and 1530 m have been referred to a separate species. They may, however, be variations of B. globulosa.

GENUS: BRIZALINA Costa, 1856

Brizalina spathulatus (Williamson, 1848)

Plate 3, Fig. 12

Bolivina dilatata - Brady, 1884, p.418, pl.52, figs.20,21.Bolivina dilatata Brady - Cushman, 1922, p.33.Brizalina spathulatus Williamson - Hedley, et al., 1965, p.21, t.f.6, pl.6, fig.23.Fig.33. Distribution of B. spathulatus expressed as percent total population.

Remarks: Occurring at 39 stations and constituting more than 25% of the population at several, this is one of the most persistent species in this area. It is also extremely small (63 $\mu$  to 180 $\mu$ ) and this coupled with its tremendously variability often made it difficult to identify. The very small specimens were less compressed than the larger specimens, and a lack of development of the keel made these small specimens almost indistinguishable from small specimens of Bolivina globulosa. The larger specimens compare well with those illustrated by Hedley, et al (1965) though specimens from this area tend to be broader toward the apertural end.

Distribution: Brady (1884) recovered this species from the eastern Atlantic in 183 fms. Hedly, et al (1965) noted it on the continental shelf off North Island, New Zealand in the intertidal zone. Heron-Allen and Earland (1915) also recorded it off New Zealand.

FAMILY ISLANDIELLIDAE Loeblich &amp; Tappan, 1964

GENUS: CASSIDULINOIDES Cushman, 1927

Cassidulinoides bradyi (Norman, 1880)

Plate 5, Fig. 1

Cassidulina bradyi Norman - Brady, 1884, p.431, pl.54, figs.6-9.

Cushman, 1922, p.128, pl.12, figs.6,7.

Cassidulinoides bradyi Norman - Barker, 1960, p.132, pl.54, figs.6-9.

Remarks: Although occurring at 16 stations and ranging in depth from 135 to 1495 m, this species does not attain great prominence. The specimens from this area appear identical to those illustrated by Brady (1884) and Cushman (1922).

Distribution: Brady recorded the species from south of Ireland from 90 to 1630 m. Cushman reported it from colder waters off New England and in the mid-Atlantic at depths from 53 to 2512 fms.

FAMILY: EOUVIGERINIDAE Cushman, 1927

GENUS: STILOSTOMELLA Guppy, 1894.

Stilostomella cf lepidula (Schwager, 1866)

Plate 10, Fig. 6

Three specimens resembling this species were recovered from station 3205 in 995 m of water. Boltovskoy (1978) discusses this species at length, stating its great morphological variation made it one of the most difficult to identify. The specimens from this area most closely resemble his plate seven, number 40; the spines are short, sparse, and randomly scattered, and the chambers are separated by a thick 'waist' rather than a narrow tube. Parker (1964) also noted the wide variation in morphology in the specimens from the Mohole drilling.

FAMILY: BULIMINIDAE Jones, 1875

SUBFAMILY: BULIMININAE Jones, 1875

GENUS: BULIMINA d'Orbigny, 1826

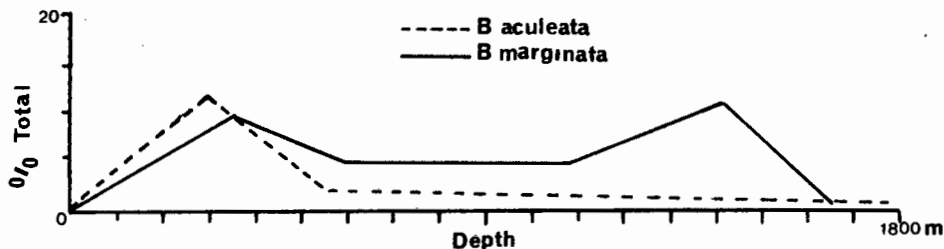


Fig. 34. Distribution of Bulimina spp expressed as % of total population.

Bulimina aculeata d'Orbigny, 1826

Plate 4, Figs. 1, 2

Bulimina aculeata d'Orbigny - Brady, 1884, p.405, pl.51, figs.7-9.

Bulimina aculeata d'Orbigny Cushman, 1922, p.96, pl.22, figs.1,2.

Remarks: Occurring at 13 stations with a depth range of 19 to 1530 m, B. aculeata is best represented in the deeper stations. This is a distinctive species, and the specimens recovered in this area compare favorably with those illustrated by the above authors. It is not highly variable, though shows some differences in the length and distribution of the spines.

Distribution: Brady's (1884) specimens were recovered from the central Pacific in 580 fms. Cushman (1922) noted the species to be widely distributed both geographically and bathymetrically, but never very common. Phleger and Parker (1951) found it distributed between 100 and 2800 m. Heron-Allen and Earland (1915) noted it to be best developed in the New Zealand area, and remarked that the spines were not pronounced in the deeper water forms.

Bulimina cf alazanensis (Cushman, 1927)

Plate 4, Figs. 3,4

Remarks: Occurring at 25 stations ranging from 51 to 1530 m this species attains its highest concentrations between 190 and 360 m. It has been tentatively referred to B. alazanensis though some individuals more closely resemble B. rostrata Brady. It shows a degree of variation in the configuration of the costae; in most specimens the costae are discontinuous the length of the test, though in a few the costae are continuous. There is also some variation in the number and height of the costae and it is possible that further comparison with other material would indicate some of the specimens to be referable to other species.

Bulimina elongata d'Orbigny, 1846

Plate 4, Fig. 5

Bulimina elongata d'Orbigny - Cushman, 1911, p.80, fig.131.Bulimina elongata d'Orbigny Cushman, 1922, p.107.Bulimina elongata d'Orbigny McMillan, 1974, p.52, pl.4, fig.10.

Remarks: This species is found at eight stations ranging in depth from 87 to 280 m; it never constitutes more than 5% of the population. Although resembling B. gibba Fornasini, this species is distinguished by its narrow, more parallel-sided test. Distribution: McMillan (1974) recorded this species in up to 112 m on the Agulhas Bank. Cushman (1911) noted B. elongata in the western North Pacific at 1817 and 756 fms.

Bulimina gibba (Fornasini, 1898)

Plate 4, Fig. 6

Bulimina elegans d'Orbigny - Brady, 1884, p.398, pl.50, figs.1-4.Bulimina elegans d'Orbigny Cushman, 1922, p.105.Bulimina gibba Fornasini - Barker, 1960, p.102, pl.50, figs.1-4.

Remarks: This is a distinctive species which occurs in five samples ranging from 51 to 1430 m in depth. It shows little variation and is almost identical to Brady's (1884) figures.

Distribution: Brady's (1884) specimens were recovered from 1630 fms west of Ireland. Cushman (1911) found it between 282 and 584 fms off Japan. Albani (1968) recorded this species at one station in his study of Port Hacking. Heron-Allen and Earland (1915) noted it near New Zealand, but stated their specimens were not common or typical of the species.

Bulimina cf notovata (Chapman, 1941)

Plate 4, Fig. 10

Remarks: Several specimens which have been referred to B. ovata Chapman were recovered from three stations ranging from 984 to 1495 m in depth. They most closely resemble B. ovata d'Orbigny as illustrated by Brady (1884) which has been reassigned to B. notovata Chapman (Barker, 1960).

Bulimina inflata (Seguenza, 1862)

Plate 4, Fig. 7

This species group occurs at 14 stations with depths ranging between 178 and 1780 m; it is more common in the deeper water samples. The species was originally placed under the name B. striata v. mexicana because of its strong resemblance to Brady's (1884) illustrations of that species. Brady had originally referred his specimens to B. inflata Seguenza, but Barker (1960) noted they had been placed in B. striata v. mexicana. Further investigation of more individuals from this area showed many of the specimens to be comparable to B. inflata Seguenza as illustrated by Boltovskoy (1978), but not as illustrated by McMillan (1974). The variation in the configuration of the spines, some of which are shorter and less sharp makes the taxonomy even less certain, and it would be desirable to compare specimens from this area with type specimens in order to clarify the position.

Bulimina marginata d'Orbigny, 1826

Plate 4, Figs, 8,9

Bulimina marginata d'Orbigny - Brady, 1884, p.405, pl.51, figs.3-5.

Bulimina marginata d'Orbigny Cushman, 1922, p.91, pl.21, figs.4,5.

Remarks: Occurring at 37 stations with depths ranging from 92 to 1530 m, this is the most widespread and persistent species of its genus. It is highly variable, principally in the configuration of the spines, which in some specimens are a barely discernible fringe at the lower end of each chamber, and in others are longer and more widely distributed. In its extreme, the latter tendency makes the specimens approach B. aculeata; this was particularly pronounced at station 3015. This tendency was also noted by Heron-Allen and Earland (1915) who reported a fine series of gradation running into B. aculeata. This great variability in B. marginata has also been noted by Cushman (1922) and by Hedley et al (1965).

Distribution: Brady's (1884) figured specimens were from west of Ireland, but he reports that it occurs in widespread localities from littoral to 1630 fm. Phleger and Parker (1951) give most records of B. marginata from depths greater than 100 m. Eade (1967) reports this species to occur most abundantly between 80 and 220 m.

Bulimina sp.

Plate 4, Fig. 11

This species of Bulimina occurred at two stations as very rare constituents of the faunal assemblages. At both stations the specimens were very worn and abraded, but the species appears distinct from the rest noted in this area. It most closely resembles B. aculeata, but is more finely tapering, and the spines were probably more robust and less widely distributed.

GENUS: GLOBOBULIMINA Cushman, 1927

Globobulimina cf turgida (Bailey, 1851)

Plate 7, Fig. 9

A species of Globobulimina resembling that illustrated and described by McMillan (1974) as G. turgida Bailey was recovered from seven stations ranging in depth from 98 to 1530 m. Highest concentrations were found in the deep water stations. The specimens all displayed at least one small spine at the initial end of the test, and are somewhat elongate, with strongly overlapping chambers and distinct sutures. The only variability is in the amount of inflation shown by the chambers.

GENUS: PRAEGLOBOBULIMINA Hofker, 1951

Praeglobobulimina spinescens (Brady, 1884)

Plate 9, Fig. 9

Globobulimina pyrula d'Orbigny v. spinescens - Brady, 1884, p.400, pl.50, figs.11,12.

Globobulimina pyrula Cushman, 1922, p.102, pl.20, fig.2.

Praeglobobulimina spinescens Brady - Loeblich & Tappan, 1964, p.561.

Remarks: This is a distinctive and persistent species, occurring at 28 stations with depths ranging between 98 and 1430 m. It comprises between 15% and 25% of the population at a number of stations. It shows little variation in this area, and always has a number of short spines at the lower end of the test.

Distribution: Brady (1884) recorded the species from 580 fms in the Central Pacific. Cushman (1922) states it is apparently abundant in cold waters.

FAMILY: UVIGERINIDAE Haeckel, 1894

GENUS: UVIGERINA d'Orbigny, 1826

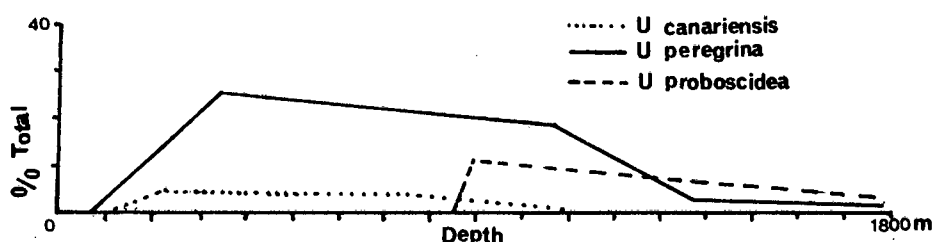


Fig. 35.. Distribution of Uvigerina spp expressed as % of total population

Uvigerina canariensis d'Orbigny, 1839

Plate 10, Fig. 9

Uvigerina canariensis d'Orbigny - Brady, 1884, p.573, pl.74, figs.1-3.

Uvigerina canariensis Cushman, 1923, p.161, pl.41, figs.14-16.

Remarks: This distinctive species occurs at 19 stations with depths ranging from 162 to 995 m, and generally comprises less than 5% of the fauna. There is some variation in the species, particularly in the ornamentation: some individuals are more hispid than others on the final chambers and some have more prominent costae on the initial chambers. The shape of the test remains fairly constant throughout. Distribution: Brady (1884) noted this species from 1900 fms in the South Atlantic, 40 to 140 fms off Patagonia, and 435 fms off Bermuda. Bagg (1908) states that the distribution of this species is somewhat peculiar, being known from very shoal waters and from depths of nearly 2000 fms.

Uvigerina cf. cushmani (Todd 1948)

Plate 10, Fig. 10

Remarks: The specimens placed into this group appear similar to illustrations of U. cushmani Todd in having a fairly parallel sided test and numerous fine costae. As was noted by McMillan (1974), however, many of the specimens are intermediate to and approach U. peregrina, and it is possible that this is a variant of that

species.

Uvigerina peregrina (Cushman, 1923)

Plate 10, Figs. 12-14

Uvigerina peregrina Cushman, 1923, p.166, pl.42, figs.7-10.

Uvigerina peregrina Phleger & Parker, 1951, p.18, pl.8, figs.22,24-26.

Remarks: This species was the most problematical in this area, due to the enormous variation found here and in the literature. It occurs at 24 stations at depths ranging from 92 to 1495 m, but is best represented at stations between 117 and 736 m. In many of these stations it constitutes 30% to 40% of the fauna. It varies immensely in the shape of the test, which in general is ovate, broadest in the middle, and round at the ends, but which sometimes approaches parallel-sided. The costae are always prominent and granular, but in some cases become finer than others; the spinose portions of the test are generally not prominent. Phleger and Parker (1951) note that specimens of U. peregrina from deeper water are typical of the type but those from shallower samples are smaller and more coarsely costate. This could be the case in the present area, but further investigation is necessary to verify this. Hofker (1951) placed this species in the genus Euuvigerina on the basis of tooth plate structure, however, Boltovskoy (1978) retains the species in Uvigerina, and this practice has been followed here.

Distribution: This is a widely distributed species occurring in large numbers in many areas. Cushman (1923) noted it to be common in cool waters. Eade (1967) found it abundantly from 80 to 220 m. Boltovskoy (1978) noted it as rare in his Oligocene, lower Miocene, Middle Miocene, Upper Miocene and Pliocene horizons, and rare to frequent in the Quaternary sequence of the Ninetyeast Ridge. McMillan (1974) noted it as most common at station 353 (210 m) on the Agulhas Bank.

Uvigerina proboscidea (Schwager, 1866) s.l.

Plate 10, Figs. 11, 15

Siphouvigerina proboscidea Schwager - Hayward & Buzas, 1979, p.74, pl.27, fig.334.

Uvigerina proboscidea Schwager - Boltovskoy, 1978, p.171, pl.8, figs.22-32.

Remarks: Specimens of a finely hispid uvigerinid occur at seven stations and with the exception of one specimen found at station 2924 (158 m), all occur in deep water stations. Following Boltovskoy's example, these have been placed in U. proboscidea Schwager, though the apertural end was damaged in most specimens and the characteristic long neck not present. The specimens found here appear to fall within the variation allowed by Boltovskoy, though the final chamber is often more inflated than his illustrations, and those of Hayward and Buzas (1979). The spines are arranged randomly.

Distribution: Boltovskoy states finely hispid uvigerinids are common dwellers of deep waters in Recent and Neogene oceans. He noted this species as rare to frequent

throughout the sequence in the Ninetyeast Ridge. Hayward and Buzas found it commonly in thanatotores C and D (outermost neritic and upper bathyal).

GENUS: RECTUVIGERINA Mathews, 1945

Rectuvigerina nicoli Mathews, 1945

Plate 10, Fig. 1

Sagrina nodosa Parker & Jones - Brady, 1884, p.583, pl.114, fig.18.

Rectuvigerina nicoli Mathews - Barker, 1960, p.236, pl.114, fig.18.

Remarks: This is a persistent species, occurring as a rare constituent at 21 stations with depths ranging from 22 m to 1430 m, but with a definite preference for the more moderate depths from 158 to 326 m. It is not highly variable though some individuals display more prominent costae on the lower chambers; in all cases the costae disappear toward the apertural end and the test becomes finely and irregularly hispid. The aperture is always at the end of a short neck. Originally placed in Siphogenerina by Parker and Jones (1865), this species was placed in Sagrina by Brady (1884), then into Rectuvigerina in Mathews' (1945) re-study of Siphogenerina (Barker, 1960).

Distribution: This apparently is a fairly localized species, and was found by Brady in 150 fms off South Africa. Parker and Jones (1865) described it from the North Atlantic.

GENUS: TRIFARINA Cushman, 1923

Trifarina sp. A

Plate 10, Fig. 7

Six specimens of Trifarina were recovered from four stations with depths of 190, 352, 478, and 1780 m. The surface ornamentation of this species is reminiscent of T. angulosa Williamson, however the chambers of these specimens appear to be too inflated for that species-

Trifarina sp. B

Plate 10, Fig. 8

Three specimens of Trifarina were recovered from two stations: 2852 and 3202. These specimens are considerably more inflated than the previous species and display fewer, less prominent costae. It is possible, however, that they are variants of the same species.

SUPERFAMILY: DISCORBACEA Ehrenberg, 1838

FAMILY: DISCORBIDAE Ehrenberg, 1838

SUBFAMILY: DISCORBINAE Ehrenberg, 1838

GENUS: DISCORBIS Lamarck, 1804.

Discorbis sp.

Plate 6, Fig. 8

Three specimens were recovered from three stations at depths of 19, 194, and 418 m. The species displays a sharply angled periphery with a high trochospiral dorsal side. Imperforate flaps extend from the base of each chamber toward the umbilicus on the ventral side, but are not as extensive as those displayed by many species of Discorbis.

GENUS: EPISTOMINELLA Husezima and Maruhasi, 1944

Epistominella sp.

Plate 6, Fig. 13

Ten specimens of Epistominella were recovered from two stations at depths of 178 and 360 m. They resemble E. exigua Brady as illustrated by Brady (1884), Boltovskoy (1978) and Parker (1964), but differ in having a smaller, less elongate aperture. In addition, the previously mentioned authors all report E. exigua from deep water (mostly deeper than 1000 m), whereas the specimens found here are from middle and outer shelf (178-360 m).

GENUS: GAVELINOPSIS Hofker, 1951

Gavelinopsis sp.

Plate 7, Fig. 8

A species of Gavelinopsis occurred as a frequent constituent of the fauna at two stations: 2848 and 3354, both of which are among the deeper stations in this area. The species resembles G. lobatulus Parr, but the sutures on the ventral side are not as severely curved as in that species, nor is the periphery as strongly lobulated.

GENUS: LATICARININA Galloway and Wissler, 1927

Laticarinina pauperata (Parker and Jones, 1865)

Plate 8, Fig. 4

Pulvinulina pauperata Parker & Jones - Cushman, 1931, p.114, pl.20, fig.4, pl.21, fig.1.

Laticarinina pauperata Parker & Jones - Boltovskoy, 1978, p.162, pl.4, fig.32.

Remarks: One specimen which has been referred to this species was found at station 3354 (1780 m). It appears very similar to illustrations by both Cushman and Boltovskoy, and to Cushman's description.

Distribution: Brady (1884) found it at 12 localities in the north Atlantic at depths ranging from 390 to 2176 fms. In the South Atlantic, it occurs at four stations ranging between 675 and 2350 fms. Cushman (1931) found it to be common in the western Atlantic, especially in the Gulf of Mexico, with depths ranging from 159 to

1330 fm. He notes it is usually found in globigerinid oozes. Boltovskoy (1978) found it to have a rare occurrence at five stations on the Ninetyeast Ridge.

GENUS: ROSALINA d'Orbigny, 1826

Rosalina sp.

Plate 10, Fig. 2

Six specimens of Rosalina were recovered from two stations: 3398 (87 m) and RS45. Most specimens were damaged and no specific determination was possible.

SUBFAMILY: BAGGININAE Cushman, 1927

GENUS: CANCRIS de Montfort, 1808

Cancris oblonga Group

Plate 4, Figs. 13, 14

Cancris oblonga (Williamson, 1858)

Pulvinulina oblonga Williamson - Brady, 1884, p.688, pl.106, fig.4.

Cancris oblonga Williamson - Barker, 1960, p.218, pl.106, figs.4,5?.

Cancris oblonga Phleger & Parker (1951), p.20, pl.9, figs.17,18.

Remarks: The species of Cancris found in this area vary between C. oblonga and C. auricula as first illustrated by Brady. Barker (1960) noted there has been confusion regarding these two species, and he considered them both to be variations of C. oblonga, with the stipulation that further investigation was needed. The majority of the specimens found in this area tend toward C. oblonga. In some stations, particularly 2924 and 3016, most of the specimens were worn and abraded. Distribution: Brady (1884) recorded C. oblonga from 150 fms off South Africa and 390 fms in the West Indies. McMillan (1974) found small numbers at almost all stations on the Agulhas Bank. Heron-Allen and Earland (1915) recorded the species as not uncommon in their New Zealand and Antarctic study, noting most of the specimens to be small and thin-walled.

FAMILY: SIPHONINIDAE Cushman, 1927

GENUS: SIPHONINA Reuss, 1850

Siphonina sp.

Plate 10, Fig. 4

One badly pitted specimen of Siphonina was recovered from the Tripp Sea Mount.

SUPERFAMILY: ROTALIACEA Ehrenberg, 1839

FAMILY: ROTALIIDAE Ehrenberg, 1839

SUBFAMILY: ROTALIINAE Ehrenberg, 1839

GENUS: AMMONIA Brunnich, 1772.

Ammonia beccarii (Linné, 1758)

Plate 3, Figs. 2,3

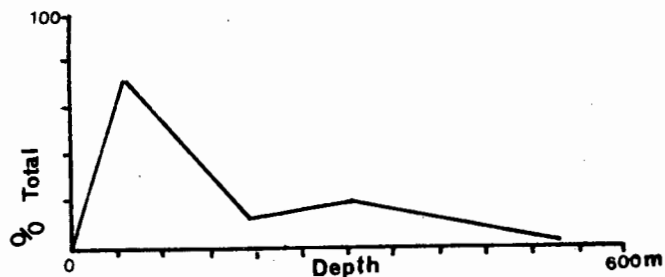
Nautilus beccarii - Linné, 1758, p.710.Rotalia beccarii Linné, - Brady, 1884, p.704, pl.107, figs.2,3.Rotalia beccarii Linné - Cushman, 1931, p.58, pl.12, figs.1-7, pl.13, figs.1,2.

Fig. 36. Distribution of A. beccarii expressed as percent of total population.

Remarks: This highly variable species has a wide distribution in this area, occurring at 46 stations, and constituting up to 100% of the fauna at some stations. The enormous variation in test morphology of A. beccarii has resulted in the erection of a large number of varieties, but it was decided here to consider them under the single name A. beccarii Linné. The varieties found in this area are of two types. The most common has a large (>355 $\mu$ ) robust test, with a broadly rounded, slightly lobulated periphery and pronounced excavation of the umbilicus. The less common variety occurs primarily in stations very close to shore and in the river samples. These are smaller, more compressed, with a more angular periphery and an umbonal plug rather than an excavated umbilicus. Many stations dominated by the larger variety showed a number of smaller individuals which displayed umbonal plugs, suggesting that the excavation may be a maturity feature.

Distribution: This is an extremely widely distributed species found in shallow waters in most areas of the world. Brady (1884) stated its geographic range as 60°N to 35°S and reported it from the 'Challenger' sample off the Cape of Good Hope. He points out that its home is usually less than 50 feet, though he noted some smaller specimens in deeper water. He states that it inhabits the margins of all the great oceans except in the extreme north and south. Cushman (1931) gives many references for it on both sides of the Atlantic.

GENUS: PARAROTALIA Y. Le Calvez, 1949

Pararotalia cf nipponica Asano

Plate 9, Fig. 6

This species, which Miss Ruth Todd (pers. comm.) has compared with P. nipponica Asano occurs as an abundant constituent of many nearshore stations. It is found in nine samples with depths down to 360 m, but is most prominent in those stations that are shallower. In the deeper samples it is abraded. The species is not

highly variable, displaying seven or eight chambers in the final whorl, an acute, lobulate periphery with a narrow keel, and deeply depressed, radial, slightly curved sutures on the umbilical side. Most variation is found in the umbilical area, which is deeply sculpted in many individuals.

FAMILY: ELPHIDIIDAE Galloway, 1933

SUBFAMILY: ELPHIDIINAE Galloway, 1933

GENUS: Elphidium de Montfort, 1808

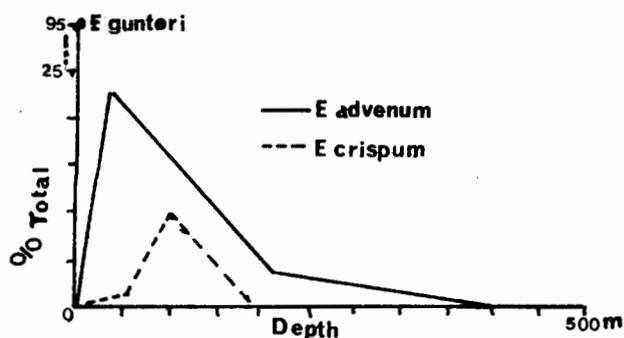


Fig. 37. Distribution of Elphidium spp. expressed as percent of total population.

Elphidium advenum (Cushman, 1922)

Plate 6, Fig. 9

Polystomella subnodosa Munster - Brady, 1884, p.734, pl.110, fig.1.

Elphidium advenum - Cushman, 1930, p.25, pl.10, figs.1,2.

Remarks: This species is one of the commonest of the inner shelf, occurring at 29 stations. Although it ranges from 12 to 418 m in depth, it is most prevalent in the samples less than 200 m. The specimens in this area correspond closely with Cushman's (1930) description and illustrations, and show little variation. Most display a narrow carina; a few have a slightly lobulate periphery.

Distribution: E. advenum is a widely distributed species, common to shallow waters in many parts of the world, chiefly in tropical seas. Cushman's (1930) types are from Tortuga, off southern Florida. Todd and Bronniman (1957) report it as common in the nearshore zone and abundant in the offshore zone in the Gulf of Paria.

Brady (1884) recorded it from eight fms in the Torres Strait, and from 25 to 29 fms off southern Papua. Albani (1968) noted it as rare to common at seven stations in Port Hacking, New South Wales.

Elphidium crispum (Linné 1758)

Plate 6, Fig. 10

Polystomella crispa Linné - Brady, 1884, p.736, p.110, figs.6,7.

Elphidium crispum Linné - Cushman, 1930, p.20.

Elphidium crispum Albani, 1968, p.111, pl.10, fig.7.

Remarks: Although occurring at only eight stations, E. crispum is a common constituent at several (15%-25% of the population), particularly station 2994 and the beach sample. At most stations, E. crispum is heavily abraded, much more so than the other species of Elphidium.

Distribution: Brady (1884) records this species from littoral depths down to 258 fms. Albani (1968) noted it as common or frequent at nine stations in Port Hacking. McMillan (1974) reported it in "large numbers" at his station 1259 (91 m) on the Agulhas Bank, but decreasing in number in deeper water.

Elphidium gunteri (Cole, 1931)

Plate 6, Fig. 11

Elphidium gunteri - Cole, 1931, p.34, pl.4, figs.9-10.

Elphidium gunteri Bandy, 1956, p.194, pl.30, fig.19.

Remarks: This species occurs at only two stations, both from the Orange River mouth. In a sample taken from the marshland just behind the bar at the mouth of the river, benthic foraminifera were very abundant, with E. gunteri comprising 95% of these. At one up-river station, a single specimen was found. All specimens were small and appeared fresh and unaltered, the tests translucent.

Distribution: Bandy (1956) records this species as being among the dominant species of Fauna 1 (8 to 40 feet) in the northeastern Gulf of Mexico. Buzas, et al (1977) report it as occurring rarely on a back-reef flat (Station 1) in Jamaica.

Elphidium cf macellum (Fichtel and Moll 1798)

Plate 6, Fig. 12

Two specimens of Elphidium which appear very similar to E. macellum as illustrated by Brady (1884) were recovered from station 3132 (118 m). They are distinct from E. crispum in having a boss, which, though prominent, is not greatly raised and which shows marked pitting. In addition, the carina of this species is not as broad or well-defined as that of E. crispum.

SUPERFAMILY: ORBITOIDACEA Schwager, 1876

FAMILY: EPNIDIDAE Hofker, 1951

GENUS: EPONIDES de Montfort, 1808

Eponides tenera (Brady, 1884)

Plate 6, Fig. 14

Truncatulina tenera - Brady, 1884, p.665, pl.95, fig.11.

Eponides tenera Brady - Cushman, Todd, and Post, 1954, p.359, pl.89, fig.20.

Remarks: This species occurs at seven stations ranging from 360 to 1780 m, reaching its highest concentration at the deepest station where it constitutes 9% of the population. Specimens in this area closely resemble Brady's (1884) illustration; they generally have six to seven chambers in the final whorl with dorsal sutures radial and ventral sutures slightly curved or sinuous. The periphery is sharply angled and lobulate.

Distribution: Brady (1884) recorded it from the west coast of Patagonia at 120 fms. Cushman, Todd and Post (1954) reported it from the guyot and outer slopes in the Marshall Islands. Eade (1967) noted it as being persistent between 80 and 220 m off New Zealand.

FAMILY: CIBICIDIDAE Cushman, 1927

SUBFAMILY: PLANULININAE Bermudez, 1952

GENUS: PLANULINA d'Orbigny, 1826

Planulina ariminensis d'Orbigny, 1826

Plate 9, Fig. 8

Anomalina ariminensis d'Orbigny - Brady, 1884, p.674, pl.93, figs.10,11.

Planulina ariminensis d'Orbigny - Cushman, 1931, p.110.

Remarks: Occurring at 19 stations with depths ranging from 19 to 736 m, this species is typical of the middle shelf fauna. It varies little, maintaining a highly compressed profile, square periphery, thick, heavily curved sutures, and a thick keel. Distribution: This is a cosmopolitan species, with numerous records. McMillan (1974) obtained six specimens from deep water locations on the Agulhas Bank. Brady (1884) noted it from 357 fms off Pernambuco in the Atlantic. Bagg (1908) recorded it to be abundant in the North Atlantic, but rare in the South Atlantic and South Pacific. He noted it from the Abrahlos Bank in the Pacific (47 to 990 fms) and in Hong Kong harbor.

GENUS: HYALINEA Hofker, 1951

Hyalinea balthica (Schroeter, 1783)

Plate 7, Fig. 15

Nautilus balthica - Schroeter, 1783, p.20.

Operculina ammonoides Gronovius - Brady, 1884, p.745, pl.112, figs.1,2.

Anomalina balthica Schroeter - Cushman, 1931, p.108, pl.19, fig.3.

Hyalinea balthica Schroeter - Barker, 1960, p.230, pl.112, figs.1,2.

Remarks: This species occurs at 20 stations with depths ranging from 92 to 995 m. It is a distinctive constituent, though always rare. In this area it shows little morphological variation, and closely resembles Brady's (1884) figures. It is sometimes abraded, and commonly opaque.

Distribution: Brady (1884) found H. balthica at 150 fms off the Cape of Good Hope, but stated it has wide geographic and bathymetric ranges. Cushman (1931) reports it to be abundant in cold and often deep waters of the North Atlantic. Bagg (1908) reported it as rare to abundant at 12 stations in the South Pacific. McMillan (1974) found 20 specimens at station 353 (210 m) on the Agulhas Bank.

SUBFAMILY: CIBICIDINAE Cushman, 1927

GENUS: CIBICIDES de Montfort, 1808

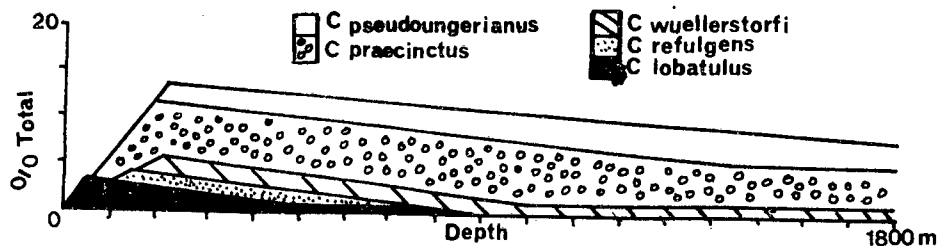


Fig. 38. Distribution of Cibicides spp expressed as percent of total population

Cibicides cf bradyi (Trauth, 1918)

Plate 5, Fig. 3

Truncatulina dutemplei d'Orbigny - Brady, 1884, p.665, pl.95, fig.5.

Cibicides bradyi Trauth - Boltovskoy, 1978, p.155, pl.3, figs.6-8.

This species occurs as a rare constituent at two stations in depths of 182 and 996 m. It is most similar to Boltovskoy's (1978) illustrations.

Cibicides lobatulus (Walker and Jacob, 1798)

Plate 5, Figs. 4,5,6

Truncatulina lobatulus Walker & Jacob - Brady, 1884, p.660, pl.92, fig.10, pl.93, figs.1,4,5, pl.115, figs.4,5.

Cibicides lobatulus Walker & Jacob - Cushman, 1931, p.118, pl.21, fig.3.

Remarks: Though never abundant, this is a persistent species, occurring in water as shallow as 51 m and as deep as 995 m. It is highly variable, apparently due to its tendency to conform to the shape of the vegetation on which it usually lives. The most highly deformed specimens occur on the Tripp Sea Mount and at station 3264. Distribution: McMillan found C. lobatulus to be common on the middle and outer shelf on the Agulhas Bank. Brady's (1884) figured specimens are from 18 fms off the Friendly Islands in the Pacific, but he notes the species to be ubiquitous and most abundant in shallow waters, though conspicuous as deep as 3000 fms. Cushman (1931) notes it to be common in cool waters and highly variable.

Cibicides praecinctus (Karrer, 1868)

Plate 5, Fig. 7

Truncatulina praecinctus Karrer - Brady, 1884, p.627,677, pl.95, figs.1-3.

Cushman, 1915, p.39, pl.26, fig.2, t.f. 42.

Remarks: Specimens of Cibicides closely resembling Brady's (1884) figures of C. praecinctus Karrer occur at 12 stations. As noted by McMillan (1974) the separation of C. praecinctus from C. pseudoungerianus Cushman, can be extremely difficult, especially in juveniles. In this study, McMillan's guidelines for the distinction of the two species have been used:

1) Curvature of sutures -- juvenile specimens of both species have similar curvature, but those of mature specimens of C. pseudoungerianus become more curved, sometimes nearly attaining a right angle.

2) The outline of the test of C. praecinctus has a conical ventral side with a planar or faintly convex dorsal side. With maturity, the dorsal side becomes markedly convex, and the ventral side flattens considerably, though it is still convex. Juveniles of C. pseudoungerianus are similar, but the mature specimens retain a plano-convex outline and develop a spreading test.

3) The aperture of C. praecinctus is developed primarily on the ventral side and extends only slightly to the dorsal. That of C. pseudoungerianus is almost equally developed on both sides, with a flap-like projection over it.

Distribution: Brady (1884) recorded the species from a number of stations in the Pacific with a depth range of 17 to 100 fms. Cushman (1915) noted it from 770 and 66 fms off Japan. Bagg (1908) found it at 438 fms off Hawaii.

Cibicides pseudoungerianus (Cushman, 1922)

Plate 5, Fig. 8,9

Truncatulina ungeriana d'Orbigny - Brady, 1884, p.664, pl.94, fig.9.

Cibicides pseudoungerianus - Cushman, 1931, p.123, pl.22, figs.3-7.

Remarks: Occurring at 21 stations, this species along with C. praecinctus is a common constituent of the fauna in this area. Its distinction from C. praecinctus has been described in the previous section; however, it displays a certain amount of variability in the convexity of the ventral side.

Distribution: Brady's (1884) figured specimen is from 862 fms southwest of Ireland, and he reports a few specimens from the South Atlantic off the Cape of Good Hope. He notes it prefers moderate to deep waters. McMillan (1974) reported the species as abundant at middle and outer shelf stations on the Agulhas Bank. Heron-Allen and Earland (1915) record it as being almost universal in their New Zealand and Antarctic samples.

Cibicides refulgens Montfort, 1808

Plate 5, Figs. 10,11

Truncatulina refulgens Montfort - Brady, 1884, p.659, pl.92, figs.7-9.

Cibicides refulgens Montfort - Cushman, 1931, p.116, pl.21, fig.2.

Todd & Bronniman, 1957, p.41, pl.12, fig.12.

Remarks: Although occurring at 26 stations, this species does not attain large numbers except in the Tripp Sea Mount sample, where it constitutes 12.7% of the population. It displays a certain amount of variability in the shape of the ventral side, many individuals becoming more dome-like than conical. This tendency is particularly well-developed in the Tripp Sea Mount sample, and was also noted by McMillan (1974) in the Agulhas Bank samples.

Distribution: Cushman (1931) notes this species is widely reported from the Recent and as a fossil, and is primarily a cool water form. Brady (1884) recorded the species from southwest of Ireland at 725 fms, and from the west coast of Patagonia at 120 fms, and off the Cape of Good Hope at 150 fms. Heron-Allen and Earland (1915) reported it to be universal in their New Zealand and Antarctic samples, attaining its maximum development in the south.

Cibicides cf robertsonianus (Brady, 1884)

Plate 5, Figs.12,13

Two specimens of Cibicides strongly resembling C. robertsonianus Brady were recovered in sample 3354 at 1780 m. Both display the partially evolute ventral side shown in Brady's (1884) figures, and the nearly right-angled sutures on the dorsal side.

Cibicides wuellerstorfi (Schwager, 1866)

Plate 6, Figs. 1,2

Truncatulina wuellerstorfi Schwager, Brady, 1884, p.662, pl.93, figs.8,9.

Planulina wuellerstorfi Schwager, Cushman, 1931, p.110, pl.19, figs.5,6.

Cibicidioides wuellerstorfi Schwager - Parker, 1964, p.625, pl.100, fig.24.

Cibicides wuellerstorfi Schwager - Boltovskoy, 1978, p.157, pl.3, figs.19-21.

Remarks: Occurring at 26 stations. C. wuellerstorfi is the most persistent species of its genus, though never more than a frequent member of the population. Although ranging in depth from 98 to 1780 m, it is commonest between 190 m and 280 m. There is little variation in the species in this area; pores are generally large, with some smaller, sutures are thickened and strongly arched, and a thickened keel is always present.

Distribution: This is a widely distributed species. Brady's (1884) figured specimen is from 275 fathoms off the west coast of New Zealand. Parker (1957) recorded it from all twelve Mohole samples. Boltovskoy used the ratio of Planulina marialana gigas to C. wuellerstorfi as an indicator of the Lower/Middle Miocene boundary in the Ninetyeast Ridge samples.

FAMILY: CAUCASINIDAE N.k. Bykova, 1959

SUBFAMILY: FURSENKOININAE Loeblich & Tappan, 1961

GENUS: FURSENKOINA Loeblich & Tappan, 1961.

Fursenkoina rotundata (Parr, 1950)

Plate 7, Figs.5, 7

Virgulina subsquamosa Egger - Brady, 1884, p.415, pl.52, figs.10,11.

V. rotundata Parr Barker, 1960, p.106, pl.52, figs.10,11.

Remarks: This species occurs at 11 stations ranging in depth from 162 to 1530 m. It is generally rare, and there is little variation among the individuals. Although placed in Virgulina by Brady and Barker, this species should be termed Fursenkoina,

as this name has priority over the former (Loeblich & Tappan, 1964).

Distribution: Brady records this species from 620 fathoms off Tahiti.

Fursenkoina cf davisi (Chapman and Parr, 1931)

Plate 7, Fig. 6

Remarks: This graceful species appears in 13 samples with depths between 153 and 1530 m, achieving its highest concentrations in the deeper samples. Taxonomy of this species is somewhat problematic. It closely resembles specimens illustrated by Brady (1884) which Barker (1960) points out have been assigned to Fursenkoina (= Virgulina) davisi. It does not resemble F. schriebersiana as illustrated by Bandy (1954) or Hayward and Buzas (1979). Brady's (1884) Figure 2 was tentatively assigned to Cassidella pacifica Hofker, but the specimens in this area lack the early triserial stage of Cassidella. They are, however, less severely twisted than would be expected of Fursenkoina, though the comma-shaped aperture is typical.

FAMILY: CASSIDULINIDAE d'Orbigny, 1839

GENUS: CASSIDULINA d'Orbigny, 1826

Cassidulina carinata (Silvestri, 1896)

Plate 4, Fig. 15

Cassidulina laevigata d'Orbigny v. carinata - Cushman, 1922, p.124, pl.25, figs.6,7.

Phleger & Parker, 1951, p.27, pl.14,

figs.7(a,b).

Cassidulina carinata Silvestri - Eade, 1967, p.429, figs.5-9.

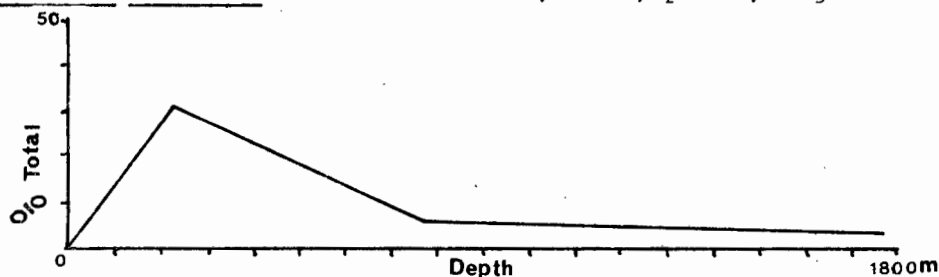


Fig. 39. Distribution of C. carinata expressed as percent of total population

Remarks: Occurring at 45 stations at concentrations up to 48%, C. carinata is second only to Ammonia beccarii in persistence. Its depth range is between 12 and 1780 m, with greatest concentrations between 110 and 200 m. The separation of C. carinata Silvestri and C. laevigata d'Orbigny is difficult; specimens in this area generally display a carina which does, however, vary from extremely narrow to wide and distinct. A few specimens from deeper waters did not appear to display this carina and should more correctly be referred to C. laevigata. Without exception, however, these were worn and abraded, and may originally have been carinate. All specimens have therefore been referred to C. carinata.

Distribution: Brady noted this species at 150 fathoms off New Zealand and 1630 fathoms at Porcupine station 11 in the north Atlantic. Cushman found it to be

widely distributed, but more common in deeper waters. Eade (1967) gave its distribution as ranging from intertidal to deep sea, with maximum development of keel and aperture between 120 and 500 m.

FAMILY: NONIONIDAE Schultze, 1854

SUBFAMILY: NONIONINAE Schultze, 1854

GENUS: NONION de Montfort, 1808

Nonion affine (Reuss, 1850)

Plate 8, Fig. 11

Nonionina umbilicatula Montagu - Brady, 1884, p.726, pl.109, figs.8,9.

Melonis affine Reuss - Parker, 1964, p.626, pl.100, figs.11,12.

Nonion affine Reuss - Boltovskoy, 1978, p.162, pl.5, figs.1,2.

Remarks: This species occurs at 13 stations with depths ranging from 280 to 1780 m and is best developed at the deeper stations. It is not highly variable; some specimens display a more angular and very slightly lobulate periphery. Considerable confusion surrounds this species; a species which appears very similar was figured by Brady (1884) and designated as Nonionina umbilicatula Montagu. Barker refers it to Gavelonion barleeanum Williamson, but states that Boltovskoy refers all such species to Nonion affine Reuss (1850). Loeblich and Tappan (1964) regard Gavelonion as a junior synonym of Melonis, and Parker (1964) refers this species to Melonis. Boltovskoy (1978) however, retains it as Nonion affine Reuss, and he has been followed here.

Distribution: Brady (1884) recorded the species from 390 fms in the West Indies and 2350 fms off Tahiti. Parker (1964) found it in 11 samples from the Mohole drilling, in a fauna which she considers typical of 1000 m and deeper. Boltovskoy noted it as rare to frequent in five samples from the Ninetyeast Ridge. Heron-Allen and Earland (1915) found it to be general throughout their New Zealand and Antarctic samples. At one Antarctic station it became very thick, approaching N. pompilioides.

GENUS: FLORILUS de Montfort, 1808

Florilus boueanum (d'Orbigny, 1826)

Plate 7, Fig. 4

Nonionina boueana d'Orbigny - Brady, 1884, p.720, pl.109, figs.12,13.

Nonion boueanum d'Orbigny - Todd & Bronniman, 1957, p.32, pl.5, figs.25,26.

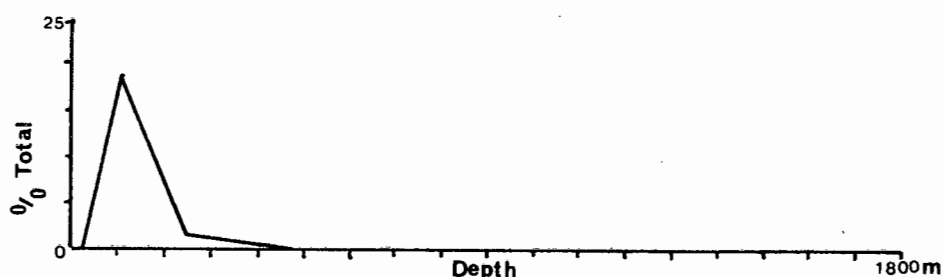


Fig. 40. Distribution of Florilus boueanum expressed as percent of total population

Remarks: Occurring at 13 stations with a depth range of 51 to 418 m, this species is a distinctive constituent of the inner to middle shelf fauna. It reaches its highest concentrations between 92 and 123 m, but is abundant at only one station (3132). There is little variation in the species, though some individuals exhibit less than typical flare in the final chambers. Although Brady assigned the species to Nonionina, Barker places Brady's specimens in comparison with Nonion asterizans Fichtel and Möll as illustrated by Cushman (1939). As one reason for the transfer, Barker cites Cushman's records of N. boueanum from Miocene and Pliocene of Europe only. Todd and Bronniman (1957), however, note boueanum as being a common constituent of the offshore zone in the Gulf of Paria. Todd later placed the species in the genus Florilus (pers. comm.).

GENUS: NONIONELLA Cushman, 1926

Nonionella turgida (Williamson 1858)

Plate 8, Fig. 12

Nonionina turgida Williamson - Brady, 1884, p.731, pl.109, figs.17-19.

Nonionella turgida Williamson - Cushman, 1930, p.18, pl.6, figs.1-4.

Remarks: This species occurs at 11 stations with depths between 117 and 1530 m. Except at station 3635 (117 m) it is a rare constituent of the assemblage. It is generally of small size (63 $\mu$  to 180 $\mu$ ) and shows little variation, except in the amount of inflation of the final chamber, which is less in the smaller individuals. Distribution: Brady (1884) noted it as a shallow water species, and rare in the South Atlantic. He recorded it from 64 to 75 fms east of the Shetland Islands and 150 fms off the west coast of New Zealand. Cushman (1930) states it is a common species in the muddy dredgings about the British Isles. Todd and Bronniman (1957) noted it to be abundant in the offshore zone of the Gulf of Paria. Heron-Allen and Earland recorded it fairly frequently in their New Zealand and Antarctic samples.

GENUS: NONIONELLINA Voloshinova, 1958

Nonionellina labradorica Dawson, 1868

Plate 8, Fig. 14

Nonion labradoricum Dawson - Cushman, 1930, p.11, pl.4, figs.6-12.

Florilus labradoricum Dawson - Todd & Low, 1967, p.35, pl.5, fig.9.

Remarks: Five specimens of this species were recovered from two stations at depths of 335 and 352 m. They appear identical to those illustrated by Cushman and Todd and Low, and are distinctive for their deep umbilicus and broad, inflated, triangular final chamber.

Distribution: Cushman (1930) states the species is abundant in cold waters from northern New England northwards and is also found on the west coast of the United

States. Todd and Low (1967) found it to be fairly abundant in Kosaan Bay and Clarence Strait of southeastern Alaska.

GENUS: PULLENIA Parker & Jones, 1862

Pullenia bulloides (d'Orbigny, 1826)

Plate 9, Fig. 11

Pullenia sphaeroides d'Orbigny - Brady, 1884, p.615, pl.84, figs.12,13.

Cushman, 1924, p.40, pl.8, figs.3,4.

Pullenia bulloides d'Orbigny - McMillan, 1974, p.87, pl.9, fig.4.

Remarks: With the exception of two specimens recovered from station 3398 (87 m), this species is confined to the stations from 736 m deeper. All specimens appear typical, with four chambers in the final whorl, sutures distinct, nearly flush, and an almost round profile.

Distribution: This is a widely distributed deep water species. Brady (1884) noted it in the North Pacific at 1850 fms and in the South Atlantic in 2200 fms. McMillan (1974) found eight specimens, mainly from stations on the outer shelf.

Pullenia subcarinata (d'Orbigny, 1826)

Plate 9, Fig. 12

Pullenia quinqueloba Reuss - Brady, 1884, p.617, pl.84, figs.14,15.

Phleger & Parker, 1951, p.29, pl.15, figs.12,13.

Remarks: Occurring at 19 stations ranging between 158 and 1780 m, this species is characteristic of the mid-shelf and upper slope. It always appears fresh and unaltered and usually displays a subangular periphery and six chambers in the final whorl. Considerable discussion has occurred regarding the taxonomy of this species. It was referred by Brady (1884) to P. quinqueloba Reuss, but Heron-Allen and Earland (1915) considered it synonymous with P. subcarinata d'Orbigny. Boltovskoy (1978) on the other hand, feels the two should be distinguished as subspecies. Those with depressed sutures, lobulate periphery and five chambers per whorl are termed P. subcarinata quinqueloba, and those with five or six chambers per whorl are termed P. subcarinata subcarinata. Specimens from this area generally fall within the definition of P. subcarinata and are therefore considered such, though a few individuals did display only five chambers per whorl and a less angular periphery.

Distribution: Brady noted this species from 120 fms off the Kerguelen Island and 50 to 150 fms off Prince Edward Island, stating it is best developed in the southern hemisphere. Cushman (1924) considered it to be typical of cold deep waters. Phleger and Parker (1951) found it to have a wide range of depths, but primarily below 940 m.

FAMILY: ALABAMINIDAE Hofker, 1951

GENUS: GYROIDINA, d'Orbigny, 1826

Gyroidina orbicularis d'Orbigny, 1826

Plate 7, Figs. 10,11

Rotalia orbicularis d'Orbigny - Brady, 1884, 706, pl.115, fig.6.Gyroidina orbicularis d'Orbigny - Cushman, 1931, p.37, pl.8, figs.1,2.

Remarks: This species occurs at 23 stations ranging from 148 to 1430 m, but is generally very rare. It is most prominent in samples from the outer shelf and slope. The specimens occurring here display a fairly small umbilicus and angled, slightly lobulated periphery, with dorsal sutures generally tending to be right angled rather than oblique. Brady's (1884) illustrations show more angled dorsal sutures, but Boltovskoy's (1978) specimens appear to have right-angled dorsal sutures. The umbilical flaps figured so prominently by Loeblich and Tappan (1964) are not evident in the specimens from this area, but are also not evident in the previously mentioned illustrations.

Distribution: Brady's (1884) specimens are from 150 fms off South Africa. Boltovskoy (1978) lists it as a rare constituent of one sample from the Ninetyeast Ridge. Phleger and Parker (1957) list it as being most notable in moderate to deep waters.

Gyroidina soldanii d'Orbigny, 1826

Plate 7, Figs. 12,13

Rotalia soldanii d'Orbigny - Brady, 1884, p.706, pl.107, figs.6,7.Gyroidina soldanii d'Orbigny - Cushman, 1931, p.18, pl.8, figs.3-8.

Remarks: This species occurs at five deep water stations as a rare or very rare constituent. It is differentiated from G. orbicularis in having a much thicker, more robust profile and a more prominent umbilicus. Sutures are straight to slightly angled, chambers are fairly numerous.

Distribution: Brady (1884) records it from the South Pacific in 1450 fms and 2050 fms. Cushman, Todd, and Post (1954) found it on the guyot and outer slopes near the Marshall Islands. Boltovskoy (1978) noted it as a rare to frequent constituent of several samples on the Ninetyeast Ridge.

GENUS: ORIDORSALIS Andersen, 1961

Oridorsalis umbonatus (Reuss, 1850)

Plate 9, Figs.1,2

Pulvinulina umbonata Reuss - Brady, 1884, p.695, p.105, fig.2.Eponides umbonata Reuss - Cushman, 1923, p.52, pl.11, figs.1-3.Oridorsalis umbonatus Reuss - Boltovskoy, 1978, p.162, pl.5, figs.5,6.

Remarks: This species was found at 10 stations ranging from 326 to 1780 m with the highest concentration at station 3406 (1530 m). The taxonomic position of this species has been much debated; Barker points out that it has been placed in Pulvinulina (Brady, 1884), Rotalia (Galloway & Morrey), Gyroidina (Hofker), and

Eponides (several authors). Boltovskoy (1978) places it in Oridorsalis, stating that a number of his specimens display the supplementary apertures characteristic of that genus. SEM micrographs of specimens from this area reveal what appear to be supplementary apertures on both dorsal and ventral sides, but particularly well-developed on the spiral sides at the junction of the spiral and septal sutures. It was therefore decided to retain these specimens in Oridorsalis.

Distribution: Brady (1884) considers this to be a deep water species, ranging from 675 to 2475 m, in the South Atlantic. Cushman (1923) states it is a long-ranging, widespread species. Boltovskoy (1978) noted it as rare to common throughout the Oligocene to Quaternary sequence of the Ninetyeast Ridge.

FAMILY: ANOMALINIDAE Cushman, 1927

SUBFAMILY: ANOMALININAE Cushman, 1927

GENUS: ANOMALINA d'Orbigny, 1826

Anomalina colligera (Chapman & Parr, 1931)

Plate 3, Fig. 4

Anomalina ammonoides Reuss - Brady, 1884, p.672, pl.104, figs.2,3.

Cushman, 1915, p.46, pl.19, fig.2.

Anomalina colligera Chapman & Parr - Barker, 1960, p.194, pl.94, figs.2,3.

Remarks: Specimens of Anomalina which correspond closely with Brady's figures occur at depths ranging from 98 to 1430 m. In the Tripp Sea Mount sample, it constitutes 15,9% of the total, but here and in the shallower water samples, the specimens are worn and abraded.

Distribution: Brady records it from two Pacific stations at 37 and 210 fms. Cushman found it at four Pacific stations, ranging from 206 to 1254 fms.

Anomalina globulosa (Chapman & Parr, 1931)

Plate 3, Fig. 5

Anomalina grosserugosa Gumbel - Brady, 1884, p.673, pl.94, figs.4,5.

Anomalina globulosa Chapman & Parr - Boltovskoy, 1978, p.143, pl.1, figs.5-8.

Remarks: The specimens found in this area correspond to those illustrated by both Brady and Boltovskoy. Depth range is 900 to 1780 m and all specimens are well-preserved.

Distribution: A. globulosa was noted by Brady in the Atlantic at Ascension Island (420 fms) and in the North Pacific (2050 fms). Boltovskoy noted it throughout the entire upper Oligocene to Quaternary sequence of the Ninetyeast Ridge of the Indian Ocean. Parker (1964) found the species in eight samples from the Miocene of the Mohole drilling and noted that the fauna indicated a depth greater than 1000 m.

Anomalina cf punctata d'Orbigny 1926

Plate 3, Figs.6,7

Remarks: Two specimens which have been tentatively referred to A. punctata d'Orbigny were recovered from station 3202 at a depth of 900 m. They are similar to Cushman's (1931) description, however they are not quite as involute on the ventral side as would be expected. The boss over the umbilicus is well developed.

GENUS: PAROMALINA Loeblich &amp; Tappan, 1957

Paromalina coronata Parker & Jones, 1857

Plate 9, Fig. 5

Anomalina coronata Parker & Jones - Brady, 1884, p.672, pl.97, figs.1,2.

Cushman, 1931, p.104, pl.18, figs.3,4.

Paromalina coronata Parker & Jones - Barker, 1960, p.200, pl.97, figs.1,2.

Remarks: This robust and distinctive species was found only on the Tripp Sea Mount, where it is a frequent constituent of the assemblage. It closely resembles Brady's illustrations, though the umbilical flaps are better developed than those on Brady's specimens. Many of the specimens in this area were worn and abraded.

Distribution: Brady reported it in 50 to 150 fms off Prince Edward Island, and 620 fms off the Canaries. Bagg (1908) states it is rare within the tropics, but abundant in temperate dredgings in the north and south Atlantic.

SUPERFAMILY: ROBERTINACEA Reuss, 1850

SUBFAMILY: CERATOBULIMININAE Cushman, 1927

GENUS: CERATOBULIMINA Toulou, 1915

Ceratobulimina cf pacifica Cushman & Harris

Plate 5, Fig. 2

Remarks: Occurring as a very rare constituent of two samples, this species resembles those illustrated by Brady (1884) as Bulimina contraria Reuss. Barker (1960) notes that Brady's figures were referred by Chapman and Parr to Ceratobulimina pacifica Cushman and Harris.

SUBFAMILY: EPISTOMININAE Wedekind, 1937

GENUS: HOEGLUNDINA Brotzen, 1948

Hoeglundina elegans d'Orbigny, 1826

Plate 7, Fig. 14

Pulvinulina elegans d'Orbigny - Brady, 1884, p.699, pl.105, figs.3-6.Epistomina elegans d'Orbigny - Cushman, 1931, p.65, pl.13, fig.6.

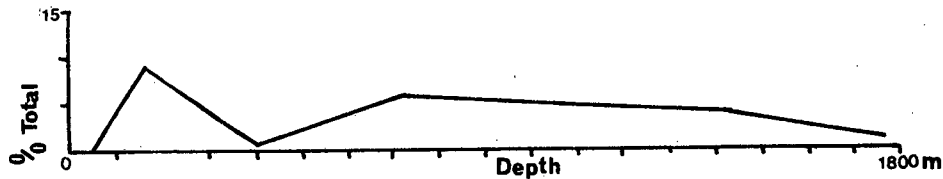


Fig. 41. Distribution of *H. elegans* expressed as percent of total population

Remarks: Occurring at 15 stations with depths ranging between 98 and 1780 m, this beautiful species is often a significant contributor to the microfauna of the middle to outer shelf and upper slope. Generally it attains highest concentration from 178 m deeper. Although a distinctive species, at many stations it was worn and abraded, making identification more difficult. Most specimens are typical of Cushman's description and illustrations by various authors; they show seven to nine chambers in the final whorl, and a robust biconvex profile with a rounded periphery. On those specimens which were worn or had become opaque, the sutures were indistinct, as were the boss and supplementary aperture.

Distribution: Brady noted it at 100 to 150 fms off Tristan d'Acuna, and 390 fms in the West Indies. Cushman (1917) found it to be common in the north Pacific and in 1931 stated it is widely distributed and characteristic of globigerinid oozes. Bagg recorded it from nine stations off the Hawaiian Islands at depths ranging from 367 to 1544 fms. McMillan noted it to be abundant at six middle and outer shelf stations on the Agulhas Bank.

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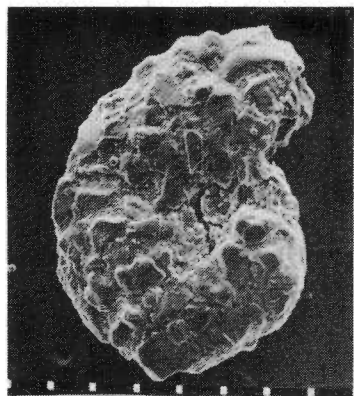
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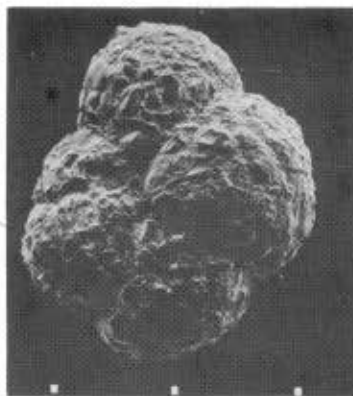
PLATE 1 - TEXTULARIINA

<u>FIGURE</u>		<u>Text page</u>
1.	<u>Ammobaculites americanus</u> Cushman (Scale 100 $\mu$ ) (Sta.2958,100m)	21
2.	<u>Cribrostomoides subglobosum</u> (G.O. Sars) (Scale 300 $\mu$ ) (Sta.3015,195m)	20
3.	<u>Eggerella bradyi</u> (Cushman) (Scale 100 $\mu$ ) (Sta.3020,1258m)	23
4.	<u>Eggerella propinqua</u> (Brady) (Scale 30 $\mu$ ) (Sta.2918,984m)	23
5.	<u>Gaudryina</u> sp. (Scale 500 $\mu$ ) (Tripp Sea Mount)	22
6.	<u>Haplophragmoides canariensis</u> d'Orbigny (Scale 30 $\mu$ ) (Sta.2903,135m)	20
7.	<u>Karrerella bradyi</u> (Cushman) (Scale 100 $\mu$ ) (Sta.3198,350m)	23
8.	<u>Karrerella</u> sp. (Scale 300 $\mu$ ) (Sta.3205,995m)	24
9.	<u>Martinotiella communis</u> (d'Orbigny) (Scale 300 $\mu$ ) (Tripp Sea Mount)	24
10.	<u>Sulcophax</u> sp. (Scale 300 $\mu$ ) (Sta.2744,110m)	20
11.	<u>Textularia agglutinans</u> d'Orbigny (Scale 300 $\mu$ ) (Tripp Sea Mount)	21
12.	<u>Textularia</u> cf <u>goesii</u> Cushman (Scale 100 $\mu$ ) (Sta.2873,178m)	21

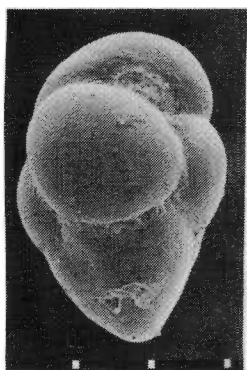
PLATE 1 - Textulariina



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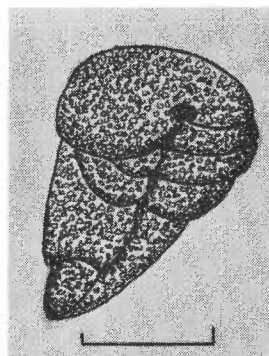
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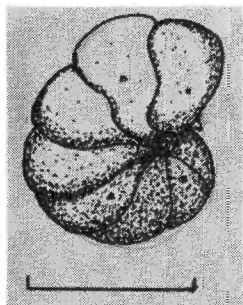
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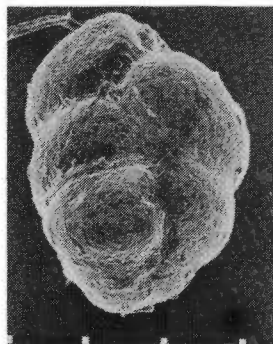
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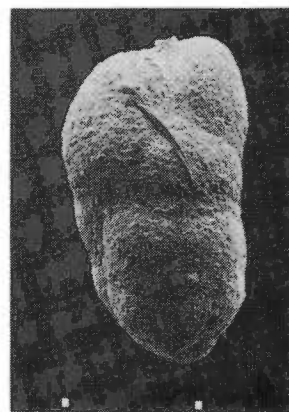
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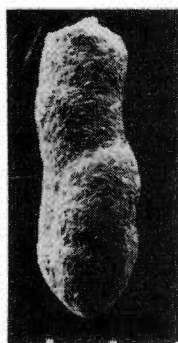
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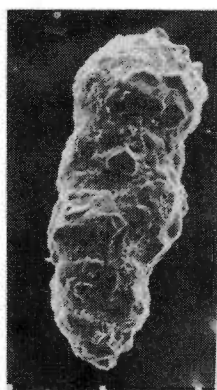
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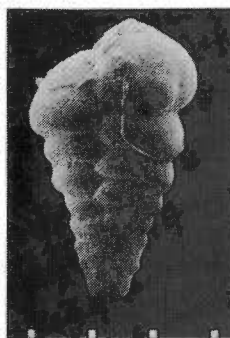
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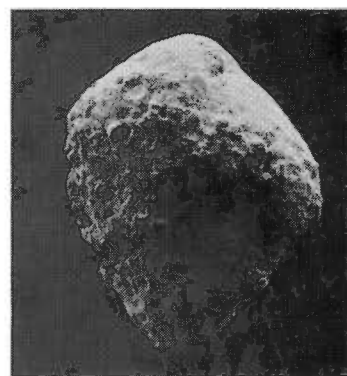
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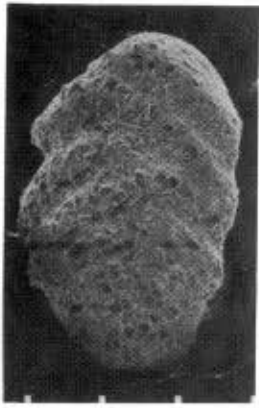


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PLATE 3 - MILIOLIINA AND ROTALIINA

<u>FIGURE</u>		<u>Text. page</u>
1.	<u>Spiroloculina limbata</u> d'Orbigny (Scale 100 $\mu$ ) (Sta.2753,191m)	24
2.	<u>Ammonia beccarii</u> Linné Involute side (Scale 100 $\mu$ ) (Sta.2956,16m)	48
3.	<u>Ammonia beccarii</u> Linné, spiral side (Scale 100 $\mu$ ) (Sta.2956,16m)	48
4.	<u>Anomalina colligera</u> Chapman & Parr (Scale 100 $\mu$ ) (Tripp Sea Mount)	60
5.	<u>Anomalina globulosa</u> Chapman & Parr (Scale 100 $\mu$ ) (Sta.3354,1780m)	60
6.	<u>Anomalina punctata</u> d'Orbigny, involute side (Scale 300 $\mu$ ) (Sta.3202,900m)	61
7.	<u>Anomalina punctata</u> d'Orbigny, spiral side (Scale 100 $\mu$ ) (Sta.3202,900m)	61
8.	<u>Bolivina globulosa</u> Cushman (Scale 100 $\mu$ ) (Sta.2922,190m)	37
9.	<u>Bolivina subspinescens</u> Cushman (Scale 100 $\mu$ ) (Sta.2999,280m)	37
10.	<u>Bolivina</u> sp. (Scale 100 $\mu$ ) (Sta.2918,984m)	38
11.	<u>Bolivinita</u> sp. (Scale 100 $\mu$ ) (Sta.3406,1530m)	36
12.	<u>Brizalina spathulatus</u> Williamson (Scale 100 $\mu$ ) (Sta.3271,153m)	38
13.	<u>Brizalina spathulatus</u> Williamson (Scale 100 $\mu$ ) (Sta.3271,153m)	38

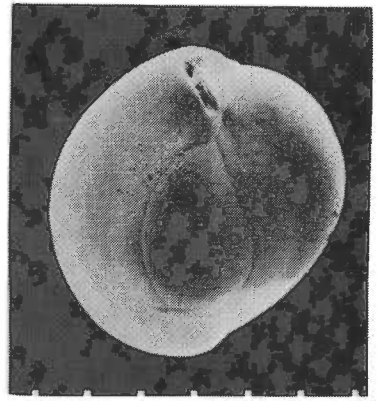
PLATE 2 — Textulariina & Miliolina



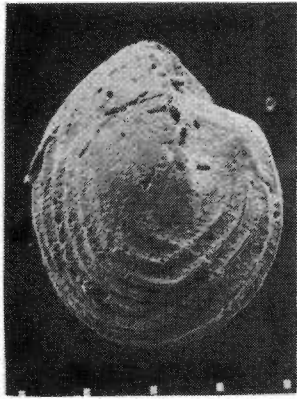
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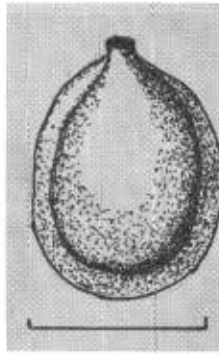
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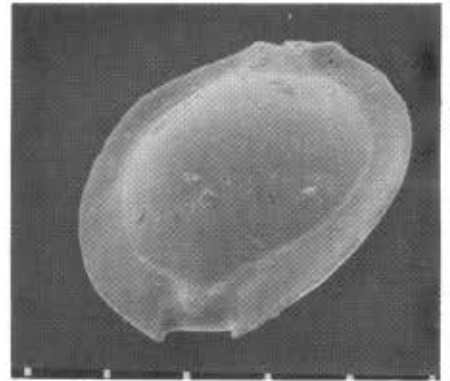
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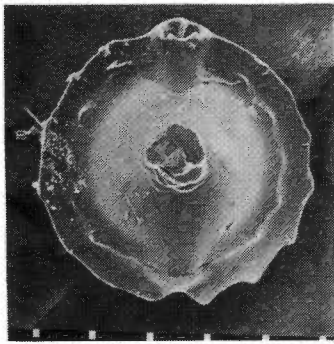
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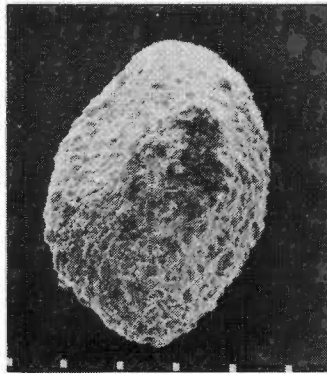
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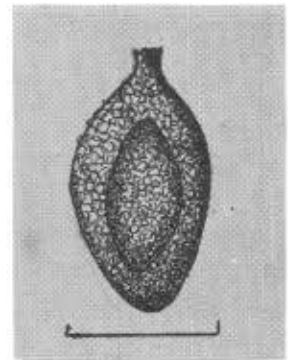
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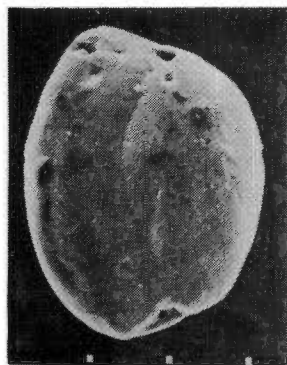
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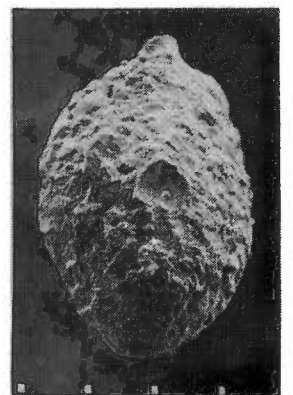
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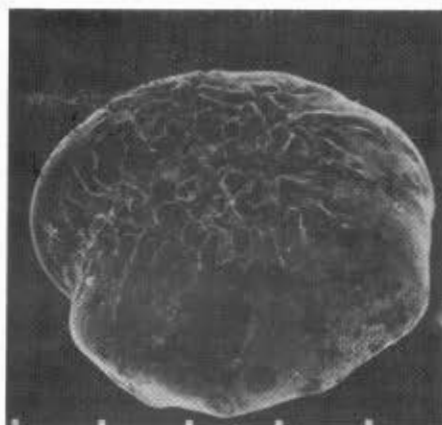
PLATE 2 - TEXTULARIINA AND MILIOLIINA

<u>FIGURE</u>		<u>Text page</u>
1.	<u>Textularia millettii</u> Cushman (Scale 100 $\mu$ ) (Tripp Sea Mount)	22
2.	<u>Textularia sagittula</u> DeFrance (Scale 100 $\mu$ ) (Sta.2858,122m)	22
3.	<u>Miliolinella circularis</u> Bornemann (Scale 100 $\mu$ ) (Tripp Sea Mount)	28
4.	<u>Peneroplis</u> sp. (Scale 100 $\mu$ ) (Sta.2873,178m)	28
5.	<u>Pyrgo lucernula</u> Schwager (Scale 1mm) (Sta.3354,1780m)	26
6.	<u>Pyrgo murrhyna</u> Schwager (Scale 100 $\mu$ ) (Sta.3020,1258m)	26
7.	<u>Pyrgo serrata</u> L.W. Bailey (Scale 300 $\mu$ ) (Sta.2848,1495m)	27
8.	<u>Quinqueloculina agglutinans</u> d'Orbigny (Scale 100 $\mu$ ) (Sta.2922,190m)	25
9.	<u>Quinqueloculina</u> cf <u>horrida</u> Cushman (Scale 300 $\mu$ ) (Tripp Sea Mount)	25
10.	<u>Quinqueloculina lamarckiana</u> d'Orbigny (Scale 100 $\mu$ ) (Sta.2971,162m)	25
11.	<u>Quinqueloculina seminulum</u> Linné (Scale 100 $\mu$ ) (Sta.2900,68m)	26
12.	<u>Sigmoilina tenuis</u> Czjzek (Scale 300 $\mu$ ) (Sta.2856,194m)	27
13.	<u>Sigmoilopsis schlumbergeri</u> Silvestri (Scale 100 $\mu$ ) (Sta.3020,1258m)	27

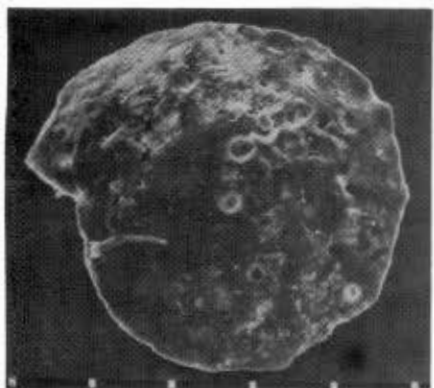
PLATE 3 – Miliolina & Rotaliina



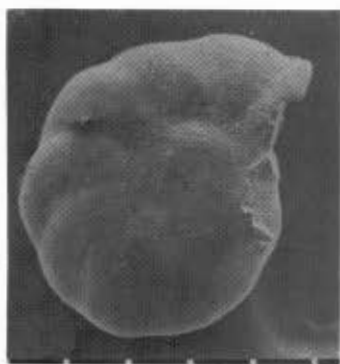
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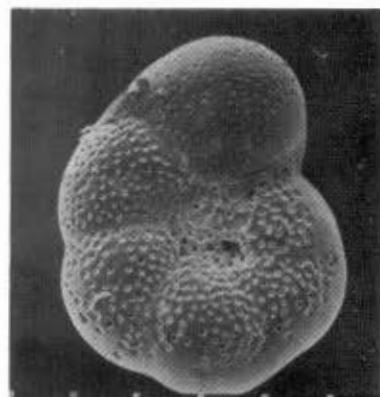
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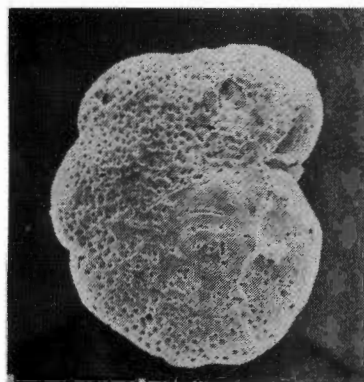
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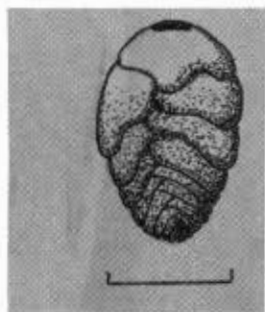
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PLATE 4 - ROTALIINA

<u>FIGURE</u>		<u>Text . page</u>
1.	<u>Bulimina aculeata</u> d'Orbigny (Scale 100 $\mu$ ) (Sta.3015,195m)	39
2.	<u>Bulimina aculeata</u> d'Orbigny (Scale 100 $\mu$ ) (Sta.3635,117m)	39
3.	<u>Bulimina</u> cf <u>alazanensis</u> Cushman (Scale 100 $\mu$ ) (Sta.2856,194m)	40
4.	<u>Bulimina</u> cf <u>alazanensis</u> Cushman (Scale 100 $\mu$ ) (Sta.3146,352m)	40
5.	<u>Bulimina elongata</u> d'Orbigny (Scale 100 $\mu$ ) (Sta.3635,117m)	40
6.	<u>Bulimina gibba</u> Fornasini (Scale 100 $\mu$ ) (Sta.3264,51m)	40
7.	<u>Bulimina inflata</u> Seguenza (Scale 100 $\mu$ ) (Sta.3146,352m)	41
8.	<u>Bulimina marginata</u> d'Orbigny (Scale 100 $\mu$ ) (Sta.3257,98m)	41
9.	<u>Bulimina marginata</u> d'Orbigny (Scale 100 $\mu$ ) (Sta.2999,280m)	41
10.	<u>Bulimina</u> cf <u>notovata</u> d'Orbigny (Scale 100 $\mu$ ) (Sta.2918,984m)	40
11.	<u>Bulimina</u> sp. (Scale 100 $\mu$ ) (Sta.3016,360m)	41
12.	<u>Buliminella elegantissima</u> d'Orbigny (Scale 300 $\mu$ ) (Sta.3398,87m)	36
13.	<u>Cancris oblonga</u> Williamson (Scale 300 $\mu$ ) (Sta.3132,998m)	47
14.	<u>Cancris oblonga</u> Williamson (Scale 100 $\mu$ ) (Sta.3198,350m)	47
15.	<u>Cassidulina carinata</u> Silvestri (Scale 100 $\mu$ ) (Sta.2905,148m)	55

PLATE 4 – Rotaliina



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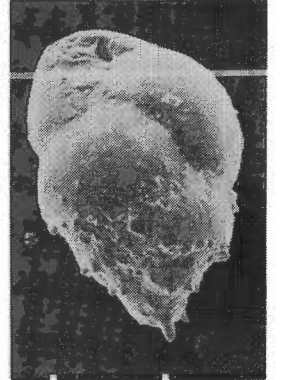
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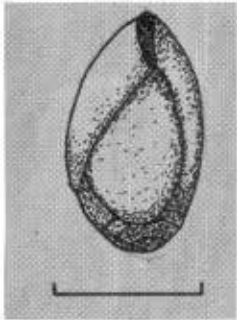
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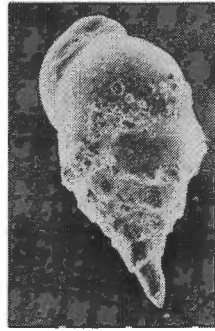
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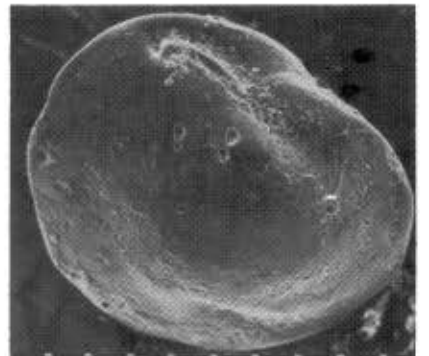
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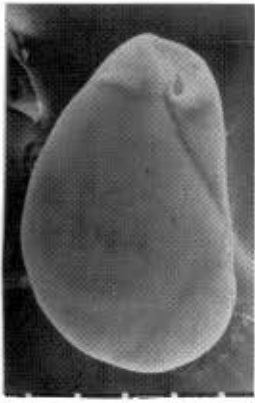


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PLATE 5 - ROTALIINA

<u>FIGURE</u>	<u>Text page</u>
1. <u>Cassidulinoides bradyi</u> Norman (Scale 30 $\mu$ ) (Sta.3260,182m)	38
2. <u>Ceratobulimina</u> cf <u>pacifica</u> Cushman & Harris (Scale 100 $\mu$ ) (Sta.3354,1780m)	61
3. <u>Cibicides</u> cf <u>bradyi</u> Trauth (Scale 100 $\mu$ ) (Sta.3400,182m)	52
4. <u>Cibicides lobatulus</u> Walker & Jacob, involute side, (Scale 100 $\mu$ ) (Sta. 3264,51m)	52
5. <u>Cibicides lobatulus</u> Walker & Jacob, spiral side, (Scale 100 $\mu$ ) (Tripp Sea Mount)	52
6. <u>Cibicides lobatulus</u> Walker & Jacob, involute side, (Scale 100 $\mu$ ) (Tripp Sea Mount)	52
7. <u>Cibicides praecinctus</u> Karrer (Scale 100 $\mu$ ) (Tripp Sea Mount)	52
8. <u>Cibicides pseudoungerianus</u> Cushman, involute side (Scale 100 $\mu$ ) (Sta.2873,178m)	53
9. <u>Cibicides pseudoungerianus</u> Cushman, spiral side (Scale 100 $\mu$ ) (Sta.2873,178m)	53
10. <u>Cibicides refulgens</u> Montfort, involute side (Scale 300 $\mu$ ) (Sta.2905,148m)	53
11. <u>Cibicides refulgens</u> Montfort, peripheral view (Scale 300 $\mu$ ) (Tripp Sea Mount)	53
12. <u>Cibicides robertsonianus</u> Brady, involute side, (Scale 100 $\mu$ ) (Sta.3354,1780m)	54
13. <u>Cibicides robertsonianus</u> Brady, spiral side (Scale 300 $\mu$ ) (Sta.3354,1780m)	54

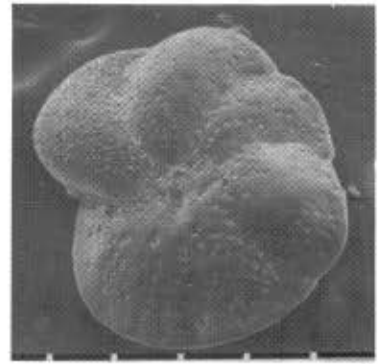
PLATE 5 — Rotaliina



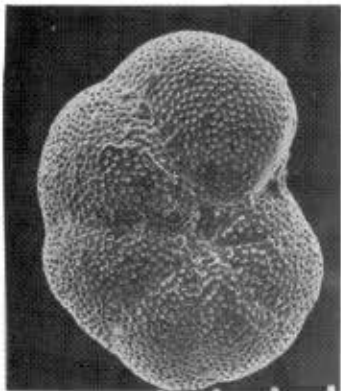
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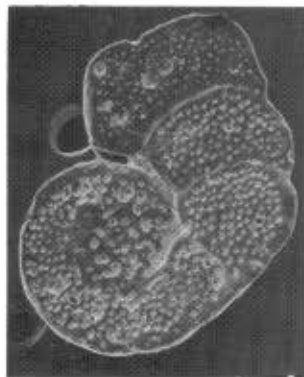
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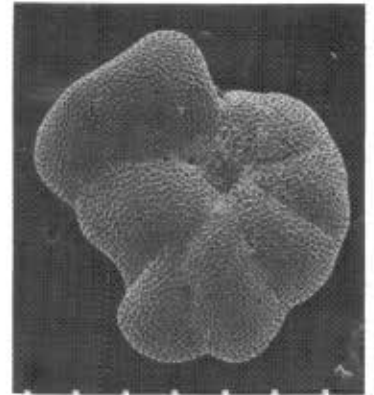
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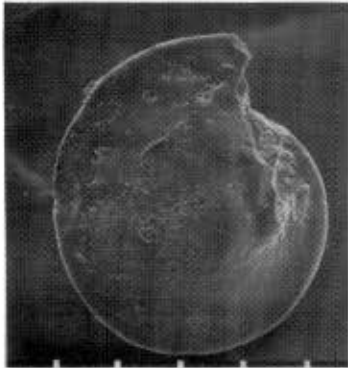
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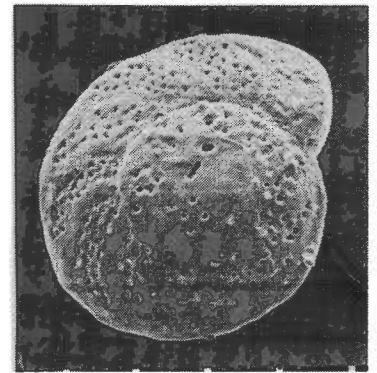
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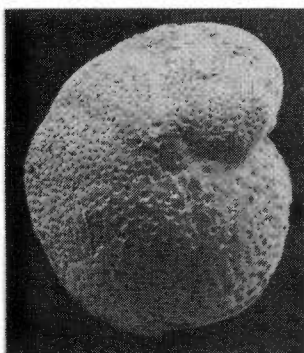
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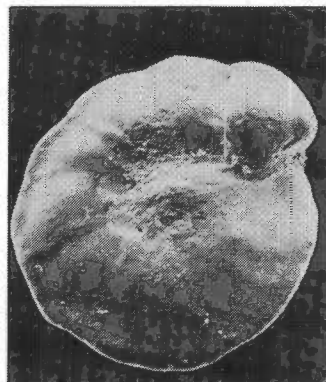
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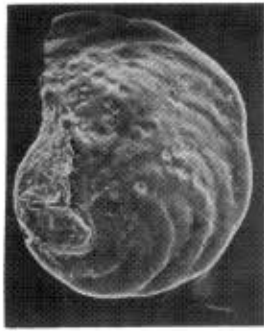


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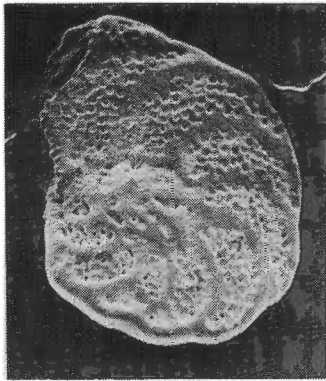
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PLATE 6 - Rotaliina



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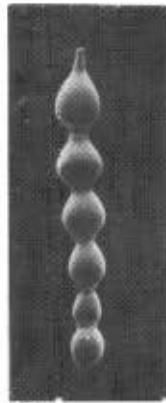
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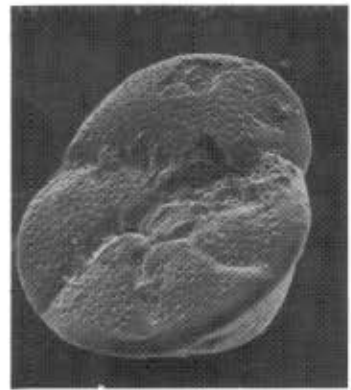
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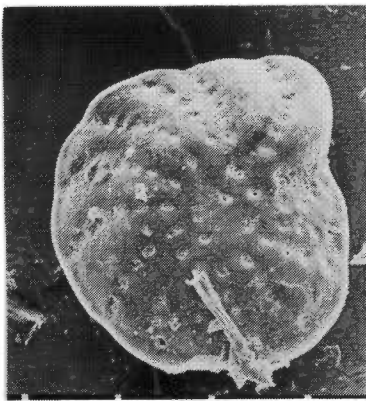
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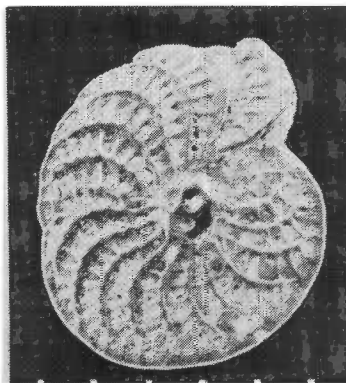
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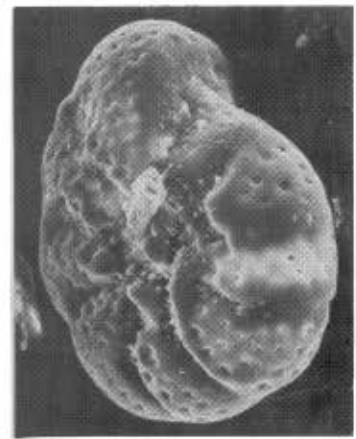
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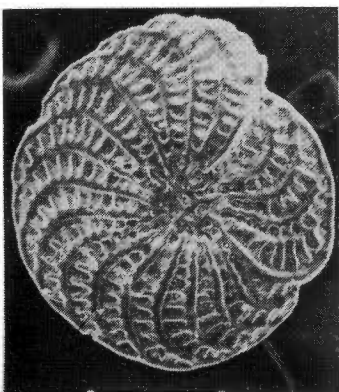
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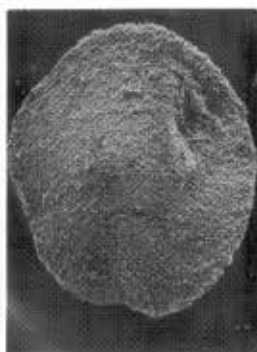
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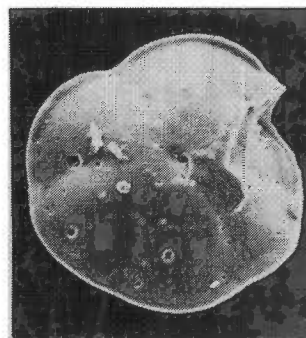
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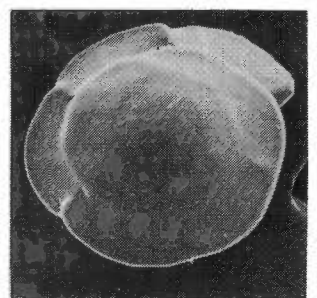
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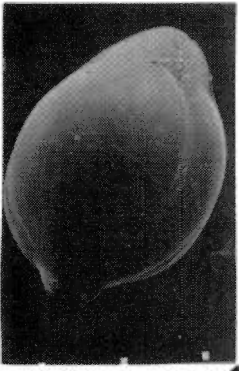


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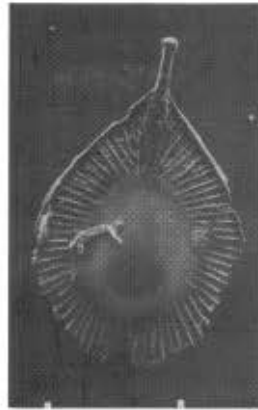
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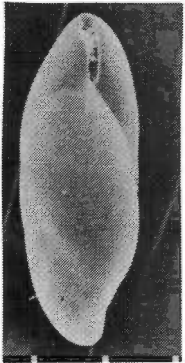
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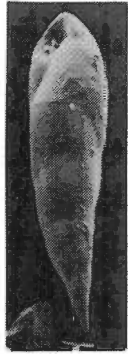
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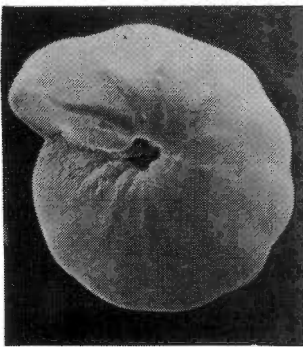
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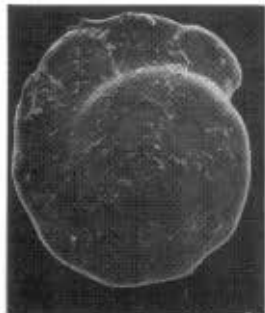
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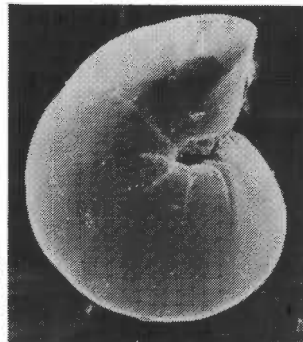
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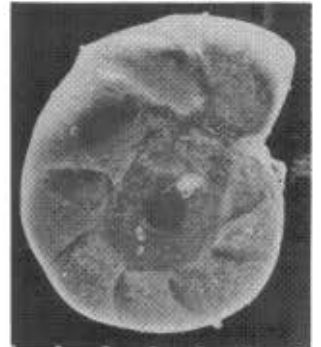
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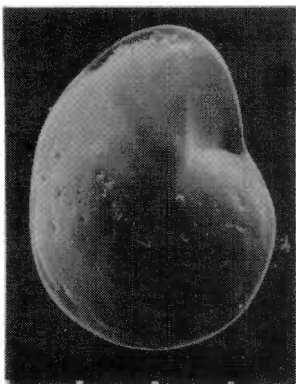
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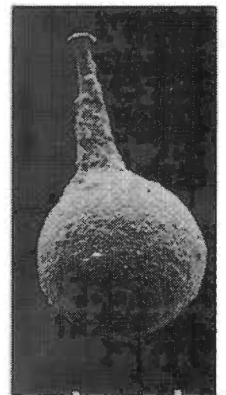
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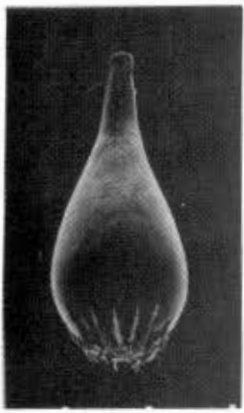


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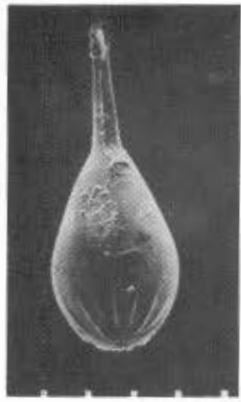
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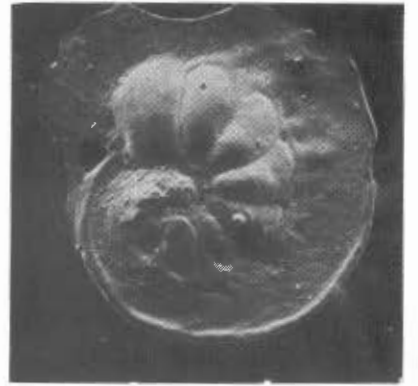
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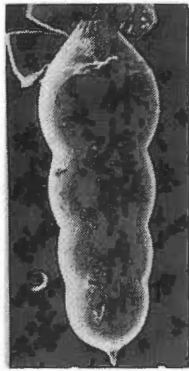
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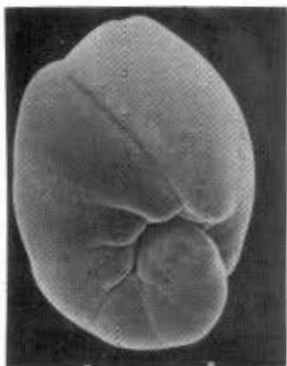
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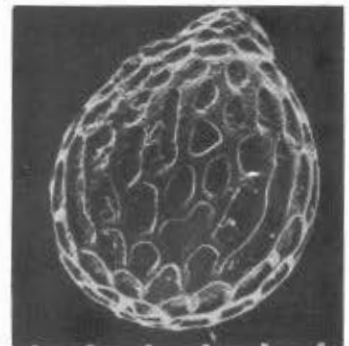
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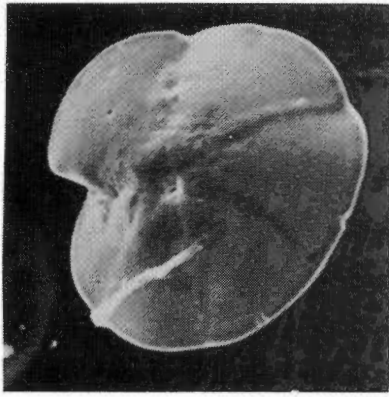


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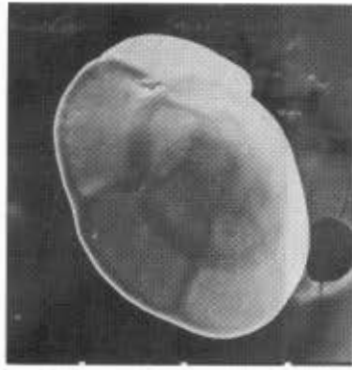
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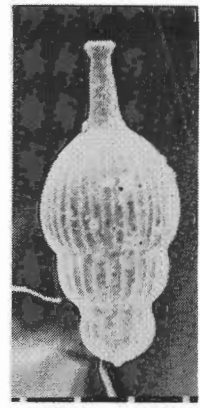
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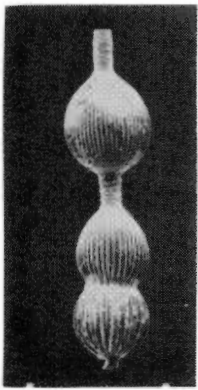
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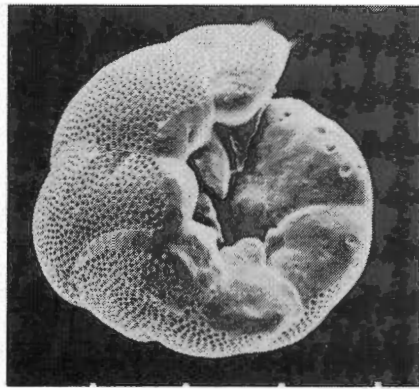
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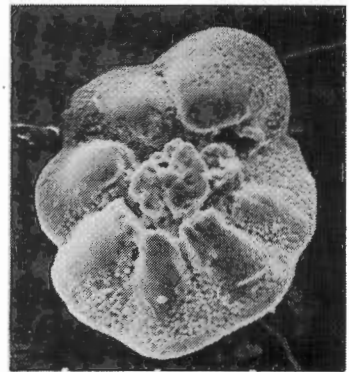
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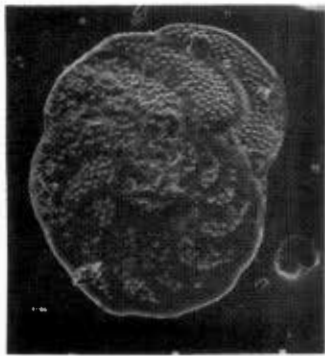
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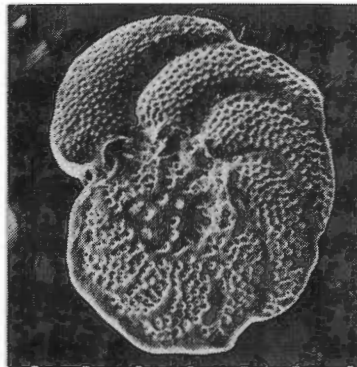
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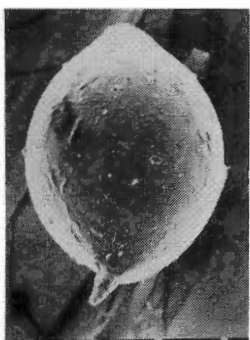
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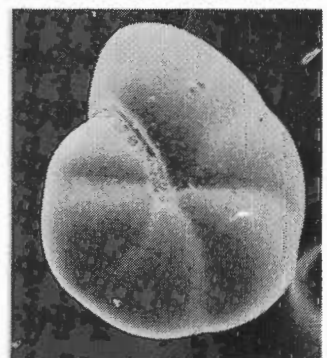
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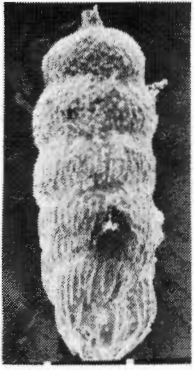


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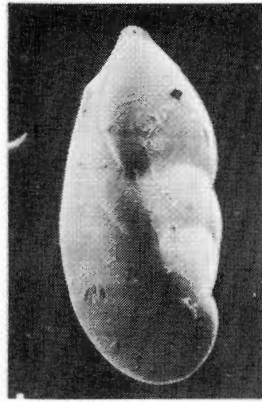
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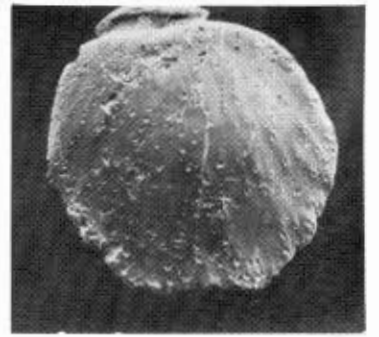
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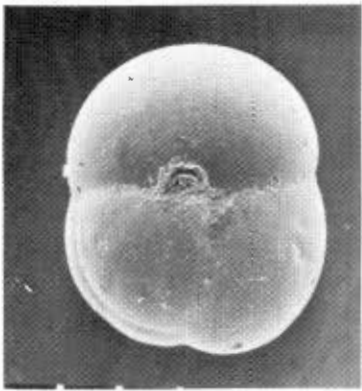
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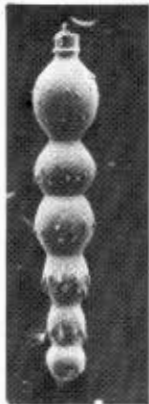
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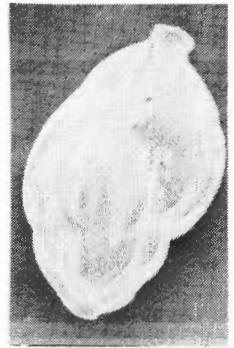
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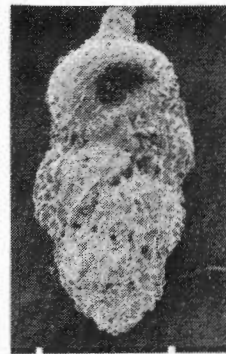
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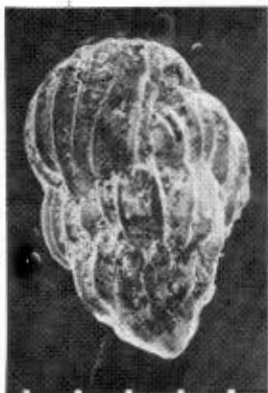
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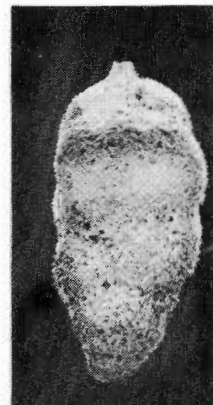
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<u>Buliminella elegantissima</u> d'Orbigny	36	4(12)
<u>Cancris oblonga</u> Williamson	47	4(13,14)
<u>Cassidulina carinata</u> Silvestri	55	4(15)
<u>Cassidulinoides bradyi</u> Norman	38	5(1)
<u>Ceratobulimina cf pacifica</u> Reuss	61	5(2)
<u>Cibicides bradyi</u> Trauth	52	5(3)
<u>C. lobatulus</u> Walker and Jacob	52	5(4-6)
<u>C. praecinctus</u> Karrer	52	5(7)
<u>C. pseudoungeriana</u> Cushman	53	5(8,9)
<u>C. refulgens</u> Montfort	53	5(10,11)
<u>C. robertsonianus</u> Brady	54	5(12,13)
<u>C. wuellerstorfi</u> Schwager	54	6(1,2)
<u>Cribrostomoides subglobosum</u> Sars	20	1(2)
<u>Dentalina emaciata</u> Reuss	29	6(3)
<u>D. filiformis</u> d'Orbigny	30	6(4)
<u>D. nummulina</u> Gümbel	30	6(5)
<u>D. subsoluta</u> Cushman	30	6(7)
<u>Dentalina (?) sp.</u>	30	6(6)
<u>Discorbis sp.</u>	46	6(8)
<u>Eggerella bradyi</u> Cushman	23	1(3)
<u>E. propinqua</u> Brady	23	1(4)
<u>Elphidium advenum</u> Cushman	49	6(9)

	<u>Text</u>	<u>Plate</u>
<u>Peneroplis</u> sp.	28	2(4)
<u>Planulina ariminensis</u> d'Orbigny	51	9(7,8)
<u>Praeglobobulimina spinescens</u> Brady	43	9(9)
<u>Pseudonodosaria torrida</u> Cushman	34	9(8)
<u>Pullenia bulloides</u> d'Orbigny	58	9(11)
<u>P. subcarinata</u> d'Orbigny	58	9(12)
<u>Pyrgo lucernula</u> Schwager	26	2(5)
<u>P. murrhyna</u> Schwager	26	2(6)
<u>P. serrata</u> Bailey	27	2(7)
<u>Quinqueloculina agglutinans</u> d'Orbigny	25	2(8)
<u>Q. cf horrida</u> Cushman	25	2(9)
<u>Q. cf lamarckiana</u> d'Orbigny	25	2(10)
<u>Q. seminulum</u> Linné	26	2(11)
<u>Rectuvigerina nicoli</u> Mathews	45	10(1)
<u>Rosalina</u> sp.	47	10(2)
<u>Saracenaria italica</u> Defrance	34	10(3)
<u>Sigmoilina tenuis</u> Czjzek	27	2(12)
<u>Sigmoilopsis schlumbergeri</u> Silvestri	27	2(13)
<u>Siphonina</u> sp.	47	10(4)
<u>Sphaeroidina bulloides</u> d'Orbigny	36	10(5)
<u>Spiroloculina cf limbata</u> d'Orbigny	24	3(1)
<u>Stilostomella cf lepidula</u>	39	10(6)
<u>Sulcophax</u> sp.	20	1(10)
<u>Textularia cf agglutinans</u> d'Orbigny	21	1(11)
<u>T. cf goesii</u> Cushman	21	1(12)
<u>T. millettii</u> Cushman	22	2(1)
<u>T. sagittula</u> Defrance	22	2(2)
<u>Trifarina</u> sp. A	45	10(7)
<u>Trifarina</u> sp. B	45	10(8)
<u>Uvigerina canariensis</u> d'Orbigny	43	10(9)
<u>U. cf cushmani</u> Todd	43	10(10)
<u>U. peregrina</u> Cushman	44	10(11-14)
<u>U. proboscidea</u> Schwager	44	10(15)

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