THE DISTRIBUTION OF RECENT FORAMINIFERA IN SOUTHEAST BAFFIN BAY

HOWARD RICHARD HUME

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by

Howard R. Hume

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Department of Oceanography

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Author Howard R. Hume

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ABSTRACT

In a study of foraminiferal distribution in southeast Baffin Bay and the associated environmental parameters, 44 grab samples and 4 cores were analysed for their foraminiferal and sediment contents. Environmental parameters studied were bathymetry, sediment distribution and calcium carbonate content of the sediments.

Of the environmental factors considered depth and substrate were found to be most closely associated with foraminiferal distribution, with the sediment type related to the source of sedimentary particles and the prevailing currents.

A foraminiferal depth zonation based on the grouping of stations with like faunas was worked out and showed: a shallow water (40-250 metres) diverse calcareous fauna dominated by *Cibicides lobatulus* and *Astrononion gallowayi*; an intermediate depth (150-400 metres) arenaceous fauna with *Adercotryma glomeratum*, *Textularia torquata*, *Trochammina nana* and *Spiroplectammina biformis* dominant; a deep water (300-750 metres), very sparse mixed fauna with calcareous specimens in the majority and *Melonis zaandami* a common species.

In the core samples arenaceous Foraminifera virtually disappear at distances greater than 5-10 cm below the top, probably as a result of mechanical or chemical disintegration soon after burial, caused by compaction of the sediments or the action of annelids or both. Accordingly only calcareous assemblages could be considered for further paleoenvironmental reconstructions.

Planktonic foraminiferal tests were rare in the sediments despite being present in the water column in the area. Tests were almost all *Globigerina pachyderma* and were found in the more calcareous benthonic populations.

The inorganic calcium carbonate content of the sediments was found to be closely associated with the calcareous foraminiferal content, indicating a negligible carbonate contribution to the sediments from terrestrial sources.

The application of Similarity Analysis and Group Average Sorting techniques gives a grouping of stations with like faunal assemblages similar to that obtained from a visual inspection of the raw data, but these techniques also extract some finer distinctions not otherwise obvious. This indicates that Similarity and Cluster Analyses, and statistical techniques are valuable for studies using larger amounts of more complex data.

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CHAPTER 1

INTRODUCTION

This study concerns the foraminiferal fauna of southeast Baffin Bay, the species of Foraminifera which are to be found, and their descriptions, distribution and relationship to the marine environment.

The study area and location of sampling stations (fig. 1 and 2) were selected in an endeavour to find a region with a sufficient variation in measurable environmental factors as well as recognizable faunal distribution trends so that any associations existing between the two might be determined.

In addition to the description of the foraminiferal fauna comparisons were made between groups of stations with similar faunal assemblages and the factors of depth, sediment distribution and the calcium carbonate content of the sediments. From any correlations found it was hoped that faunal assemblages from levels deeper in the sedimentary record might provede clues to former paleoenvironments.

Previous Work

In previous studies in high latitude areas depth zonations have been outlined on the basis of the groupings of species e.g. Cooper (1964) in the Chukchi Sea, Leslie (1965) in the Hudson Bay and Vilks (1969) in the North Canadian Arctic. One problem to be faced here was the wide ranges of several of the dominant species. Kennett (1968) working in the Ross Sea area of Antarctica based his depth zonation on the arenaceous/calcareous ratio of benthonic Foraminifera.

McKnight (1962) in the Ross Sea and Vilks (1969) had indicated a marked reduction of foraminiferal abundance in the subsurface sediments.

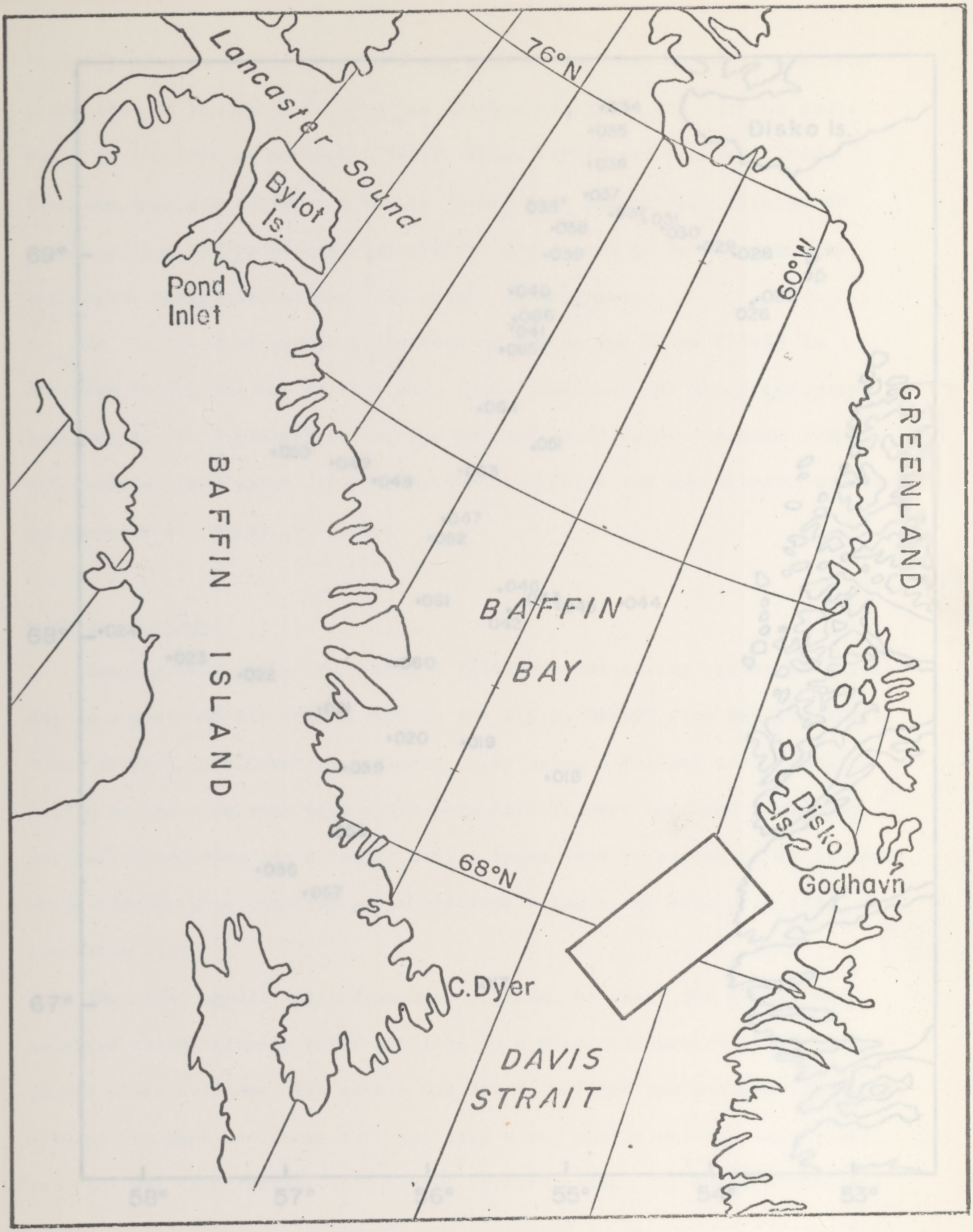

Fig. 1 Location of Study Area

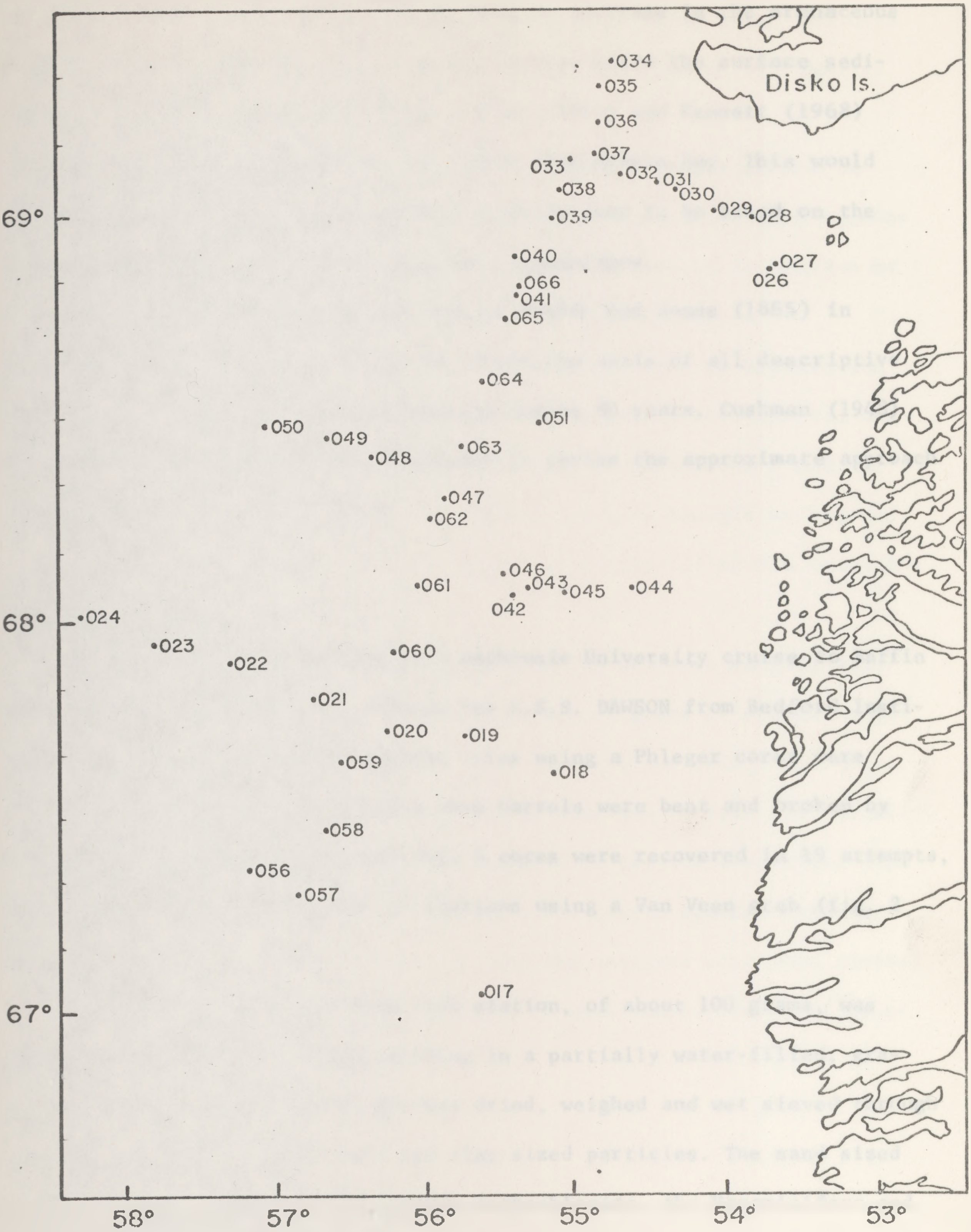

Fig. 2 Location of Stations

Possibly of more significance was the drastic decrease in the arenaceous percentage of the total fauna a few centimetres below the surface sediments as reported by McKnight (1962), Pflum (1963) and Kennett (1968) from the Ross Sea region and Leslie (1965) from Hudson Bay. This would indicate that paleoenvironmental studies would need to be based on the calcareous benthonic, rather than total, assemblages.

In the field of taxonomy the work of Parker and Jones (1865) in Northern Baffin Bay and Davis Strait formed the basis of all descriptive works on Arctic Foraminifera for the succeeding 80 years. Cushman (1948) and Loeblich and Tappan (1954) undertook to revise the approximate approach to taxonomy of Parker and Jones.

Methods of Study

Samples were collected during a Dalhousie University cruise to Baffin Bay in August and September, 1970 in the C.S.S. DAWSON from Bedford Institute. Efforts at recovering sediment cores using a Phleger corer were foiled by the frequency with which core barrels were bent and broken by ice rafted boulders. As a result only 4 cores were recovered in 19 attempts, while samples were obtained at 44 stations using a Van Veen grab (fig. 2 and Table 1).

The first sample split from each station, of about 100 grams, was measured volumetrically after settling in a partially water-filled, graduated glass cylinder. The sample was dried, weighed and wet sieved through a 63 micron mesh to remove silt and clay sized particles. The sand sized material was then treated with carbon tetrachloride, the Foraminifera and other light particles floated off and recovered by filtration (Bandy 1954). Foraminifera were hand picked from the concentrate. Where the numbers floated off were high the sample was systematically split using the Otto microsplitter to obtain a specimen count of between 300 and 400 (Walton 1955).

Identifications were made from descriptions and illustrations of Recent Foraminifera in the literature and representatives of each species were compared directly with type material from the Cushman collection of Foraminifera at the U.S. National Museum, Washington, D.C.

From a second split, silts and clays were separated by decantation after wet sieving (Krumbein and Pettijohn 1938). Sand sized material was dry sieved at ½ Ø intervals. Results are tabled in Appendices I and II. pH measurements were made as soon as the samples were brought on board using the Corning model 101 pH meter at stations from 017 to 036 until the instrument was irreparably damaged.

The organic calcium carbonate content of the sediment samples was measured by a Beckman IR 15 A Infrared Analyser. 5 grams of crushed sediment was placed in orthophosphoric acid to dissolve the $CaCO_3$; the CO_2 given off was transported to the analyser by nitrogen carrier gas. Standard weights of pure $CaCO_3$ were dissolved similarly to provide a straight line graph of percent of $CaCO_3$ from a standard sized sample against readings from the integrator. Integrated values from the analyser were then applied to the graph to give a percentage of $CaCO_3$ in each sample. An accuracy of approximately $\pm$ 5 % was obtained.

TABLE 1

Station Data

Station	Latitude North	Longitude West	Depth metres	Station	Latitude North	Longitude West	Depth metres
017	67°07.0'	55°38.5'	90	041	68°50.6'	55°26.5'	200
018	67°36.7'	55°10.6'	40	042	68°11.0'	55°25.0'	351
019	67°42.4'	55°45.8'	110	043	68°12.0'	55°21.0'	239
020	67°44.0'	56°17.8'	150	044	68°11.0'	54°38.8'	161
021	67°48.0'	56°47.0'	180	045	68°12.1'	55°04.7'	110
022	67°53.0'	57°20.0'	280	046	68°15.1'	55°28.9'	379
023	67°57.0'	57°49.5'	336	047	68°20.8'	55°53.6'	494
024	68°01.8'	58°20.0'	380	048	68°24.8'	56°22.2'	455
026	68°53.0'	53°44.3'	221	049	68°27.3'	56°41.8'	348
027	68°53.0'	53°44.2'	750	050	68°29.6'	57°05.0'	366
028	69°00.0'	53°49.9'	170	051	68°30.9'	55°16.1'	200
029	69°01.6'	54°02.8'	121	056	67°22.3'	57°14.0'	250
030	69°04.0'	54°21.8'	117	057	67°18.8'	56°53.5'	224
031	69°05.1'	54°28.0'	113	058	67°28.7'	56°42.0'	183
032	69°07.0'	54°42.2'	150	059	67°39.0'	56°33.0'	194
033	69°09.0'	54°55.0'	159	060	67°56.0'	56°15.0'	147
034	69°23.8'	54°48.1'	177	061	68°06.0'	56°04.0'	160
035	69°19.0'	54°53.2'	181	062	68°15.5'	55°58.0'	333
036	69°14.2'	54°53.0'	120	063	68°26.0'	55°46.8'	504
037	69°09.6'	54°53.6'	154	064	68°36.0'	55°37.0'	303
038	69°04.7'	55°07.8'	164	065	68°45.0'	55°26.5'	227
039	69°00.0'	55°13.2'	180	066	68°50.1'	55°22.0'	220
040	68°55.3'	55°26.5'	173				

CHAPTER 2

REGIONAL SETTING

Physiography and Geology

The survey area to the southwest of Disko Island is contained within the broad West Greenland continental shelf that extends 150 to 200 kilometres offshore (fig. 1). The adjoining landmass is mountainous and covered further inland by the Greenland ice cap. The coastline is heavily glaciated and dissected by deep fiords extending tens of kilometres inland.

The adjacent coastline to the east consists of Precambrian and reworked Precambrian granodioritic gneisses with some local granites on the inshore islands. To the north, in the vicinity of Disko Island, the Precambrian basement is overlain by thick sequences of Cretaceous and Lower Tertiary marine and non-marine shales and sandstones, which are in turn overlain by Tertiary basalts (Henderson 1971, Park 1971).

In the central portion of the Bay, thick sedimentary sequences are underlain by oceanic crust (Barrett et al. 1971). To the south of Disko Island in the north-eastern segment of the survey area, an extension of the Tertiary basalt province is indicated by a shipborn magnetometer survey and confirmed by dredge hauls. The inshore contact between basalts and pre-Cambrian rocks is marked by a well defined marginal trough (Park et al. 1971).

Bathymetry and Oceanography

A wide continental shelf terminates abruptly to the west at the continental rise at a depth of about 350 metres. To the southward the shelf merges with the Davis Strait sill (fig. 3). In the centre of the survey

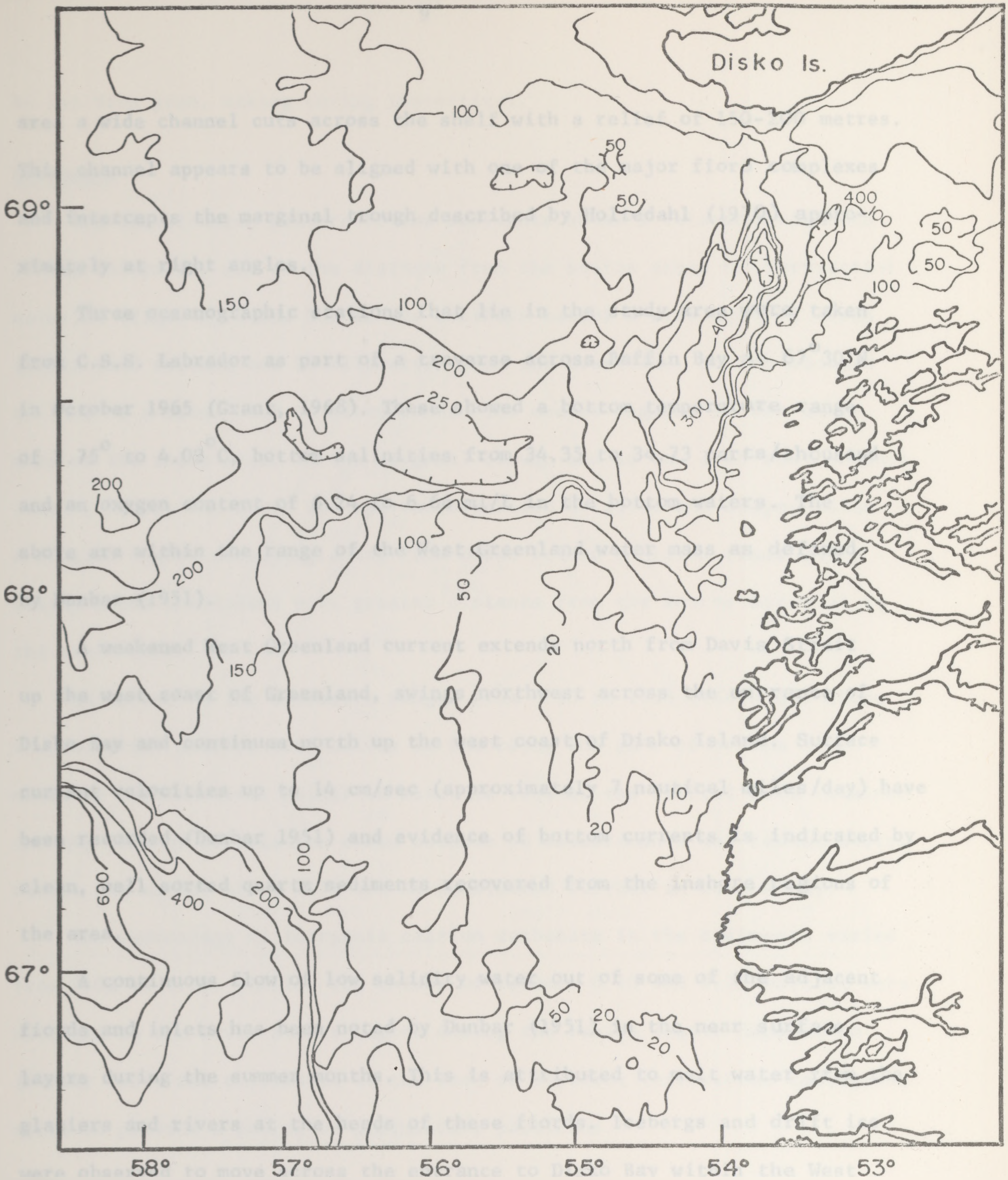

Fig. 3 Bathymetry of the Area

(contours in Fathoms)

area a wide channel cuts across the shelf with a relief of 150-200 metres. This channel appears to be aligned with one of the major fiord complexes and intercepts the marginal trough described by Holtedahl (1970) approximately at right angles.

Three oceanographic stations that lie in the study area were taken from C.S.S. Labrador as part of a traverse across Baffin Bay at 67°30'N in October 1965 (Grant, 1968). These showed a bottom temperature range of 2.75° to 4.02°C, bottom salinities from 34.35 to 34.73 parts/thousand and an oxygen content of 6.24 to 6.66 ml/L in the bottom waters. The above are within the range of the West Greenland water mass as defined by Dunbar (1951).

A weakened West Greenland current extends north from Davis Strait up the west coast of Greenland, swings northwest across the entrance of Disko Bay and continues north up the west coast of Disko Island. Surface current velocities up to 14 cm/sec (approximately 7 nautical miles/day) have been recorded (Dunbar 1951) and evidence of bottom currents is indicated by clean, well sorted quartz sediments recovered from the inshore regions of the area.

A continuous flow of low salinity water out of some of the adjacent fiords and inlets has been noted by Dunbar (1951) in the near surface layers during the summer months. This is attributed to melt water from the glaciers and rivers at the heads of these fiords. Icebergs and drift ice were observed to move across the entrance to Disko Bay within the West Greenland current with many of the larger icebergs grounding in the shallow water on the south coast of Disko Island.

In the path of icebergs visible in the area the bottom sediments were characterized by an increase in ice rafted boulders and pebbles recovered by Van Veen grab, making coring impractical.

Sediments

The distribution pattern of the sediments shows a relationship both to the bathymetry and to the distance from the source areas of terrestrial material (figs. 3, 4 and 5). In the southern sector a wide band of clean quartz sand extends out 90 kilometres from the coastline. To the seaward of this is a broad band of silty sands. The deeper regions to the westward of the study area, in the marginal trough and in the east-west channel cutting across the shelf are all characterized by silts and clayey silts. A shallow region extending south from Disko Island contains finer silty clayey sands consistent with greater distance from the source material to the south-west.

pH values in the sediments ranged from 7.10 to 7.58 (Table 2). There are, however, obvious limitations in recording the pH's of bottom sediments at surface level rather in situ. In view of the limited data obtained and the lack of correlation shown between pH measurements and faunal distribution the matter of pH will not be considered further in this study.

The percentage of inorganic calcium carbonate in the sediments varied from 0.02 to 1.16. Similar low values of between 0.10 and 0.35 percent were obtained in the Davis Strait region during the Danish Ingolf Expedition (Dunbar 1951) and attributed to the lack of adjacent terrestrial calcareous rocks to provide a source of sedimentary particles.

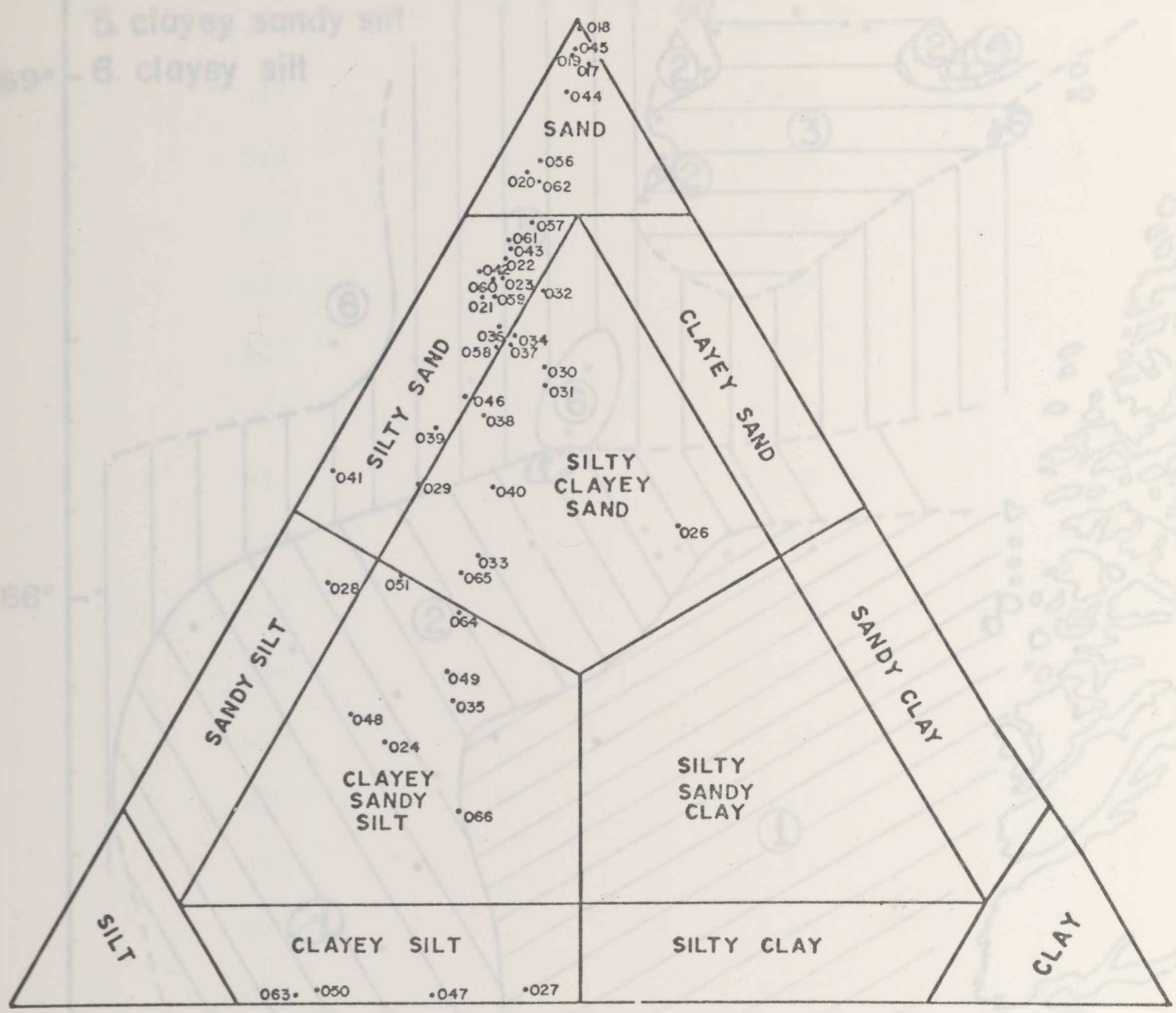

Fig. 4 Sand - silt - clay ratios of the Sediments
(Trefethen 1950)

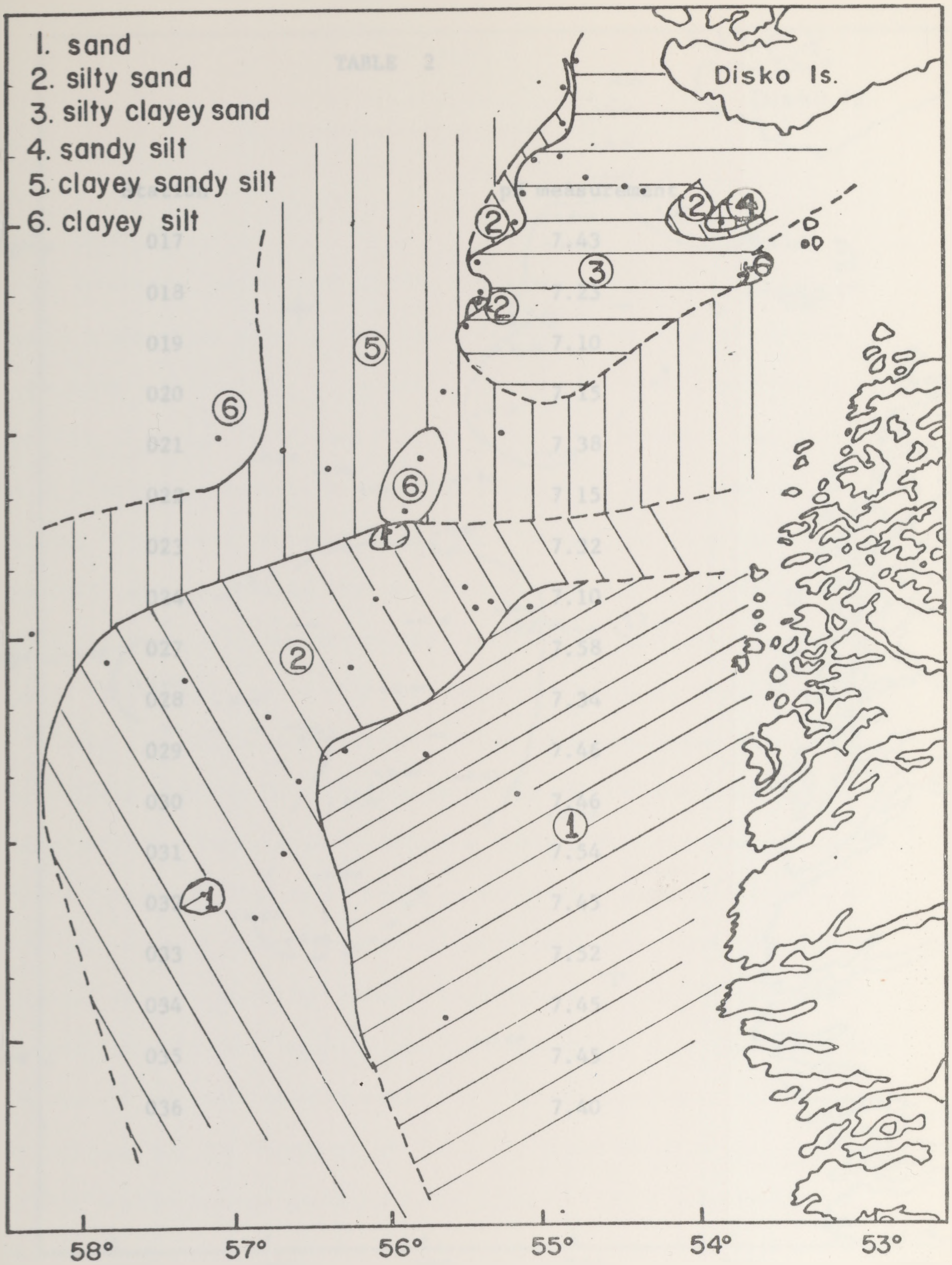

Fig. 5 Sediment Distribution

TABLE 2

Station	pH measurement
017	7.43
018	7.23
019	7.10
020	7.15
021	7.38
022	7.15
023	7.32
024	7.10
027	7.58
028	7.34
029	7.46
030	7.46
031	7.54
032	7.45
033	7.52
034	7.45
035	7.45
036	7.40

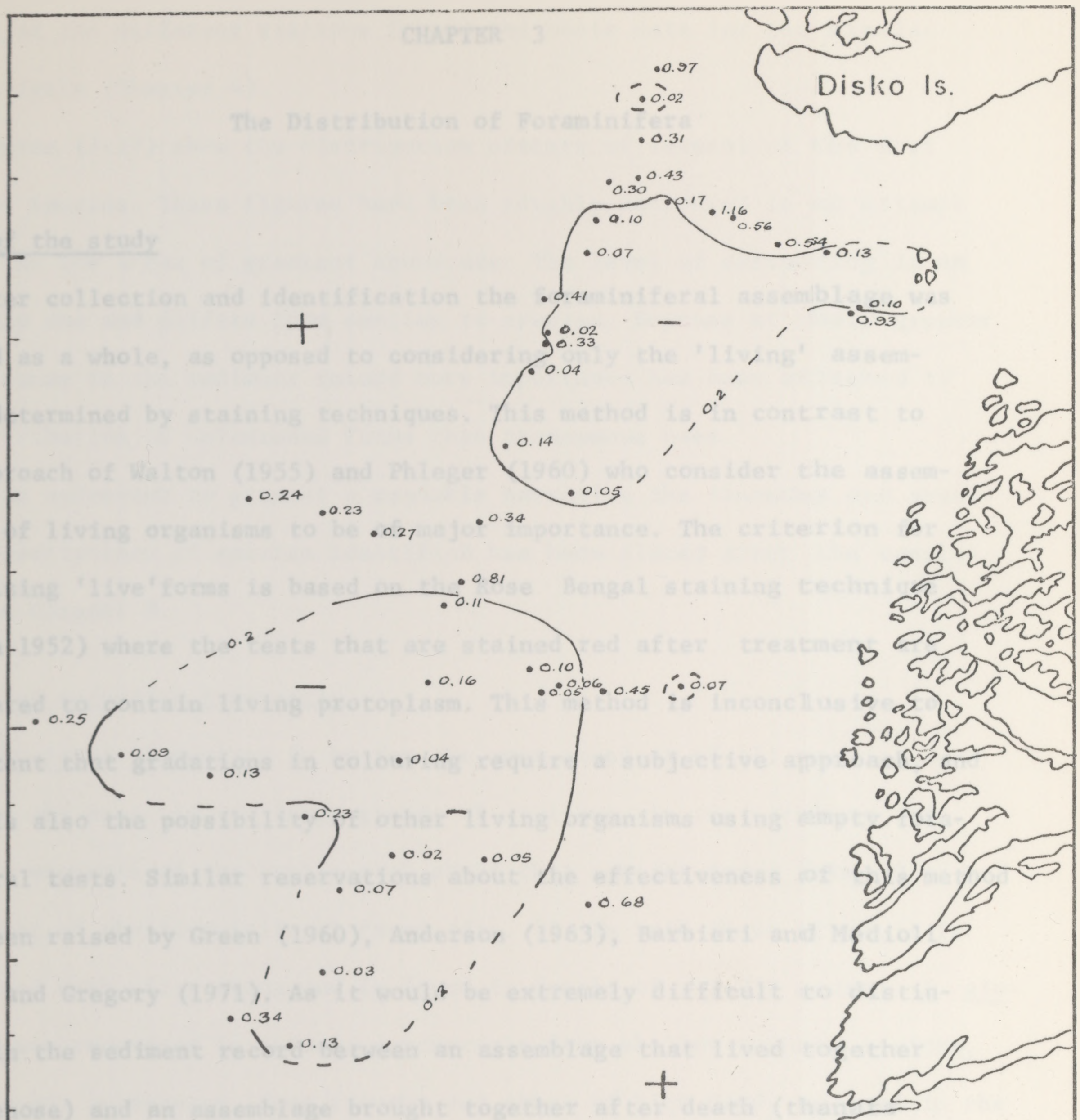

Fig. 6 Distribution of $CaCO_3$ content of Sediments (%)

CHAPTER 3

The Distribution of Foraminifera

Scope of the study

After collection and identification the foraminiferal assemhblage was treated as a whole, as opposed to considering only the 'living' assemblage determined by staining techniques. This method is in contrast to the approach of Walton (1955) and Phleger (1960) who consider the assemblages of living organisms to be of major importance. The criterion for recognizing 'live' forms is based on the Rose Bengal staining technique (Walton 1952) where the tests that are stained red after treatment are considered to contain living protoplasm. This method is inconclusive to the extent that gradations in colouring require a subjective approach, and there is also the possibility of other living organisms using empty foraminiferal tests. Similar reservations about the effectiveness of this method have been raised by Green (1960), Anderson (1963), Barbieri and Medioli (1969) and Gregory (1971). As it would be extremely difficult to distinguish in the sediment record between an assemblage that lived together (biocoenose) and an assemblage brought together after death (thanatacoenose) it was felt that treating the test assemblage as a whole was more appropriate for an environmental study. Post mortem transport of tests in bottom currents and the reworking of 'relict' faunas which might complicate the present distributional patterns would also be likely occurrences in paleoenvironments.

Species which occur at 10 or more stations (out of 45) were considered separately. This arbitrary division was made to facilitate clearer presentation of the relevant data and because the speciment counts of these species at the different stations formed the basic data for the similarity analysis (Chapter 4).

Figures (7-17) show the distribution pattern of several of t the most abundant species. These figures have been roughly contoured in a an attempt to outline the areas of greatest abundance. The level of contourring is an arbitrary one and differs from species to species. Because of ththeir greater significance in the sediment record more importance has been atttached to the distribution of calcareous forms than arenaceous ones.

In an endeavour to present a readable narrative the taxonomymy and systematic descriptions of species identified has been placed after the conclusions,in Chapter 8.

1. Species occurring frequently

Adercotryma glomeratum is by far the most abundant of all sspecies found in the area. In two large groups of stations, in the northtern and southern segments of the continental shelf this species forms ffrom 30 to 69 percent of the foraminiferal fauna (fig. 7). In both these areas it is associated with silty sands and is found in depths of 117-379 metres. *A. glomeratum* was recovered in reduced percentages from shallow inshore regions, coarse sandy substrates, deep troughs and areas of high $CaCO_3$ content in the sediments. Both Anderson (1963) and Leslie (1965) found the species numerous in depths of 100-230 metres. The widespread abundance of this form is far greater than in other comparative high latitude studies.

Textularia torquata (fig. 8), although present in considerably smaller numbers than *A. glomeratum*, follows the same outline of distribution. Vilks (1969) found the species dominant in a shallow range (0-200 metres). The rarer *T. earlandi* is found together with *T. torquata*.The very similar patterns

STATION NUMBER	017	018	019	020	021	022	023	024	026	027	028	029	030	031	032	033	034	035	036	037	038	039	040	041	042	043	044	045	046	047	048	049	050	051	056	057	058	059	060	061	062	063	064	065	066
Adercotryma glomerata	12.2	0.5	12.0	43.5	50.0	48.0	42.0	27.6	0.9	33.3	45.2	35.7	42.7	10.8	35.6	10.2	8.1	30.7	4.8	24.5	27.5	30.5	33.6	53.7	55.4	57.1	17.3	4.5	54.8	25.0	17.1	23.5	7.7	45.5	12.0	44.4	56.0	44.8	34.1	45.3	48.1	27.6	44.2	56.0	69.9
Asterellina pulchella					0.2						0.3	0.2	0.3	0.1			0.8			1.6		0.8	2.2					0.2				0.8							0.3	1.0					
Astrononion gallowayi	17.3	6.3	0.2	0.6		0.3			4.6		0.6	0.6	2.9	2.7	1.4	6.4	5.8	7.7	9.6	10.0	2.5	1.9	2.2	0.3	1.1		0.2	15.1	0.5		2.4				10.6				0.9	1.0	1.0	3.4	0.6		
Bolivina pseudopunctata	0.1			0.3	0.2								0.2	0.1					0.5					0.3			0.1												0.3	0.1		3.4			
Buccella frigida	1.7	0.5	0.7				0.4	0.5	0.5		0.5	0.6	0.6	1.4		3.1	0.4		0.5	0.8		0.8	2.6		0.1										0.3						0.2				0.4
B. inusitata	1.6	1.6			1.2		1.1	0.5	0.9		0.2	1.0	0.4	0.9	0.3	0.9	0.4		1.0	2.0		3.4	1.8		0.6		0.1	1.2	0.9			0.8	23.1		2.5	1.7		0.2			1.2			0.3	
Bulimina exilis									0.6			0.2	0.1	0.1		0.7	1.1		1.1	0.4		1.5	0.4	0.6											0.3						0.2		0.5		
Cibicides lobatulus	18.3	8.4	0.7		2.1	0.3	0.4		45.0		0.3	7.3	3.8	26.9	3.1	36.8	42.7	7.7	51.0	24.5	7.5	9.9	6.9	2.6				52.2	1.8	50.0	4.9				38.6				1.2	0.8	0.4	3.4	1.4		0.4
Cribrostomoides crassimargo	0.2		0.3	17.8	3.1	0.6	1.6				1.3		1.0		0.3	0.7		7.7	0.1	0.8		3.4	0.4		2.9	2.7	1.0	0.1	0.5	25.0		1.7		18.2		16.2	6.0	12.6	14.4	3.1	6.4			4.1	2.8
C. jeffreysi	0.7				8.6	12.9	11.0	9.9		6.7	2.1	2.1			1.7													3.9								0.6			0.9	2.4	1.8		1.8		
Eggerella advena	27.2	42.0	65.0	1.5			0.4				0.3	7.1	5.2	1.1											0.3	1.1	68.7	14.6				20.2											0.5	1.1	
Elphidiella arctica									0.5			0.8	0.1	0.3	0.6	8.1	1.1		1.0	0.4		0.4																							
Elphidium bartletti		27.6	0.5		0.5	0.3			0.1			0.2	0.2	1.1	0.3	0.2			0.4	0.8		3.1		0.3			0.1				2.4				1.4					0.1			1.4		
E. frigidum	0.1	0.2			0.2				0.5			0.2		2.0					0.5			0.4	0.4												0.3										
E. orbiculare	1.4						6.3				0.8		0.2	0.1		0.5	3.5			2.0								1.4												0.1					
E. subarcticum	3.0	7.0			0.2		0.2		0.9			0.4	1.1	2.6		0.2			4.7	0.4								0.8							0.3	3.3			0.3	0.3			1.0	0.4	
Fissurina marginata	0.4		0.2						5.6			0.4	0.4	2.4		0.7	0.8		0.3	0.4	2.5		0.7					4.7							0.8					0.1		3.5			
Globobulimina auriculata				1.7					0.1			0.4	0.2	0.1	0.3	0.2	0.4	7.7	0.1	0.4		1.1	0.7	0.3								0.8				2.8			1.2		0.2		2.8	0.3	
Islandiella islandica	2.0	1.4	0.3		0.2			1.0	2.8		0.2	1.6	0.3	2.6	0.6	3.1	0.4		1.9	4.0		1.5	1.8		0.2		0.1	1.2					7.7		0.8										
I. norcrossi			0.2			0.6			0.2		0.2	0.4	0.4	0.2		0.7			0.3	0.4		0.4	0.7	1.0	0.2											0.6									
I. teretis	4.2		0.3		0.2				0.4			1.2	0.6	2.4	0.3	0.5	0.4		0.3	1.2		0.4	0.4	0.3			0.1	0.2	0.5								0.3							0.4	
Lagena apiopleura	0.1								0.3			0.2	0.2	1.9	0.3	0.2	0.4		0.4				0.4																	0.1					
L. flatulenta					0.2				0.3			0.2	0.1	0.3		0.2	0.8		0.1				0.4																	0.1					
L. laevis					0.5		0.2	0.5	0.1		0.3	0.2	0.3			0.5	0.4			0.8			0.4	0.3		0.3									0.3					0.1	0.6		0.9		
Melonis zaandami					5.2	4.8	6.4	1.6	2.2	13.3	1.0	1.2	2.0	0.2	2.3	3.1	10.0	15.4	1.1	2.1	2.5	5.1	12.8	2.3	6.1	1.4			11.1		4.9	3.4	15.4		2.8	4.5			0.6	2.7	8.8	6.9	6.0	3.0	1.2
Nonionella auriculata	1.2	0.9	0.8	0.3		1.1				6.7	0.6				2.6							0.4	2.2				0.4	1.2	0.9		26.8					7.3			1.2		0.2				
Nonionellina labradorica					0.5	0.3	1.1	4.2	4.6		0.6	6.0	3.5	7.9		2.4	6.9		4.1	3.2		0.8	1.8	0.6	0.8		0.2	0.3	1.8		2.4	4.2	7.7	18.2	4.7				5.9	0.1	2.7	24.1	4.1	0.3	
Recurvoides turbinatus	0.2		0.7	3.6										1.3	0.3	0.2			0.4	2.4		1.1		0.3		0.3	0.4	0.2				0.8			0.6	2.8	1.1	1.4	1.8	0.8			0.5	0.3	0.4
Robertinoides charlottensis	0.1								0.1					0.3		0.9	0.4		0.3	0.4		0.8				0.3					4.9				0.5				2.1						
Saccammina atlantica		0.2		0.6		12.4	16.4	12.5			5.3	0.6	0.6	0.1	3.1	0.2	0.4	15.4		0.8		1.1	1.1	1.0	5.0	8.2	0.2		10.6			4.2			1.1	1.7	3.9	2.3	4.7	1.8	0.2		2.3	2.2	2.8
Spiroplectammina biformis	1.5		5.2	9.4	6.6				0.1		1.1	3.7	4.0	0.6	5.7				0.2	0.8		0.8	0.7	4.8	0.9	8.8	4.2	0.5	0.9							7.3	8.4	25.8	15.3	5.7	0.6		0.5		2.0
Textularia torquata	0.2		1.7	8.4	7.1	8.7	4.7	3.1			17.8	4.1	10.8	1.4	15.1	3.6			1.5	1.2	30.0	1.5	6.6	11.3	7.4	10.4	1.4	0.7				4.2			1.7	1.1	12.3	5.5	7.9	19.8	4.3	3.4	8.8	14.2	8.0
Trifarina angulosa	0.9	0.5	0.8		7.8	0.3			5.8		2.9	11.8	5.3	4.6	2.3	4.7	5.4		1.0	4.8	7.5	7.6	6.6	1.9	1.2	0.8	0.2	0.2	0.9				30.8		1.7	2.8	1.1		1.2	1.2	1.0	3.5	2.8	1.6	0.4
Tritaxis atlantica	0.4			3.9		1.4	2.5			40.0		1.2	3.1		5.1	0.7	0.4		0.4	0.4	12.5	1.1	2.5	1.3	1.2	0.5	0.7					0.8			0.3		2.1	0.6	0.9	1.4	0.2			1.1	
Trochammina inflata						0.3	3.8	7.8			0.2														1.1				1.8		19.5	5.9		9.1							0.6	3.4	0.9		
T. nana	0.5			5.7		6.2		28.6			16.0	4.4	5.8	0.7	19.7	3.1	6.2		5.6	6.8		7.6	6.6	11.0	11.3	5.5	3.4		9.7		9.7	23.5		9.1	10.6	0.4	8.8	1.4	0.3	10.8	17.9	3.4	15.2	13.7	10.1
T. rotaliformis	0.1				0.2		2.4				0.2		0.1	0.1	0.6								1.8	1.0	0.3													0.2		0.2				0.3	
Globigerina pachyderma						0.6		0.5	15.5				0.1	1.0					0.9			0.4			0.2			0.2	1.4						3.6	0.6			0.3				0.9		

Table 3 Distribution of frequently occurring Foraminifera in percentage of total population.

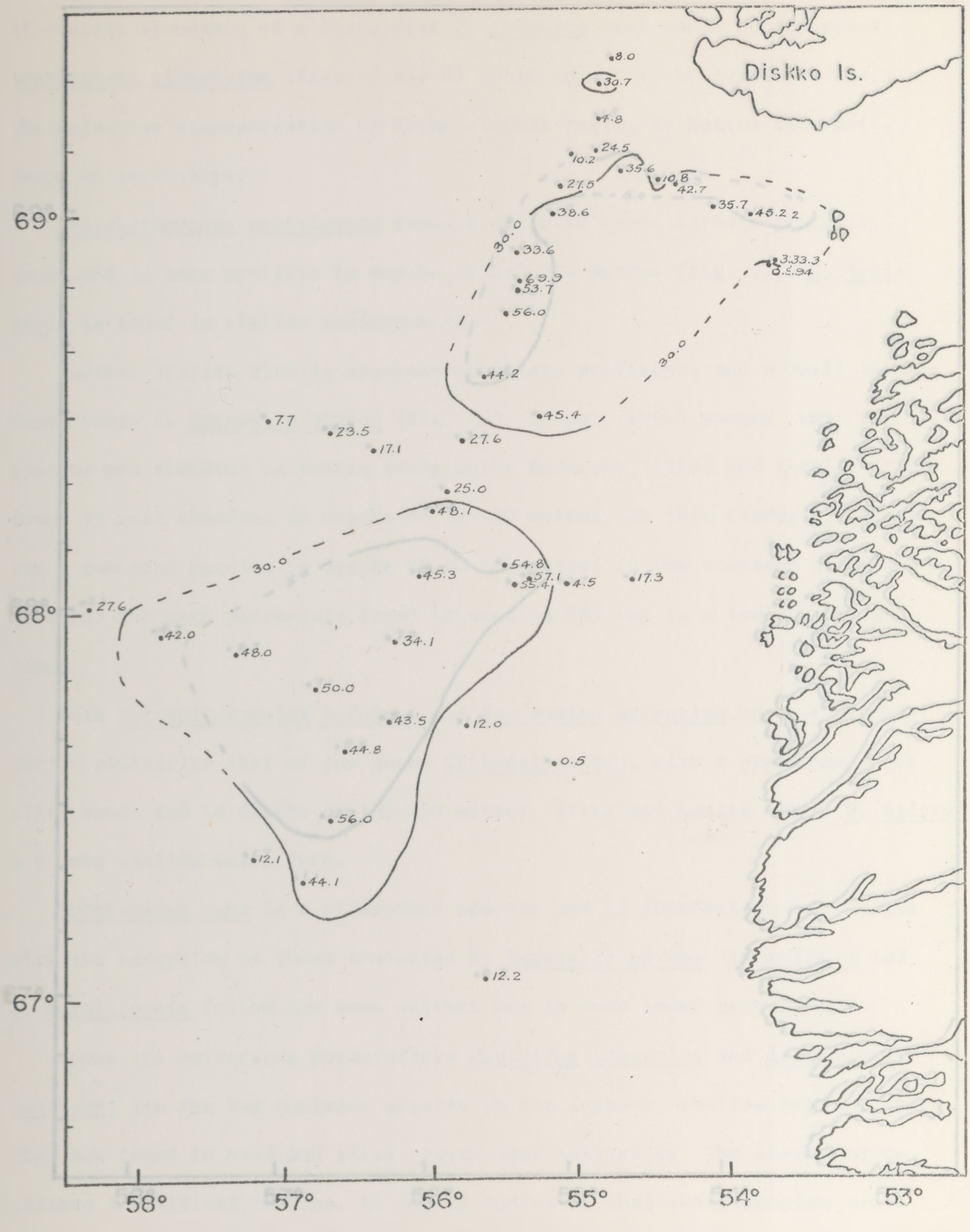

Fig. 7 Distribution of *Adercotryma glomeratum* in percentage of total population.

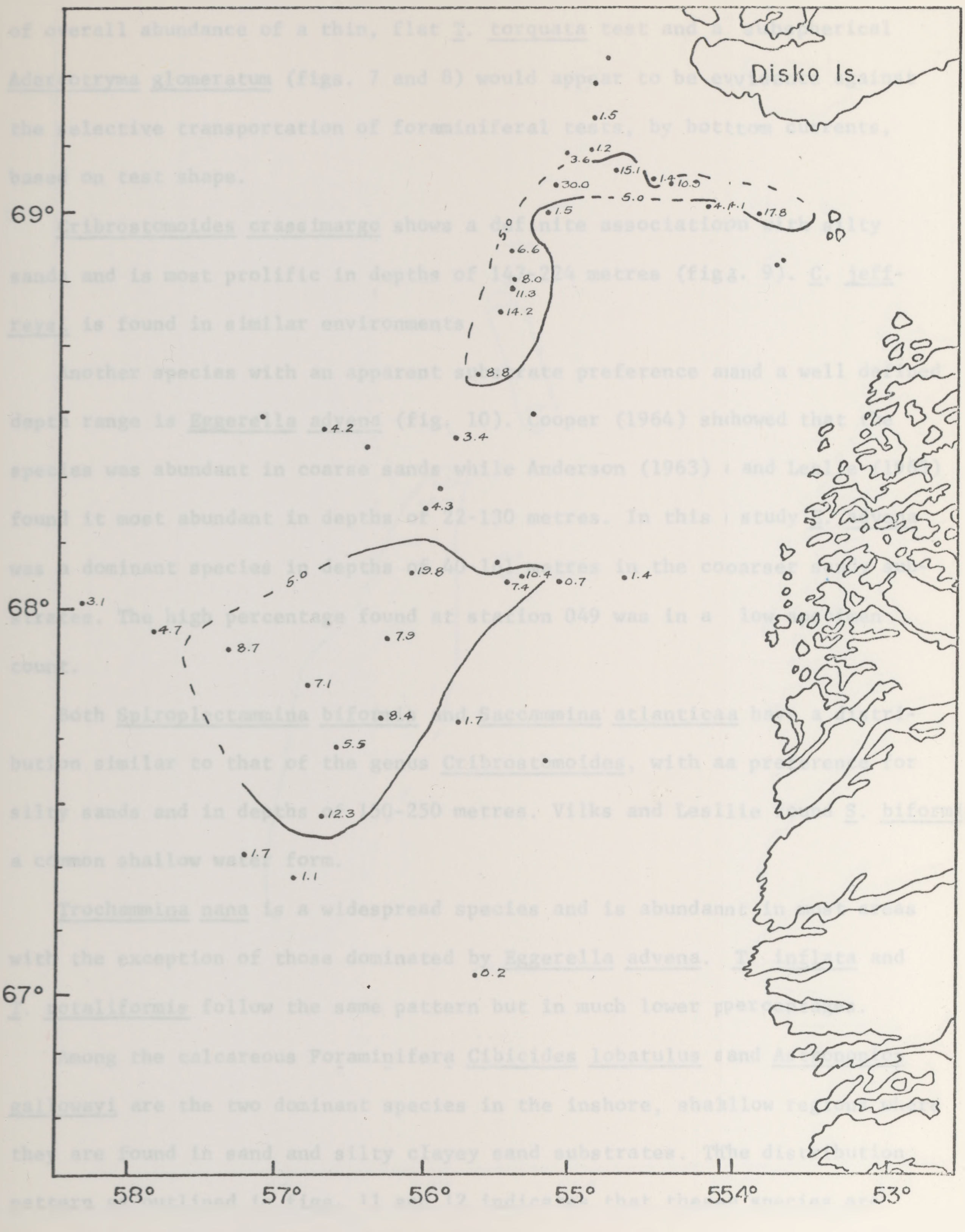

Fig. 8 Distribution of Textularia torquata (% of totall population)

of overall abundance of a thin, flat T. torquata test and a subspherical Adercotryma glomeratum (figs. 7 and 8) would appear to be evidence against the selective transportation of foraminiferal tests, by bottom currents, based on test shape.

Cribrostomoides crassimargo shows a definite association with silty sands and is most prolific in depths of 147-224 metres (fig. 9). C. jeffreysi is found in similar environments.

Another species with an apparent substrate preference and a well defined depth range is Eggerella advena (fig. 10). Cooper (1964) showed that the species was abundant in coarse sands while Anderson (1963) and Leslie (1965) found it most abundant in depths of 22-130 metres. In this study E. advena was a dominant species in depths of 40-161 metres in the coarser sandy substrates. The high percentage found at station 049 was in a low specimen count.

Both Spiroplectammina biformis and Saccammina atlantica have a distribution similar to that of the genus Cribrostomoides, with a preference for silty sands and in depths of 150-250 metres. Vilks and Leslie found S. biformis a common shallow water form.

Trochammina nana is a widespread species and is abundant in most areas with the exception of those dominated by Eggerella advena. T. inflata and T. rotaliformis follow the same pattern but in much lower percentages.

Among the calcareous Foraminifera Cibicides lobatulus and Astrononion gallowayi are the two dominant species in the inshore, shallow regions where they are found in sand and silty clayey sand substrates. The distribution pattern as outlined in figs. 11 and 12 indicates that these species are dominant in the areas where the Adercotryma glomeratum and Textularia torquata assemblage are found in reduced percentages. Both these groups are

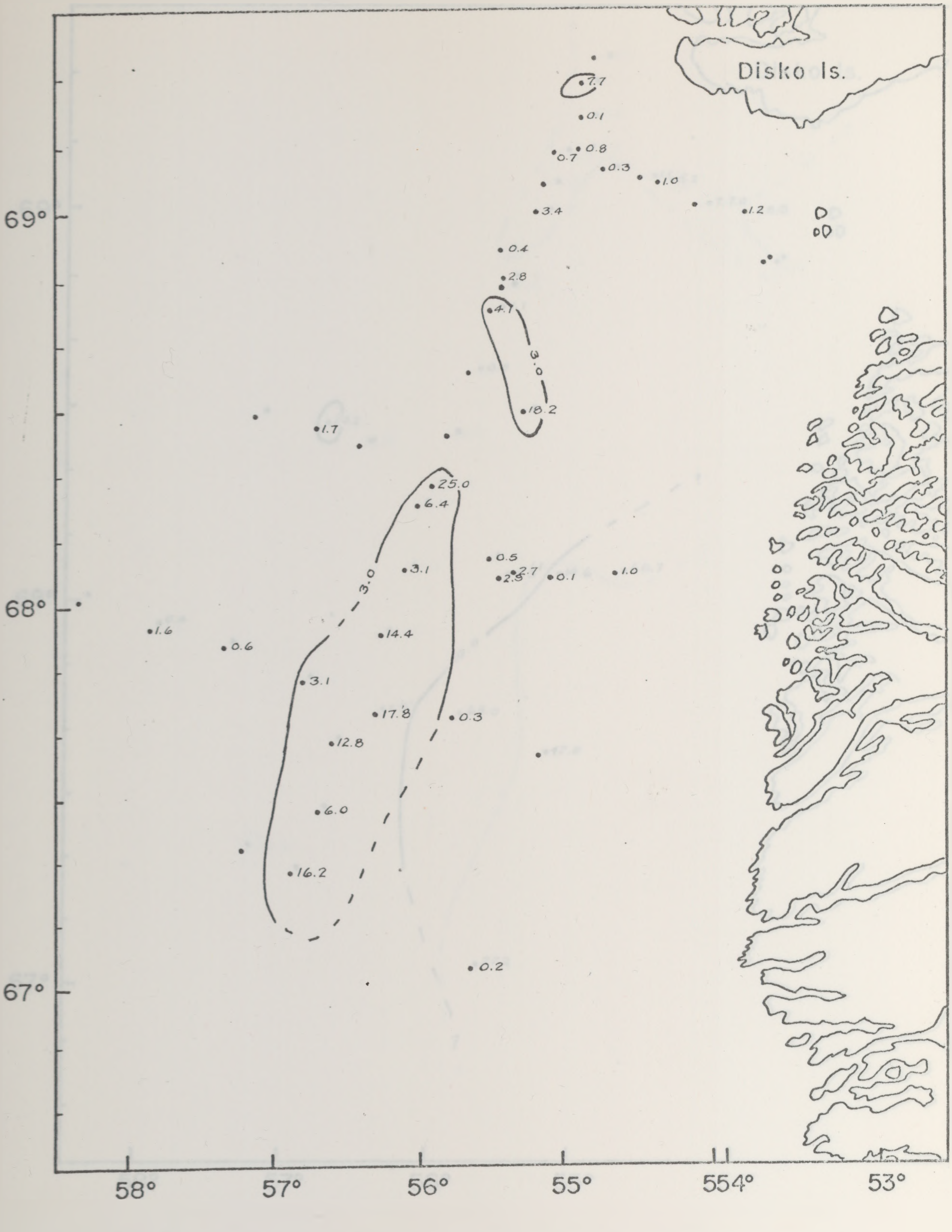

Fig. 9 Distribution of Cribrostomoides crassimargo (% of total population).

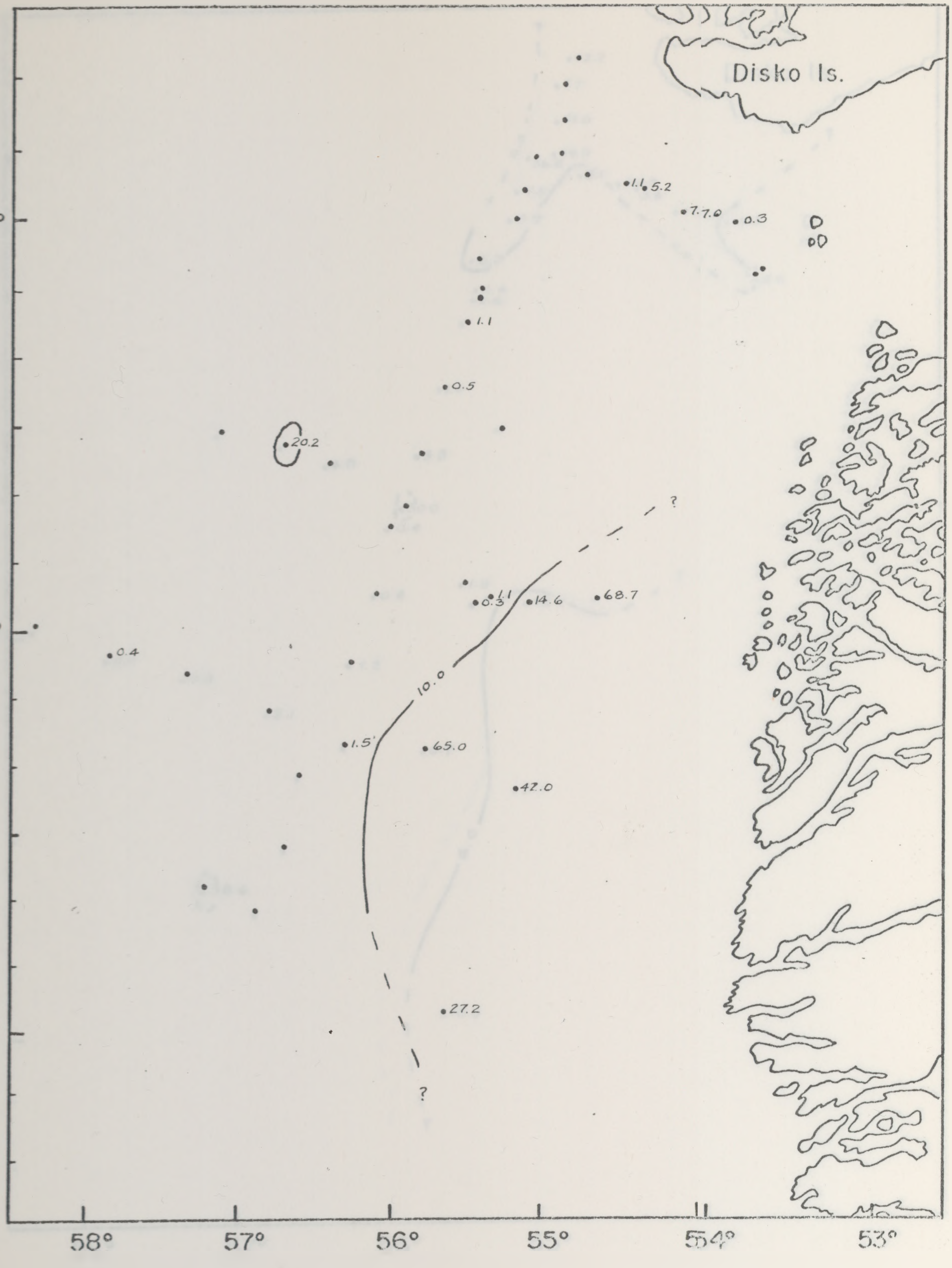

Fig. 10 Distribution of <u>Eggerella</u> <u>advena</u> (% of total population)

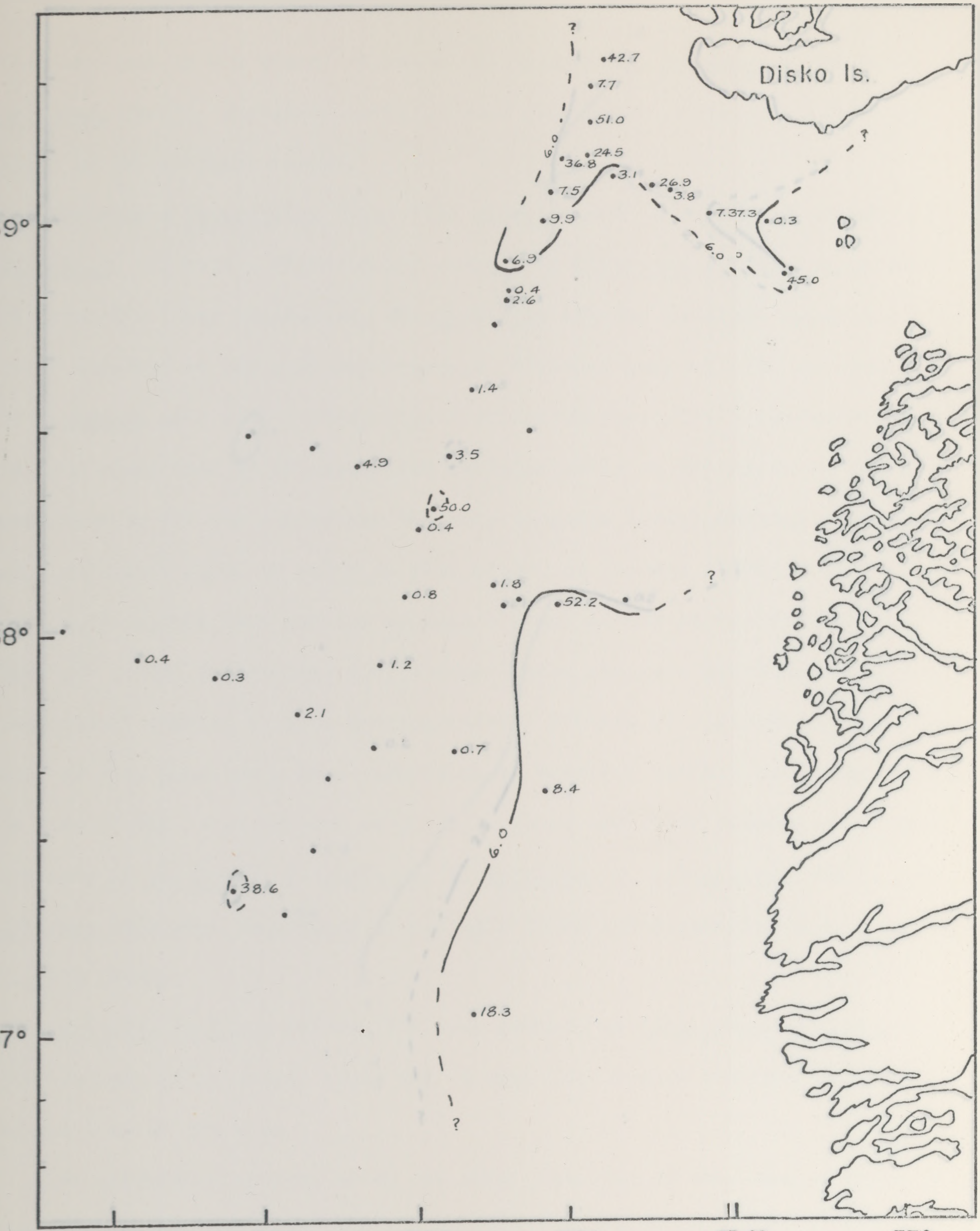

Fig. 11 Distribution of Cibicides lobatulus (% of total population)

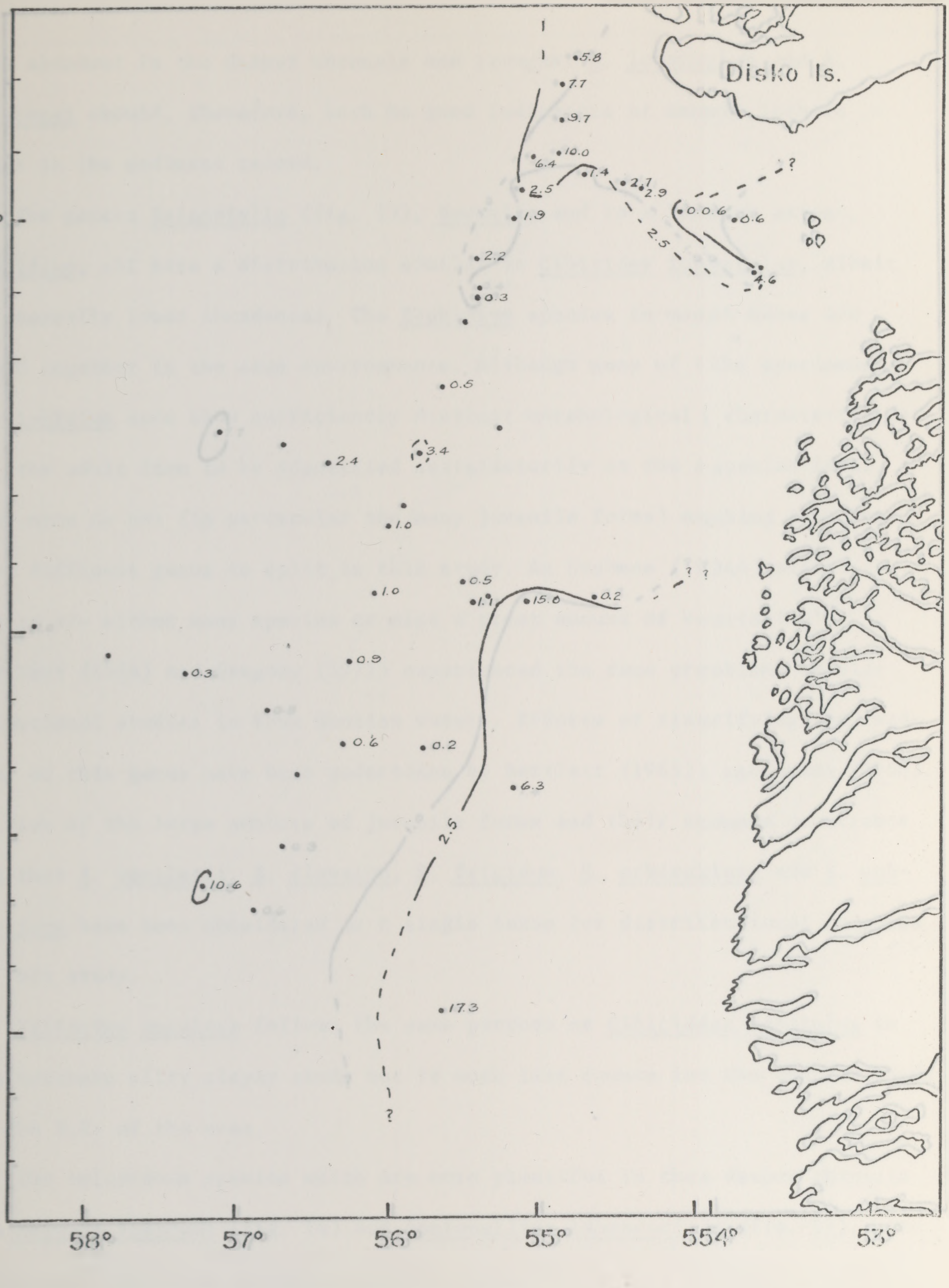

Fig. 12 Distribution of Astrononion gallowayi (% of total population)

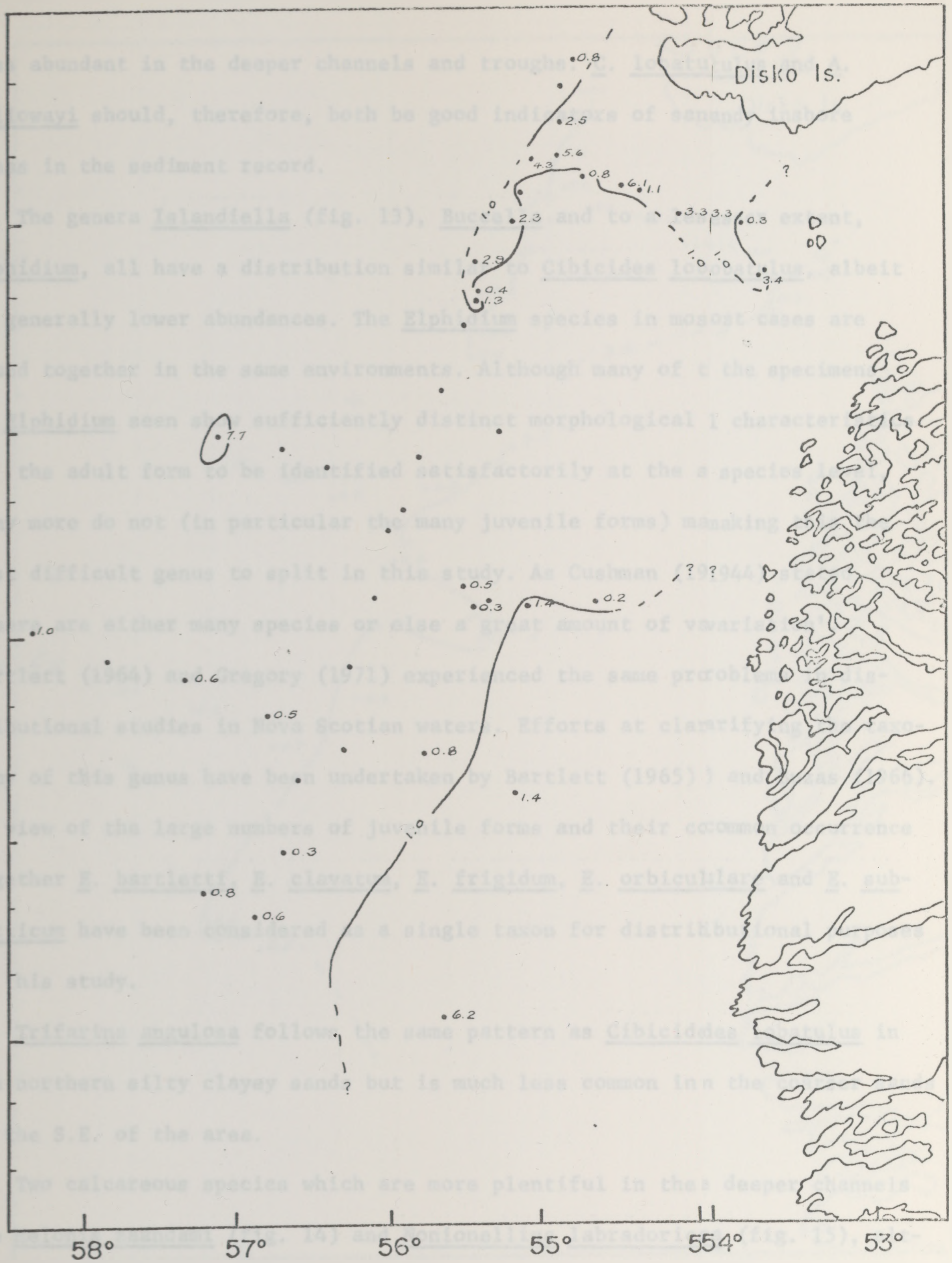

Fig. 13 Distribution of g. Islandiella (% of total population)

less abundant in the deeper channels and troughs. C. lobatulus and A. gallowayi should, therefore, both be good indicators of sandy inshore areas in the sediment record.

The genera Islandiella (fig. 13), Buccella and to a lesser extent, Elphidium, all have a distribution similar to Cibicides lobatulus, albeit in generally lower abundances. The Elphidium species in most cases are found together in the same environments. Although many of the specimens of Elphidium seen show sufficiently distinct morphological characteristics in the adult form to be identified satisfactorily at the species level, many more do not (in particular the many juvenile forms) making this the most difficult genus to split in this study. As Cushman (1944) stated 'there are either many species or else a great amount of variation'. Bartlett (1964) and Gregory (1971) experienced the same problems in distributional studies in Nova Scotian waters. Efforts at clarifying the taxonomy of this genus have been undertaken by Bartlett (1965) and Buzas (1966). In view of the large numbers of juvenile forms and their common occurrence together E. bartletti, E. clavatum, E. frigidum, E. orbiculare and E. subarcticum have been considered as a single taxon for distributional purposes in this study.

Trifarina angulosa follows the same pattern as Cibicides lobatulus in the northern silty clayey sands but is much less common in the coarser sands to the S.E. of the area.

Two calcareous species which are more plentiful in the deeper channels are Melonis zaandami (fig. 14) and Nonionellina labradorica (fig. 15), although their relative abundance may be masked by the more numerous arenaceous forms found there. The presence of N. labradorica becomes significant in

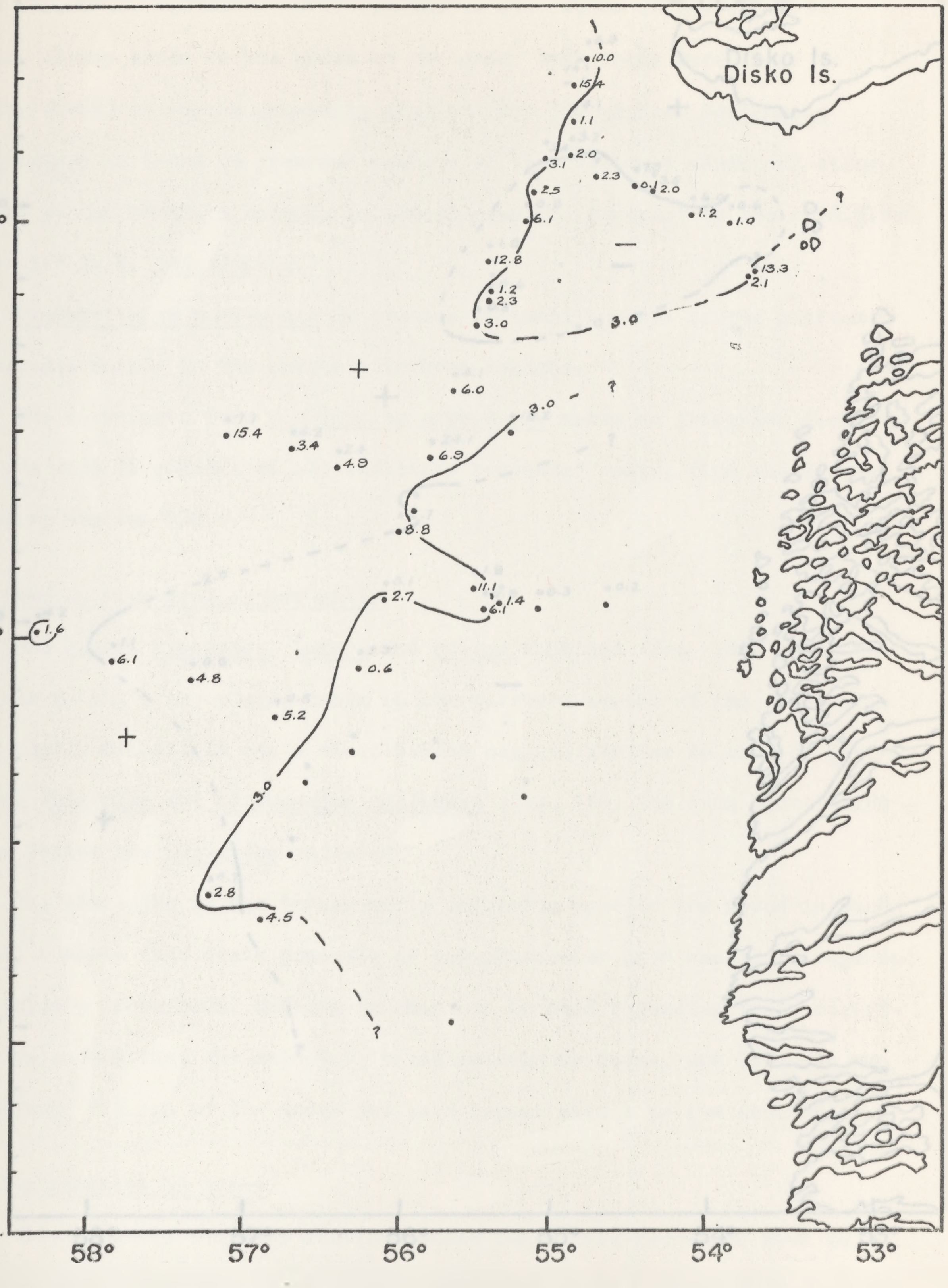

Fig. 14 Distribution of Melonis zaandami (% of total population)

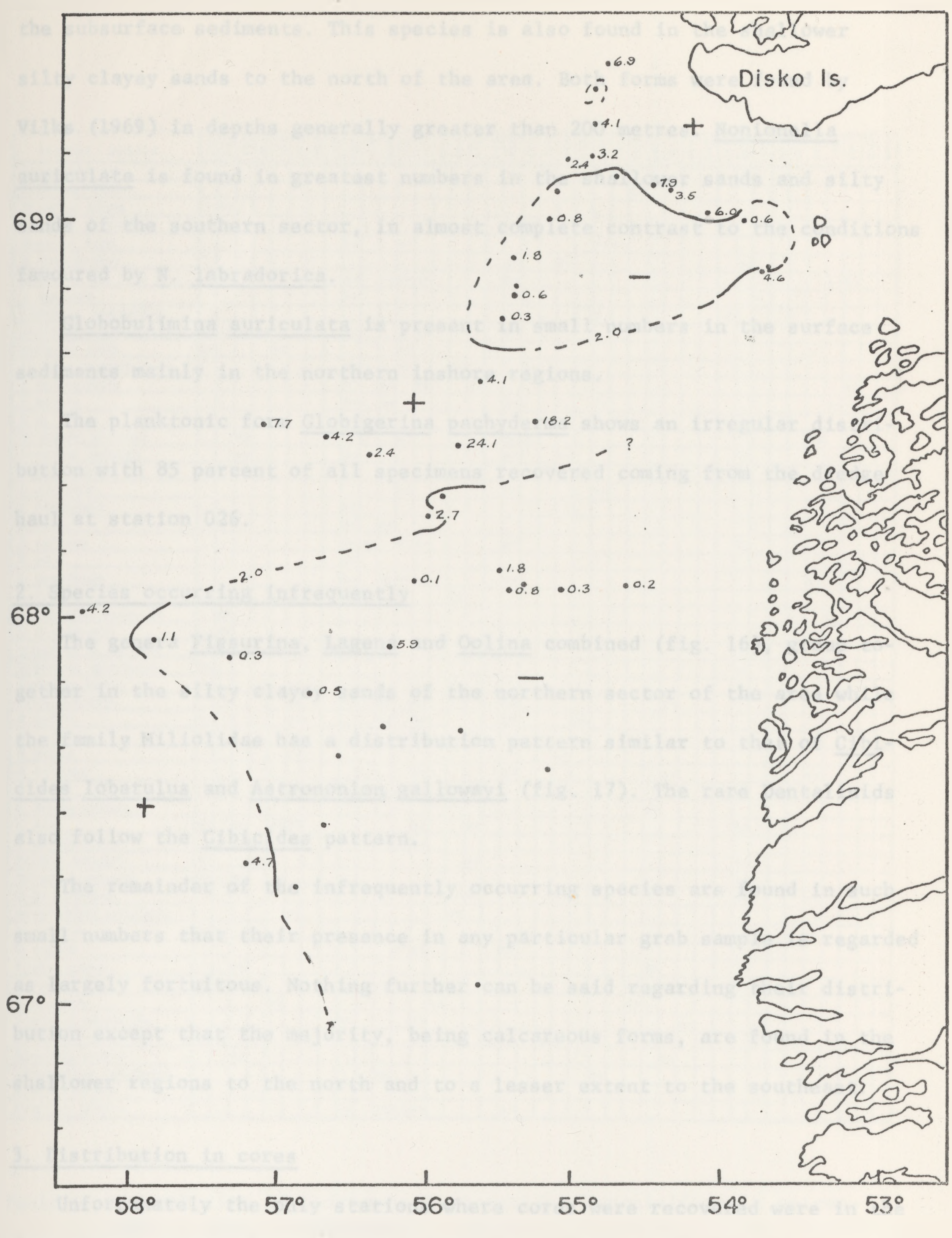

Fig. 15 Distribution of Nonionellina labradorica (% of total population).

the subsurface sediments. This species is also found in the shallower silty clayey sands to the north of the area. Both forms were found by Vilks (1969) in depths generally greater than 200 metres. Nonionella auriculata is found in greatest numbers in the shallower sands and silty sands of the southern sector, in almost complete contrast to the conditions favoured by N. labradorica.

Globobulimina auriculata is present in small numbers in the surface sediments mainly in the northern inshore regions.

The planktonic form Globigerina pachyderma shows an irregular distribution with 85 percent of all specimens recovered coming from the dredge haul at station 026.

2. Species occurring infrequently

The genera Fissurina, Lagena and Oolina combined (fig. 16), group together in the silty clayey sands of the northern sector of the area while the family Miliolidae has a distribution pattern similar to that of Cibicides lobatulus and Astrononion gallowayi (fig. 17). The rare Dentalinids also follow the Cibicides pattern.

The remainder of the infrequently occurring species are found in such small numbers that their presence in any particular grab sample is regarded as largely fortuitous. Nothing further can be said regarding their distribution except that the majority, being calcareous forms, are found in the shallower regions to the north and to a lesser extent to the southeast.

3. Distribution in cores

Unfortunately the only stations where cores were recovered were in the deeper areas where the surface fauna was sparse. One feature was apparent from the cores studied (Table 7), namely the almost complete disappearance

STATION NUMBER	017	018	019	020	021	022	023	024	026	028	029	030	031	032	033	034	035
Ammodiscus spp.																	
Ammotium cassis																	
Bileculina inflata		0.2															
Cyclogyra cf. foliacea																0.4	
Dentalina baggi									0.1			0.1					
D. frobisherensis																	
D. ittai									0.1		0.2	0.4	0.6				
D. pauperata									0.1								
Elphidiella groenlandica																	
Elphidium clavatum	4.0	0.5		0.6					2.7				6.7				
Esosyrinx curta	0.2				0.2							0.1					7.7
Fissurina cucurbitasema									0.1			0.1			0.2		
F. semimarginata									0.1		0.4		0.3			0.4	
F. serrata									0.1		0.4						
F. sp.									0.2				0.3				
Fursenkoina fusiformis			0.3									0.1					
Glandulina laevigata			0.2						0.1								
Lagena distoma									0.1		0.2	0.1	0.1				
L. gracillima												0.1					
L. meridionalis									0.1								
L. mollis									0.1		0.2						
L. nebulosa									0.1	0.2		0.1	0.1				
L. parri									0.1								
L. semilineata									0.1		0.4	0.1	1.4				
L. striata															0.2		
Laryngosigma hyalascida		0.2															
L. cf. williamsoni		0.2															
Lenticulina cf. angulata								0.5	0.5								
Miliolinella chukchiensis	0.1																
Nonionella turgida						0.3	0.5										
Oolina apiculata						0.3			0.3		0.4		0.1				
O. borealis	0.1					0.6					0.4		0.2				
O. caudigera						0.3							0.2				
O. globosa						0.1											
O. hexagona													0.2				
O. lineata						0.3					0.4				0.2	0.8	
O. lineato-punctata																	
O. melo	0.1		0.2		0.5	0.3							1.0			0.4	
O. striatopunctata						0.3							0.1				
Patellina corrugata	0.1															0.4	
Pateoris hauerinoides	0.1		0.2														
Pyrgo williamsoni															0.2	0.4	
Quinqueloculina agglutinata						0.1									0.2		
Q. seminulum	0.1	0.9															
Q. stalkeri												0.1	0.3				
Reophax arctica			0.8														
R. curtus			0.3	0.3							0.4	0.1		0.3			
R. scorpiurus					0.2									0.2			
Rosalina cf. columbiensis									0.1				0.1				
Scutuloris tegminis		0.5															
Sigmoidella pacifica			0.2														
Silicosigmoilina groenlandica											0.2						
Textularia earlandi				2.1													
Triloculina trihedra									0.5		0.2	0.1	0.3				

STATION NUMBER	036	037	038	039	040	041	042	043	044	045	046	049	050	056	057	058	059	060	061	062	063	064
Ammodiscus spp.	0.1		5.0																0.1			
Ammotium cassis								0.5														
Bileculina inflata																						
Cyclogyra cf. foliacea																						
Dentalina baggi						0.3	0.2															
D. frobisherensis	0.1			0.4										0.3								
D. ittai	0.3																		0.1	0.2		
D. pauperata																						
Elphidiella groenlandica													7.7									
Elphidium clavatum	0.1																					
Esosyrinx curta																		0.3				
Fissurina cucurbitasema		0.4																				
F. semimarginata																				0.2		
F. serrata	0.3					0.3													0.1			
F. sp.																						
Fursenkoina fusiformis	0.5	0.1																0.3				
Glandulina laevigata	0.1			0.8										0.3					0.1			
Lagena distoma					0.4																	0.5
L. gracillima	0.1					0.4																
L. meridionalis																						
L. mollis																						
L. nebulosa	0.1													0.3								
L. parri																						
L. semilineata	0.1																	0.3				
L. striata																						
Laryngosigma hyalascida																			0.1			
L. cf. williamsoni																						
Lenticulina cf. angulata																						
Miliolinella chukchiensis														1.7								
Nonionella turgida																						
Oolina apiculata	0.1									0.1												
O. borealis	0.3				0.4																	
O. caudigera																						
O. globosa				0.4																		
O. hexagona	0.1									0.1								0.3				
O. lineata										0.1				0.3				0.3	0.1		3.5	
O. lineato-punctata									0.1													
O. melo														0.3								
O. striatopunctata																						
Patellina corrugata														0.3								
Pateoris hauerinoides														0.3								
Pyrgo williamsoni				0.8										0.3				1.5				
Quinqueloculina agglutinata																						
Q. seminulum		0.4																				
Q. stalkeri	0.2																					
Reophax arctica									0.2													
R. curtus								1.4		0.1												
R. scorpiurus								0.3														
Rosalina cf. columbiensis																						
Scutuloris tegminis	0.1									0.1												
Sigmoidella pacifica										0.1												
Silicosigmoilina groenlandica						0.3																
Textularia earlandi			2.5				0.3					0.8			1.7		1.2		0.5	0.2		
Triloculina trihedra	0.1																	0.3				

Table 4 Distribution of infrequently occurring Foraminifera in percentage of total population.

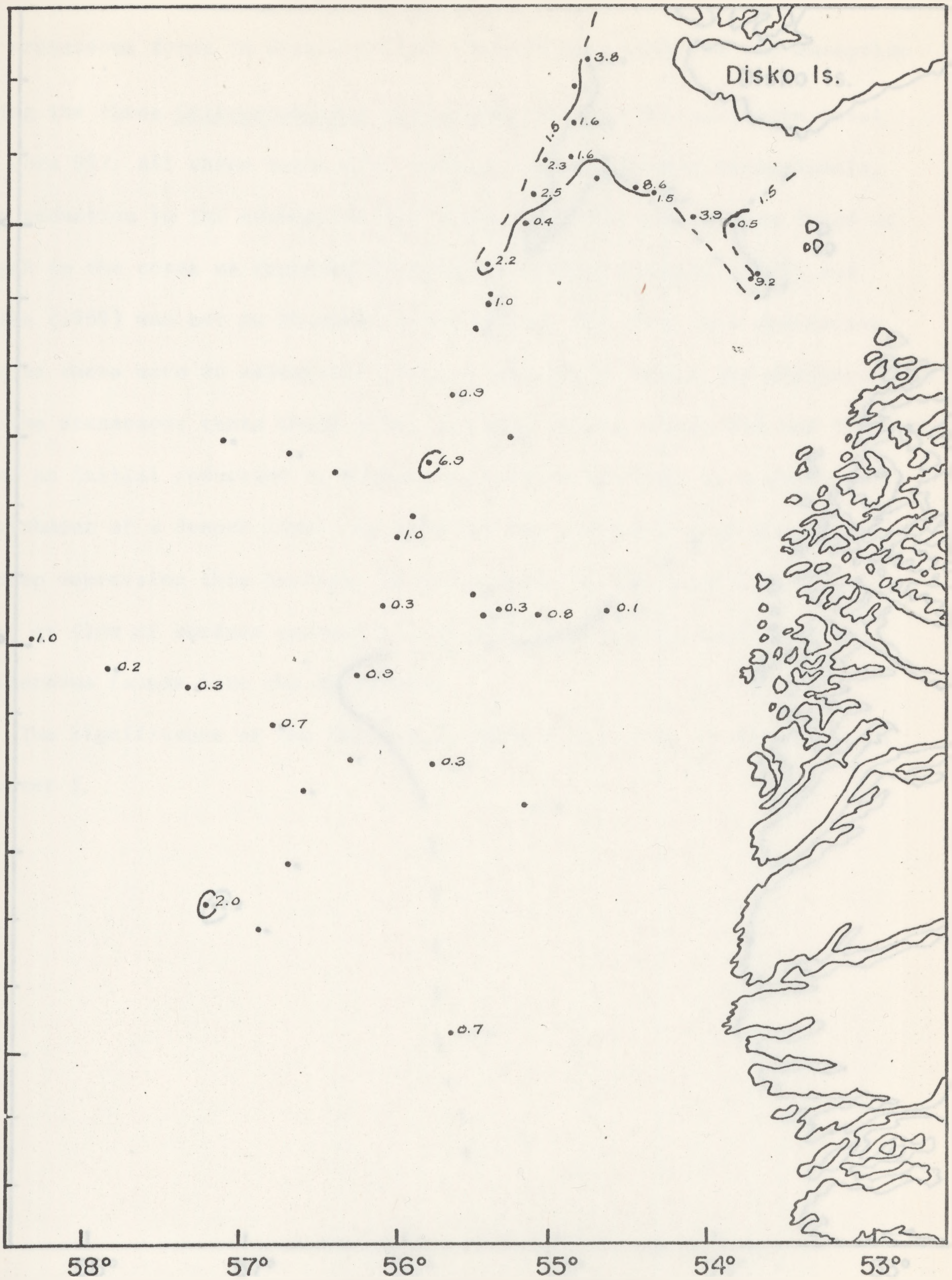

Fig. 16 Distribution of the Fissurina, Lagena and Oolina genera (% of total population).

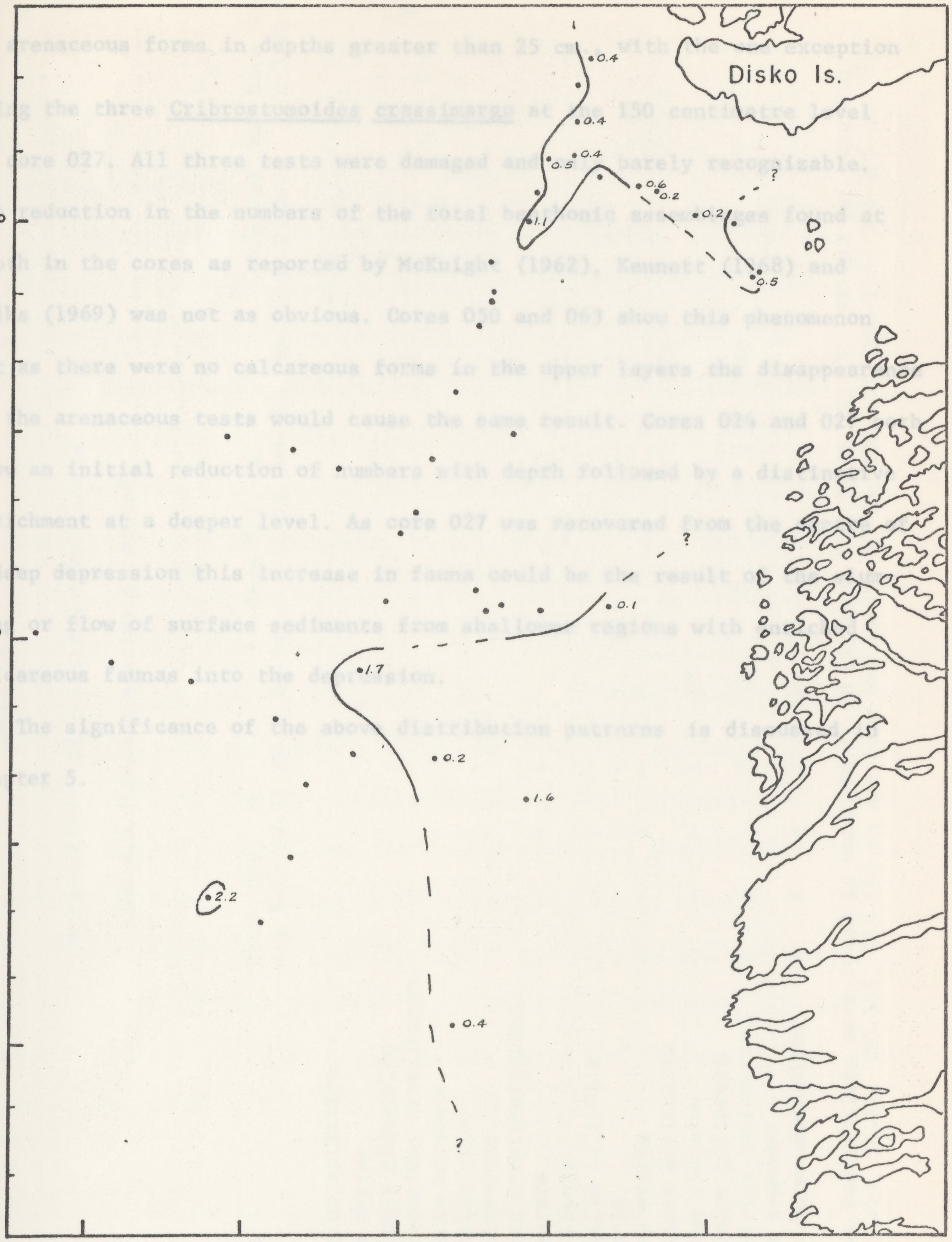

Fig. 17 Distribution of the Miliolids (% of total population)

of arenaceous forms in depths greater than 25 cm., with the one exception being the three Cribrostomoides crassimargo at the 150 centimetre level in core 027. All three tests were damaged and only barely recognizable. The reduction in the numbers of the total benthonic assemblages found at depth in the cores as reported by McKnight (1962), Kennett (1968) and Vilks (1969) was not as obvious. Cores 050 and 063 show this phenomenon but as there were no calcareous forms in the upper layers the disappearance of the arenaceous tests would cause the same result. Cores 024 and 027 both show an initial reduction of numbers with depth followed by a distinctive enrichment at a deeper level. As core 027 was recovered from the centre of a deep depression this increase in fauna could be the result of the slumping or flow of surface sediments from shallower regions with enriched calcareous faunas into the depression.

The significance of the above distribution patterns is discussed in Chapter 5.

TABLE 5

Foraminiferal Distribution from 4 cores

(Numbers indicate specimens counted)

Species	Core 024, cm					Core 027, cm				Core 050, cm		Core 063, cm		
	0-5	5-12	18-25	25-40	40-54	0-3	10-15	100-105	150-155	0-3	10-15	0-3	20-25	220-224
Saccammina atlantica										2	1			
Reophax curtus										2	-			
Adercotryma glomeratum										4	-	1		
Cribrostomoides crassimargo						-	-	-	3	-	1	1	2	
Textularia torquata										9	1			
Trochammina nana										2	-	1		
T. rotaliformis										2	-			
Dentalina frobisherensis						-	-	-	1					
D. pauperata	-	-	-	1	-									
Lagena laevis						-	-	-	1					
Islandiella islandica	-	-	-	-	3									1
I. teretis	-	-	-	-	9	-	-	-	1					
Bulimina exilis	-	-	1	-	6									
Globulimina auriculata						3	-	2	13					
Elphidium clavatum	-	-	-	3	19									
Astrononion gallowayi						-	-	-	1					
Nonionellina labradorica	2	5	-	8	19	10	1	6	60					
Melonis zaandami						-	1	-	-					
Globobulimina auriculata	-	-	-	1	2									

Note: No Foraminifera were found in core 024 12-18 cm; core 027 20-25, 50-55, 198-202 cm; core 050 20-25, 50-55, 100-105, 145-150 cm and core 063 10-15, 50-55, 100-105, 150-155, 200-205 cm.

CHAPTER 4

Similarity Analysis

Method of Analysis

Similarity analyses have been applied to studies of the distribution patterns of benthonic fauna by Field and McFarlane (1968), Stephenson et al (1970) and Field (1970 and 1971). This type of analysis has been found to give more accurate results than the association analyses based on the presence/absence of species (Field 1969).

Numbers of specimens of the frequently occurring species found at each station form the raw data. In this study, in some cases where two or more species of the same genus occur regularly together they have been considered as a single taxon e.g. the genera *Buccella*, *Islandiella*, *Elphidium*, *Fissurina*, *Lagena* and *Oolina*. An even larger grouping combines the family Miliolidae as a single taxon. The number of specimens in this last taxon is so small that if individual species were considered they would have no significance. Justification for these groupings can be made from their regular occurrence together in both this and similar studies.

The raw data was log transformed to prevent the domination of the groups by the abundant species, and a comparison made with each taxon between every possible pairing of stations using the Bray Curtis measure of Similarity (Field 1971). This coefficient is

$$S = 2\,W/(A+B)$$

where A is the sum of the species scores for sample a, B is the sum of the species scores for sample b, and W is the sum of the smaller scores of each species in the two samples being compared. Thus a coefficient is obtained to express the similarity of each station with every other station giving a matrix of similarity coefficients.

To simplify the similarity matrix the group average sorting method is applied giving a hierarchial classification of the stations in the form of a dendrogram (fig. 18). As a check against oversimplification by the group average sorting technique the nearest neighbour method has been used (Field and McFarlane 1968). The dendrogram indicates that as the similarity criteria to join a group are decreased, each group increases in size as more stations qualify for inclusion within the group. The sequence of fusion of groups or individual stations in the dendrogram is determined by the degree of similarity between the different groups. Because the choice of groups selected from the dendrogram is to some extent subjective a technique has been developed to reduce this subjectivity (Field 1969). This method uses the information statistic $2\Delta I$ (Lambert and Williams 1966) to test each fusion in the dendrogram to determine whether any two stations or groups of stations could have come from the same population or, alternatively, are statistically significantly different. Stations or groups of stations found to be significantly different at approximately the 5 % level are joined by a dotted line in the dendrogram while those that do not differ significantly are joined by solid lines. Because of the testing procedure followed, the tests of significance give approximate not accurate levels of probability.

The use of the information statistic has the additional advantage of giving any 'indicator' species whose presence or absence might be useful in defining faunal assemblages in any of the major groupings of stations. Indicators were defined as those taxa which differ significantly (at the 5 % or 1 % level of probability) between the two groups of stations under test. 'Perfect indicators' are those taxa which are present in all stations of one group and are absent from all those of the other (Field 1970).

The selected groups from the dendrogram may then be compared to environmental parameters known to exist at the stations. If clear relationships are found, the faunal assemblages may have some significance as paleoenvironmental indicators. This method may indicate associations between faunal assemblages and environmental parameters not obvious to visual inspection of sets of raw data.

Limitations

The neat classes which can be found by numerical techniques are simplifications of complex situations and the danger of over-simplification is real. In interpreting the data the actual level of simplification is not of great importance whereas the grouping of samples to show their relative affinities is important (Field and McFarlane, 1968).

The grouping of taxa does not indicate the environmental parameters to which the taxa are responding; hence a general knowledge of the faunal characteristics and the parameters involved must be utilized to interpret the groupings as shown.

Results

From the dendrogram groups A_1, A_2, B_1, B_2 and C were selected as being distinct and compared with the physical parameters of depth, substrate, percentage of calcareous Foraminifera and the percentage of calcium carbonate in the sediments (Table 8). The location of stations from each grouping was plotted (fig. 19) and roughly contoured. A more detailed contouring showing a possible interpretation of the distribution of station groups based on the general bathymetry of the area (fig. 3) is given in fig. 19b. The following general associations were observed.

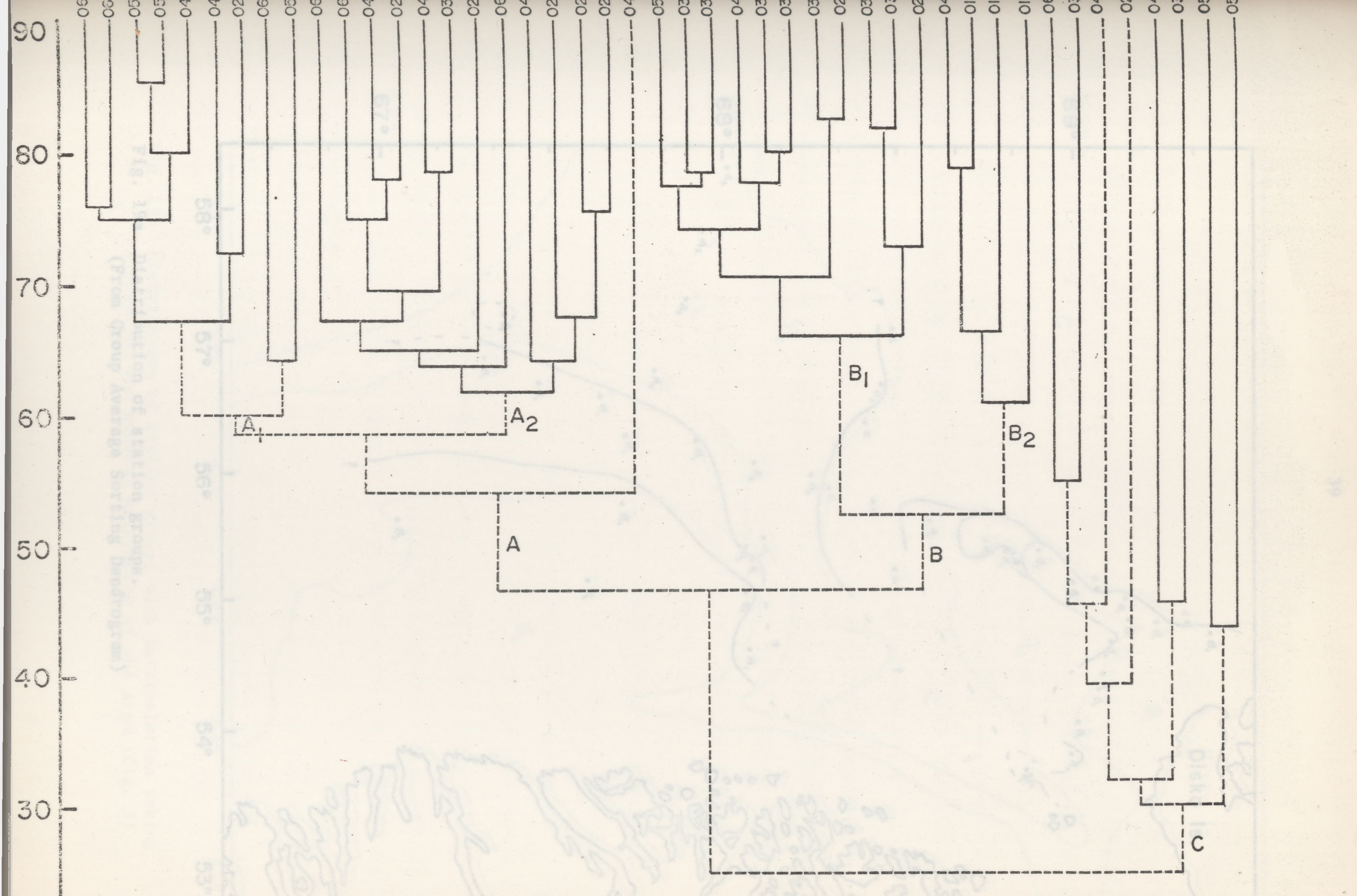

Fig. 18 Dendrogram showing the similarity between stations based on analysis of the fauna. The axis shows percentage similarity obtained by the Bray-Curtis coeficient using abundances at sorting. The firm lines indicate that the stations or groups of stations differ significantly at the 5% level when tested using the information statistic.

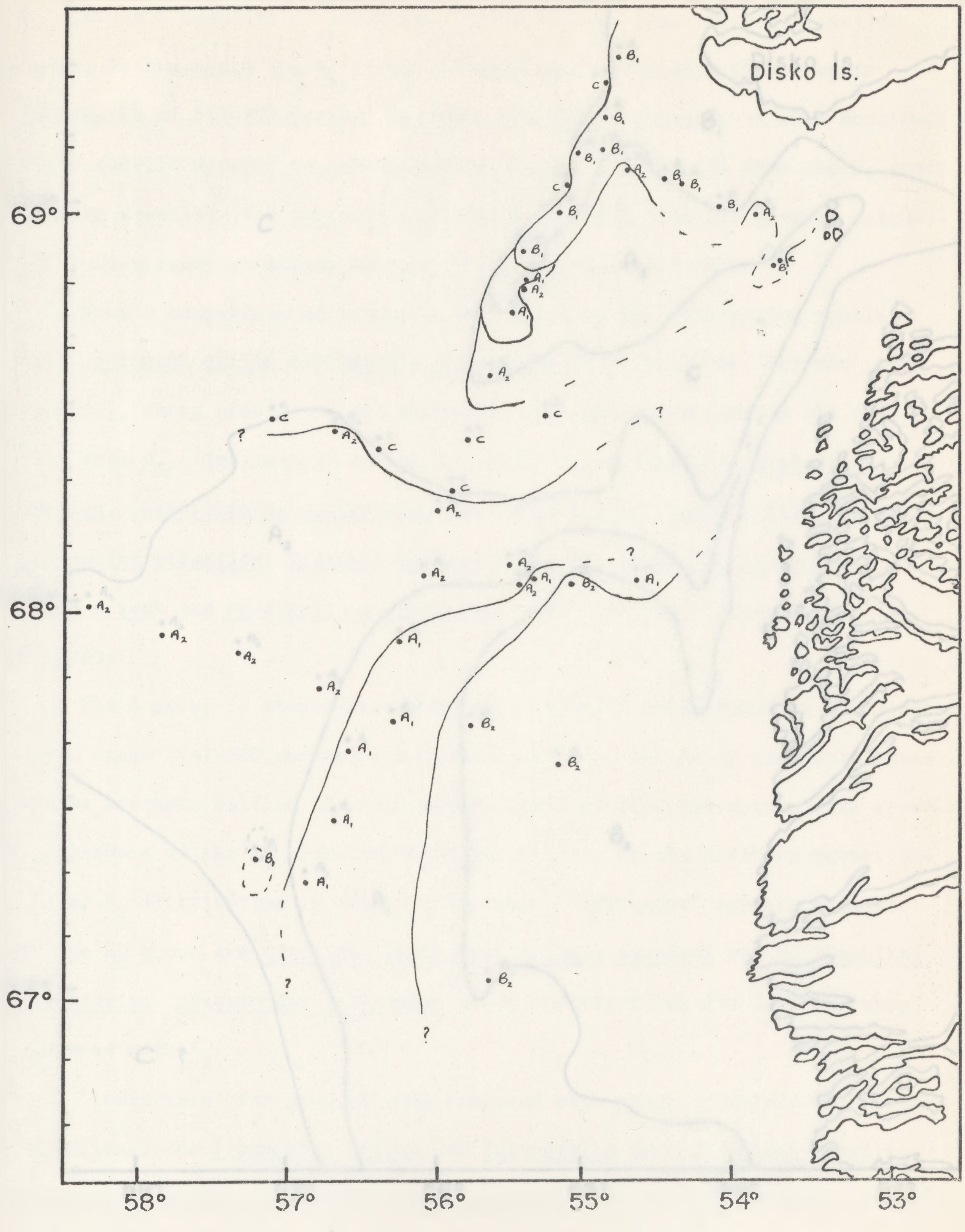

Fig. 19a Distribution of station groups.
(From Group Average Sorting Dendrogram)

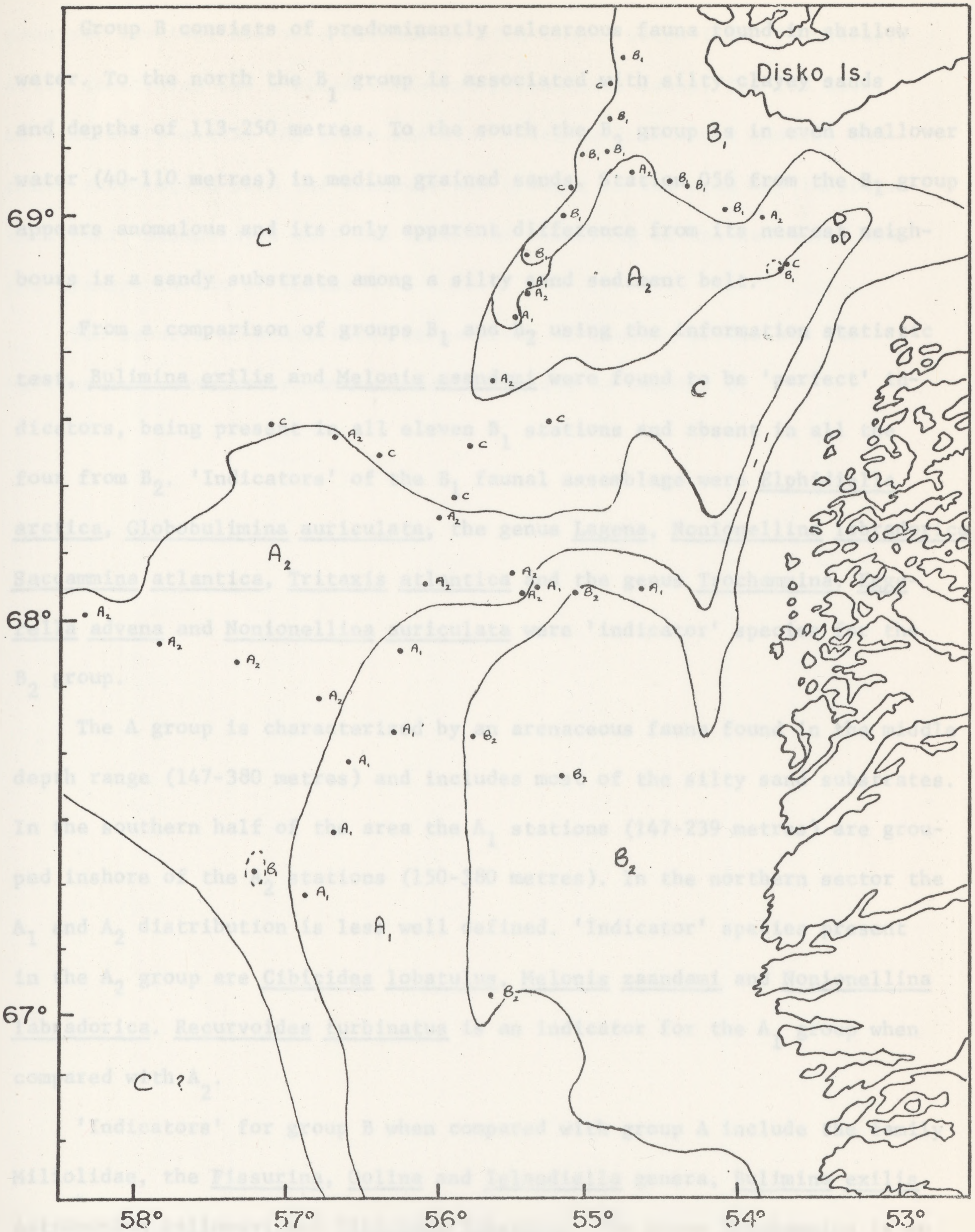

Fig. 19b Distribution of station groups with interpolation taking account of the general bathymetry of the area (fig. 3).

Group B consists of predominantly calcareous fauna found in shallow water. To the north the B_1 group is associated with silty clayey sands and depths of 113-250 metres. To the south the B_2 group is in even shallower water (40-110 metres) in medium grained sands. Station 056 from the B_1 group appears anomalous and its only apparent difference from its nearest neighbours is a sandy substrate among a silty sand sediment belt.

From a comparison of groups B_1 and B_2 using the information statistic test, Bulimina exilis and Melonis zaandami were found to be 'perfect' indicators, being present in all eleven B_1 stations and absent in all the four from B_2. 'Indicators' of the B_1 faunal assemblage were Elphidiella arctica, Globobulimina auriculata, the genus Lagena, Nonionellina labradorica, Saccammina atlantica, Tritaxis atlantica and the genus Trochammina. Eggerella advena and Nonionellina auriculata were 'indicator' species for the B_2 group.

The A group is characterized by an arenaceous fauna found in the middle depth range (147-380 metres) and includes most of the silty sand substrates. In the southern half of the area the A_1 stations (147-239 metres) are grouped inshore of the A_2 stations (150-380 metres). In the northern sector the A_1 and A_2 distribution is less well defined. 'Indicator' species present in the A_2 group are Cibicides lobatulus, Melonis zaandami and Nonionellina labradorica. Recurvoides turbinatus is an indicator for the A_1 group when compared with A_2.

'Indicators' for group B when compared with group A include the family Miliolidae, the Fissurina, Oolina and Islandiella genera, Bulimina exilis, Astrononion gallowayi and Cibicides lobatulus. The genus Trochammina is an indicator for group A.

Group C assemblages all consist of very sparse faunas (4 to 41 specimens per station) and were associated with deeper water (164-750 metres), silty substrates and a mixed calcareous/arenaceous fauna. The low level of similarity within the group and with stations from other groups, and their association with the channels and troughs in the area may indicate that these assemblages were the result of reworking of the sediments and the transportation of tests.

The results of statistical comparisons of station groups and the various environmental parameters are discussed in Chapter 6.

TABLE 6

Comparison of faunal groups from the dendrogram with environmental parameters.

Group	Station	Substrate	Depth (metres)	% calcar. specimens	% $CaCO_3$ in seds.
A_1	066	C S Si	220	4.0	0.02
	065	Si C S	227	7.1	0.04
	059	Si S	194	4.3	0.07
	058	Si S	183	1.4	0.03
	043	Si S	239	3.0	0.06
	044	S	161	2.8	0.07
	020	S	150	3.3	0.02
	060	Si S	147	19.7	0.04
	057	Si S	224	24.0	0.13
A_2	064	C S Si	303	25.4	0.14
	062	S	333	19.6	0.11
	042	Si S	351	12.9	0.05
	028	S Si	170	10.7	0.13
	041	Si S	200	15.2	0.33
	032	Si C S	150	12.3	0.17
	021	Si S	180	16.4	0.23
	061	Si S	160	8.1	0.16
	046	Si S	379	21.7	0.10
	024	C S Si	380	10.4	0.25
	023	Si S	336	17.1	0.09
	022	Si S	280	9.6	0.13
	(049)	C S Si	348	14.3	0.23

TABLE 6 (continued).

Group	Station	Substrate	Depth (metres)	%calc. specimens	% $CaCO_3$ in seds.
B_1	056	S	250	73.7	0.34
	034	Si C S	117	85.0	1.97
	033	Si C S	159	81.0	0.30
	040	Si C S	173	46.7	0.41
	039	Si S	180	44.7	0.07
	037	Si C S	154	62.5	0.43
	030	Si C S	117	26.5	0.56
	029	Si S	121	40.9	0.54
	036	Si S	120	87.0	0.31
	031	Si C S	113	79.4	1.16
	026	Si C S	221	98.9	1.93
B_2	045	S	110	75.4	0.45
	017	S	90	56.6	0.59
	019	S	110	14.2	0.05
	018	S	40	57.3	0.68
C	063	C Si	504	62.1	0.34
	038	Si C S	164	27.5	0.10
	048	C S Si	455	53.7	0.27
	027	C Si	750	20.0	0.10
	047	C Si	494	50.0	0.81
	035	C S Si	181	46.2	0.02
	051	C S Si	200	18.2	0.05
	050	C Si	366	92.3	0.24

CHAPTER 5

GENERAL FAUNAL TRENDS

Abundance

To signify the abundance of Foraminifera in the sediment samples the measurement of Foraminifera /c.c. of wet sediment is used (Table 7 and fig. 20). The Foraminiferal Number or Foraminifera/gram of dry sediment is also given for comparison with other studies (Table 7), (Walton 1955 and Phleger 1960).

The greatest overall abundances are found in the shallow inshore regions to the north and the south-east and are associated with calcareous faunas and a relatively high $CaCO_3$ content in the sediments. High faunal concentrations occur in the north in silty clayey sands, and to the south-east in the coarser sands. Values of 30-75 Foram./c.c. of wet sediments are recorded in the northern sector in an area containing stations from the B_1 group of the Similarity Analysis. To the southeast a B_2 grouping of stations is associated with a range of values of 30-55 (with the exception of station 019). The remainder of the shelf area has abundances of 1 to 15, except for stations 056 and 061 in the 25-30 range, in an area occupied by the A type stations. The C group are found to have abundances of less than 1.

Taxa that are consistently associated with areas of high abundances are Cibicides lobatulus, Astrononion gallowayi, Islandiella genus and the Miliolidae family. Eggerella advena is limited to the southeastern section while the Fissurina, Lagena and Oolina genera are found most commonly to the north.

TABLE 7

Abundance of Foraminifera

Station	No. of spec.	Foram. No.	Forams/c.c. wet sed.	Station	No. of spec.	Foram. No.	Forams/c.c. wet sed.
017	808	37.6	55.7	041	309	13.2	15.2
018	426	2.0	3.2	042	657	4.1	5.3
019	592	21.4	30.7	043	364	29.3	39.9
020	331	4.3	5.4	044	1776	26.8	37.4
021	421	3.9	5.4	045	844	21.4	34.8
022	356	8.0	9.2	046	217	1.4	1.6
023	445	7.8	9.4	047	4	0.04	0.03
024	192	1.7	1.7	048	41	0.4	0.2
026	1489	69.2	62.7	049	119	1.3	0.7
027	15	0.3	0.1	050	13	0.3	0.1
028	624	8.8	9.2	051	11	0.1	0.1
029	482	5.6	6.4	056	358	20.2	29.2
030	967	25.2	32.8	057	179	0.6	0.9
031	700	51.9	74.7	058	284	5.4	7.4
032	351	17.4	21.3	059	511	3.8	3.7
033	421	3.6	4.8	060	340	10.8	12.6
034	260	10.6	18.4	061	2156	17.1	25.4
035	13	0.1	0.1	062	486	3.2	4.2
036	1150	41.1	60.1	063	29	0.4	0.2
037	249	8.9	10.8	064	217	2.2	2.0
038	40	0.5	0.4	065	366	4.2	3.5
039	262	3.8	4.7	066	249	5.7	4.3
040	274	11.2	11.1				

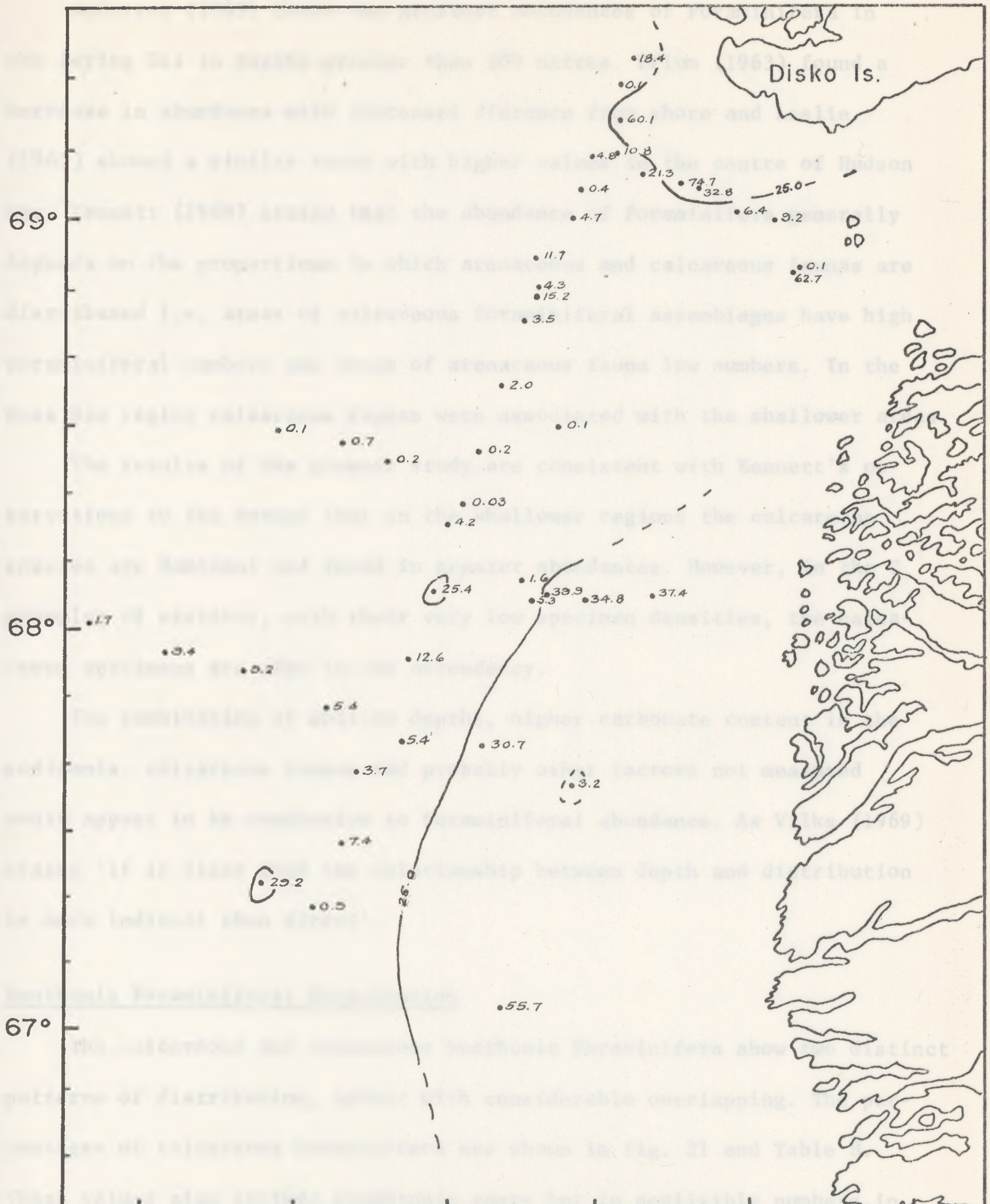

Fig. 20 Abundance of Foraminifera (Foram /c.c. wet sediment)

Anderson (1963) found the greatest abundances of Foraminifera in the Bering Sea in depths greater than 200 metres. Pflum (1963) found a decrease in abundance with increased distance from shore and Leslie (1965) showed a similar trend with higher values in the centre of Hudson Bay. Kennett (1968) stated that the abundance of Foraminifera generally depends on the proportions in which arenaceous and calcareous faunas are distributed i.e. areas of calcareous foraminiferal assemblages have high foraminiferal numbers and areas of arenaceous fauna low numbers. In the Ross Sea region calcareous faunas were associated with the shallower areas.

The results of the present study are consistent with Kennett's observations to the extent that in the shallower regions the calcareous species are dominant and found in greater abundances. However, in the C grouping of stations, with their very low specimen densities, the calcareous specimens are also in the ascendency.

The combination of shallow depths, higher carbonate content in the sediments, calcareous faunas and probably other factors not measured would appear to be conductive to foraminiferal abundance. As Vilks (1969) states 'it is clear that the relationship between depth and distribution is more indirect than direct'.

Benthonic Foraminiferal Distribution

The calcareous and arenaceous benthonic Foraminifera show two distinct patterns of distribution, albeit with considerable overlapping. The percentages of calcareous Foraminifera are shown in fig. 21 and Table 8. These values also include planktonic tests but in negligible numbers in all cases except station 026. The two major groupings in the surface sediments are an arenaceous fauna with Adercotryma glomeratum and Textularia torquata dominant, and a calcareous assemblage with Cibicides lobatulus

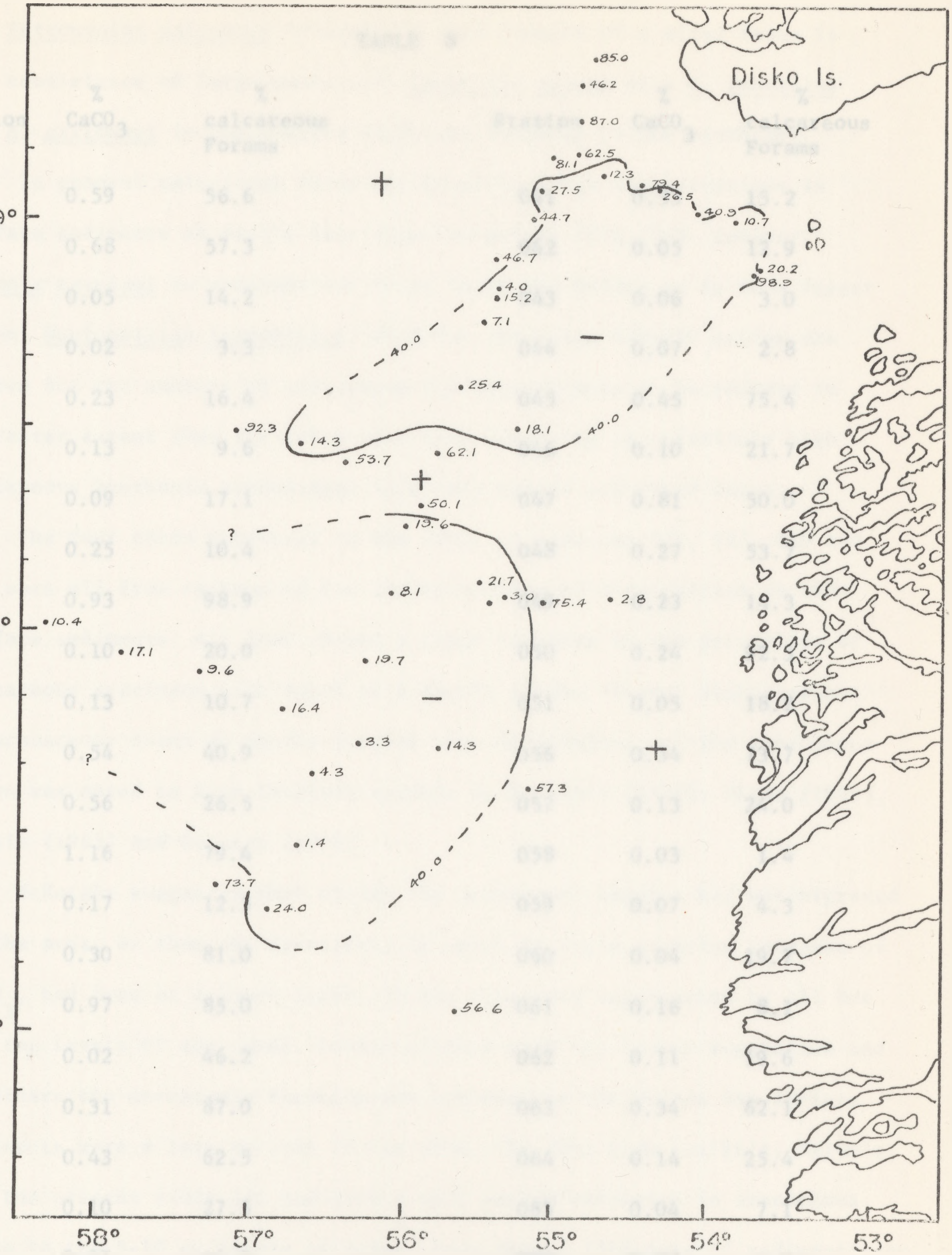

Fig. 21 Distribution of calcareous Fauna (% of total population)

TABLE 8

Station	% $CaCO_3$	% calcareous Forams	Station	% $CaCO_3$	% calcareous Forams
017	0.59	56.6	041	0.33	15.2
018	0.68	57.3	042	0.05	12.9
019	0.05	14.2	043	0.06	3.0
020	0.02	3.3	044	0.07	2.8
021	0.23	16.4	045	0.45	75.4
022	0.13	9.6	046	0.10	21.7
023	0.09	17.1	047	0.81	50.0
024	0.25	10.4	048	0.27	53.7
026	0.93	98.9	049	0.23	14.3
027	0.10	20.0	050	0.24	92.3
028	0.13	10.7	051	0.05	18.2
029	0.54	40.9	056	0.34	73.7
030	0.56	26.5	057	0.13	24.0
031	1.16	79.4	058	0.03	1.4
032	0.17	12.3	059	0.07	4.3
033	0.30	81.0	060	0.04	19.7
034	0.97	85.0	061	0.16	8.1
035	0.02	46.2	062	0.11	19.6
036	0.31	87.0	063	0.34	62.1
037	0.43	62.5	064	0.14	25.4
038	0.10	27.5	065	0.04	7.1
039	0.07	44.7	066	0.02	4.0
040	0.41	46.7			

and Astrononion gallowayi abundant. A good example of a mixed fauna is the coexistence of large numbers of Eggerella advena with C. lobatulus and A. gallowayi in the shallow sandy environments to the southeast.

In general calcareous forms are found in large concentrations in surface sediments at depths less than 250 metres (fig. 20). However, Melonis zaandami is abundant out to at least 400 metres as is to a lesser extent Nonionellina labradorica. Data for the range 400-750 metres are scarce but the numbers of arenaceous specimens appear to be reduced to a greater extent than the calcareous ones resulting in relatively high calcareous benthonic percentages in a very sparse and mixed fauna.

The four cores recovered in the area, at stations 024, 027, 050 and 063 were all from regions of low concentrations of Foraminifera in the surface sediments. All four showed a large increase in the percentage of calcareous specimens with depth as a result of the virtual disappearance of arenaceous forms at depths greater than 20 centimetres. The same phenomenon was noted in high latitude studies by McKnight (1962), Pflum (1963), Leslie (1965) and Kennett (1968).

McKnight suggested that either the arenaceous species had not migrated to the area, or that the lysocline, or level of rapid solution increase of $CaCO_3$, had been at a lower level, in the time span represented by all but the top levels of the cores. Leslie concurs with the former suggestion and considers the arenaceous Foraminifera abundant in the Hudson Bay surface sediments were a late arrival in the area. The data from Leslie's, Pflum's and the present study all indicate a very marked reduction in arenaceous fauna in the 5-10 cm levels of cores. From Vilk's 1969 rate of sedimentation in the central Arctic of 4.4 cm/1000 years this would indicate a widespread invasion of arenaceous Foraminifera into Arctic waters in the last 2000 years.

Pflum offers a simpler solution, namely that arenaceous tests are disintegrated by mechanical or chemical means soon after burial and are for the most part completely absent by the time they are buried to a depth of 30 centimetres. A mechanism for the disintegration of these tests may be the effect of annelid worms and other sediment eating organisms reworking the surface and near surface sediments (Shrock and Twenhofen 1953). Annelid worms and worm tubes were found in considerable numbers in over a third of the stations samples. If the organic cement of the test was removed when passing through the digestive tract of these organisms the test would be more likely to disintegrate under the effects of the compaction of the sediment.

In view of the widespread nature of the disappearance of arenaceous tests in cores and the short distance below the surface of the sediments this is observed to occur the writer is inclined to accept Pflum's explanation, with the activities of sediment eating organisms, where present, actively assisting the process. The implication that follows is that an arenaceous/calcareous ratio would have very limited value in a paleoenvironmental sense. Longer cores from the Baffin Bay area might provide further evidence for or against this interpretation.

Planktonic Foraminiferal Distribution

Globigerina pachyderma forms almost the entire planktonic foraminiferal assemblage found. Among some 200 specimens identified there was a single G. bulloides test. The number of planktonic tests in the sediments was very limited. Where present they were found together with the larger concentrations of Cibicides lobatulus and Astrononion gallowayi. Over three quarters of all tests identified were recovered from sediments on top of a basalt dredge haul at station 026. Dredging was conducted upslope in a well defined trench from a depth of 450 metres to 220 metres and although it is considered likely that the sediments were from near the latter depth this is by no means certain.

Where vertical tows were conducted in the same vicinity as bottom sediment sampling it was found that the numbers of living Globigerina in the water column were not reflected in the sediments below. Stehman (in press) found densities of 7085 and 835 planktonic Foraminifera/1000 cubic metres at stations 018 and 024 respectively.

It would appear that either tests were removed from the area by currents before settling or that they were dissolved or destroyed en route to, or at the bottom. Boltovskoy (1965) describes Zenkevich's (1951) experiments where foraminiferal tests with a mean diameter of 0.4 mm were calculated to have a settling velocity of about 2.1 cm/sec., equivalent to a descent of 500 metres in 7 hours. This would indicate that even using maximum surface current values of 7 nautical miles per day (Dunbar 1951) transportation during the settling period would be less than 2 miles in most of the survey area. This would appear to rule out complete removal by currents or dissolution whilst sinking thus leading one to the conclusion that the tests were dissolved or disintegrated at the sediment-water interface.

CHAPTER 6

Environmental Influences on Faunal Trends

Depth

There is a close relationship between bathymetry (fig. 3) and the foraminiferal distribution as shown in the distribution patterns of individual taxa (figs. 7-17), percentages of calcareous Foraminifera (figs. 21 and 22) and the station groupings from the similarity Analysis - Group Average Sorting dendrogram (figs. 19a, b). These correlations are shown in Table 9, which lists the results of statistical comparisons between each pairing of station groups with each environmental parameter in turn, using the non-parametric Mann-Whitney U test. This test indicates whether two independent groups have been drawn from the same population e.g. whether groups B_1 and B_2 have come from the same depth range or, alternatively, whether these two groups are significantly different with respect to depth (or any other parameter) at the 5 % level of probability (Siegel 1956). Table 9 indicates which pairs differ significantly with respect to any of the chosen parameters. It must be emphasized that these tests do not prove a dependency between any station group or assemblage and an environmental parameter, but rather show the relative association with each parameter.

Previous efforts at defining foraminiferal depth zones on the basis of specific groupings have been less than conclusive as many of the dominant species cover several zones. Leslie (1965) found in Hudson Bay three overlapping depth zones with a shallow (26-130 metres) zone dominated by <u>Egge-</u>

rella advena, an intermediate zone (50-175 metres) containing Spiroplectammina biformis and Buccella frigida, and a deep zone (100-230 metres) with Recurvoides turbinatus, Adercotryma glomeratum and Melonis zaandami abundant.

Vilks (1969) showed a depth boundary at approximately 200 metres, with a shallow water arenaceous fauna containing Trochammina nana, Tritaxis atlantica, Saccammina atlantica and Recurvoides turbinatus, and a deeper calcareous fauna with Islandiella teretis, I. norcrossi and Globigerina pachyderma dominant.

In northern Baffin Bay and Lancaster Sound Phleger (1952) noted a depth boundary at about 250 metres with a shallow water calcareous assemblage consisting of Trifarina angulosa, Islandiella norcrossi, Cibicides lobatulus, Elphidiella arctica and Buccella frigida.

Comparing the above zones with the depth ranges of commonly occurring species in the present study it will be seen that Phleger's grouping shows a similar distributional pattern. Leslie's faunal zonation also bears some resemblance although the ranges of species appears to be compressed in the shallower depths of Hudson Bay. Vilks presents a reversed order of depth sequence with arenaceous species occurring in shallower depths than the calcareous fauna. From the above evidence it would seem likely that environmental factors more complex than depth alone affect the distribution of foraminiferal species.

Kennett (1966, 1968) found a depth barrier at approximately 550 metres, dividing predominantly calcareous assemblages above from arenaceous ones below. He suggested that this zonation might result from the raising of the lysocline, or level of rapid solution increase, from its normally accepted level of about 4000 metres to 550 metres. Kennett attributed this elevation

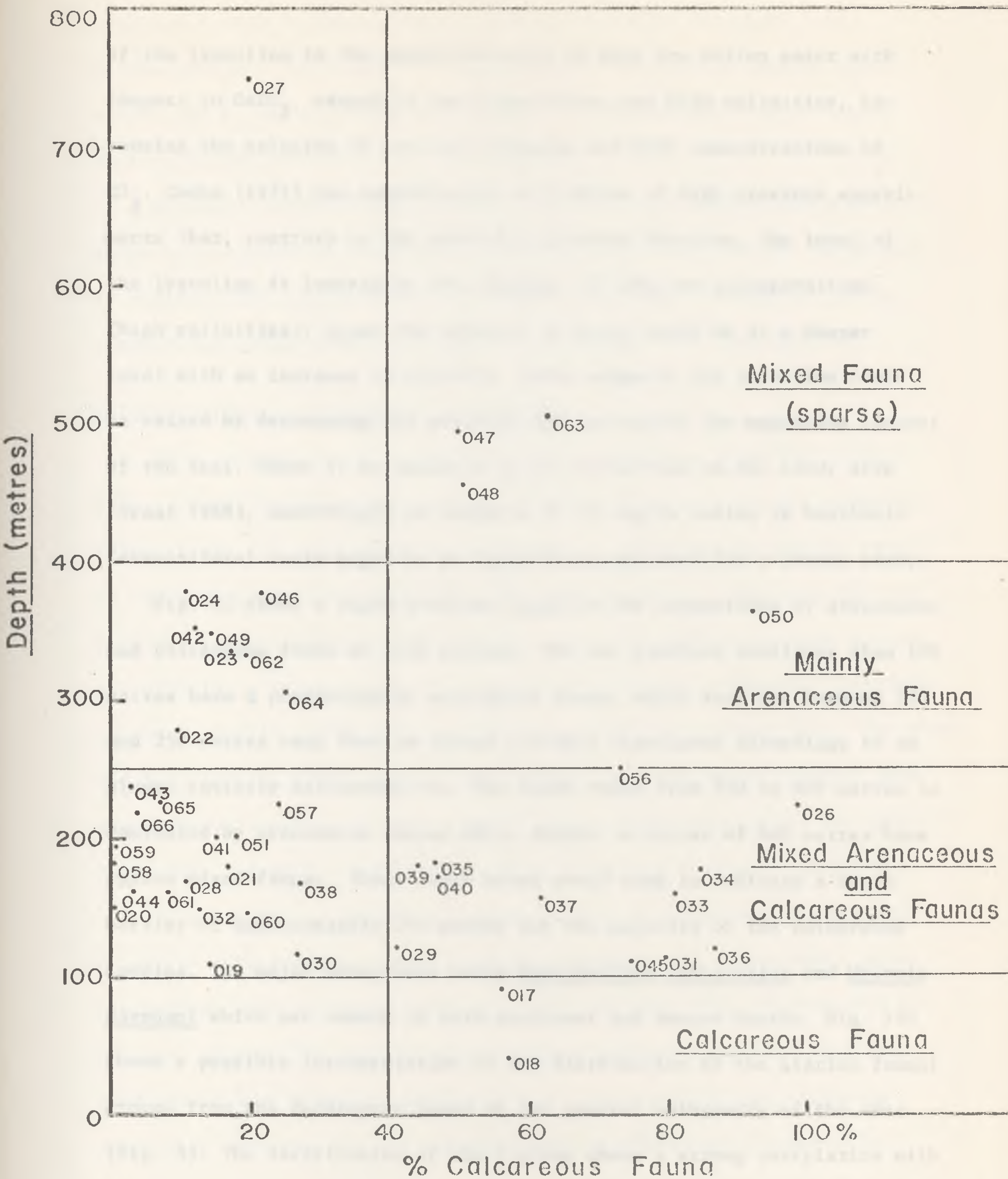

Fig. 22 Depth v % calcareous benthonic specimens

of the lysocline to the undersaturation of Ross Sea Bottom water with respect to $CaCO_3$, caused by low temperatures and high salinities, favouring the solution of calcium carbonate and high concentrations of CO_2. Cooke (1971) has demonstrated in a series of high pressure experiments that, contrary to the generally accepted theories, the level of the lysocline is lowered by the presence of high ion concentrations (high salinities); hence the solution of $CaCO_3$ would be at a deeper level with an increase in salinity. Cooke suggests the lysocline could be raised by decreasing the salinity and increasing the magnesium content of the test. There is no evidence of low salinities in the study area (Grant 1968), accordingly an analysis of the Mg/Ca ratios in benthonic foraminiferal tests might be an interesting approach for a future study.

Fig. 22 shows a depth zonation based on the proportions of arenaceous and calcareous fauna at each station. The two stations shallower than 100 metres have a predominantly calcareous fauna, while stations between 100 and 250 metres vary from an almost entirely arenaceous assemblage to an almost entirely calcareous one. The depth range from 250 to 400 metres is dominated by arenaceous faunas while depths in excess of 400 metres have sparse mixed faunas. These depth zones would seem to indicate a depth barrier of approximately 250 metres for the majority of the calcareous species. The major exceptions being Nonionellina labradorica and Melonis zaandami which are common in both shallower and deeper depths. Fig. 19b shows a possible interpretation of the distribution of the station faunal groups from the dendrogram based on the general bathymetry of the area (fig. 3). The distribution of the C group shows a strong correlation with the deeper waters to the westward, and in the transverse trough and marginal channel. In the southern sector the B_2, A_1 and A_2 groups show a grouping consistent with increasing depth, and distance from the shore line. In the northern region the B_1 group occupies the shallow inshore area while the A_1 and A_2 groups are found in a transitional zone of intermediate depths between the B_1 and C groups.

Although the foraminiferal distribution in the present study can be shown to be closely related to the bathymetry it also follows the pattern of sediment and calcium carbonate distribution, thus leading to the inference that these three environmental parameters are interrelated.

Calcium Carbonate Content of the Sediments

There appears to be a good correlation between a relatively high $CaCO_3$ content in the sediments, and the more calcareous faunal assemblages (figs. 6 and 21). This would suggest that the relationship was the result of two measurements of essentially the same parameter. That test material provided the bulk of the carbonate content of the sediments would be consistent with a general lack of terrestrial carbonate sedimentary particles observed. Leslie (1965) came to this conclusion and proposed that 'the Foraminifera are the major cause of the higher carbonate content rather than occurring as a result of it'. Kennett (1968) found essentially the same relationship but with a contribution from calcareous benthonic macrofauna.

In an effort to measure the contribution of calcareous Foraminifera to the calcium carbonate content of the sediments all recognizable calcareous forms were extracted from splits of sediments from stations 017 and 034 and weighed. The results showed that calcareous benthonic Foraminifera constituted approximately 2.6 % and 10.9 % by weight of the carbonate content of stations 017 and 018 respectively. Shells and fragments of molluscs, brachiopods and bryozoans were found in several of the sediment samples and would account for a further proportion of the carbonate material. The irregular distribution of these shell fragments, in the limited number of samples studied, makes a quantitative assessment of their contribution to the overall carbonate total impractical.

An additional source of carbonate material may well be fragments of foraminiferal tests and other calcareous material disintegrated to silt size and smaller. Annelid worms were recovered in considerable numbers in over one third of the stations sampled. Shrock and Twenhofen (1953) suggest that marine sediments in areas of reasonably slow rates of deposition pass through the digestive tracts of annelids present and are modified both physically and chemically in the process. In a microscopic examination of terrigenous particles, in the presence of dilute hydrochloric acid, no carbonate material was detected in sediments from stations 017 and 034. This would appear to confirm the view that the majority of the carbonate content of the sediments was of an organic origin.

Grant (1965) in a study of recent sediments from Northern Baffin Bay found carbonate values ranging from 2 to 18 percent. As foraminiferal tests were virtually absent from all samples he attributed the higher carbonate values in the west of his area to carbonate rock-types found in the northern extremities of the Bay, together with southward movement of Arctic water through the western section of the study area. By comparison, the geological survey maps of the southwest Greenland coast south of Disko Island reveal no source of carbonate rock types for the provision of detrital material for transportation and deposition in the northward flowing West Greenland current.

In statistical comparisons between pairs of station groups with respect to both the calcium carbonate content of the sediments and the percentages of calcareous fauna, significant differences were found to exist between the A-B, B-C and A_1-A_2 groups (Table 9). As mentioned previously the former parameter is probably related to the latter. While the division between A and B, and B and C station groups on the basis of their percentages of calcareous benthos is obvious from an inspection of the raw data the distinction between the A_1 and A_2 groupings is not. "Indicator' species, from the information statistic tests, which are present in most of the A_2 stations and absent in most of the A_1 group are Cibicides lobatulus, Melonis zaandami and Nonionellina labradorica. The former is abundant in the inshore shallow regions while the two latter species are deeper water forms. The presence of these species provides a more mixed fauna, and hence a slightly higher calcareous percentage, in the A_2 samples compared with the more arenaceous A_1 station assemblages.

The very low inorganic carbonate content of the sediments in southeast Baffin Bay may have an effect on Foraminiferal distribution that is peculiar to the area. With carbonate values of up to 50 percent, Kennett (1968) found a relatively abundant calcareous fauna extending to a depth of 550 metres in the Ross Sea. With similar high carbonate percentages Leslie (1965) had higher overall abundances of benthonic Foraminifera in the shallower Hudson Bay region.

Sediment Distribution

Sediments were divided into their sand, silt and clay contents (Appendix 1) and plotted (fig. 4 and 5) to give an outline of sedimentary trends. The distribution of the various sediment facies followed a well defined pattern with medium grained quartz sands adjacent to the coastal pre-Cambrian granites and gneisses, and grading into silty sands further offshore. The deeper waters to the west of the area, the channel cutting across the shelf and the inshore marginal trough are outlined by the finer clayey silts and clayey sandy silts. The shallow waters to the south of Disko Island contain silty clayey sands consistent with their distance from the source material to the southwest. Particles greater than 2 mm were not considered in this study because of the random nature of the recovery of this type of material in grab and core samples and because ice rafted material was not considered to affect the distribution of foraminiferal benthos.

Cooper (1964) found three major faunal groups in the Chukchi Sea region associated with medium sands, fine sands and silts. However, this grouping was based on the relative abundances of the three dominant species, *Eggerella advena*, *Buccella frigida* and *Elphidium clavatum* which occurred in all three groups. She also reported that a diverse calcareous assemblage was found in the coarser sediments and an arenaceous assemblage, with few species, in the finer sediments.

The apparent close correlation between the distribution of sediment types and the faunal assemblages associated with station grouping was confirmed by a further series of Mann-Whitney U tests. These tests showed significant differences between the A v C, B v C, B_1 v B_2 station groups with respect to their sand, silt and clay contents (Table 9).

TABLE 9

Significant statistical differences at the 0.05 level between pairs of station groups with respect to environmental parameters using the Mann-Whitney U - test.
(Significant differences marked with an x).

Station Pairing	Environmental Parameter					
				Sediments		
	Depth	% $CaCO_3$ in Seds.	% calc. fauna	Sand	Silt	Clay
A v B	x	x	x			
A v C	x			x	x	x
B v C	x	x	x	x	x	x
A_1 v A_2		x	x			
B_1 v B_2	x			x	x	x

CHAPTER 7

Summary and Conclusions

From the study of the distributional trends of Foraminifera in an Arctic, open water environment the following summary may be made: -

1. The benthonic foraminiferal fauna in the surface sediments of south-east Baffin Bay can be subdivided into three distinct and contrasting groups: -

   a) a calcareous fauna dominated by a diverse and abundant assemblage. 'Indicator' species for this group are *Cibicides lobatulus* and *Astrononion gallowayi*.

   b) An arenaceous fauna with *Adercotryma glomeratum*, *Textularia torquata*, *Trochammina nana* and *Spiroplectammina biformis* dominant.

   c) A very sparse mixed fauna with more calcareous than arenaceous specimens and *Melonis zaandami* a common species.

The above groupings were apparent from the raw data and confirmed by groupings from the similarity analysis. Both a) and b) can be further subdivided.

2. Faunal assemblages from the station groups selected from the Similarity Analysis - Group Average Sorting dendrogram, A_1, A_2, B_1, B_2 and C were all found to be significantly different with respect to some of the measured environmental parameters (Table 9). They could be recognized in most cases by their 'indicator' species thereby confirming the selection of the respective groups.

3. In core samples arenaceous Foraminifera are virtually non existent after the initial 5 to 10 centimetres. *Nonionellina labradorica* and

to a lesser extent *Globulimina auriculata* are the dominant species found in deep water cores.

4. *Adercotryma glomeratum* is the dominant species throughout the area and the only species found in all samples.
5. Planktonic Foraminifera are relatively rare in the surface sediments despite being present in most vertical tows in the water column throughout the area. Planktonic tests are associated with calcareous benthonic faunas.
6. *Globigerina pachyderma* is the only planktonic species found in significant numbers in the sediments. Both *G. pachyderma* and *G. bulloides* are found in the water column.
7. The limited number of pH readings obtained from the surface sediments showed very little variation and no apparent effect on foraminiferal distribution.
8. Both the bathymetry and the distribution of sediments were shown by statistical comparisons to be closely associated with faunal distribution. These two parameters were in turn closely connected, and the sediment distribution was further related to the distance from terrestrial source material, and the prevailing currents.
9. Depth zonations of fauna were shown to be: 40-250 metres for the calcareous or group B fauna; 150-400 metres for arenaceous or A faunas; 300-750 metres for the mixed or C faunas.
10. Substrate associations observed were: Clayey silty sands with B_1 faunas; sands with the B_2 group; silty sands for A_1 and A_2 assemblages; silts and clayey silts with the deep water C station group.
11. The other environmental parameter considered, the calcium carbonate content of the sediments was closely associated with the calcareous content of the total foraminiferal assemblage.

In conclusion, it would appear that because of the virtual disappearance of arenaceous fauna from the sediment record any estimation of paleoenvironments from the combination of faunal assemblages and sediment types must be based on the calcareous Foraminifera preserved in the sediments. Depths of 0 to 250 metres might be inferred from a fauna dominated by Cibicides lobatulus and Astrononion gallowayi with smaller numbers of Miliolidae and the genera Islandiella, Buccella, Elphidium, Oolina, Lagena and Fissurina. In depths greater than 250 metres Melonis zaandami, Nonionellina labradorica and Globobulimina auriculata would likely predominate. In depths in excess of 400 metres sparse faunas could be expected. These criteria could possibly be applied to other areas of the West Greenland continental shelf to the south. Extrapolation into other regions with greater abundances of terrestrial sedimentary carbonate material would be suspect.

The information provided by the inspection and comparison of sets of raw data, and the information from the grouping of like stations, based on their similar faunal assemblages, by the Similarity Analysis - Group Average Sorting programmes appear to give essentially the same results. In some cases faunal groups from the cluster analysis were not obvious in the original data. Closer inspection using 'indicator' species from the Information Statistic tests confirmed their presence.

The size of this study would appear to be about the optimum for the extraction of distribution trends manually. For studies using larger quantities of data similarity analyses have an obvious value in the maximum extraction of information.

Statistical comparisons between faunal trends and external parameters give quantitative results useful for comparisons with other similar studies.

CHAPTER 8

Systematic Descriptions

All species dealt with in the previous chapters are covered in systematic order in this section. Species have been identified from the existing literature on Recent Foraminifera and checked against type material in the Cushman Collection at the Smithsonian Institute, Washington D.C. Supra-generic classification is in accordance with Loeblich and Tappan's (1961) reclassification of the Rhizpodea, and as shown in their Treatise on Invertebrate Paleontology Part C - Protista - Sarcodina (1964).

Synonym lists have been compiled only from illustrated references sighted (Hilterman 1956), with the exception of a few initial descriptions not available to the writer. A complete list of references is given pp 124-134. All species mentioned have been illustrated using the Cambridge Stereoscan 600 Scanning Electron Microscope. All reference material used for this study has been deposited with the Department of Geology, Dalhousie University.

All tests are free, or unattached, with the probable exception of *Cibicides lobatulus*.

List of Species

Family SACCAMMINIDAE Brady, 1884

Subfamily SACCAMMININAE Brady, 1884

Genus SACCAMMINA Sars in Carpenter, 1860

SACCAMMINA ATLANTICA (Cushman)

Proteonina atlantica Cushman, 1944, p. 5, pl. 1, fig. 4.
Parker, 1952a, p. 393, pl. 1, fig. 2.
1952b, p. 454, pl. 1, figs. 1,2.
Phleger, 1952, p. 85, pl. 13, fig. 1.
Parker, Phleger and Peirson, 1953, p. 11, pl. 1, fig. 4.
Cooper, 1964, p. 92, pl. 5, fig. 1.

Saccammina atlantica (Cushman)
Todd and Bronniman, 1957, p. 22, pl. 1, fig. 14.
Leslie, 1965, p. 170, pl. 1, figs. 1,2.
Vilks, 1962, p. 43, pl. 1, fig. 13.
Gregory, 1971, p. 162, pl. 1, fig. 4.

Plate I fig I

Test large, consisting of a single oval or flask shaped chamber; no distinct neck, but with a gradual tapering toward the apertural end. The test formed of coarse interlocking angular quartz grains firmly cemented; aperture small at the tapering end of the test.

Widely distributed at the majority of stations in depths between 40 and 380 metres; frequencies up to 16 % of total specimens.

Family AMMODISCIDAE Reuss, 1862

Subfamily AMMODISCINAE Reuss, 1862

Genus AMMODISCUS Reuss, 1862

AMMODISCUS sp.

Test small, planospiral; sutures between whorls distinct, proloculum central and subspherical; wall finely arenaceous; some specimens yellowish brown, others white. Similar to Hoglund's (1947) A. planus, but insufficient detail to identify species.

Very limited distribution; found at stations 036, 038 and 061 in silty sand substrates in depths of 120 to 160 metres.

Family HORMOSINIDAE Haeckel, 1894

Subfamily HORMOSININAE Haeckel, 1894

Genus REOPHAX Montfort, 1808

REOPHAX ARCTICA (Brady)

Reophax arctica Brady; 1881, p. 405, pl. 21, figs. 2a, b.
Bigenerina arctica (Brady)
Cushman, 1948, p. 31, pl. 3, fig. 9.
Leslie, 1965, p. 156, pl. 1, figs. 8,9.
Vilks, 1968, p. 18, pl. 1, figs. 8, 9a,b.

Reophax arctica (Brady)
Parker, 1952a, p. 395, pl. 1, figs. 6,7.
Phleger, 1952, p. 85, pl. 13, fig. 3.
Loeblich and Tappan, 1953, p. 21, pl. 1, figs. 19,20.
Cooper, 1964, p. 92, pl. 5, fig. 3.
Gregory, 1971, p. 168, pl. 2, fig. 3.

Plate I fig. 2

Test small, compressed, elongate and tapering at the base; several chambers, all uniserially arranged, final chamber rounded; sutures distinct and slightly compressed; walls consist of fine quartz grains with a few mica plates; white in colour; aperture terminal.

Distribution limited, found in sandy substrates in depths less than 170 metres.

REOPHAX CURTUS (Cushman)

Reophax curtus Cushman, 1920, p. 8, pl. 2, figs. 2,3.
Cushman and McCulloch, 1939, p. 58, pl. 2, fig. 12.
Cushman, 1944, p. 10, pl. 1, figs. 15,16.

Reophax subfusiformis Earland, 1933, p. 74, pl. 2, figs. 16-19.
Hoglund, 1947, p. 82, pl. 9, figs. 1-24 (not 3), pl. 26, figs. 1-36, pl. 27, figs. 1-19, text-figs. 43-50.

Reophax curtus (Cushman)
Cushman, 1948, p. 24, pl. 2, figs. 13, 14.
Parker, 1952a, p. 395, pl. 1, figs. 11-19.
Parker, 1952b, p. 456, pl. 1, fig. 18.
Phleger, 1952, p. 85, pl. 13, fig. 2.
Loeblich and Tappan, 1953, p. 22, pl. 2, figs. 1-4.
Gregory, 1971, p. 169, pl. 2, figs. 4,5.

Plate I figs 3, 4

Test large, usually consisting of three or four chambers increasing rapidly in size as added with the last formed chamber making up the bulk of the test; most specimens strongly arcuate, final chamber tapers to form an apertural neck; walls composed of coarse angular quartz grains with many inclusions of darker mineral grains; aperture rounded, terminal.

Limited distribution, found at stations 019, 020, 028, 029, 031, 043 and 045 in sandy substrates in depths less than 240 metres; always less than 1.5 % of foraminiferal fauna.

REOPHAX SCORPIURUS (Montfort)

Reophax scorpiurus Montfort, 1808, p. 330.
Goes (part) 1894, p. 24, pl. 5, figs. 158, 159; pl. 6, figs. 168, 169 (not 160-167, 170, 171).
Cushman, 1910, p. 83, figs. 114-116.
Cushman, 1920, p. 6, pl. 1, figs. 5-7.
Cushman, 1944, p. 10, pl. 1, fig. 19.

Reophax scorpiurus (Montfort)
Hoglund, 1947, p. 81, pl. 9, figs. 9, 10; pl. 26, figs. 52-55, text-figs. 51, 52.

Reophax sp. cf. R. scorpiurus (Montfort)
Phleger, 1952, p. 86, pl. 13, fig. 5.

Reophax scorpiurus (Montfort)
Loeblich and Tappan, 1953, p. 24, pl. 2, figs. 7-10.
Leslie, 1965, p. 169, pl. 1, figs. 6,7.

Plate I fig.5

Test medium to large, elongate, nearly straight; chambers increase rapidly in length as added but less noticeably in breadth; test wall composed of clear quartz grains with several inclusions of darker mineral grains; aperture rounded and terminal at the end of a distinct neck. Very similar to Reophax curtus but in general straighter and more slender.

Very limited distribution; found in sandy bottoms in depths less than 250 metres; less than 1 % at stations 021, 032 and 043.

Family RZEHAKINIDAE Cushman, 1933

Genus SILICOSIGMOILINA Cushman and Church 1929

SILICOSIGMOILINA GROENLANDICA (Cushman)

Quinqueloculina fusca Brady var. groenlandica
Cushman, 1933, p. 2, pl. 1, fig. 4.

Quinqueloculina groenlandica (Cushman)
Cushman, 1948, p. 34, pl. 3, fig. 18.

Silicosigmoilina groenlandica (Cushman)
Loeblich and Tappan, 1953, p. 38, pl. 4, figs. 7-9.
Feyling-Hanssen, 1964, p. 224, pl. 1, figs. 17-19.
Leslie, 1965, p. 171, pl. 2, figs. 8a-c.

Plate I fig. 6

Test oblong; chambers elongate; rounded base narrowing towards the terminal aperture; walls finely arenaceous with a smooth surface.

Rare in distribution, found in sandy substrakes in depths between 100 and 200 metres at stations 029 and 041.

Family LITUOLIDAE Lamark, 1809

Subfamily HAPLOPHRAGMOIDINAE Maync, 1952

Genus ADERCOTRYMA Loeblich and Tappan, 1952

ADERCOTRYMA GLOMERATUM (Brady)

Lituola glomerata Brady, 1878, p. 433, pl. 20, figs. 1a-c.

Haplophragmium glomeratum (Brady)
Brady, 1884, p. 309, pl. 34, figs. 15-18.

Goes, 1894, p. 23, pl. 5, figs. 134-139.

<u>Haplophragmoides</u> <u>glomeratum</u> (Brady)
Cushman, 1910, p. 104, figs. 158-161.
Cushman, 1920, p. 47, pl. 9, fig. 6.
Hoglund, 1947, p. 135, pl. 10, figs. 3,4.
Cushman, 1948, p. 28, pl. 2, fig. 16.
Phleger, 1952, p. 85, pl. 13, fig. 10.

<u>Adercotryma</u> <u>glomeratum</u> (Brady)
Loeblich and Tappan, 1952, p. 141, figs. 1-4.
Loeblich and Tappan, 1953, p. 26, pl. 8, figs. 1-4.
McKnight, 1963, p. 44, pl. 1, fig. 15.
Feyling-Hanssen, 1964, p. 226, pl. 2, figs. 3,4.
Leslie, 1965, p. 155, pl. 10, figs. 8a-c.
Vilks, 1969, p. 44, pl. 1, fig. 15.
Gregory, 1971, p. 173, pl. 2, figs. 9,10.

Plate I fig .7

Test small, planospiral, subglobular, composed of two coils with 3 or 4 chambers making up the last formed coil, periphery broadly rounded; wall coarsely arenaceous; aperture a short slit at the base of the apertural face, often obscured by sand grains; colour commonly a ferruginous brown.

Very wide spread distribution, found at all stations sampled making up from 1 to 70 % of the total population.

Genus CRIBROSTOMOIDES Cushman, 1910

CRIBROSTOMOIDES CRASSIMARGO (Norman)

<u>Haplophragmium</u> <u>caneriense</u> (d'Orbigny)
Brady (part) 1884, p. 310, pl. 35, fig. 4.
Goes (part) 1894, p. 20, pl. 5, figs. 92-96.

<u>Haplophragmium</u> <u>crassimargo</u> Norman, 1892, p. 17.
Heron-Allen and Earland, 1910, p. 424, figs. 3,4.

<u>Labrospira</u> <u>crassimargo</u> (Norman)
Hoglund, 1947, p. 141, p. 11, fig. 1, text-figs. 121-125.
Parker, 1952a, p. 400, pl. 2, figs. 16a,b.
Parker, 1952b, p. 451, pl. 1, fig. 22.
Phleger, 1952, p. 85, pl. 13, figs. 11,16.

<u>Alveolophragmium</u> <u>crassimargo</u> (Norman)
Loeblich and Tappan, 1953, p. 29, pl. 3, figs. 1-3.
Feyling-Hanssen, 1964, p. 228, pl. 2, figs. 5-8.

Cribrostomoides crassimargo (Norman)
Leslie, 1965, p. 158, pl. 2, figs. 2a,b.
Vilks, 1969, p. 44, pl. 1, figs. 16a, b.
Gregory, 1971, p. 175, pl. 3, figs. 1, 2.

Plate I fig. 8

Test large, robust, planispiral, biumbilicate, partially involute, periphery rounded; chambers simple with 7 to 10 in the last whorl; wall thick, coarsely arenaceous made up of large quartz grains firmly cemented; aperture interio-areal forming a curved slit at the chamber face, sutures straight and slightly depressed.

Widely distributed in depths from 90-500 metres, favouring sandy substrates. Found in abundance in Arctic waters by Goes (1894) and Loeblich and Tappan (1953).

CRIBROSTOMOIDES JEFFREYSI (Williamson)

Nonionina jeffreysi Williamson, 1858, p. 34, pl. 3, figs. 72, 73.
Labrospira jeffreysi (Williamson)
Hoglund, 1947, p. 146, pl. 11, fig. 3, text-figs. 128, 129.
Parker, 1952a, p. 401, pl. 2, figs. 15, 17-20.
Phleger, 1952, p. 85, pl. 13, figs. 14,15.

Alveolophragmium jeffreysi (Williamson)
Loeblich and Tappan, 1953, p. 31, pl. 3, figs. 4-7.

Cribrostomoides jeffreysi (Williamson)
Leslie, 1965, p. 158, pl. 2, figs. 3a-c.
Vilks, 1969, p. 45, pl. 1, figs. 17a, b.

Plate I figs 9,10

Test planospiral, much compressed, incompletely involute, biumbilicate, umbilicus large and excavated, margin lobulated, periphery rounded; sutures distinct and depressed; walls arenaceous with smooth glassy finish; aperture interio areal; colour yellow or red-brown with final chambers lighter in colour tending to white.

Wide ranging, found at depths from 90-750 metres in concentrations up to 13 % of total population.

Genus RECURVOIDES Earland, 1934

RECURVOIDES TURBINATUS (Brady)

Haplophragmium turbinatum Brady, 1881, p. 50.
Brady, 1884, p. 312, pl. 35, figs. 9a-c.

Trochammina turbinata (Brady)
Cushman, 1920, p. 81, pl. 17, fig. 2.
Cushman, 1948, p. 43, pl. 5, figs. 2a, b.

Recurvoides turbinatus (Brady)
Parker, 1952a, p. 402, pl. 2, figs. 23, 24.
Phleger, 1952, p. 85, pl. 13, figs. 12, 13.
Loeblich and Tappan, 1953, p. 27, pl. 2, fig. 11.
Leslie, 1965, p. 169, pl. 2, figs. 1a-c.
Vilks, 1969, p. 45, pl. 1, figs. 19a, b.
Gregory, 1971, p. 176, pl. 3, figs. 3,4.

Plate I fig. II

Test streptospiral, early portion regular, later part coiled in a different plane; 5 to 8 chambers in the final whorl; umbilicate below; sutures depressed; wall arenaceous, smoothly finished; aperture a narrow elongate slit at the base of the ventral side of the chamber; colour yellow to reddish-brown.

Distributed over a depth range of 90-350 metres. Frequently occurring, but in concentrations no greater than 3.5 %. Cushman (1948) found this species rare in Arctic waters, while Phleger (1952), Loeblich and Tappan (1953) and Vilks (1969) found it a common high latitude species.

Subfamily LITUOLIDAE de Blainville, 1825

Genus AMMOTIUM Loeblich and Tappan, 1953

AMMOTIUM CASSIS (Parker)

Lituola cassis Parker in Dawson, 1870, pp. 177, 180, fig. 3
Haplophragmium cassis (Parker)
Brady, 1884, p. 304, pl. 33, figs. 17-19.

Ammobaculites cassis (Parker)
Cushman, 1920, p. 63, pl. 12, fig. 5.
Cushman and McCulloch, 1939, p. 83, pl. 7, figs. 7, 8.
Cushman, 1944, p. 12, pl. 1, figs. 23-25.
Cushman, 1948, p. 29, pl. 3, figs. 4-6.
Parker, 1952a, p. 398, pl. 2, figs. 8-10.
Phleger, 1952, p. 83, pl. 13, figs. 20, 21.

Ammotium cassis (Parker)
Loeblich and Tappan, 1953, p. 33, pl. 2, figs. 12-18.
Cooper, 1964, p. 92, pl. 5, fig. 2.
Leslie, 1965, p. 155, pl. 1, figs. 14a, b.
Gregory, 1971, p. 176, pl. 3, fig. 5.

Plate I fig. I2

Test planispiral, compressed, early portions coiled, later chambers uncoiled and flattened, periphery rounded; sutures depressed, walls medium to coarse grained with progressively larger quartz grains incorporated in later chambers; aperture terminal at the peripheral end of the chamber.

Rare in the study area. Found only at station 043 in 240 metres.

Family TEXTULARIIDAE Ehrenberg, 1838

Subfamily SPIROPLECTAMMININAE Cushman, 1927

Genus SPIROPLECTAMMINA Cushman, 1927

SPIROPLECTAMMINA BIFORMIS (Parker and Jones)

Textularia agglutinans d'Orbigny var. biformis
Parker and Jones, 1865, p. 370, pl. 15, figs. 23, 24.

Spiroplecta biformis (Parker and Jones)
Brady, 1884, p. 376, pl. 45, figs. 25-27.
Goes, 1894, p. 38, pl. 7, figs. 308-312.

Spiroplectammina biformis (Parker and Jones)
Cushman, 1927, p. 23, pl. 5, fig. 1.
Lacroix, 1932, p. 5, fig. 1.
Heron-Allen and Earland, 1932, p. 347, pl. 8, figs. 27-31.
Cushman, 1944, p. 13, pl. 2, figs. 4, 5.
Cushman, 1948, p. 30, pl. 3, figs. 7, 8.

Hoglund, 1947, p. 163, pl. 12, fig. 1, text-figs. 140, 141.
Parker, 1952a, p. 402, pl. 3, figs. 1, 2.
Phleger, 1952, p. 86, pl. 13, figs. 29, 30.
Loeblich and Tappan, 1953, p. 34, pl. 4, figs. 1-6.
Cooper, 1964, p. 92, pl. 5, fig. 4.
Leslie, 1965, p. 171, pl. 2, figs. 5-7.
Vilks, 1969, p. 45, pl. 1, figs. 20a, b.
Gregory, 1971, p. 178, pl. 3, fig. 6.

Plate I fig. I3

Test small, elongate, initial end rounded, sides nearly parallel; early portion planispiral, later chambers biserial; sutures depressed; walls arenaceous with a somewhat smooth finish; aperture at the base of inner margin of the last formed chamber.

Widely distributed over depths from 90-380 metres, generally in concentrations less than 10 %. One exception being station 059 where the species is 25 % of the faunal population. Reported common in the Davis Strait area by Parker and Jones (1865).

Subfamily TEXTULARIINAE Ehrenberg 1838

Genus TEXTULARIA Defrance in de Blainville, 1824

TEXTULARIA EARLANDI (Parker)

Textularia tenuiissima Earland, 1933, p. 95, pl. 3, figs. 21-30.
Hoglund, 1947, p. 176, pl. 13, fig. 1a, b, text-figs. 154, 155.

Textularia earlandi, Parker, 1952b, p. 458, (footnote), pl. 2, fig. 1.
Phleger, 1952, p. 86, pl. 13, figs. 22, 23.
Feyling-Hanssen, 1964, p. 238, pl. 3, figs. 9, 10.
Vilks, 1969, p. 45, pl. 1, fig. 21.

Plate I fig. I

Test small, elongate, straight, slowly tapering towards the bluntly pointed initial end, apertural end rounded, lobulate, apical end with a very small spiral, with the rest of the test biserially arranged; wall arenaceous, consisting of small quartz grains; aperture a slit at the inner margin of the last chamber.

Distributed over a range of depths 150-348 metres with a preference for sandy substrates. Found only in low concentrations and in association with Textularia torquata.

TEXTULARIA TORQUATA (Parker)

Bigenerina arctica Cushman (in part) 1948, p. 31, pl. 3, fig. 10 (not figs. 9, 11).

Textularia torquata Parker, 1952a, p. 403, pl. 3, figs. 9-11.
Phleger, 1952, p. 86, pl. 13, figs. 18, 19.
Loeblich and Tappan, 1953, p. 35, pl. 2, figs. 19-21.
Cooper, 1964, p. 94, pl. 5, fig. 9.
Vilks, 1969, p. 45, pl. 1, fig. 22.
Gregory, 1971, p. 178, pl. 4, figs. 1, 2.

Plate 2 fig. 2

Test small, compressed and flattened with the initial portion frequently twisted; biserial arrangement of chambers; sutures depressed, straight and oblique; walls arenaceous with larger quartz grains utilized for later chambers; aperture a narrow slit in the apertural face.

Wide distributed within a depth range of 90-504 metres and consisting of up to 30 % of total specimens at some stations.

Family TROCHAMMINININIDAE Schwager, 1877

Subfamily TROCHAMMININAE Schwager, 1877

Genus TRITAXIS Schubert, 1921

TRITAXIS ATLANTICA (Parker)

Trochamminella atlantica Parker, 1952a, p. 409, pl. 4, figs. 17-19.
Phleger, 1952, p. 87, pl. 14, figs. 2,4.
Loeblich and Tappan, 1953, p. 52, pl. 7, figs. 6, 7.
Leslie, 1965, p. 172, pl. 4, figs. 4a-c.
Vilks, 1969, p. 45, pl. 2, figs. 1a, b.

Tritaxis atlantica
Loeblich and Tappan, 1955, p. 19.

Plate 2 fig. 3

Test small with a trochoid spire, ventrally umbilicate, periphery rounded and slightly lobulate; chambers increase in size as added, 5-6 in last whorl; sutures depressed, slightly curved; wall thin, composed of medium sized sand grains; aperture a slit near the inner margin of the chamber, with a distinct lip.

Found at 27 stations with frequencies less than 5 % except at station 027 where a high frequency is observed in a low faunal count, exists in a depth range of 90-750 metres.

Genus TROCHAMMINA Parker and Jones, 1859

TROCHAMMINA INFLATA (Montagu)

Nautilus inflatus Montagu, 1808, p. 81, pl. 18, fig. 3.

Trochammina inflata (Montagu)
Brady, 1884, p. 338, pl. 14, figs. 4a-c.
Phleger and Walton, 1950, p. 280, pl. 2, figs. 1-3.
Parker, 1952a, p. 407, pl. 4, figs. 6, 10.
Parker, 1952b, p. 459, pl. 3, figs. 1a, b.
Phleger, 1952, p. 86, pl. 13, figs. 27, 28.
Walton, 1955, p. 1016, pl. 100, figs. 27-29.
Todd and Low, 1961, p. 15, pl. 1, figs. 22, 23.
Buzas, 1965b, p. 57, pl. 1, figs. 27-29.
Albani, 1968, p. 96, pl. 7, figs. 3-5.
Gregory, 1971, p. 180, pl. 4, figs. 3, 4.

Plate 2 figs 4,5

Test trochoid, low spired, last whorl consisting of 5 or 6 chambers, umbilicate, chambers inflated; sutures distinct and perpendicular to the periphery; thin arenaceous wall composed of fine sand grains with an excess of cement giving a smooth, shiny surface; aperture a small slit at the base of the chamber.

Found at 12 stations in depths from 170-504 metres in concentrations up to 20 %. Shows a preference for sandy silts and silty sands.

TROCHAMMINA NANA (Brady)

Haplophragmium nana Brady, 1881, p. 50.
Brady, 1884, p. 311, pl. 35, figs. 6-8.

Trochammina nana (Brady)
Cushman, 1920, p. 80, pl. 17, fig. 1.
Cushman, 1948, p. 42, pl. 5, fig. 1.
Phleger, 1952, p. 86, pl. 13, figs. 31, 32.
Loeblich and Tappan, 1953, p. 50, pl. 8, fig. 5.
Leslie, 1965, p. 172, pl. 4, fig. 6.

Plate 2 fig. 6

Test small, trochoid, biconvex, ventrically umbonate, lobulate; sutures distinct and depressed; wall arenaceous, consisting of medium sized quartz grains, and showing a smooth finish; aperture elongate at the base of the chamber near the umbilicus.

Found at 34 stations in depths from 90-504 metres, up to 28 % of fauna where present. Phleger (1952) found T. nana common in Northern Baffin Bay with concentrations up to 50 %.

TROCHAMINA ROTALIFORMIS (Wright)

Trochammina inflata var.
Balkwill and Wright, 1885, p. 331, pl. 13, figs. 11, 12.

Trochammina rotaliformis Wright, 1911, in Heron-Allen and Earland, p. 309.
Cushman, 1920, p. 77, pl. 16, figs. 1, 2.

Trochammina cf. rotaliformis (Wright)
Hoglund, 1947, p. 198, pl. 17, figs. 1,2, text-figs. 180, 181.

Trochammina rotaliformis (Wright)
Cushman, 1948, p. 42, pl. 4, figs. 16a-c.
Loeblich and Tappan, 1953, p. 51, pl. 8, figs. 6-9.
Cooper, 1964, p. 94, pl. 5, figs. 11, 12.
Leslie, 1965, p. 172, pl. 4, figs. 8a-c.

Plate 2 figs 7,8

Test small, trochoid, low dorsal spire; chambers distinct with the last one inflated to occupy one third the area of the test; sutures depressed and distinct; wall arenaceous with fine to medium sand grains and a smooth finish; aperture elongate at the base of the chamber in the umbilicate region.

Less than 2 % of the fauna where present. Found at 13 stations in depths from 90-351 metres.

Family ATAXOPHRAGMIIDAE Schwager, 1887

Subfamily GLOBOTEXTULARIINAE Cushman, 1927

Genus EGGERELLA Cushman, 1933

EGGERELLA ADVENA (Cushman)

Verneuilina advena Cushman, 1922, p. 141.

Eggerella advena (Cushman)
Cushman, 1937, p. 51, pl. 5, figs. 12-15.
Cushman, 1944, p. 13, pl. 2, figs. 6, 7.

Eggerella arctica Hoglund, 1947, p. 193, pl. 16, fig. 4.

Eggerella advena (Cushman)
Cushman, 1948, p. 32, pl. 3, fig. 12.
Parker, 1952a, p. 404, pl. 3, figs. 12, 13.
Parker, 1952b, p. 447, pl. 2, fig. 3.
Phleger, 1952, p. 83, pl. 13, fig. 24.
Loeblich and Tappan, 1953, p. 36, pl. 3, figs. 8-10.
Todd and Low, 1961, p. 14, pl. 1, fig. 4.
Cooper, 1964, p. 94, pl. 5, fig. 5.
Buzas, 1965a, p. 13, pl. 1, fig. 1.
Leslie, 1965, p. 159, pl. 2, figs. 4a, b.
Vilks, 1969, p. 46, pl. 2, fig. 3.
Gregory, 1971, p. 183, pl. 5, figs. 1-3.

Plate 2 figs 9,10

Test small, elongate, tapering; triserial chamber arrangement broadest at the apertural end, inflated; sutures distinct and depressed; aperture small in central depression at the base of the final chamber.

Found at 16 stations in depths of 40-351 metres, abundant at depths of 40-161 where it is associated with sandy substrates; forms 69 % of faunal assemblage at station 044.

Family FISHERINIDAE Millet 1898

Subfamily CYCLOGYRINIDAE Loeblich and Tappan 1961

Genus CYCLOGYRA Wood, 1842

CYCLOGYRA cf. FOLIACEA (Philippi)

Orbis foliaceus Philippi, 1844, p. 147, pl. 24, fig. 26.

Cornuspira foliacea (Philippi)
Parker and Jones, 1865, p. 408, pl. 15, fig. 33.
Goes, 1894, p. 106, pl. 18, fig. 834.
Cushman, 1929, p. 79, pl. 20, figs. 3-4.
Cushman, 1948, p. 40, pl. 4, figs. 9, 10.

Cyclogyra foliacea (Philippi)
Feyling-Hanssen, 1964, p. 245, pl. 4, fig. 8.

Test large, planispiral, evolute, rapid increase in height of coil, spiral suture depressed and distinct; wall calcareous, porcellaneous and smooth.

Single, broken specimen found at station 034; rapid increase in diameter and height of coils of second chamber are similar to the forms illustrated by Cushman (1948) and Feyling-Hanssen (1964) rather than Loeblich and Tappan's (1953) Cyclogyra (Cornuspira) involvens with its slowly expanding chamber.

Family MILIOLIDAE Ehrenberg, 1839

Subfamily QUINQUELOCULININAE Cushman, 1917

Genus PATEORIS Lobelich and Tappan, 1953

PATEORIS HAEURINOIDES (Rhumbler)

Quinqueloculina subrotunda (Montagu) forma hauerinoides
Rhumbler, 1936, pp. 206, 217, 226, text-figs. 167, 208-212.

Quinqueloculina subrotunda (Montagu)?
Cushman, 1948, p. 35, pl. 3, figs. 20, 21, pl. 4, fig. 1.

Quinqueloculina subrotunda (Montagu)
Parker, 1952a, p. 406, pl. 4, figs. 4a, b.
Parker, 1952b, p. 456, pl. 2, figs. 9a, b, 10a, b.
Todd and Low, 1961, p. 15, pl. 1, fig. 8.

Pateoris hauerinoides (Rhumbler)
Loeblich and Tappan, 1953, p. 42, pl. 6, figs. 8-12, text-figs. 1A,B.
Cooper, 1964, p. 94, pl. 5, fig. 7.
Feyling-Hanssen, 1964, p. 256, pl. 6, fig. 5.
Leslie, 1965, p. 167, pl. 4, figs. 2a-c.
Gregory, 1971, p. 188, pl. 6, figs. 3, 4.

Plate 3 fig. I

Test large, ovate to circular in plan; chambers quinqueloculine initially with final chambers in one plane; chambers less than half a coil in length, no apertural neck; walls calcareous, porcelaneous, imperforate, smooth and shiny; aperture broad, low crescent with no internal tooth.

Single specimens found at 3 localities between 90-250 metres in depth, all associated with a sand bottom.

Genus PYRGO Defrance, 1824

PYRGO WILLIAMSONI (Silvestri)

Biloculina ringens (Lamark) typica Williamson, 1858,
(not Miliolites ringens Lamark, 1804), p. 79, pl. 6, figs. 169, 170; pl. 7, fig. 171.

Biloculina williamsoni Silvestri, 1923, p. 73

Pyrgo elongata (D Orbigny)
Cushman, 1948, p. 39, pl. 4, figs. 7, 8.

Pyrgo williamsoni (Silvestri)
Loeblich and Tappan, 1953, p. 48, pl. 6, figs. 1-4.
Feyling-Hanssen, 1964, p. 264, pl. 7, figs. 5,6 pl. 8, figs. 3-5.
Gregory, 1971, pl. 6, fig. 5.

Plate 3 fig. 2

Test small, oval in outline, rounded, slightly angular margin, inflated, the young specimens elongate as described by Loeblich and Tappan (1953); sutures, distinct and depressed; walls porcelaneous, imperforate, smooth and shiny; aperture round or ovate with a small delicate, more or less bifid tooth, often broken off.

A juvenile specimen similar to Vilks (1969) Pyrgo subsphaerica was found but showed insufficient specific differentiation to be placed in a separate category, which is in agreement with Feyling-Hanssen's (1964) observations. Rare, found at 3 stations at depths between 180 and 421 metres.

Genus QUINQUELOCULINA d Orbigny, 1826

QUINQUELOCULINA AGGLUTINATA Cushman

Quinqueloculina agglutinata Cushman, 1917, p. 43, pl. 9, fig. 2.
Cushman and Todd, 1947, p. 61, pl. 14, figs. 12, 13.
Cushman, 1948, p. 33, pl. 3, fig. 13.
Loeblich and Tappan, 1953, p. 39, pl. 5, figs. 1-4.
Feyling-Hanssen, 1964, p. 247, pl. 4, fig. 11.
Leslie, 1965, p. 168, pl. 3, fig. 1.
Gregory, 1971, p. 186, pl. 5, fig. 6.

Plate 3 fig. 3

Test ovate, medium size, chambers subangular, broadest at the base and tapering towards aperture; wall arenaceous, consisting of fine agglutinated quartz grains, smooth exterior; sutures distinct and depressed; aperture oval.

Rare in occurrence, single specimens found at stations 026 and 033.

QUINQUELOCULINA SEMINULUM (Linne)

Serpula seminulum Linne, 1758, p. 786

Miliolina seminulum (Linne)
Williamson, 1858, p. 85, pl. 7, figs. 183-185.
Brady, 1884, p. 157, pl. 5, fig. 6.

Quinqueloculina seminulum (Linnaeus)
Cushman, 1917, p. 44, pl. 11, fig. 2.
Cushman, 1929, p. 24, pl. 2, figs. 1, 2.
Boltovskoy, 1954, p. 120, pl. 1, figs. 1-3.

Quinqueloculina seminula (Linne)
Cushman, 1944, p. 13, pl. 2, fig. 14.
Cushman, 1948, p. 34, pl. 3, figs. 14, 15.
Parker, 1952a, p. 406, pl. 3, figs. 21a, b, 22a, b, pl. 4, figs. 1, 2.
Parker, 1952b, p. 456, pl. 2, figs. 7a, b.

<u>Quinqueloculina</u> <u>seminulum</u> (Linne)
Todd and Bronniman, 1957, p. 27, pl. 3, figs. 9, 10.
Todd and Low, 1961, p. 15, pl. 1, fig. 14.
Feyling-Hanssen, 1964, p. 251, pl. 6, fig. 1.
Adams and Frampton, 1965, p. 55, pl. 5, fig. 16.
Leslie, 1965, p. 168, pl. 3, figs. 2a-c.
Vilks, 1969, p. 47, pl. 2, figs. 10a, b.
Gregory, 1971, p. 187, pl. 6, fig. 1.

Plate 3 figs 4,5

Test oblong, 5 visible chambers, rounded peripheral margin; sutures distinct; walls porcelaneous, white, opaque; aperture large, oval with prominent simple tooth or slightly bifid.

Rare, found at 3 stations in depths 40-154 metres in sand substrates in low percentages.

QUINQUELOCULINA STALKERI (Loeblich and Tappan)

<u>Quinqueloculina</u> <u>fusca</u> (Brady)
Cushman, 1948, (not Brady, 1870), p. 33, pl. 3, figs. 16, 17.

<u>Quinqueloculina</u> <u>stalkeri</u> Loeblich and Tappan, 1953, p. 40, pl. 5, figs. 5-9.
Feyling-Hanssen, 1964, p. 252, pl. 4, figs. 13-18.
Leslie, 1965, p. 169, pl. 3, figs. 3a-c.
Gregory, 1971, p. 187, pl. 6, fig. 2.

Plate 3 figs 6,7

Similar to <u>Quinqueloculina</u> <u>agglutina</u> except smaller in size, finer grained material in test wall and the presence of a short apertural neck with its distinct lip and a more common bifid tooth.

Also rare in the area, found at 3 stations in small percentages at depths between 113 and 120 metres in sandy bottoms.

Genus TRILOCULINA d'Orbigny, 1826

TRILOCULINA TRIHEDRA (Loeblich and Tappan)

<u>Triloculina</u> <u>trihedra</u> Loeblich and Tappan, 1953, p. 45, pl. 4, fig. 10.
Feyling-Hanssen, 1954, p. 128, pl. 1, fig. 4.
Feyling-Hanssen, 1964, p. 259, pl. 6, fig. 6.
Vilks, 1969, p. 47, pl. 2, fig. 11.

Gregory, 1971, p. 190, pl. 6, fig. 6.

Plate 3 figs 8,9

Test triangular in cross-section with rounded angles and slightly convex sides; triloculine arrangement of chambers; walls porcelaneous, smooth and shiny; aperture oval with a short broad bifid tooth.

Rare, less than 1 % in all 6 stations recovered, found in depths of 113-147 metres in sandy environments.

Subfamily MILIOLINELLINAE Vella, 1957

Genus BILOCULINELLA Wiesner, 1931

BILOCULINELLA INFLATA (Wright)

Biloculina ringens Lamark var.
Balkwill and Wright, 1885, p. 322, pl. 12, figs. 6, 7.

Biloculina inflata Wright, 1902, p. 183, pl. 13, figs. 1-4.

Biloculinella inflata (Wright)
Feyling-Hanssen, 1964, p. 267, pl. 7, figs. 11, 12.

Plate 3 fig. 10

Test small, nearly circular in outline, inflated, the last chamber overlaps the preceeding one at all margins; wall porcelaneous, white; aperture broad, cresentic.

One specimen found at the shallowest station in 40 metres.

Genus MILIOLINELLA Wiesner, 1931

MILIOLINELLA CHUKCHIENSIS (Loeblich and Tappan)

Miliolinella chukchiensis Loeblich and Tappan, 1953, p. 47, pl. 6, figs. 5, 6.
Gregory, 1971, p. 190, pl. 6, fig. 7.

Plate 3 fig. 11

Test oval in outline, rounded periphery, inflated chambers; sutures distinct and depressed; walls porcelaneous and white in the smaller forms and tending towards a chalky appearance in the larger specimens similar to those described by Gregory (1971): aperture a curved slit partially closed by a broad flap.

Rare in appearance, found at two stations 017 and 056 in 90 and 250 metres respectively, in sandy substrates.

Genus SCUTULORIS Loeblich and Tappan, 1953

SCUTULORIS TEGMINIS (Loeblich and Tappan)

Scutuloris tegminis Loeblich and Tappan, 1953, p. 41, pl. 5, fig. 10.

Scutuloris cf. tegminis (Loeblich and Tappan)
Feyling-Hanssen, 1964, p. 255, pl. 6, fig. 4.

Scutuloris tegminis (Loeblich and Tappan)
Leslie, 1965, p. 170, pl. 3, fig. 5.

Plate 3 fig. I2

Test oval with rounded periphery; quinqueloculine chamber arrangement; sutures distinct, depressed; walls porcelaneous to slightly transparent; similar aperture to that of Miliolinella chukchiensis.

Found at 3 stations in small numbers in depths between 40 and 120 metres in predominantly sandy samples.

Family NODOSARIIDAE Ehrenberg, 1838

Subfamily NODOSARIINAE Ehrenberg, 1838

Genus DENTALINA Risso 1826

DENTALINA BAGGI (Galloway and Wissler)

Nodosaria pauperata Bagg 1912 (not Dentalina pauperata d'Orbigny, 1846)
p. 57, pl. 16, figs. 2a-f.

Nodosaria calomorpha Bagg 1912 (not Reuss, 1866), p. 53, pl. 15, fig. 3.

Dentalina baggi Galloway and Wissler, 1927, p. 49, pl. 8, figs. 14,15.

Cushman and McCulloch, 1950, p. 313, pl. 41, figs. 13, 14.
Loeblich and Tappan, 1953, p. 54, pl. 9, figs. 10-15.
Leslie, 1965, p. 158, pl. 5, fig. 2.
Vilks, 1969, p. 47, pl. 2, fig. 12.

Plate 2 fig. II

Test medium, rounded base; 2-5 chambers increasing slowly in size as added; sutures distinct; walls calcareous, opaque, smooth; aperture terminal, radiate, produced and eccentric. These forms are similar to the juvenile forms illustrated by Loeblich and Tappan (1953).

Very limited distribution, single specimens found at 4 stations in depths ranging from 117 to 351 metres in predominantly sandy sediments.

DENTALINA FROBISHERENSIS (Loeblich and Tappan)

Nodosaria mucronate (Neugeboren)
Cushman (part) 1923, p. 80, pl. 12, figs. 5-7, pl. 13, figs. 7-9.

Dentalina sp.
Cushman, 1948, p. 45, pl. 5, fig. 6.

Dentalina frobisherensis Loeblich and Tappan, 1953, p. 55, pl.10, figs. 1-9.
Leslie, 1965, p. 159, pl. 5, fig. 4.
Vilks, 1969, p. 47, pl. 2, fig. 13.

Plate 2 fig. I2

Test large, arcuate. 8 chambers in one specimen with the final chamber elongated; walls calcareous, translucent, smooth; aperture terminal radiate and eccentric.

Three single specimens found in a depth range of 120-250 metres in fine sand.

DENTALINA ITTAI (Lobelich and Tappan)

Nodosaria calomorpha, Reuss in Earland, 1933 (not Nodosaria (Nodosaria) calomorpha Reuss, 1866), p. 117, pl. 4, fig. 19.

Dentalina cf. calomorpha (Reuss)
Cushman, 1948, (not Nodosaria (Nodosaria) calomorpha, Reuss, 1866),

p. 44, pl. 5, figs. 4, 5.
Cushman and McCulloch, 1950, (not Nodosaria (Nodosaria) calomorpha Reuss, 1866), p. 317, pl. 41, fig. 6.

Dentalina ittai Loeblich and Tappan, 1953, p. 56, pl. 10, figs. 10-12.
Feyling-Hanssen, 1964, p. 273, pl. 9, figs. 1, 2.
Leslie, 1965, p. 159, pl. 5, figs. 5a, b.
Gregory, 1971, p. 192, pl. 6, fig. 8.

Plate 2 figs 13,14

Test small, elongate, delicate; one or two chambers, frequently broken, terminal chamber elongate; sutures distinct; walls calcareous, hyaline to translucent; aperture terminal, radiate and central.

Found at 7 stations in small numbers in a depth range of 113-333 metres in sand and silty sand substrates.

DENTALINA PAUPERATA (d'Orbigny)

Dentalina pauperate d'Orbigny, 1846, p. 46, pl. 1, figs. 57, 58.

Nodosaria pauperata d'Orbigny
Cushman, 1923, p. 72, pl. 14, fig. 13.

Dentalina sp.
Cushman, 1948, p. 45, pl. 5, fig. 7.

Dentalina pauperata (d'Orbigny)
Loeblich and Tappan, 1953, p. 57, pl. 9, figs. 7-9.
Leslie, 1965, p. 159, pl. 5, fig. 3.
Vilks, 1969, p. 47, pl. 2, fig. 14.

Plate 2 fig. 15

Test large, cylindrical in section, arcuate, basal spine; sutures distinct; walls calcareous, translucent; aperture terminal, eccentric and radiate.

One specimen found at station 026.

Genus LAGENA Walker and Jacob in Kanmacher, 1798

LAGENA APIOPLEURA (Loeblich and Tappan)

Lagena acuticosta (Reuss)
Brady (part), 1884 (not Reuss, 1862), p. 464, pl. 58, fig. 2.
Cushman, 1913, p. 23, pl. 8, fig. 9 (not fig. 10), pl. 23, fig. 2.
Cushman, 1923, p. 5, pl. 1, figs. 1-3.
Wiesner, 1931, p. 117, pl. 18, figs. 208-210.
Cushman and McCulloch, 1950, p. 329, pl. 43, figs. 9, 10.

Lagena apiopleura Loeblich and Tappan, 1953, p. 59, pl. 10, figs. 14, 15.
Bandy and Kolpack, 1963, p. 164, text-figs. 31 B, 12.
Feyling-Hanssen, 1964, p. 284, pl. 11, fig. 3.
Vilks, 1969, p. 47, pl. 2, fig. 15.
Gregory, 1971, p. 193, pl. 7, fig. 1.

Plate 4 fig. I

Test unilocular, subglobular with a rounded base tapering towards the apex; wall calcareous, hyaline to translucent; elevated costae extending from the base to a collar just below a short smooth neck, aperture terminal and rounded.

Found at 11 stations in depths 90-177 metres in sandy substrates with concentrations below 1 % except at 031 where 1. 86 % is recorded.

LAGENA DISTOMA (Parker and Jones, M.S. Brady)

Lagena laevis
Walker and Jacob, var. striata, Parker and Jones, 1857, p. 278, pl. 11, fig. 24.

Lagena distoma Parker and Jones, M.S. Brady, 1864, p. 467, pl. 48, fig. 6.

Lagena sulcata Walker and Jacob var. distoma, Parker and Jones, 1865, p. 356, pl. 13, fig. 20.

Lagena distoma (Parker and Jones)
Brady, 1884, p. 461, pl. 58, figs. 11-15.
Goes, 1894, p. 77, pl. 13, fig. 739 (not fig. 740).
Flint, 1899, p. 306, pl. 53, fig. 5.
Cushman, 1923, p. 14, pl. 3, fig. 3 (not fig. 2).

Lagena mollis (Cushman)
Loeblich and Tappan, 1953, p. 63, pl. 11, fig. 26 (not figs. 25, 27).

Lagena distoma (Parker and Jones)
Boltovskoy, 1959, p. 68, pl. 9, fig. 17.
Feyling-Hanssen, 1964, p. 286, pl. 11, figs. 6-8.

Plate 4 fig. 2

Test unilocular, elongate; sides nearly parallel over the central portion of the test, long slender neck; walls calcareous, hyaline, with very fine longitudinal ribs which die out towards the neck; aperture terminal at the end of the neck. Feyling-Hanssen (1964) separates L. distoma from L. mollis by its greater length and parallel sides over the central section at the test. Both forms were observed in the present study.

Similar distribution to L. apiopleura with the exception of a single specimen at 060 in 303 metres in a silt bottom.

LAGENA FLATULENTA (Loeblich and Tappan)

Lagena flatulenta Loeblich and Tappan, 1953, p. 60, pl. 11, figs. 9, 10.
Leslie, 1965, p. 163, pl. 5, fig. 9.
Vilks, 1969, p. 47, pl. 2, fig. 16.

Plate 4 fig. 3

Test small, unilocular, rounded chamber extending into a long delicate neck, walls calcareous, hyaline to translucent; aperture terminal.

Found in small numbers at 10 stations in depths 113-180 metres in sandy substrates.

LAGENA GRACILLIMA (Seguenza)

Amphorina gracillima Seguenza, 1862, p. 51, pl. 1, fig. 37.

Lagena gracillima (Seguenza)
Brady, 1884, p. 456, pl. 56, figs. 21, 22, 25, 26.
Cushman, 1913, p. 11, pl. 1, fig. 4.
Cushman, 1923, p. 23, pl. 4, fig. 5.
Buchner, 1940, p. 415, pl. 2, figs. 25-27.
Loeblich and Tappan, 1953, p. 60, pl. 11, figs. 9, 10.
Feyling-Hanssen, 1964, p. 288, p. 11, fig. 11.
Leslie, 1965, p. 163, pl. 5, fig. 7.
Vilks, 1969, p. 47, pl. 2, fig. 18.
Gregory, 1971, p. 193, pl. 7, fig. 3.

Plate 4 fig. 4

Test elongate, unilocular, fusiform, arcuate, apiculate base, apertural end tapering to a long cylindrical neck with a phialine lip; walls hyaline, smooth, finely perforate; basal spines broken in all but one specimen.

Found at 3 stations in 117-200 metres.

LAGENA LAEVIS (Montagu)

Vermiculum laeve, Montagu, 1803, p. 524.

Lagena laevis (Montagu)
Williamson, 1848, p. 12, pl. 1, figs. 1, 2.

Lagena sulcata Walker and Jacob, var. laevis Montagu
Parker and Jones, 1865, p. 349, pl. 16, fig. 9a.

Lagena laevis (Montagu)
Jones, Parker and Brady, 1866, p. 33, pl. 1, fig. 28.
Hessland, 1943, pl. 2, fig. 18 (not fig. 19).
Cushman and McCulloch, 1950, p. 341, pl. 45, figs. 14, 16.
Loeblich and Tappan, 1953, p. 61, pl. 11, figs. 5-8.
Parker, 1964, p. 626, pl. 97, fig. 30.
Feyling-Hanssen, 1964, p. 289, pl. 11, figs. 13-15.
Leslie, 1965, p. 163, pl. 5, fig. 8.
Gregory, 1971, p. 194, pl. 7, fig. 2.

Plate 4 fig. 5

Test unilocular, flask shaped with an elongated neck; wall hyaline, no ornamentation, finely perforate; aperture may thicken to form a pronounced lip.

This form is the most widely distributed of the lagenids, being found at 17 stations in depths 117-380 metres, always less than 1 % of foraminiferal population.

LAGENA MERIDIONALIS (Wiesner)

Lagena caudata (d'Orbigny) Parker and Jones, 1865.
(part) (not Oolina caudata d'Orbigny, 1839), p. 352, pl. 16, fig. 7.

Lagena gracilis (Williamson_
    Brady, 1884, p. 464, pl. 58, fig. 19 (not figs. 22-24).

Lagena gracilis Williamson var.
    Cushman, 1913, p. 25, pl. 8, fig. 7.

Lagena gracilis Williamson var. meridionalis
    Wiesner, 1931, p. 117, pl. 18, fig. 211.

Lagena meridionalis (Wiesner)
    Loeblich and Tappan, 1953, p. 62, pl. 12, fig. 1.
    Leslie, 1965, p. 163, pl. 5, fig. 13.
    Vilks, 1969, p. 47, pl. 2, fig. 19.

Plate 4 fig. 6

Test unilocular, elongate, shows a slight constriction near the apertural end of the test, rounded base; walls hyaline with fine longitudinal costae; aperture rounded at the end of a short neck.

Two specimens only, found in depths less than 122 metres.

LAGENA MOLLIS (Cushman)

Lagena distome (Parker and Jones)
    Buchner, 1940, p. 414, pl. 2, figs. 20-22.

Lagena elongata distome (Parker and Jones)
    Hessland, 1943, p. 156, 262, pl. 2, fig. 28.
    Feyling-Hanssen, 1954, p. 129, pl. 1, fig. 9.

Lagena gracillima (Seguenza) var. mollis
    Cushman, 1944, p. 21, pl. 3, fig. 3.

Lagena mollis (Cushman)
    Loeblich and Tappan, 1953, p. 63, pl. 11, figs. 25, 27 (not fig. 26).
    Feyling-Hanssen, 1964, p. 290, pl. 11, figs. 16-19.
    Leslie, 1965, p. 163, pl. 5, figs. 11a, b.
    Vilks, 1969, p. 47, pl. 2, fig. 20.
    Gregory, 1971, p. 195, pl. 7, fig. 4.

Plate 4 fig. 7

Similar to L. distoma, except for its smaller size and inflated central section.

Found at 6 stations in a depth range of 113-250 metres.

LAGENA NEBULOSA (Cushman)

Lagena laevis (Montagu)
Brady, 1884 (not Lagena laevis Montagu, 1803), pl. 56, fig. 12.

Lagena laevis (Montagu) var. nebulosa Cushman, 1923, p. 29, pl. 5, figs. 4,5.

Lagena nebulosa (Cushman)
Buchner, 1940, p. 421, pl. 2, fig. 32.
Feyling-Hanssen, 1964, p. 291, pl. 12, fig. 1.
Leslie, 1965, p. 164, pl. 5, fig. 14.
Vilks, 1969, p. 48, pl. 2, fig. 21.

Plate 4 fig. 8

Test small, cylindrical, parallel sides, long slender neck, rounded base; walls hyaline, finely perforate, giving a dull appearance; aperture terminal.

Rare, found in depths 160-333 metres, associated with sandy sediments.

LAGENA PARRI (Loeblich and Tappan)

Lagena laevis (Montagu) var. baggi Cushman and Gray
Cushman and McCulloch, 1950 (not Cushman and Gray, 1946) p. 342, pl. 45, fig. 17.

Lagena parri Loeblich and Tappan, 1953, p. 64, pl. 11, figs. 11-13.
Leslie, 1965, p. 164, pl. 5, fig. 10.

Plate 4 fig. 9

Test similar to Lagena laevis but with a longer more slender neck and a distinct basal spine; aperture terminal at the end of the neck.

Rare, found at station 026 only.

LAGENA SEMILINEATA (Wright)

Lagena semilineata Wright, 1886, p. 320, pl. 26, fig. 7.
Cushman and McCulloch, 1950, p. 345, pl. 46, fig. 11

Lagena caudata (d'Orbigny)
Cushman, 1948 (not d'Orbigny, 1839), p. 46, pl. 5, figs. 8, 9.

Lagena semilineata (Wright)
Loeblich and Tappan, 1953, p. 65, pl. 11, figs. 14-22.
Todd and Bronniman, 1957, p. 31, pl. 5, fig. 16.
Feyling-Hanssen, 1964, p. 291, pl. 12, fig. 2.
Leslie, 1965, p. 164, pl. 5, fig. 12.
Gregory, 1971, p. 196, pl. 7, fig. 8.

Plate 4 fig. 10

Test elongate, unilocular, flask shaped, basal spine (frequently broken off), long slender neck; walls hyaline, basal section of the test ornamented with fine costae, the upper two thirds smooth; aperture terminal

Similar distribution to other lagenids, depth range 113-170 metres.

LAGENA STRIATA (d'Orbigny)

Oolina striata d'Orbigny, 1839, p. 21, pl. 5, fig. 12.

Lagena striata (d'Orbigny)
Reuss, 1863, p. 327, pl. 3, fig. 44 (not fig. 45), pl. 4, figs. 46, 47.
Brady, 1884, p. 460, pl. 57, figs. 22, 24 (not figs. 19,23,28-30).
Cushman, 1923, p. 54, pl. 10, fig. 9.
Buchner, 1940, p. 424, pl. 4, figs. 58-61 (not figs. 54-57).
Gregory, 1971, p. 196, pl. 7, fig. 5.

Plate 4 fig. 11

Test flask-shaped, small, long extended neck, rounded base; walls hyaline, ornamented with closely spaced costae running the length of the test.

One specimen found in 159 metres.

Genus LENTICULINA Lamert, 1804

LENTICULINA cf. ANGULATA (Reuss)

Robalina angulata Reuss, 1851, p. 154, pl. 8, fig. 6.

Lenticulina (Robulus) cf. angulata (Reuss)
Feyling-Hanssen, 1964, p. 277, pl. 9, figs. 9, 10.

Plate 4 fig. 12

Test small, planispiral, involute, bilaterally symmetrical, peripheral edges nearly straight forming an angled margin, periphery subacute; 3-5 chambers; sutures distinct, depressed; walls hyaline, smooth; aperture radiate.

Rare, found at stations 024 and 026 only.

Family POLYMORPHINIDAE d'Orbigny, 1839

Subfamily POLYMORPHININAE d'Orbigny, 1839

Genus SIGMOIDELLA Cushman and Ozawa, 1928

SIGMOIDELLA PACIFICA (Cushman and Ozawa)

Sigmoidella (*Sigmoidina*) *pacifica*
Cushman and Ozawa, 1928, p. 19, pl. 2, fig. 13.

Guttulina (*Sigmoidina*) *pacifica* (Cushman and Ozawa)
Cushman, 1948, p. 50, pl. 5, fig. 13.

Sigmoidella pacifica (Cushman and Ozawa)
Leslie, 1965, p. 170, pl. 7, fig. 7.

Plate 4 fig. I3

Test medium, ovate, rounded base; chambers elongated, arranged in sigmoidal sequence; sutures distinct, depressed; wall hyaline, translucent, smooth; aperture radiate.

Rare, found at two stations, both at 110 metres in a sandy substrate.

Family GLANDULINIDAE Reuss, 1860

Subfamily GLANDULININAE Reuss, 1860

Genus ESOSYRINX Loeblich and Tappan, 1953

ESOSYRINX CURTA (Cushman and Ozawa)

Pseudopolymorphina curta Cushman and Ozawa, 1930, p. 105, pl. 27, figs. 3a, b.
Cushman, 1944, p. 23, pl. 3, fig. 16.
Cushman, 1948, p. 52, pl. 5, fig. 18.

Esosyrinx curta (Cushman and Ozawa)
Loeblich and Tappan, 1953, p. 85, pl. 15, figs. 1-5.
Gregory, 1971, p. 198, pl. 8, figs. 2, 3.

Plate 4 fig. I4

Test oval, compressed, rounded; chambers few, arranged in a biserial series; sutures depressed, partially obscured; wall thin, hyaline, smooth; aperture terminal, radiate, with a visible internal tube in a clear transparent band around the aperture.

Distribution limited, found at 5 stations in depths 90-181 metres.

Genus GLANDULINA d'Orbigny

GLANDULINA LAEVIGATA (d'Orbigny)

Nodosaria (Glandulina) laevigata d'Orbigny, 1826, p. 252, pl. 10, figs. 1-3.

Glandulina laevigata (d'Orbigny)
d'Orbigny, 1846, p. 29, pl. 1, figs. 4, 5.
Cushman and Ozawa, 1930, p. 143, pl. 40, figs. 1a, b.
Cushman, 1948, p. 52, pl. 5, figs. 20, 21; pl. 6, fig. 1.

Pseudoglandulina laevigata (d'Orbigny)
Cushman and McCulloch, 1950, p. 325, pl. 42, fig. 4.

Glandulina laevigata (d'Orbigny)
Loeblich and Tappan, 1953, p. 81, pl. 16, figs. 2-5.
Leslie, 1965, p. 161, pl. 7, fig. 1.
Gregory, 1971, p. 198, pl. 8, fig. 4.

Plate 4 fig. I5

Test fusiform, the initial end sharply tapering, circular in cross-section; chambers increase rapidly in size as added; sutures distinct; wall hyaline and translucent, smooth, finely perforate; aperture radiate and terminal.

Relatively rare, found at 6 stations, 110-250 metres.

Genus LARYNGOSIGMA Loeblich and Tappan, 1953

LARYNGOSIGMA HYALASCIDA (Loeblich and Tappan)

Laryngosigma hyalascida Loeblich and Tappan, 1953, p. 83, pl. 15, figs. 6-8.
Gregory, 1971, p. 199, pl. 8, fig. 5.

Plate 4 fig. I6

Test ovate, biserially arranged chambers; sutures distinct; wall translucent, finely perforate; aperture terminal, radiate; short entosolenian tube visible in clear transparent 'collar' near the aperture.

Found only in sandy bottoms in shallow water, 40-160 metres.

Genus GLANDULINA d'Orbigny, 1826

LARYNGOSIGMA WILLIAMSONI (Terquem)

Polymorphina lactea (Walker and Jacob) var. oblonga
Williamson, 1858, p. 71, pl. 6, figs. 149, 149a.
Cushman, 1923, p. 147, pl. 40, figs. 7, 8.

Polymorphina williamsoni Terquem, 1878, p. 37.
Heron-Allen and Earland, 1932, p. 393, pl. 12, figs. 26-28.

Sigmomorphina williamsoni (Terquem)
Cushman and Ozawa, 1930, p. 138, pl. 38, figs. 3, 4.
Cushman, 1944, p. 23, pl. 3, fig. 21.

Laryngosigma williamsoni (Terquem)
Loeblich and Tappan, 1953, p. 84, pl. 16, fig. 1.

Plate 4 fig. I7

Test ovate, sides tapering slightly to apertural end; extremities rounded; biserial arrangement of chambers, overlapping one another; sutures oblique; walls translucent, finely perforate; aperture radiate, terminal.

Single specimen found at 40 metres.

Subfamily OOLININAE Loeblich and Tappan, 1961

Genus FISSURINA Reuss, 1850

FISSURINA CUCURBITASEMA (Loeblich and Tappan)

Fissurina cucurbitasema Loeblich and Tappan, 1953, p. 76, pl. 14, figs. 10, 11.
Leslie, 1965, p. 160, pl. 6, fig. 9.
Gregory, 1971, p. 206, pl. 9, fig. 8.

Plate 5 fig. I

Test ovate, like a flattened melon seed, marginal keel; wall translucent to hyaline, finely perforate; aperture terminal.

Rare, found in depths 117-159 metres in low concentrations.

FISSURINA MARGINATA (Montagu)

Vermiculum marginatum Montagu, 1803, p. 524

Lagena sulcata Walker and Jacob var. (Entosolenia) marginata (Montagu)
Parker and Jones, 1865, p. 355, pl. 13, figs. 42, 43.

Lagena marginata (Walker and Boys)
Brady, 1884, (part) p. 476, pl. 59, fig. 22 (not figs. 21, 23).
Cushman, 1913, p. 37, pl. 22, figs. 1-7.

Entosolenia marginata (Montagu)?
Cushman, 1948, p. 65, pl. 7, fig. 7.

Fissurina marginata (Montagu)
Loeblich and Tappan, 1953, p. 77, pl. 14, figs. 6-9.
Parker, 1964, p. 625, pl. 98, fig. 11.
Cooper, 1964, p. 94, pl. 5, fig. 17.
Leslie, 1965, p. 161, pl. 6, fig. 10.
Vilks, 1969, p. 48, pl. 2, figs. 24a, b.
Gregory, 1971, p. 207, pl. 10, fig. 1.

Plate 5 figs 2,3

Test ovate, slightly protruded apertural end, narrow marginal keel; wall hyaline to translucent; aperture terminal with an entosolenian tube extending to half the length of the test and often bent.

Widespread distribution from 90-250 metres, favouring sandy substrates in concentrations up to 5.5 %.

FISSURINA SEMIMARGINATA (Reuss)

Lagena marginata Williamson var. semimarginata Reuss, 1870, p. 468
Brady, 1884, p. 446, pl. 59, figs. 17, 19.

Lagena (Entosolenia) marginata var. semimarginata Reuss
Wiesner, 1931, p. 120, pl. 19, fig. 224.

Fissurina semimarginata (Reuss)
Loeblich and Tappan, 1953, p. 78, pl. 14, fig. 3.
Gregory, 1971, p. 208, pl. 10, fig. 2.

Plate 5 fig. 4

Similar to F. marginata except more elongate, ovate rather than rounded, with a more extended apertural end and more distinctly perforated.

Rare in appearance, found at 4 stations in depths to 333 metres in sandy bottom conditions.

FISSURINA SERRATA (Schlumberger)

Lagena serrata Schlumberger, 1894, p. 243,pl. 3, fig. 7.

Entosolenia serrata (Schlumberger)
Cushman, 1948, p. 63, pl. 7, fig. 3.

Fissurina serrata (Schlumberger)
Loeblich and Tappan, 1953, p. 78, pl. 14, fig. 5.
Leslie, 1965, p. 161, pl. 6, figs. 11a, b.
Gregory, 1971, p. 209, pl. 10, fig. 3.

Plate 5 fig. 5

Test ovate with a rounded bottom and an extended apertural end, central body surrounded by a distinctive keel containing tubules, giving a serrated appearance to the margin; wall hyaline; entosolenian tube visible extending a third to half the length of the test; aperture terminal.

Limited to small percentages in sands in depths 120-200 metres.

FISSURINA sp.

Plate 5 fig. 6

A species very similar to F. marginata but possessing a definite basal spine. Shows some similarity to F. annectens (Barker 1960).

Found at 2 stations and is associated with Oolina apiculata which also has a similar basal spine.

Subfamily OOLININAE Loeblich and Tappan, 1961

Genus OOLINA d'Orbigny, 1839

OOLINA APICULATA (Reuss)

Oolina apiculata Reuss, 1851, p. 22, pl. 2, fig. 1.
Vilks, 1969, p. 48, pl. 3, figs. 26a, b.

Plate 5 fig. 7

Test ovate in outline, circular in section, distinctive basal spine; wall hyaline, entosolenian tube extending two-thirds the length of the test, end commonly flared; aperture terminal, central, radiate.

Found at 6 localities in small numbers at depths 113-120 metres.

OOLINA BOREALIS (Loeblich and Tappan)

Entosolenia costata Williamson, 1858, p. 9, pl. 1, fig. 18.

Lagena costata (Williamson)
Cushman, 1923, p. 12, pl. 1, fig. 16, pl. 2, figs. 1, 2.
Cushman, 1944, p. 21, pl. 3, fig. 4.
Cushman and McCulloch, 1950, p. 335, pl. 44, fig. 7.

Oolina costata (Williamson)
Parker, 1952a, p. 409, pl. 4, figs. 20, 21.
Loeblich and Tappan, 1953, p. 68, pl. 13, figs. 4-6.
Gregory, 1971, p. 201, pl. 19, fig. 3.

Oolina borealis Loeblich and Tappan, 1954, p. 384.
Feyling-Hanssen, 1964, p. 310.
Leslie, 1965, p. 165, pl. 6, fig. 4.

Plate 5 figs 8,9

Test subglobular; wall hyaline to translucent; ornamented with ribs or costae, which commence at a basal ring and extend to near the apertural end where they merge into a smooth collar; aperture terminal, extended, radiate, central.

Favours sandy bottoms, found at six stations in 90-212 metres.

OOLINA CAUDIGERA (Wiesner)

Lagena (Entoselenia) globosa (Montagu) var. caudigera
Wiesner, 1931, p. 119, pl. 18, fig. 214.

Entoselenia lineata (Williamson)
Cushman, 1948, (not Williamson 1848), p. 64, pl. 7, fig. 5.

Oolina caudigera (Wiesner)
Loeblich and Tappan, 1953, p. 67, pl. 13, figs. 1-3.
Boltovskoy, 1963, p. 63, pl. 7, fig. 7.
Feyling-Hanssen, 1964, p. 310, pl. 15, fig. 3.
Leslie, 1965, p. 165, pl. 6, fig. 3.

Plate 5 fig. I0

Test globular with a prominent basal spine; walls hyaline, finely perforated; a long entoselenian tube extends the length of the test, commonly flared at its extremity; aperture terminal radiate.

Found at locality 031.

OOLINA GLOBOSA (Montagu)

"Serpula (Lagena)laevis globosa"
Walker and Boys, 1784, p. 3, pl. 1, fig. 8.

Vermiculum globosum Montagu, 1803, p. 523.

Lagena globosa (Montagu)
Brady, 1884, p. 452, pl. 61, figs. 1-3, text-figs. 11a-m.
Cushman, 1923, p. 20, pl. 4, figs. 1, 2.

Oolina globosa (Montagu)
Vilks, 1969, p. 48, pl. 2, figs. 27a, b.
Gregory, 1971, p. 202, pl. 9, fig. 5.

Plate 5 fig . II

Test subspherical; walls hyaline translucent, finely perforate; aperture terminal, radiate.

Rare, occurring at stations 026 and 039.

OOLINA HEXAGONA (Williamson)

Entosolenia squamosa (Montagu) var. hexagona
Williamson, 1848, p. 20, pl. 2, fig. 23.

Lagena hexagona (Williamson)
Brady, 1884, p. 472, pl. 58, figs. 32, 33.
Cushman, 1913, p. 17, pl. 6, figs. 2, 3.
Cushman, 1923, p. 24, pl. 4, fig. 6.
Hessland, 1943, p. 262, pl. 3, fig. 34.

Oolina hexagona (Williamson)
Loeblich and Tappan, 1953, p. 69, pl. 14, figs. 1, 2.
Feyling-Hanssen, 1964, p. 311, pl. 15, fig. 4.
Leslie, 1965, p. 165, pl. 6, fig. 5.
Vilks, 1969, p. 48, pl. 2, fig. 28.

Plate 5 fig. I2

Test ovate with a short extended neck; walls hyaline, surface ornamented with a regular hexagonal reticulation; aperture rounded, central.

Rare, occurs at 4 stations at 110-147 metres in sands.

OOLINA LINEATA (Williamson)

Entosolenia lineata Williamson, 1848, p. 18, pl. 2, fig. 18.

Entosolenia globosa (Montagu) var. lineata Williamson
Williamson, 1858, p. 9, pl. 1, fig. 17.

Lagena lineata (Williamson)
Brady, 1884, p. 461, pl. 57, fig. 13.
Cushman, 1923, p. 31, pl. 5, fig. 10.

Oolina lineata (Williamson)
Loeblich and Tappan, 1953, p. 70, pl. 13, figs. 11-13.
Gregory, 1971, p. 203, pl. 9, figs. 1, 2.

Plate 5 fig. I3

Test subglobular with a small basal spine; walls hyaline, finely perforated with very fine closely spaced vertical striae, often indistinct; aperture terminal, rounded.

One of the more common oolinids. Favours shallow depths and fine sandy substrates.

OOLINA LINEATO-PUNCTATA (Heron-Allen and Earland)

Lagena globosa (Montagu) var. lineato-punctata
Heron-Allen and Earland, 1922, p. 142, pl. 5, figs. 12-14.

Oolina lineato-punctata (Heron-Allen and Earland)
Loeblich and Tappan, 1953, p. 70, pl. 13, fig. 8.
Feyling-Hanssen, 1964, p. 311, pl. 15, fig. 5.
Leslie, 1965, p. 166, pl. 6, fig. 8.
Gregory, 1971, p. 204, pl. 9, fig. 6.

Plate 5 fig. I4

Similar to O. lineata but with a protruding neck and fine pits aligned in vertical columns between slightly wider spaced striae.

One specimen recovered at 161 metres.

OOLINA MELO (d'Orbigny)

Oolina melo d'Orbigny, 1839, p. 20, pl. 5, fig. 9.

Lagena squamosa (Montagu)
Brady, 1884, p. 471, pl. 58, figs. 28-31.

Lagena melo (d'Orbigny)
Heron-Allen and Earland, 1932, p. 370, pl. 10, figs. 25-27.

Oolina melo (d'Orbigny)
Loeblich and Tappan, 1953, p. 71, pl. 12, figs. 8-15.
Cooper, 1964, p. 94, pl. 5, fig. 16.
Feyling-Hanssen, 1964, p. 312, pl. 15, figs. 6, 7.
Adams and Frampton, 1965, p. 57, pl. 5, fig. 4.
Leslie, 1965, p. 166, pl. 6, fig. 2.
Vilks, 1969, p. 48, pl. 2, fig. 29.
Gregory, 1971, p. 205, pl. 9, fig. 4.

Plate 5 fig. I5

Test subglobular with rounded base and slightly protruding apertural end; wall hyaline, finely perforated and ornamented with vertical costae and traverse ridges producing a rectalinear honeycomb effect; aperture terminal, rounded.

Found in small numbers in shallow sandy areas.

OOLINA STRIATOPUNCTATA (Parker and Jones)

Lagena sulcata (Walker and Jacob) var. striatopunctata
Parker and Jones, 1865, p. 350, pl. 13, figs. 25-27.

Entosolenia striatopuncata (Parker and Jones)
Dawson, 1870, p. 178, fig. 11.

Lagena striatopunctata (Parker and Jones)
Brady, 1884, p. 468, pl. 58, figs. 37, 40.
Cushman, 1913, p. 30, pl. 14, fig. 10.
Cushman, 1923, p. 55, pl. 10, fig. 10.
Cushman, 1948, p. 47, pl. 5, fig. 10.

Oolina striatopuncata
Loeblich and Tappan, 1953, p. 74, pl. 12, figs. 2-5.
Leslie, 1965, p. 166, pl. 6, fig. 1.

Plate 5 fig. I6

Test oval or flask-shaped with a long extended neck; walls hyaline, decorated with longitudinal costae which have a row of pores on either side; aperture terminal, radiate, commonly with a lip.

Found at 3 stations in sandy environments.

Family BOLIVINITIDAE Cushman, 1927

Genus BOLIVINA d'Orbigny, 1839

BOLIVINA PSEUDOPUNCTATA (Hoglund)

Bolivina pseudopunctata Hoglund, 1947, p. 273, pl. 24, fig. 5, pl. 32, figs. 23, 24, text-figs. 280, 281, 287.
Parker, 1952a, p. 414, pl. 5, figs. 20, 21.
Phleger, 1952, p. 83, pl. 14, fig. 19.
Loeblich and Tappan, 1953, p. 111, pl. 20, figs. 13, 14.

Feyling-Hanssen, 1964, p. 319, pl. 16, fig. 7.
Gregory, 1971, p. 213, pl. 10, fig. 10.

Plate 6 fig. I

Test small, elongate, periphery rounded, gradually tapering, sutures distinct, depressed, oblique; walls thin, hyaline; aperture elongate and terminal.

Found in small numbers at depths 90-200 metres in sandy substrates.

Family ISLANDIELLIDAE Loeblich and Tappan, 1964

Genus ISLANDIELLA Norvang, 1958

ISLANDIELLA ISLANDICA (Norvang)

Cassiculina islandica Norvang, 1945, p. 41, text-figs. 7, 8d-f.
Cushman, 1948, p. 75, pl. 8, fig. 13.
Loeblich and Tappan, 1953, p. 118, pl. 24, fig. 1.
Cooper, 1964, p. 102, pl. 6, fig. 21.
Leslie, 1965, p. 157, pl. 10, figs. 4a-c.
Adams and Frampton, 1965, p. 57, pl. 5, fig. 13.

Cassidulina islandica Norvang forma minuta
Norvang, 1945, p. 43, text-figs. 8a-c.
Cushman, 1948, p. 75, pl. 8, fig. 11.
Parker, 1952a, p. 421, pl. 6, figs. 22a, b, 23.

Islandiella islandica (Norvang)
Vilks, 1969, p. 49, pl. 3, fig. 3.
Gregory, 1971, p. 213, pl. 11, fig. 1.

Plate 6 figs 2,3

Test medium, broadly rounded; chambers inflated; walls calcareous translucent, perforate; aperture rounded and triangular in shape.

Widespread distribution. Found at depths 90-380 metres in a variety of substrates in up to 4 % of total fauna.

ISLANDIELLA NORCROSSI (Cushman)

Cassiculina norcrossi (Cushman)
Cushman, 1933, p. 7, figs. 7a-c.
1944, p. 35, pl. 4, fig. 26.

Cushman, 1948, p. 75, pl. 8, fig. 12.
Norvang, 1945, p. 44, text-fig. 10.
Parker, 1948, p. 75, pl. 8, fig. 12.
Parker, 1952a, p. 422, pl. 6, figs. 24, 25.
Loeblich and Tappan, 1953, p. 120, pl. 24, fig. 2.
Leslie, 1965, p. 158, pl. 10, figs. 3a-c.

Islandiella norcrossi (Cushman)
Norvang, 1958, p. 32, pl. 7, figs. 8-13, pl. 8, fig. 14.
Feyling-Hanssen, 1964, p. 325, pl. 16, fig. 20, pl. 17, fig. 1.
Vilks, 1969, p. 49, pl. 3, figs. 4a, b.
Gregory, 1971, p. 214, pl. 1, fig. 2.

Plate 6 fig. 4

Test medium, biconvex, periphery subacute or keeled; chambers triangular in side view; wall hyaline, finely perforate; aperture elongate.

Widespread in small numbers in depths to 351 metres in sandy locations.

ISLANDIELLA TERETIS (Tappan)

Cassidulina laevigata d'Orbigny
Brady, 1884, (not d'Orbigny,1826), p. 428, pl. 54, figs. 1-3.
Bowen, 1954, p. 741, text-fig. 1, figs. 1, 2.

Cassidulina teretis (Tappan)
Tappan, 1951, p. 7, pl. 1, figs. 30a-c.
Loeblich and Tappan, 1953, p. 121, pl. 24, figs. 3, 4.
Leslie, 1965, p. 158, pl. 10, figs. 5a-c.

Islandiella teretis (Tappan)
Feyling-Hanssen, 1964, p. 326, pl. 16, fig. 17.
Vilks, 1969, p. 49, pl. 3, fig. 5.

Plate 6 figs 5,6

Test medium, lenticular, biumbonate, chambers biserially arranged, peripheral keel, walls calcareous, translucent; aperture narrow, elongate, crescentic, at the base of the final chamber.

Similar distribution to *I. norcrossi*, generally in larger numbers.

Family BULIMININAE Jones, 1875

Subfamily BULIMININAE Jones, 1875

Genus BULIMINA d'Orbigny, 1826

BULIMINA EXILIS (Brady)

Bulimina elegans d'Orbigny var. exilis
Brady, 1884, p. 399, pl. 50, figs. 5, 6.
Cushman, 1911, p. 82, text-fig. 135.
Cushman, 1922, p. 106, pl. 17, figs. 7-12, pl. 19, figs. 2, 3.

Bulimina exilis (Brady)
Cushman and Parker, 1940, p. 11, pl. 2, figs. 18-21.
Cushman and Parker, 1947, p. 123, pl. 28, figs. 27, 28.
Loeblich and Tappan, 1953, p. 110, pl. 20, figs. 4, 5.

Plate 6 figs 7,8

Test elongate, slender, tapering sometimes to a basal spine; chambers elongate, slightly inflated; sutures distinct, depressed, oblique; walls translucent, finally perforate; aperture broad, loop-shaped.

Distributed over several stations in 113-303 metres in sands, always in small numbers.

Genus GLOBOBULIMINA Cushman, 1927

GLOBOBULIMINA AURICULATA ARCTICA (Hoglund)

Bulimina ellipsoides
Goes (part) 1894, (not Costa), p. 45, pl. 8, figs. 431-434, not figs. 435-436.

Globulimina auriculata (Bailey) forma arctica
Hoglund, 1947, p. 254, text-figs. 266, 267, 270, 271.

Globulimina (Desinobulimina) auriculata (Bailey) var. arctica Hoglund
Phleger, 1952, p. 85, pl. 14, fig. 3.

Globulimina auriculata subsp. arctica Hoglund
Loeblich and Tappan, 1953, p. 110, pl. 20, figs. 8, 9.

Globulimina auriculata arctica (Hoglund)
Feyling-Hanssen, 1964, p. 305, pl. 14, fig. 6.
Leslie, 1965, p. 161, pl. 9, figs. 6a-c.

Plate 6 figs 9,I0

Test large, ovate in outline, circular in section; chambers distinct with those in the last whorl occupying the large part of the test; sutures distinct; walls semitransparent, perforate; aperture surrounded by a fan shaped tongue.

Wide distribution over depth range 113-348 metres in low percentages of the total fauna.

Family UVIGERINIDAE Haeckel, 1894

Genus TRIFARINA Cushman, 1923

TRIFARINA ANGULOSA (Williamson)

Uvigerina pygmaea (d'Orbigny)
Parker and Jones, 1857 (part) (not Uvigerina pygmaea d'Orbigny, 1826), p. 297, pl. 11, figs. 41-43.

Uvigerina angulosa (Williamson)
Williamson, 1858, p. 67, pl. 5, fig. 140.
Brady, 1884, p. 576, pl. 74, figs. 15, 16.
Goes, 1894, p. 51, pl. 9, figs. 502-509.
Cushman, 1923, p. 170, pl. 41, figs. 17-20.
Heron-Allen and Earland, 1932, p. 397, pl. 12, figs. 32-39.
Hoglund, 1947, p. 283, fig. 8, text-figs. 305-308.

Angulogerina fluens, Todd, 1947 in Cushman and Todd, p. 67, pl. 16, figs. 6, 7.
Todd, 1948, in Cushman and McCulloch, p. 288, pl. 36, fig. 1.
Loeblich and Tappan, 1953, p. 112, pl. 20, figs. 10-12.

Angulogerina angulosa (Williamson)
Cushman, 1944, p. 30, pl. 4, fig. 9.
Cushman, 1948, p. 66, pl. 7, fig. 8.
Phleger, 1952, p. 83, pl. 14, fig. 12.
Leslie, 1965, p. 155, pl. 8, figs. 13a-c.

Trifarina angulosa (Williamson)
Barbieri and Medioli, 1969, p. 857, pl. 65, figs. 1-5.

Plate 6 fig. II

Test elongate, fusiform; several chambers, with three comprising each whorl; walls calcareous, finely perforate, ornamented by vertical costae which curve with the chambers; aperture terminal often with a phialine lip.

The specimens vary from the decidedly triangular form (in cross section) described by Hoglund (1947) to the more rounded T. fluens of Loeblich and Tappan (1953) in a gradational series, and have all been included in T. angulosa.

Wide ranging in depth of 40-504 in a variety of substrates and in concentrations up to 11 %.

Family DISCORBIDAE Ehrenberg, 1838

Subfamily DISCORBINAE Ehrenberg, 1838

Genus BUCCELLA Anderson, 1952

BUCCELLA FRIGIDA (Cushman)

Pulvinulina frigida Cushman, 1922, p. 12

Eponides frigidus (Cushman)
Cushman, 1941, p. 37, pl. 9, figs. 16, 17.
Parker, 1952a, p. 419, pl. 6, figs. 12a, b.
Parker, 1952b, p. 449, pl. 5, figs. 2a, b.
Phleger, 1952, p. 84, pl. 14, figs. 23-24.

Buccella frigida (Cushman)
Anderson, 1952, p. 144, figs. 4a-c, 5, 6a-c.
Loeblich and Tappan, 1953, p. 115, pl. 22, figs. 2, 3.
Todd and Low, 1961, p. 18, pl. 1, figs. 24, 25.
Cooper, 1964, p. 102, pl. 6, fig. 12.
Feyling-Hanssen, 1964, p. 337, pl. 18, figs. 15-18.
Adams and Frampton, 1965, p. 58, pl. 5, fig. 9.
Leslie, 1965, p. 156, pl. 10, figs. 2a-c.
Vilks, 1969, p. 49, pl. 3, figs. 7a, b.
Gregory, 1971, p. 220, pl. 12, figs. 1-3.

Plate 6 fig. 12

Test small, trochoid, biconvex, rotaliform, periphery rounded; chambers distinct with 5-7 in the final whorl; sutures distinct, oblique on the dorsal side, radial and depressed on the ventral; walls translucent and clear on the dorsal side; aperture arched, at the base of the final chamber.

Widely distributed from 40-380 metres in concentrations up to 3 %.

BUCCELLA INUSITATA (Anderson)

Eponides frigidus (Cushman)
Cushman and Todd, 1947, p. 21.
Cushman, 1948, p. 71, pl. 8, fig. 7.

Buccella inusitata Anderson, 1952, p. 148, figs. 10a-11c.
Loeblich and Tappan, 1953, p. 116, pl. 22, fig. 1.

Plate 6 figs I3,I4

Similar to B. frigida except larger, more shaply keeled and more strongly convex.

Similar distribution to B. frigida but rather more common, found in concentrations up to 3.5 %.

Genus ROSALINA d'Orbigny, 1826

ROSALINA COLUMBIENSIS (Cushman)

Discorbis columbiensis Cushman, 1925, p. 43, pl. 6, figs. 13a-c.
Parker, 1952a, p. 418, pl. 6, figs. 7a, b, 8a, b, 9a, b.
Parker, 1952b, p. 446, pl. 4, figs. 17a, b, 18a, b, 19a, b.

Rosalina columbiensis (Cushman)
Uchio, 1960, p. 66, pl. 8, figs. 1, 2.

Plate 6 figs I5,I6

Test medium, planoconvex, dorsal side rounded, ventral side flat to slightly concave; chambers distinct, 4 or 5 in the last whorl; sutures distinct, slightly curved on the dorsal side; walls calcareous; coarsely punctate on the dorsal side; aperture umbilicate, elongate.

Rare, found at stations 026, 031 and 046.

Family ASTERIGERINIDAE d'Orbigny, 1839

Genus ASTERELLINA Anderson, 1963

ASTERELLINA PULCHELLA (Parker)

Pninaella? pulchella Parker, 1952a, p. 420, pl. 6, figs. 18-20.

Asterellina pulchella (Parker)
Anderson, 1963, p. 314, pl. 1, figs. 5-7.
Leslie, 1965, p. 156, pl. 9, figs. 9a-c.
Vilks, 1969, p. 50, pl. 3, figs. 10a, b.

Plate 7 figs I,2

Test small, plano convex, rounded in outline, low spire on dorsal side, flat or slightly concave on the ventral side; several chambers in the last whorl increasing gradually in size as added; star shaped central portion on the ventral side formed by secondary plates; walls thin, translucent, finely perforate; aperture loop-shaped, at the base of the chamber on the ventral side.

Found at 13 stations at depths 110-180 metres

Family SPIRILLINIDAE Reuss, 1862

Subfamily PATELLININAE Rhumbler, 1906

Genus PATELLINA Williamson, 1858

PATELLINA CORRUGATA (Williamson)

Patellina corrugata Williamson, 1858, p. 46, pl. 3, figs. 86-89.
Cushman, 1931, p. 11, pl. 2, figs. 6, 7.
Cushman, 1944, p. 30, pl. 4, fig. 14.
Cushman and Todd, 1947, p. 67, pl. 16, fig. 9.
Cushman, 1948, p. 67, pl. 7, fig. 11.
Parker, 1952a, p. 420, pl. 6, figs. 16, 17.
Loeblich and Tappan, 1953, p. 114, pl. 21, figs. 4, 5.
Feyling-Hanssen, 1964, p. 335, pl. 18, fig. 9.
Leslie, 1965, p. 167, pl. 9, figs. 8a-c.
Vilks, 1969, p. 50, pl. 3, fig. 11.

Plate 7 fig. 3

Test free, plano-convex or concavo-convex, ventrically umbilicate;

initial chambers spirally arranged, final ones nearly annular and overlapping previous whorl; internal septa common, sutures distinct; walls hyaline or translucent; aperture ventral and elongate at the base of the last chamber.

Rare, single specimens found in depths 90-250 metres in sandy environments.

Family ELPHIDIIDAE Galloway, 1933

Subfamily ELPHIDIINAE Galloway, 1933

Genus ELPHIDIELLA Cushman, 1936

ELPHIDIELLA ARCTICA (Parker and Jones)

Polystomella arctica Parker and Jones, *in* Brady, 1864, p. 471, pl. 48, fig. 18.

Elphidium arcticum (Parker and Jones)
Cushman, 1930, p. 27, pl. 11, figs. 1-6.

Elphidiella arctica (Parker and Jones)
Cushman, 1939, p. 65, pl. 18, figs. 11-14.
Hessland, 1943, pl. 4, figs. 44, 45.
Cushman and Todd, 1947, p. 65, pl. 15, fig. 20.
Cushman, 1948, p. 59, pl. 6, fig. 15.
Phleger, 1952, p. 83, pl. 14, fig. 14.
Loeblich and Tappan, 1953, p. 106, pl. 20, figs. 1-3.
Cooper, 1964, p. 95, pl. 6, fig. 10.
Leslie, 1965, p. 159, pl. 8, figs. 12a, b.

Plate 7 fig. 4

Test large, planispiral, compressed, periphery rounded, margin lobulate at later chambers; 8-12 chambers in final whorl; sutures distinct, depressed, outlined by a double row of pores; walls calcareous, smooth; aperture a row of pores in the apertural face.

Limited distribution, found at ten stations at depths 113-180 metres in sand localities, 8 % of fauna at station 033 elsewhere 1 % or less.

ELPHIDIELLA GROENLANDICA (Parker and Jones)

Polystomella arctica Parker and Jones in Brady, 1864, p. 471, pl. 48, fig. 18.

Elphidium arcticum (Parker and Jones)
Cushman, 1930, p. 27, pl. 11, figs. 1-6.

Elphidiella arctica (Parker and Jones)
Cushman, 1939, p. 65, pl. 18, figs. 11-14.
Cushman and Todd, 1947, p. 65, pl. 15, fig. 20.
Cushman, 1948, p. 52, pl. 6, fig. 15.
Loeblich and Tappan, 1953, p. 106, pl. 20, figs. 1-3.

Single juvenile specimen found at station 050. Shows distinctive sutures bordered by a double row of pores and subacute periphery as illustrated by Loeblich and Tappan, 1953.

Genus ELPHIDIUM de Montfort, 1808

ELPHIDIUM BARTLETTI (Cushman)

Elphidium bartletti Cushman, 1933, p. 4, pl. 1, fig. 9.
Cushman, 1939, p. 64, pl. 18, fig. 10.
Loeblich and Tappan, 1953, p. 96, pl. 18, figs. 10-14.
Cooper, 1964, p. 95, pl. 6, figs. 1, 2.
Feyling-Hanssen, 1964, p. 343, pl. 21, figs. 1, 2.
Leslie, 1965, p. 160, pl. 8, figs. 10a, b.
Vilks, 1969, p. 50, pl. 3, fig. 12.
Gregory, 1971, p. 225, pl. 13, figs. 4-6.

Plate 7 fig. 5

Test large, lobulate, rounded periphery, umbilical area depressed; sutures distinct, depressed, gently curved; retral processes short and broad.

Widespread to depths of 350 metres, consisting of 3 % or less of the fauna except at station 018 where it constitutes 27 % of the total in 40 metres.

ELPHIDIUM CLAVATUM (Cushman)

Elphidium incertum (Williamson) var. clavatum
Cushman, 1930, p. 20, pl. 7, figs. 10a, b.
Cushman and Cole, 1930, p. 96, pl. 13, figs. 8, 9.
Cushman, 1939, p. 57, pl. 16, figs. 1, 2.
Cushman, 1944, p. 25, pl. 3, figs. 32, 33.
Cushman, 1948, p. 57, pl. 6, figs. 8a, b.
Parker, 1952a, p. 412, pl. 5, figs. 10, 11.
Phleger, 1952, p. 83, pl. 14, fig. 7.

Elphidium clavatum (Cushman)
Loeblich and Tappan, 1953, p. 98, pl. 19, figs. 8-10.
Cooper, 1964, p. 95, pl. 6, figs. 5-7.
Buzas, 1965a, p. 23, pl. 3, figs. 3a, b, 4a, b.
Buzas, 1966, p. 591, pl. 71, figs. 1-8.

Plate 7 fig. 6

Test large, periphery sub-acute. Commonly biumbonate with prominent elevated bosses, planispiral; sutures distinct, gently curved, distinct retral processes; walls translucent to transparent, finely perforate; aperture a line of pores at base of chamber face.

Found at 6 stations in depths to 150 metres in sand samples in concentrations of up to 7 %.

ELPHIDIUM FRIGIDUM (Cushman)

Elphidium frigidum Cushman, 1933, p. 5, pl. 1, fig. 8.
Cushman, 1939, p. 64, pl. 18, fig. 8.
Cushman, 1948, p. 57, pl. 6, figs. 9-11.
Loeblich and Tappan, 1953, p. 99, pl. 18, figs. 4-9.
Cooper, 1964, p. 95, pl. 6, figs. 3, 4.
Gregory, 1971, p. 227, pl. 14, fig. 3.

Plate 7 fig. 7

Test large, discoidal, planispiral, broad shallow umbilicus; final chambers inflated and appear to open out from the general direction of coiling; sutures distinct, slightly depressed and curved; walls calcareous and coarsely perforate.

Limited distribution in sand facies to depths of 250 metres in concentrations of up to 2.5 %.

ELPHIDIUM ORBICULARE (Brady)

Nonionina orbicularis Brady, 1881, p. 415, pl. 21, figs. 5a, b.

Nonion orbiculare (Brady)
Cushman, 1930, p. 12, pl. 5, figs. 1-3.
Cushman, 1939, p. 23, pl. 6, figs. 17-19.
Cushman, 1948, p. 53, pl. 6, fig. 3.

Elphidium orbiculare (Brady)
Loeblich and Tappan, 1953, p. 102, pl. 19, figs. 1-4.
Cooper, 1964, p. 95, pl. 5, fig. 21.
Gregory, 1971, p. 228, pl. 14, figs. 5, 6.

Plate 7 fig. 8

Test large, sides flat or gently concave, periphery rounded; chambers increase gradually in size, often with an arenaceous covering; sutures depressed and distinct, thicken and merge into granular and depressed umbilical area; aperture a linear series of pores at the base of the apertural face.

Similar distribution pattern to other Elphidiums except for extension to slightly deeper waters i.e. 336 metres at 023.

ELPHIDIUM SUBARCTICUM (Cushman)

Elphidium subarcticum Cushman, 1944, p. 27, pl. 3, figs. 34, 35.
Cushman, 1948, p. 58, pl. 6, fig. 12.
Parker, 1952a, p. 412, pl. 5, fig. 9.
Parker, 1952b, p. 449, pl. 4, figs. 3-6, 8.
LoeblLoeblich and Tappan, 1953, p. 105, pl. 19, figs. 5-7.
Feyling-Hanssen, 1964, p. 347, pl. 20, figs. 17-19.
Buzas, 1966, p. 593, pl. 72, figs. 7-10.
Gregory, 1971, p. 229, pl. 14, fig. 7.

Plate 7 fig. 9

Test large, periphery rounded, slightly lobulate, inflated final chamber, umbilicus depressed; sutures distinct, with small sutural pores flanked by wide opaque granular bands; apertural face contains a row of pores at base plus extra pores scattered over the face.

Relatively widespread occurrence at depths to 303 metres and concentrations to 7 % with the highest fractions in shallow sandy conditions.

Family CIBICIDIDAE Cushman, 1927

Subfamily CIBICIDINAE Cushman, 1927

Genus CIBICIDES de Montfort, 1808

CIBICIDES LOBATULUS (Walker and Jacob)

Nautilus lobatulus Walker and Jacob, 1798, p. 642, pl. 14, fig. 36.

Cibicides lobatula (Walker and Jacob)
Cushman, 1931, p. 118, pl. 21, figs. 3a-c.

Cibicides lobatulus (Walker and Jacob)
Parker, 1952a, p. 422, pl. 6, figs. 26a, b.
Parker, 1952b, p. 446, pl. 5, figs. 11a, b.
Phleger, 1952, p. 83, pl. 14, fig. 29.
Todd and Low, 1961, p. 21, pl. 2, fig. 20.
Cooper, 1964, p. 102, pl. 6, figs. 19, 20.
Feyling-Hanssen, 1964, p. 339, pl. 19, figs. 1-3.
Adams and Frampton, 1965, p. 58, pl. 5, fig. 10.
Leslie, 1965, pl. 10, figs. 6a-c.
Vilks, 1969, p. 50, pl. 3, figs. 17a, b.
Gregory, 1971, p. 231, pl. 15, figs. 1, 2.

Plate 7 figs Io,II

Test plano-convex, periphery generally rounded, slightly lobulate; many chambers, usually 7 in final whorl; sutures distinct, depressed slightly on the dorsal side; wall calcareous, opaque, perforate; aperture on the dorsal side at the inner margin of the final chamber. The irregular depressions on the ventral side of the test would seem to indicate that specimens were probably attached to substrate particles during life.

Widespread in its occurrence, 40-504 metres, especially prevalent in shallow sandy substrates, where it replaces the arenaceous forms as the dominant species, found in concentrations of up to 52 % of the foraminiferal population.

Family CAUCASINIDAE Bykova, 1959

Subfamily FURSENKOININAE Loeblich and Tappan, 1961

Genus FURSENKOINA Loeblich and Tappan, 1961

FURSENKOINA FUSIFORMIS (Williamson)

Bulimina pupoides var. fusiformis
Williamson, 1858, p. 63, pl. 5, figs. 129, 130.

"Bulimina fusiformis (Williamson)
Hoglund, 1947, p. 232, pl. 20, fig. 3, text-figs. 219-233.

Virgulina fusiformis (Williamson)
Parker, 1952a, p. 417, pl. 6, figs. 3-6.
Parker, 1952b, p. 461, pl. 4, fig. 10.
Phleger, 1952, p. 87, pl. 14, figs. 15, 16.
Feyling-Hanssen, 1954, p. 132, pl. 1, fig. 13.
Feyling-Hanssen, 1964, p. 307, pl. 14, figs. 15-18.
Buzas, 1965b, p. 61, pl. 3, fig. 7.

Plate 7 fig. 12

Test small, elongate, slender, fusiform, slightly compressed; chambers increase rapidly in size, inflated, biserially arranged; sutures distinct, depressed; wall hyaline, thin, finely perforate; aperture terminal.

Juvenile forms show some similarity to F. Schreibersiana as illustrated by Feyling-Hanssen (1964).

Limited numbers found at depths 110-154 metres.

Family NONIONIDAE Schultze, 1854

Subfamily NONIONINAE Schultze, 1854

Genus ASTRONONION Cushman and Edwards, 1937

ASTRONONION GALLOWAYI (Loeblich and Tappan)

Astrononion stellatum Cushman and Edwards, 1937, p. 32, pl. 3, figs. 9-11.
Cushman, 1939, p. 36, pl. 10, figs. 3-5.
Cushman and McCulloch, 1940, p. 168, pl. 18, fig. 11.
Cushman and Todd, 1947, p. 13, pl. 2, fig. 15.
Parker, 1952a, p. 410, pl. 5, figs. 2, 3.
Leslie, 1965, p. 156, pl. 7, figs. 9a, b.

Astrononion gallowayi Loeblich and Tappan,1953, p. 90, pl. 17, figs. 4-7.
Feyling-Hanssen, 1954, p. 139, pl. 2, fig. 9.
Feyling-Hanssen, 1964, p. 332, pl. 18, fig. 4.
Vilks, 1969, p. 51, pl. 3, fig. 19.
Gregory, 1971, p. 232, pl. 15, fig. 3.

Plate 8 figs I,2

Test planispiral, involute, compressed, periphery rounded, slightly lobulate; 7-9 chambers in the final whorl, umbilical area slightly depressed; wall hyaline, perforate; aperture at the base of the final chamber.

Distribution very similar to Cibicides lobatulus except in generally smaller percentages, highest frequency 17 % at station 017.

Genus NONIONELLA Cushman, 1926

NONIONELLA AURICULATA(Heron-Allen and Earland)

Nonionella auriculata Heron-Allen, 1930, p. 192, pl. 5, figs. 68-70.
Cushman, 1939, pl. 9, figs. 7-9.
Cushman, 1944, p. 25, pl. 3, figs. 26, 27.
Parker, 1952a, p. 413, pl. 5, figs. 13a, b, 14a, b.
Loeblich and Tappan, 1953, p. 92, pl. 16, figs. 6-10.
Todd and Bronniman, 1957, p. 32, pl. 5, fig. 32.
Cooper, 1964, p. 95, pl. 5, fig. 20.
Feyling-Hanssen, 1964, p. 327, pl. 16, figs. 21-23.
Leslie, 1965, p. 164, pl. 7, figs. 7a-c.
Gregory, 1971, p. 233, pl. 15, fig. 6.

Plate 8 fig. 3

Test compressed, ovate, periphery rounded, chambers increase rapidly in size, 8-11 in the final whorl, final chamber inflated; walls thin, hyaline, perforated; aperture at the base of the final chamber.

Limited distribution, found mainly in shallow water and sandy substrates.

NONIONELLA TURGIDA (Williamson)

Rotalina turgida Williamson, 1858, p. 50, pl. 4, figs. 95-97.

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

Nonionella turgida (Williamson)
Cushman, 1930, p. 15, pl. 6, figs. 1-4.
Cushman, 1939, p. 32, pl. 9, figs. 2, 3.
Feyling-Hanssen, 1954, p. 137, pl. 2, fig. 6.
Todd and Bronniman, 1957, p. 32, pl. 6, figs. 3, 4.
Boltovskoy, 1959, p. 76, pl. 10, fig. 12.
Feyling-Hanssen, 1964, p. 328, pl. 17, figs. 2-6.

Plate 8 fig. 4

Similar to N. auriculata but distinguished by an inflated, asymmetrical last chamber which overlaps all previous chambers.

Found at stations 022, 023 and 026 in small numbers.

Genus NONIONELLINA Voloshinova, 1958

NONIONELLINA LABRADORICA (Dawson)

Nonionina labradorica Dawson, 1860, p. 191, fig. 4.

Nonionina scapha (Fichtel and Moll) var. labradorica
Dawson, 1870, p. 177, fig. 5.

Nonion labradorica (Dawson)
Cushman, 1930, p. 11, pl. 4, figs. 6-12.

Nonion labradoricum (Dawson)
Cushman, 1939, p. 23, pl. 6, figs. 13-16.
Phleger, 1939, p. 1403, pl. 2, figs. 13, 14.
Cushman, 1944, p. 24, pl. 3, fig. 23.
Cushman, 1948, p. 52, pl. 6, fig. 2.
Parker, 1952a, p. 413, pl. 5, fig. 12.
Phleger, 1952, p. 85, pl. 14, fig. 5.
Loeblich and Tappan, 1953, p. 86, pl. 17, figs. 1, 2.

Nonionellina labradorica (Dawson)
Barbieri and Medioli, 1969, p. 861, pl. 62, figs. 4a-c.
Vilks, 1969, p. 51, pl. 3, figs. 20a, b.
Gregory, 1971, p. 234, pl. 15, figs. 4, 5.

Plate 8 figs 5,6

Test planispiral, involute, biconvex, biumbonate; chambers increase rapidly in size as added, 6-8 in final whorl; sutures distinct, slightly depressed; walls hyaline, perforate; aperture a slit at the base of the apertural face.

Widespread coverage over a depth range 110-504 metres. Found in high percentages where the total fauna is sparse e.g. 24 % at station 063.

Family ANOMALINIDAE Cushman, 1927

Subfamily ANOMALININAE Cushman, 1927

Genus MELONIS De Montfort, 1808

MELONIS ZAANDAMI (Van Voorthuysen)

Nonionina barleena Williamson, 1858, p. 32, pl. 3, figs. 68, 69.
Cushman, 1948, p. 54, pl. 6, fig. 4.

Nonion pompiloides (Fichtel and Moll)
Cushman, 1930, p. 4, pl. 2, figs. 1, 2 (not pl. 1, figs. 7-11).
Feyling-Hanssen, 1954, p. 137, pl. 2, fig. 7.

Anomalinoides barleeanum (Williamson) var. zaandamae
Van Voorthuysen, 1952, p. 681.

Nonion zaandamae (Van Voorthuysen)
Loeblich and Tappan, 1953, p. 87, pl. 16, figs. 11, 12.

Nonion barleeanum (Williamson)
Feyling-Hanssen, 1964, p. 329, pl. 17, figs. 7-12.

Melonis zaandami (Van Voorthuysen)
Leslie, 1965, p. 164, pl. 7, figs. 10a, b.
Vilks, 1969, p. 51, pl. 3, figs. 21a, b.

Plate 8 figs 7,8

Test medium, planospiral, involute, biumbilicate, periphery rounded; 9-12 chambers in the final whorl; umbilicus open, sutures distinct, curved; walls hyaline, coarsely perforate; aperture a slit at the base of the final chamber.

Widely distributed in silty sands and sandy silts. Most abundant in depths in excess of 250 metres. May comprise up to 10 % of the total population.

Family ROBERTINIDAE Reuss, 1850

Genus ROBERTINOIDES Hoglund, 1947

ROBERTINOIDES CHARLOTTENSIS (Cushman)

Cassidulina charlottensis Cushman, 1925, p. 41, pl. 6, figs. 6, 7.

Robertina charlottensis (Cushman)
Cushman and Parker, 1936, p. 97, pl. 16, figs. 12a, b.
Walton, 1955, p. 1014, pl. 102, figs. 11, 12.

Robertinoides charlottensis (Cushman)
Uchio, 1960, p. 62, pl. 4, fig. 29.
Leslie, 1965, p. 170, pl. 9, figs. 5a, b.
Vilks, 1969, p. 51, pl. 3, fig. 22.
Gregory, 1971, p. 236, pl. 15, fig. 7.

Plate 8 figs 9,I0

Test elongate, spiral, twice as long as broad, initial end bluntly pointed, distal end rounded; sutures distinct, very slightly depressed; chambers increase slowly in size as added; wall calcareous, smooth; aperture elongate, open, extending half way up the apertural face; supplementary aperture elongate, short and at an acute angle to the main aperture.

Some specimens are difficult to distinguish from Hoglund's (1947) Robertina arctica.

Found in small numbers at 12 stations in depths 90-455 metres.

Family GLOBIGERINIDAE Carpenter, Parker and Jones, 1862

Subfamily GLOBIGERININAE Carpenter, Parker and Jones, 1862

Genus GLOBIGERINA d'Orbigny, 1826

GLOBIGERINA PACHYDERMA (Ehrenberg)

Aristerospira pachyderma Ehrenberg, 1861, p. 303

Globigerina bulloides d'Orbigny, arctic var.
Brady, 1878, p. 435, pl. 21, fig. 10.

Globigerina pachyderma (Ehrenberg)
Brady, 1884, p. 600, pl. 114, figs. 19, 20.
Parker, 1962, p. 224, pl. 1, figs. 26-35.

Globigerina borealis (Brady)
Banner and Blow, 1960, p. 4, pl. 3, fig. 4.

Globigerina pachyderma (Ehrenberg)
Be, 1960, p. 66, text-fig. 1.

Plate 8 figs II,I2

Test trochospiral, chambers spherical, 4 to 4½ chambers in the final whorl; walls calcareous, smooth, perforate; aperture umbilical, interiomarginal.

Found in very small numbers at 14 stations in depths 113-379 metres. Found in large numbers at station 026 in sediments recovered from a dredge haul up a steep channel wall.

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APPENDIX 1

Sediment Analyses. Percentages of sand,

silt and clay size material at each station.

Station	% Sand	% Silt	% Clay
017	95.40	1.58	3.02
018	99.00	0.32	0.68
019	96.40	2.30	1.30
020	84.60	12.15	3.25
021	71.90	22.69	5.41
022	75.30	18.78	5.92
023	73.30	19.94	6.76
024	26.70	53.87	19.43
026	48.40	17.07	34.53
027	1.02	54.17	44.81
028	42.97	50.57	6.46
029	52.79	37.26	9.95
030	64.80	20.53	14.67
031	62.91	21.50	15.59
032	72.23	16.37	11.40
033	45.08	36.24	18.68
034	67.81	21.74	10.45
035	30.81	45.86	23.33
036	68.73	22.55	8.72
037	66.97	22.20	10.83
038	59.51	28.63	11.86
039	58.03	33.75	8.22
040	51.45	32.47	16.08
041	54.22	44.66	1.12
042	74.35	21.58	4.07
043	76.35	17.69	5.96
044	92.04	4.97	2.99
045	96.06	2.07	1.87
046	61.17	29.23	9.60
047	0.78	62.32	36.90
048	29.15	55.09	15.76
049	33.86	44.62	21.52
050	1.43	72.34	26.23
051	43.17	43.93	12.90
056	86.06	10.15	3.79
057	79.15	14.10	6.75

APPENDIX 1

(cont.)

Station	% Sand	% Silt	% Clay
058	66.82	23.96	9.22
059	71.42	21.81	6.77
060	73.61	20.64	5.75
061	77.59	17.28	5.13
062	83.30	11.79	4.91
063	0.48	74.68	24.84
064	39.39	40.79	19.82
065	43.64	38.43	17.93
066	19.84	50.77	29.39

APPENDIX 2

Sand Size Fraction
(after Inman 1952)

Station	Mean diameter Ø	Standard deviation	Station	Mean diameter Ø	Standard deviation
017	1.89	0.59	041	1.74	1.21
018	1.34	0.47	042	3.16	0.31
019	2.75	0.43	043	2.88	0.49
020	2.75	0.62	044	2.96	0.30
021	1.31	1.87	045	1.74	0.86
022	2.92	0.52	046	2.84	0.69
023	2.88	0.61	047	2.21	1.41
024	2.46	1.01	048	1.06	2.06
026	1.44	1.44	049	1.25	1.87
027	1.85	1.54	050	2.36	1.11
028	2.16	1.32	051	1.36	2.22
029	2.00	1.39	056	1.77	1.19
030	2.25	1.03	057	2.81	0.66
031	1.77	1.46	058	3.04	0.44
032	1.87	1.20	059	2.11	1.26
033	2.42	0.92	060	2.60	0.86
034	1.32	1.42	061	1.84	1.36
035	0.71	2.47	062	2.48	0.72
036	1.71	1.46	063	2.17	1.53
037	1.47	1.57	064	2.17	1.12
038	1.58	1.53	065	1.80	1.27
039	0.46	2.36	066	1.41	1.65
040	1.90	1.23			

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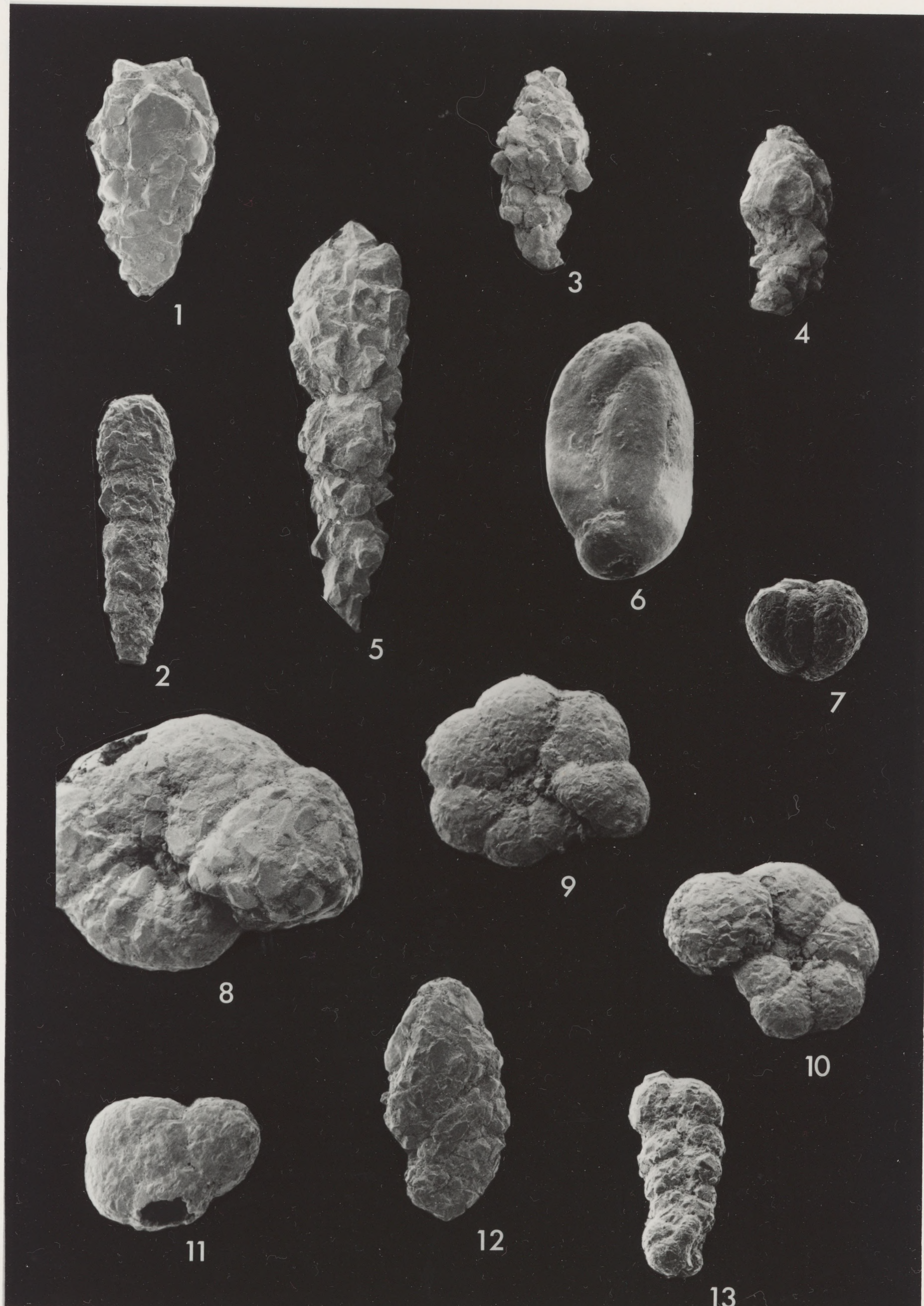
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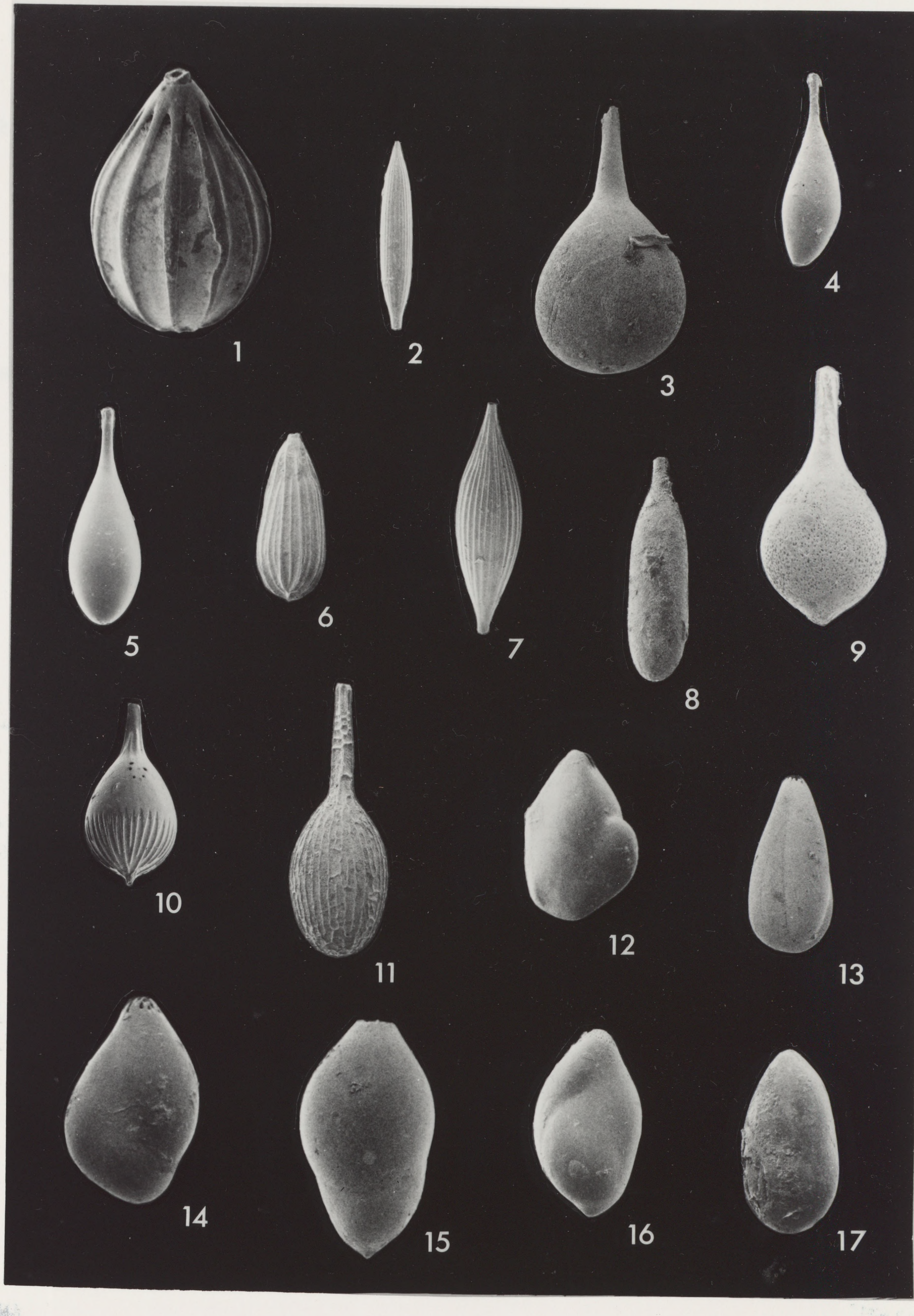
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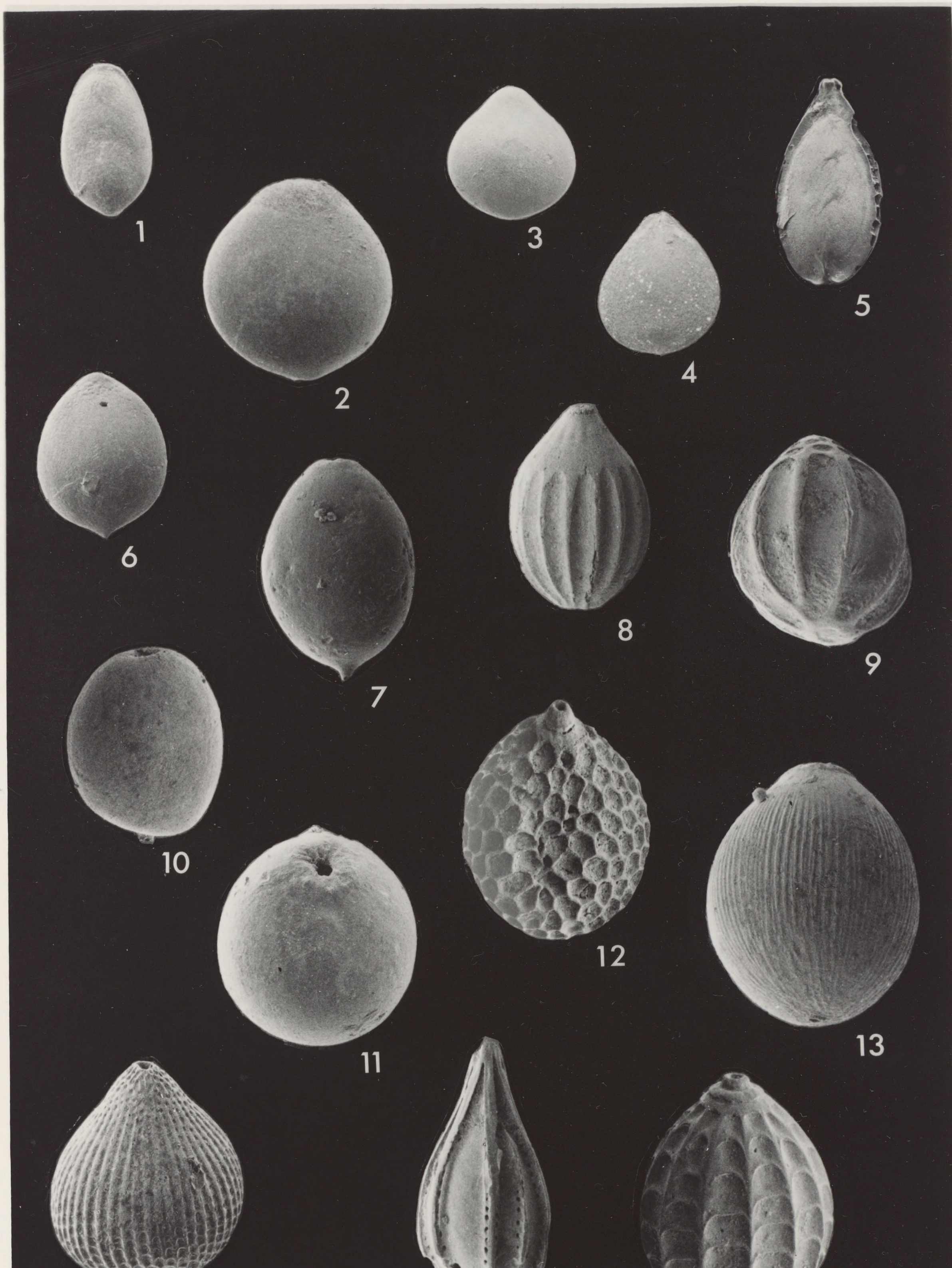
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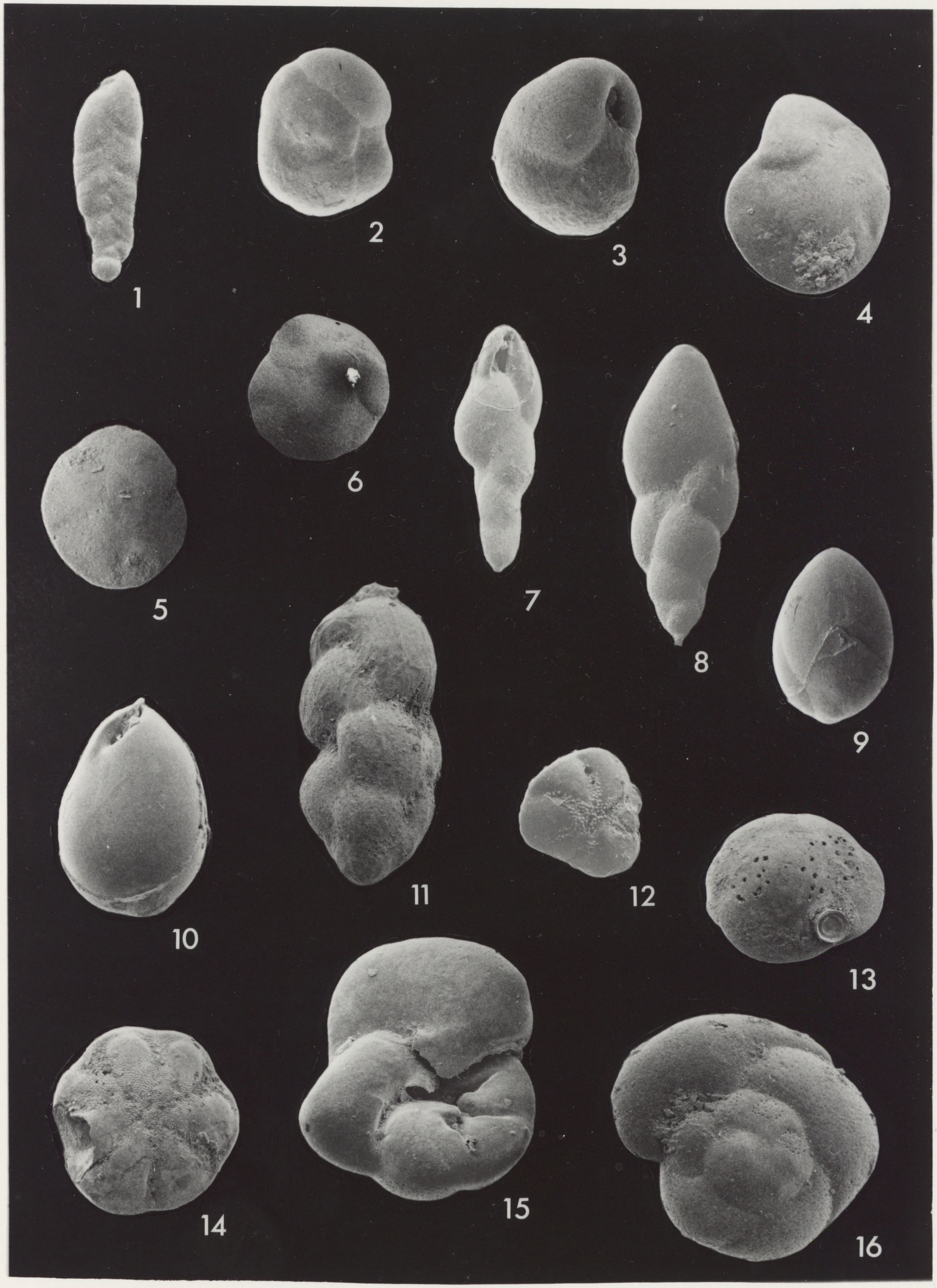
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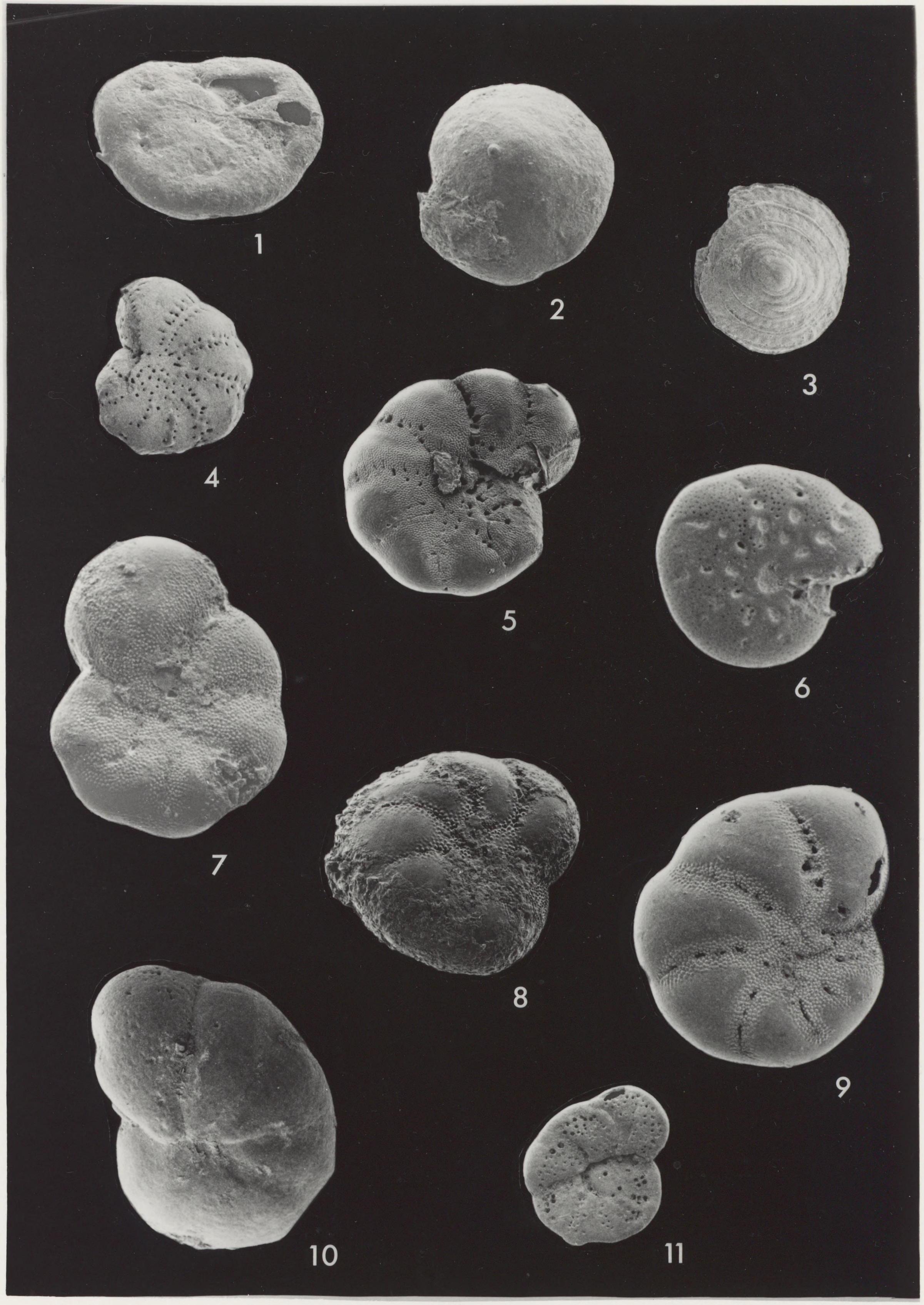
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