Foraminifera of the Minas Basin
and Their Distributions

by

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Submitted in partial fulfillment of the requirements for the degree of Bachelor of Science (Honours)

at

Dalhousie University
Halifax, Nova Scotia

- August 31, 1977

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Dalhousie University, Department of Geology

B.Sc. Honours Thesis

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Abstract

One hundred and twenty-one samples of surficial sediment from all parts of the Minas Basin are analysed for foraminiferal content. Thirty-nine species are identified and described and maps of distribution are presented.

This survey represents the first study of its kind in this area, and so establishes a much-needed baseline for further foraminiferal work in the Minas Basin.

It is found that the distributions of the species may be primarily controlled either by the strength of the test of each species or by the swift removal of fragile forms from certain areas. Species with robust or attached tests are usually widespread in the study area, while those with thin, fragile tests are characteristically more restricted to lower-energy areas of the Minas Basin, such as the shallow-water near shore areas.

Acknowledgements

First of all, I wish to thank Dr. Charles Schafer for the original idea for this thesis, and for his work with the computer program. Also I wish to thank Dr. Barnard Long for his information on carbonates in the Minas Basin and especially to Mr. Bahn Deonarine for his patience and skill with the scanning electron microscope. (Dr. Schafer, Dr. Long and Mr. Deonarine are all with the Atlantic Geoscience Centre at Bedford Institute of Oceanography, Dartmouth, Nova Scotia.)

Thanks also go to Dr. Franco Medioli, my supervisor, for all his time and effort, and to Mr. David Scott for all sorts of useful suggestions and information.

Finally, I wish to thank Mrs. Lane Thomas for undertaking such a large typing job on such very short notice and Ms. Judy Haynes for her moral support during a very long effort.

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Introduction

The purpose of this study is to identify species of foraminifera in the surficial sediments of the Minas Basin and to determine what parameters affect their patterns of distribution. The samples were made available by the Atlantic Geoscience Centre at Bedford Institute of Oceanography, Dartmouth, Nova Scotia.

Sample sites represent some of the intersections of an imaginery grid placed over the Minas Basin with approximately twenty lines running north-south and an approximately equal number running east-west. This means that the sample sites are usually less than one mile apart.

Sample sites for this survey were chosen from the nearly three hundred available. As chosen in Fig. 1, most have been chosen from near-shore localities, with fewer towards the center of the Basin. This is because most of the samples from the latter area were unsuitable for foraminiferal study, being composed largely of pebbles and cobbles.

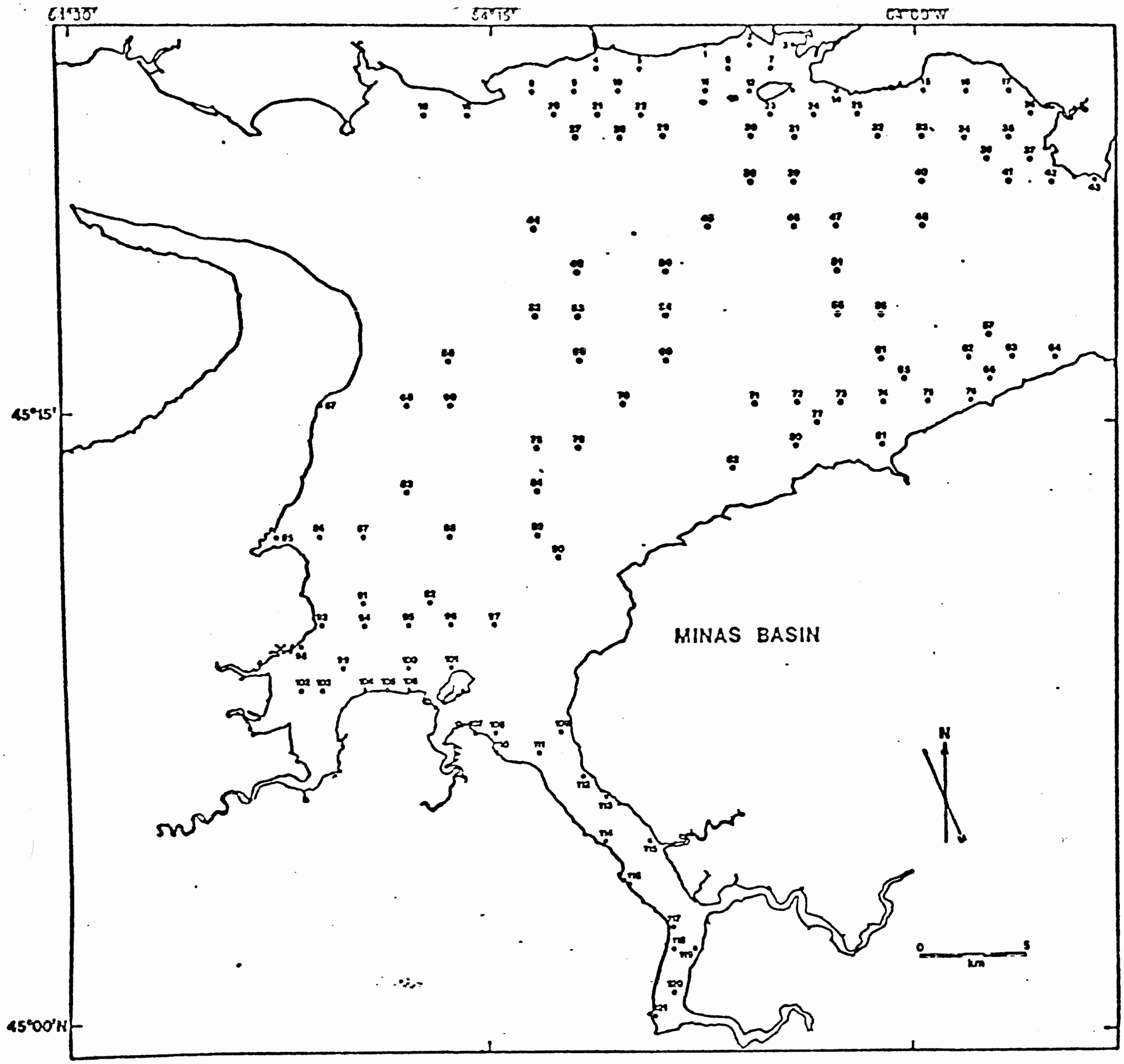

Fig. 1. Map showing sample locations.

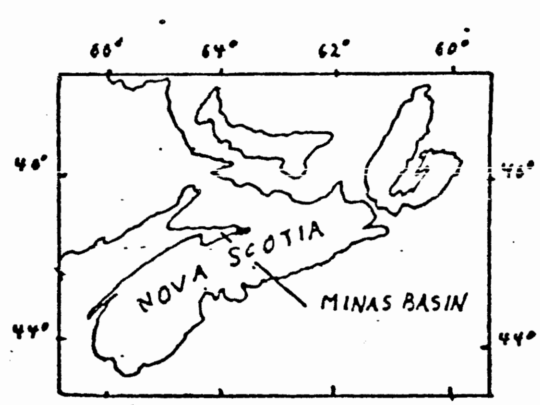

Fig. 2. Map showing location of study area.

Previous Work and Purpose of this Study

Previous foraminiferal study of the Minas Basin is limited to examinations of 5 vibrocores taken from C.S.S. "Dawson" during the cruise which collected some of the grab samples for this survey, (Amos et al., 1976). The results of these examinations show that those samples may include middle Holocene or older material (Amos et al., 1976).

Samples from all stations included in Amos et al., (1976) were examined for sedimentological data and salinity. Tidal current readings were also taken.(Amos and Joice, 1977). A detailed examination of the results of this study is in a following chapter.

The importance of the present study becomes apparent when one considers this lack of previous material.

First of all, the Minas Basin is the only large body of salt water in the Atlantic Canada region which has not been examined for foraminifera, therefore a taxonomic investigation is in order.

Secondly, this study will form a valuable reference for a record of what foraminifera were to be found in the Minas Basin in 1976, so that if manmade alterations were to occur in this environment, (for example as the result of a tidal power dam being installed) a clear record of changes in the foraminiferal assemblage of the study area could easily be obtained.

Thirdly, the Minas Basin is a unique environment (see section on Minas Basin, page 7) and a record of what species of foraminifera are found there could furnish more data on the ecology of some of these species.

Methods

Samples from the deeper-water portions of the Minas Basin were collected in the late May, 1976 by C.S.S. "Dawson" using a medium Van Veen grab. (Amos et al. 1976). Those from shallower water were collected by the "Oran II" and samples from intertidal areas and the Avon River were taken either on foot with a spade or from an inflatable boat with a small grab.

(Unfortunately the samples were not stained at the time of collection with rose bengal nor were they preserved with formaldehyde at any time, so it could not be determined what tests represented living animals when they were examined. Of course this omission places restrictions on much speculation regarding the distributions of the species encountered.)

The samples were then washed through a 63 - micron sieve, and the coarse fraction was dried and weighed. This fraction was then concentrated for foraminiferal content using the carbon tetrachloride method described by Bandy (1954). These concentrated residues were then examined under the microscope, and those with large numbers of foraminifera were split repeatedly (using an Otto microsplitter) until a manageable number of foraminifera was left (usually about 300 - 500).

Foraminifera were counted in each sample and relative abundances of the various species were calculated (see Appendix II and III). The number of foraminifera in the samples varied widely ranging from 1 in samples # 56, # 107 and # 121 to over 33,000 in sample # 118.

For the purposes of this study I have given new numbers to all the samples used, as the original numbers in the form of co-ordinates on a grid system was found to be impractical. The original station numbers for the survey are given in Appendix II.

The photomicrographs of the foraminifera were obtained on the scanning electron microscope at Bedford Institute of Oceanography in June of 1977. Magnifications were indicated by the machine, then recalculated for the reduced size of the plates from the originals.

Eighty of the samples were chosen to include in a dendrogram generated by the Jaccards coeifficients of association unweighted pair-group method run through the computer at Bedford Institute of Oceanography. The results of this exercise proved inconclusive, indicating a diffuse pattern of distribution for the species used, and so will not be used in this work.

The Minas Basin

The Minas Basin is an approximately triangular body of salt water, measuring about 40 km along the northern shore, 45 km along the southeastern shore and 35 km along the western shore. It lies between the land mass comprising the Isthmus of Chignecto on the north, and the peninsular part of Nova Scotia on the west and south. At its eastern extremity, marked by Economy Point on the north shore, the Minas Basin flows into the long, narrow body of water known as Cobequid Bay, but the survey area ends at Economy Point. To the west the Minas Basin connects to the larger Bay of Fundy through a relatively narrow (5 km) channel called the Minas Passage. The entrance to this channel has the deepest water in the Basin, measuring 112 m at one station (Amos et al., 1976).

Near Economy Point the water depth is approximately 30 m (Amos et al., 1976) and the westward depth gradation to the Minas Channel appears fairly steady.

At the southern tip of the Basin the Avon River enters. By the outward appearance of this river one would suspect it to be well laden with suspended sediment and the patterns of sediment distribution throughout the bottom would tend to support this hypothesis.

A full range of sediment types is found in the Minas Basin, ranging from the silty muds found near the mouth of the Avon River to the bedrock of the bottom in the Minas Channel. Most of the survey area was found to be composed of coarse sand, pebbles and cobbles. Amos et al (1975) report that in many cases the jaws of the grab remained ajar during the raising process because of cobbles in them, thereby losing much of the finer sediment. For a map showing distributions of sediment types in the study area, see Fig. 3. Much of the sediment in the Basin appears to be derived from rapid erosion of the high, steep cliffs found in many places along the shores. (Amos and Joice, 1977). A wide band of intertidal mud and sand flats, in many places being more than 1.0 km across, border the water's edge. The very high tidal range (up to 16.3 m; Amos and Joice, 1977) accounts for such extensive exposures.

Although much sediment is contributed each year to the Minas Basin through erosion and river output, there is a net sediment loss due to tidal action (i.e. sediment is continually washed out into the Bay of Fundy through the Minas Passage).

Tidal action is the most striking feature of the Minas Basin, generating currents with speeds in excess of 1.0 m/sec. along the bottom. As shown in Fig. 4, these currents flow generally east or west (depending on the tidal phase)

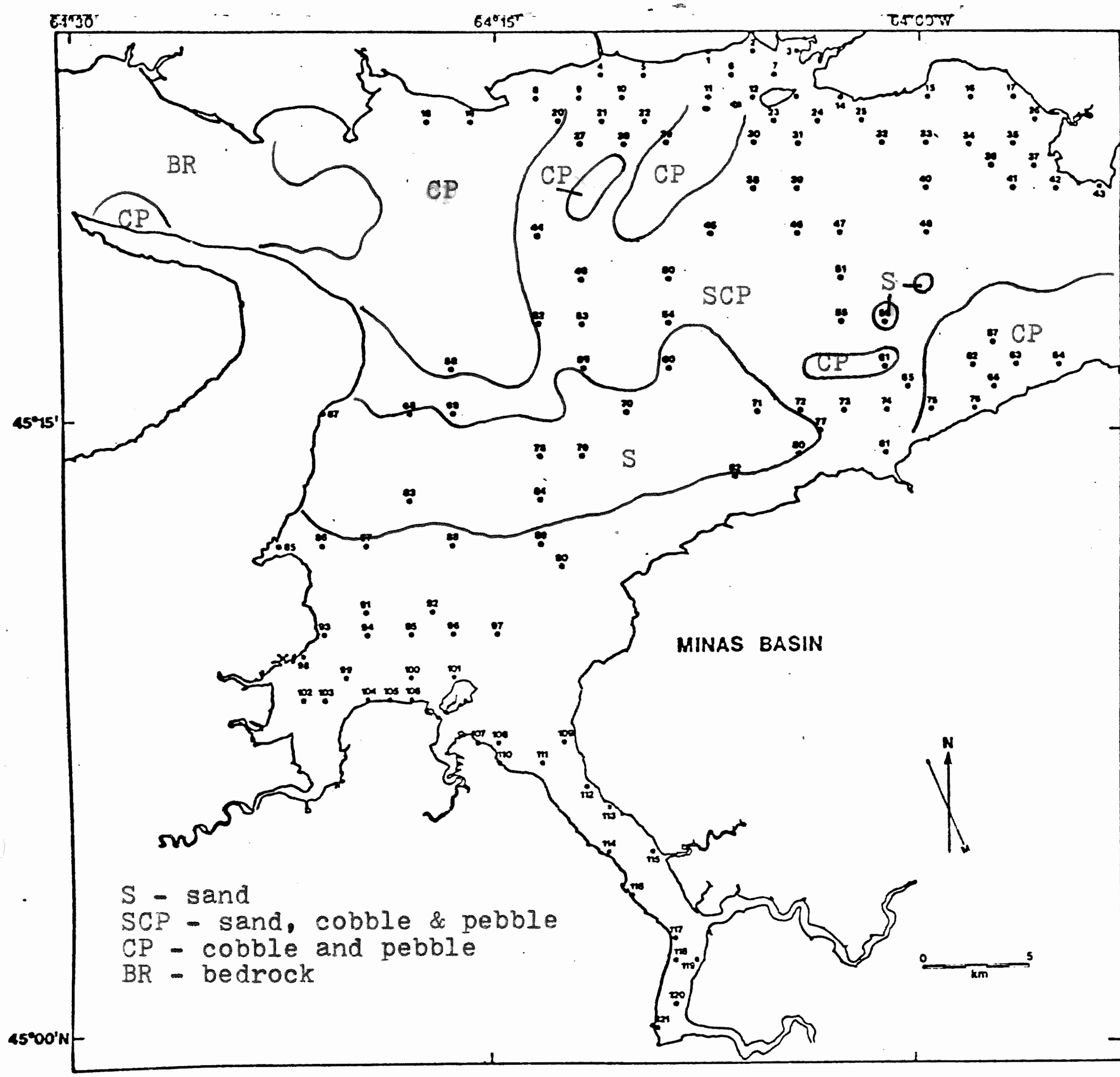

Fig. 3. Distribution map of bottom sediment size, based on hand specimen observation. (After Amos et al, 1976).

in the northern section of the Basin, and north-south in the southern part. Given these speeds, the currents are quite strong enough to move sediment particles up to cobble size, and, as noted previously, the Minas Passage, where tidal currents are strongest, has a floor of bare bedrock.

Salinities in the Minas Basin vary from 27 - 31% with the lower readings near the entrance to Cobequid Bay and the mouth of the Avon River, as would be expected. (Amos and Joice, 1977). There is little variation in salinity with depth at the stations tested, but the lowest readings for all the stations are at low tide.

Dr. Bernard Long of the Atlantic Geoscience Centre in Bedford Institute of Oceanography, is, at the time of this writing, working on calcium carbonate concentrations in the sediments of the Minas Basin and has kindly provided this author with the information necessary to compile a map showing carbonate distribution (Fig. 5). As shown, there are only five widely scattered locations where the carbonate makes up more than 10% of the sediment, and in the remainder of the area the concentrations are much lower.

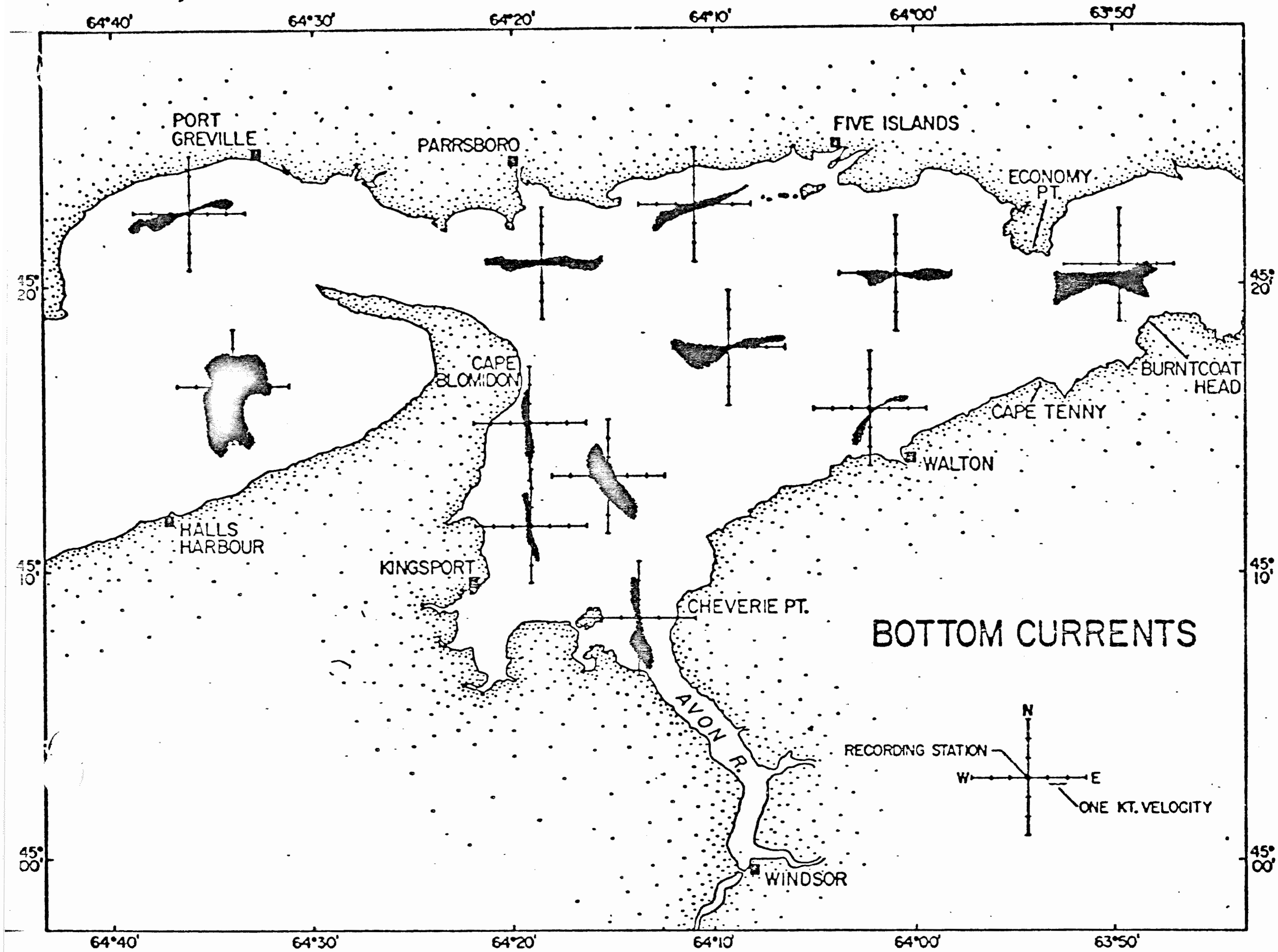

Fig. 4. Rose diagram plots of the current speed and direction, measured above the seabed, at each of the offshore locations, studied by Amos and Joice, 1977. (From Amos and Joice, 1977).

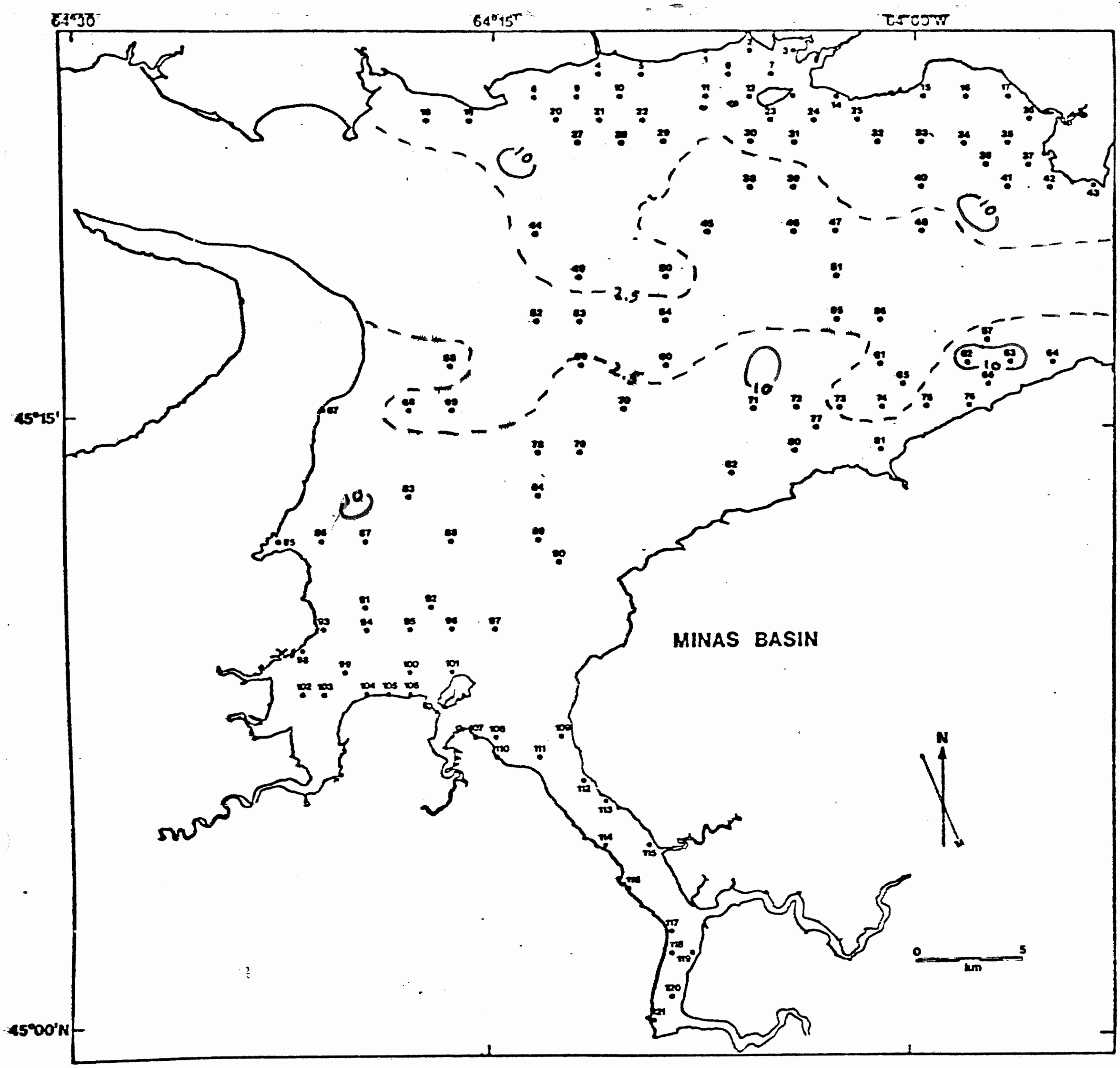

Fig. 5. Map showing concentrations of carbonates (in percentages) of sediments in Minas Basin. (Courtesy of B. Long, Atlantic Geoscience Centre).

Distributions of Species and Interpretations

Maps showing the distributions of some of the more common species in the study area have been compiled and are presented as figs. 6 - 26 in this section.

From these maps it seems clear that the species shown fall into three main categories. The first of these contains such forms as *Milliammina fusca* (fig. 6), those of the genus *Lagena* (fig. 13), those of the genus *Oolina* (fig. 14), and species of the genus *Bolivina* (fig. 15). All of these types appear in only relatively small numbers of samples, usually more often in near-shore environments. In fact, the only genus completely restricted to very shallow or intertidal areas is *Lagena*. Significantly, the members of this genus found in the Minas Basin all have light, rather fragile tests. On the other hand, *Milliammina fusca*, and members of the genera *Bolivina* and *Oolina* all have relatively stronger tests. This would seem to indicate that the ability to withstand abrasion may play an important role in determining how widespread a distribution any given species may attain in the Minas Basin.

The second category contains those forms which are found in many near-shore samples (especially near the mouth of the Avon River) and in at least a few samples from the central portions of the Basin. This group includes _Trochammina inflata_ (fig. 7), _T. lobata_,(fig. 8), _T. ochracea_ (fig. 9), members of the genus _Islandiella_ (fig. 16), _Trifarina angulosa_ (fig. 17), _Rosalina columbiensis_ (fig. 18), _Bucella frigida_ (fig. 19), _Elphidium margaritaceum_ (fig. 23), and the planktonic foraminifera (fig. 26). These are mostly rather robust forms with tests that can apparently survive even the strong currents and vigorous abrasion in the central parts of the Basin. In this group however, there are a few exceptions. _Rosalina columbiensis_ (fig. 18), _Bucella frigida_ (fig. 19), and the planktonic forms, (fig. 26), seem equally scarce in both environments, despite their being small, relatively fragile forms. Perhaps these small forms are carried into upper water layers during transport and so avoid the abrasion on the bottom, as reported by some other workers (Boltovsky, 1976).

The third and final group includes those forms with widespread distributions throughout the study area. _Eggerella advena_ (fig. 10), _Quinqueloculina seminulum_ (fig. 11), _Pyrgo williamsoni_ (fig. 12), _Ammonia beccarii_ (fig. 20), _Elphidium clavatam_ "_complex_" (fig. 21), _Elphidium frigidum_ (fig. 22), _Elphidium subarcticum_ (fig. 24), and _Cibicides lobatulus_ (fig. 25) all belong to this group.

With only one exception these are species with characteristically strong, robust tests. That exception is *Elphidium frigidum*, which in this study area was usually one of the smallest and most fragile forms. It may be inferred in the light of this fact that members of this species are also carried up into upper water layers by the strong currents, much like the tests of *Rosalina columbiensis* and *Bucella frigida*.

Before we progress any further, a brief summary of how foraminiferal tests behave before and after the death of the organism would seem to be in order here.

Almost all of the foraminiferal species described in this study are benthonic forms which live on the surface of the substrate. Two of them, *Cibicides lobatulus* and *Rosalina columbiensis* live firmly attached to the bottom, the former to inorganic material, the latter to marine plants. (Medioli, personal communication). All benthonic forms, however, are loosened from the substrate upon death and may then behave more or less like a sand grain of comparable size in a turbid environment. In effect, this means that the empty tests would be subjected to abrasion by being rolled around on the bottom by tidal currents (Boltovsky, 1976). (For a further elaboration of this idea, the reader is referred to Langhus et al, 1972).

It is not known with certainty how far these dead tests could be transported in the Minas Basin, but given the very strong tidal currents observed there, it is not unreasonable to suppose that tests originating in a near-shore environment could in fact find their way to the central parts of the Basin.

This hypothesis is supported by the distribution of Rosalina columbiensis. Given the observed preference exhibited by this species for being attached to marine plants, the species could only live in very near-shore localities in the Minas Basin, because the marked turbidity of the water (Amos and Joice, 1977) would prevent plant growth in the deeper waters of the Basin. Yet Rosalina columbiensis (fig. 19) is found even in samples from quite deep water, indicating extensive transport of the tests of at least this species.

Finally, the patterns of distribution for all of the species found seem to bear little or no relation to salinities, calcium carbonate concentrations (see fig. 5) on to type of bottom sediment (see fig. 3).

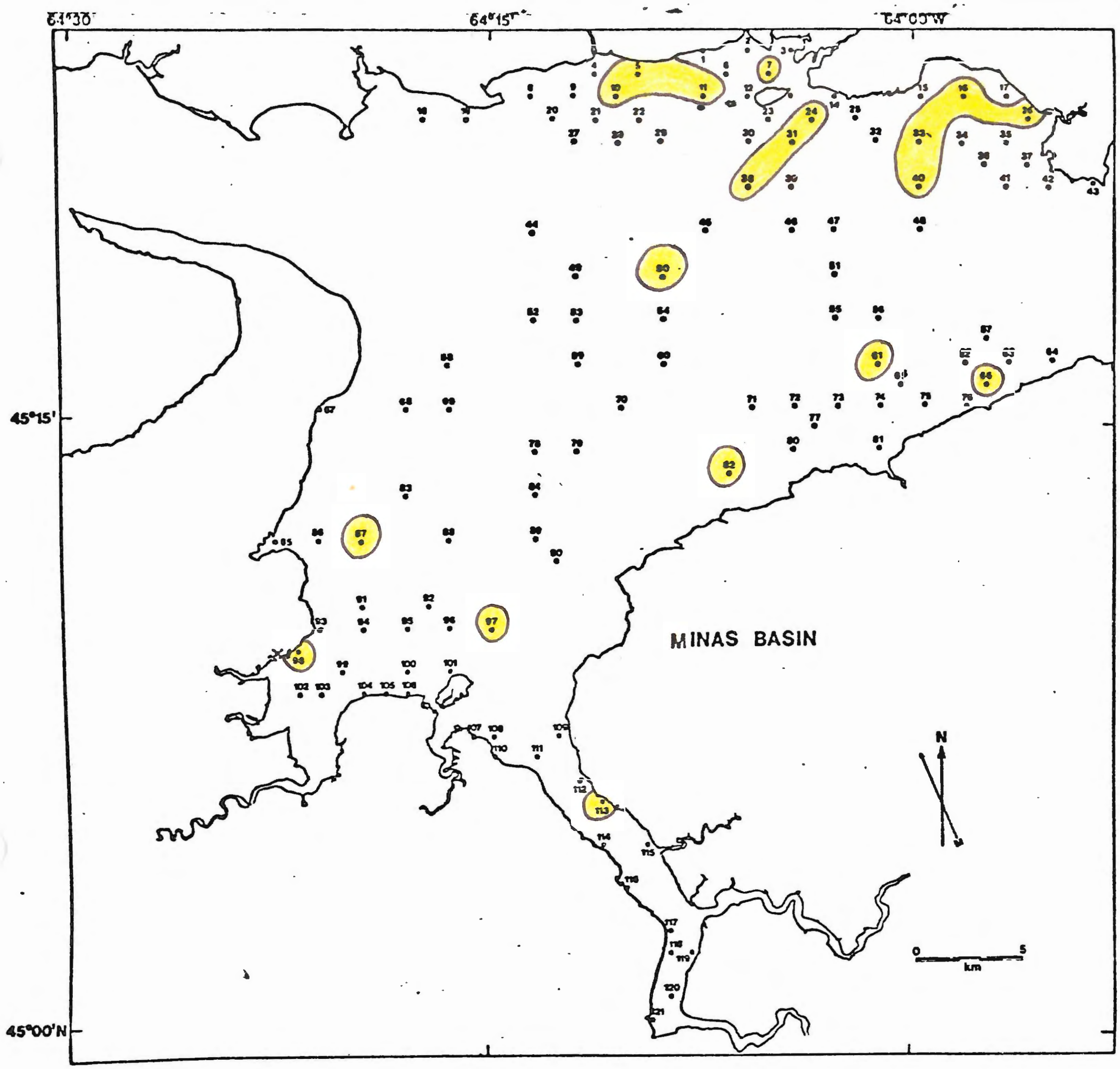

Fig. 6. Distribution of Miliammina fusca

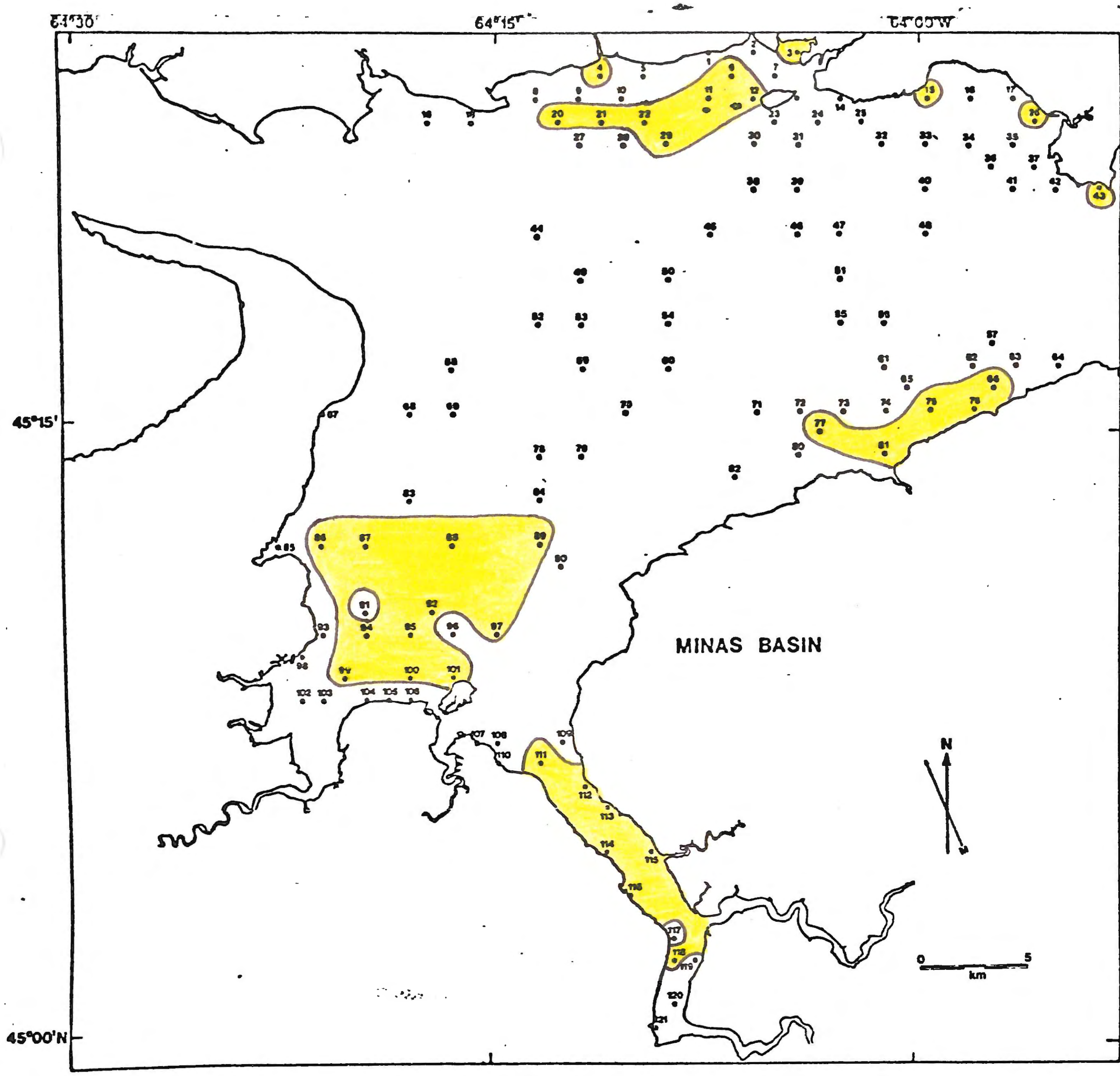

Fig. 7. Distribution of Trochammina inflata.

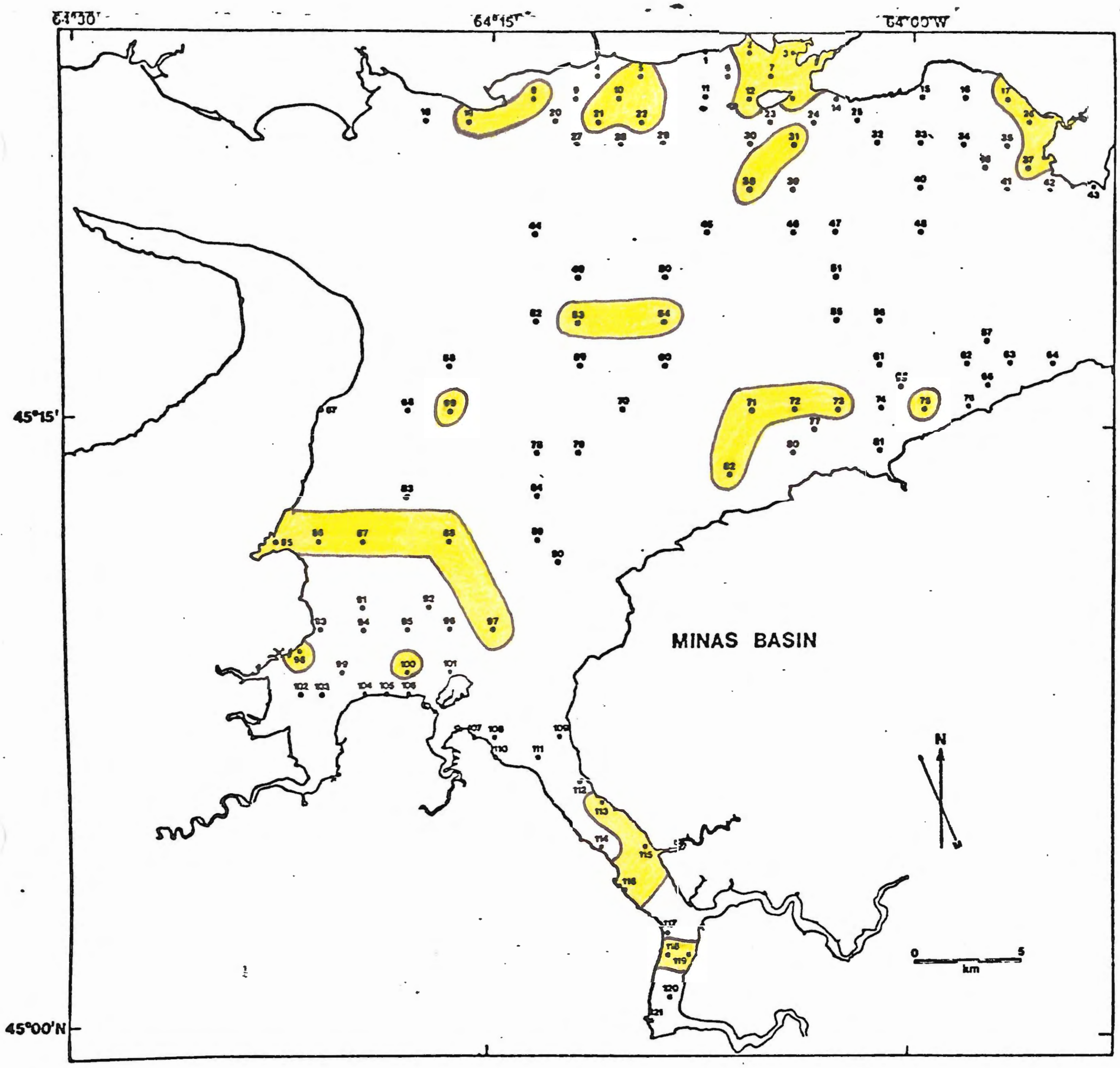

Fig. 8. Distribution of Trochammina lobata.

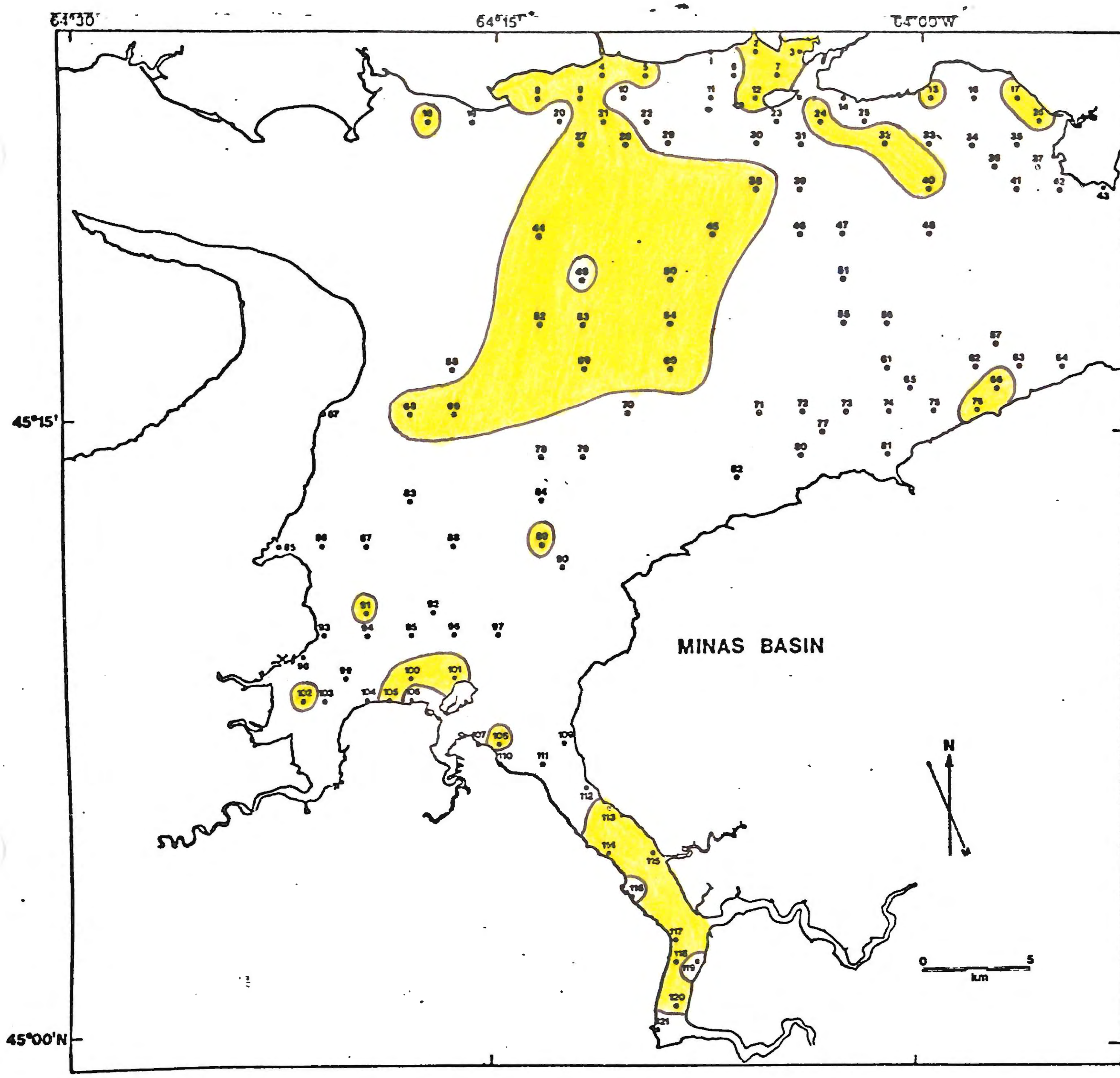

Fig. 9. Distribution of Trochammina ochracea.

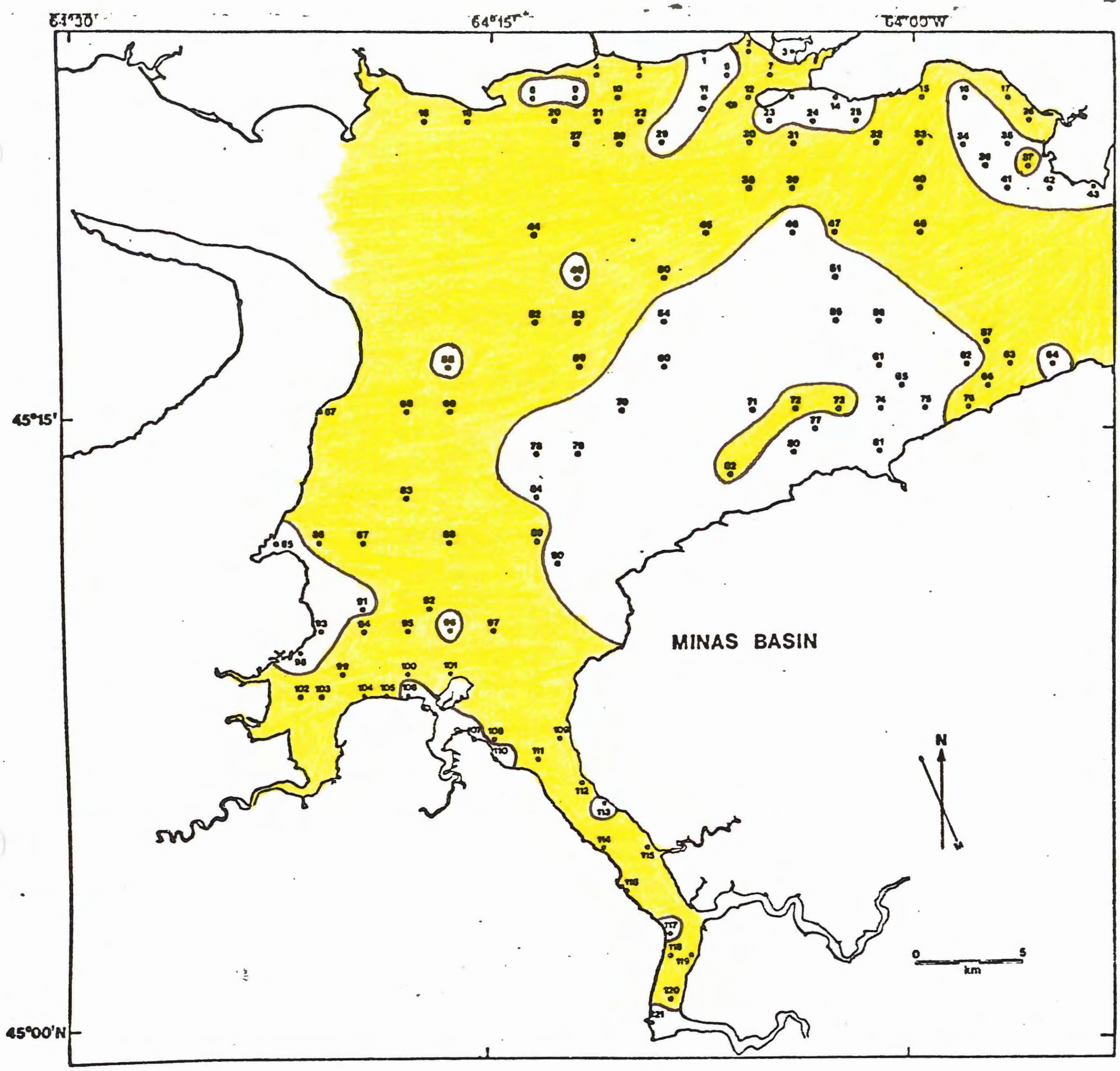

Fig. 10. Distribution of Eggerella advena.

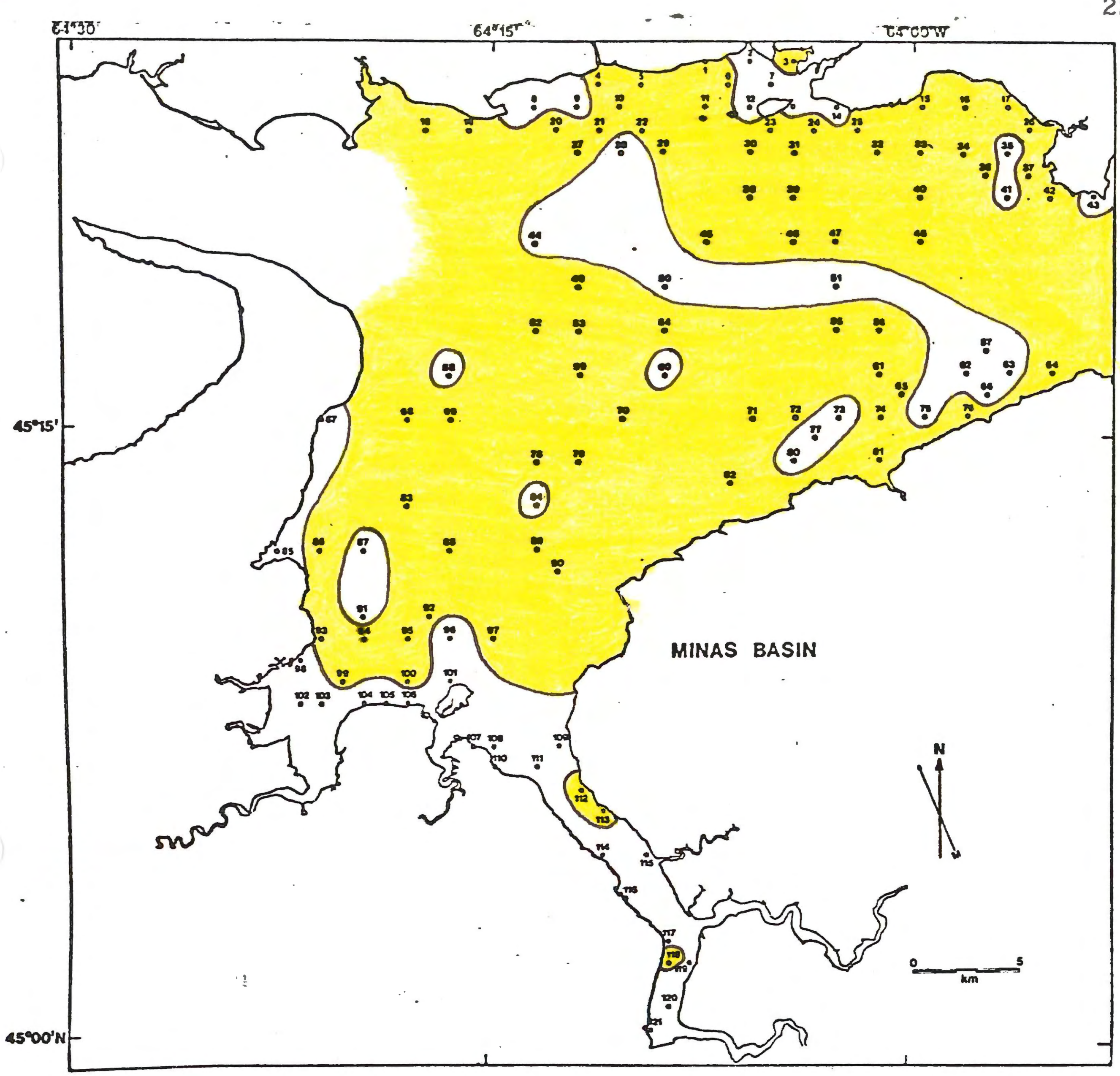

Fig. 11. Distribution of Quinqueloculina seminulum.

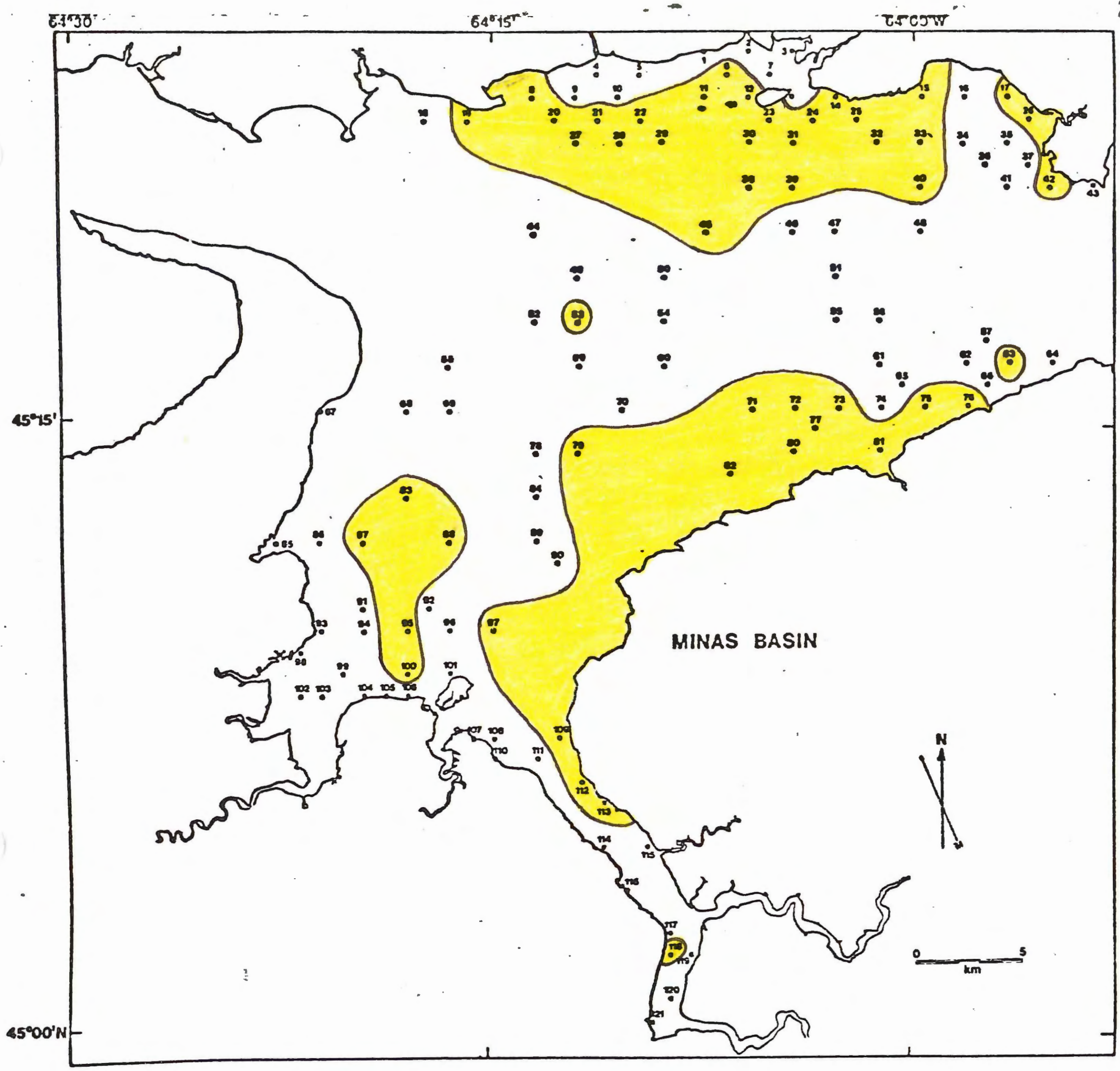

Fig. 12. Distribution of Pyrgo williamsoni.

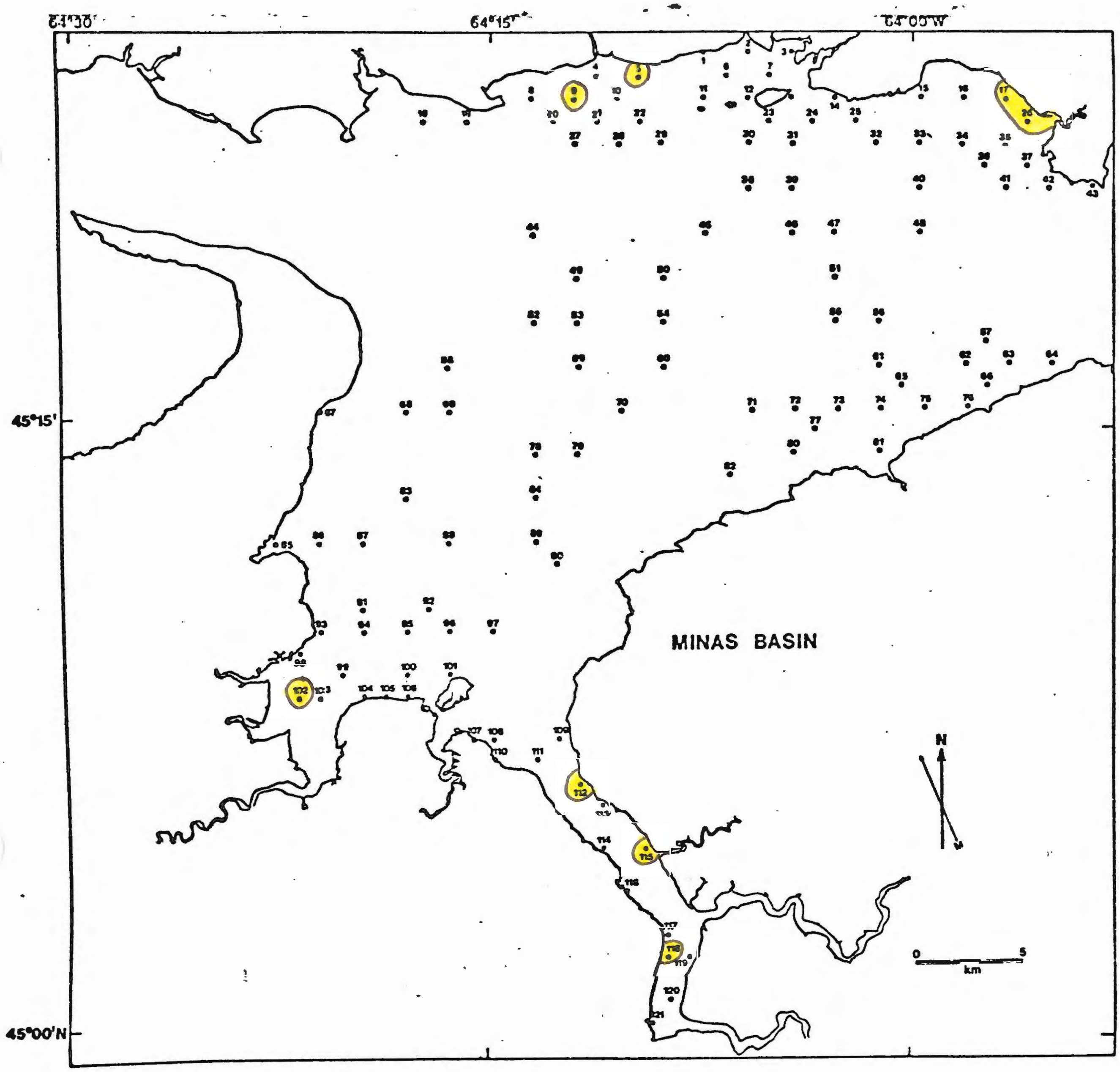

Fig. 13. Distribution of Genus Lagena.

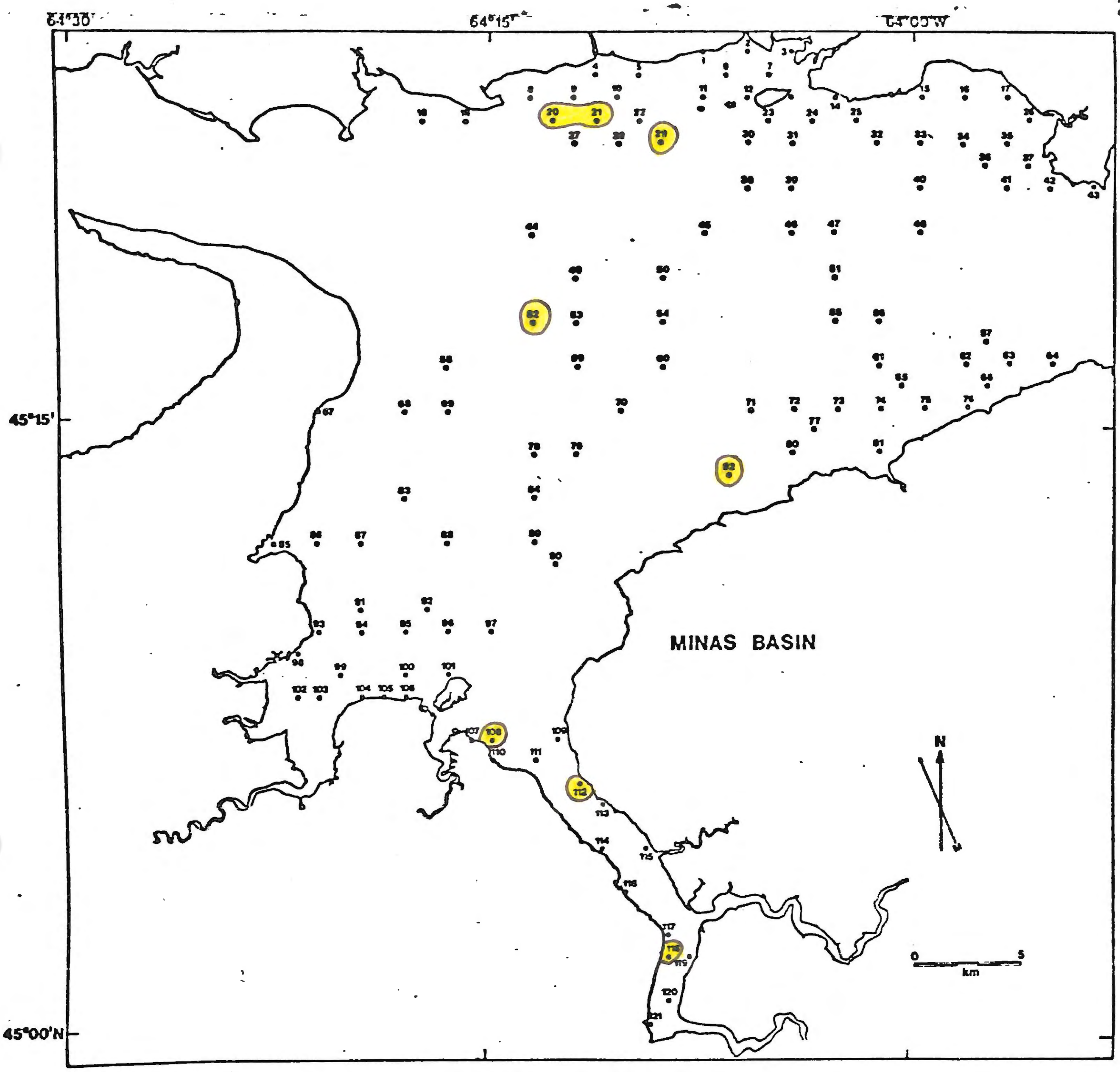

Fig. 14. Distribution of Genus Oolina.

(includes Oolina sp.)

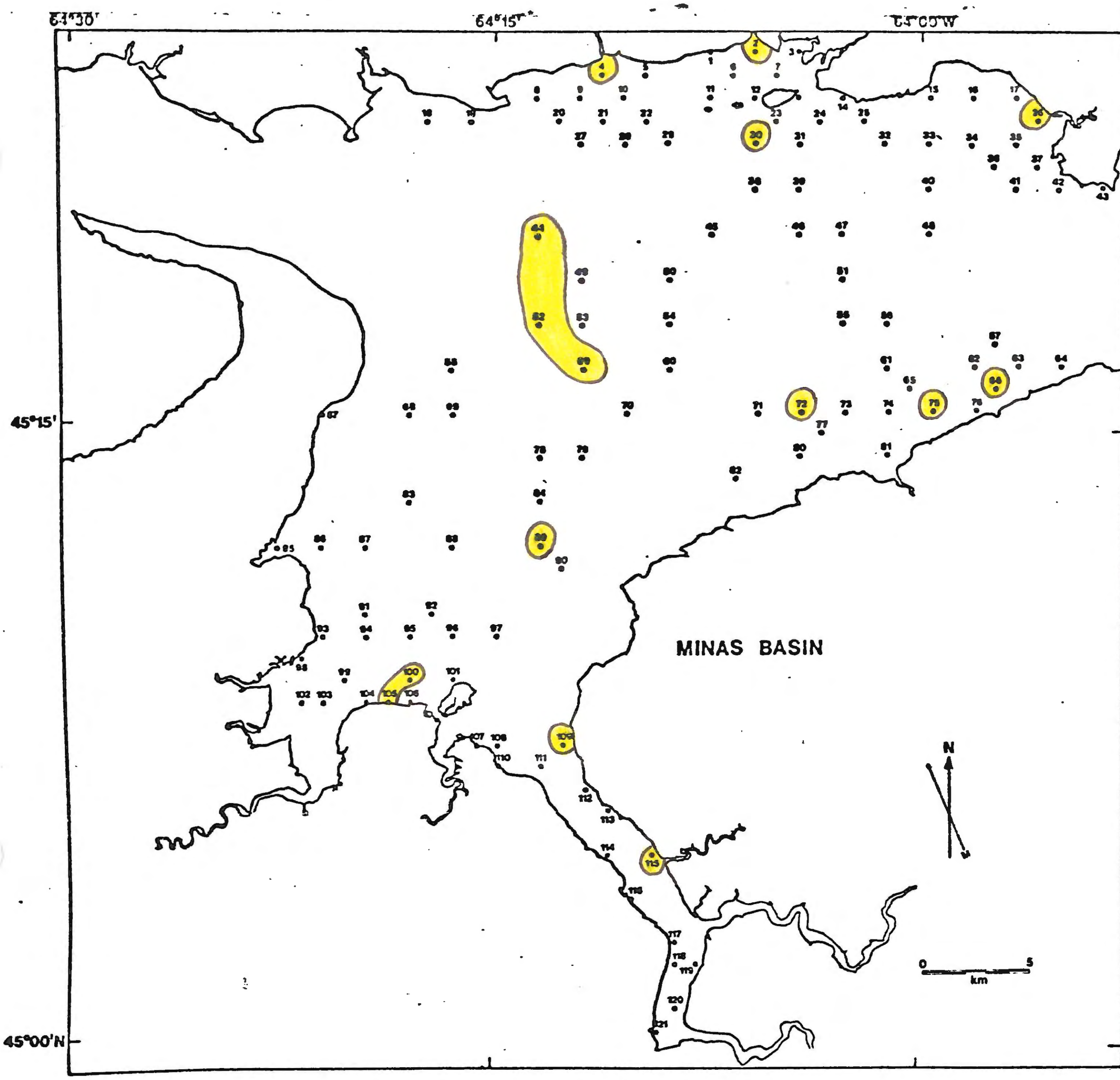

Fig. 15. Distribution of Genus Bolivina.

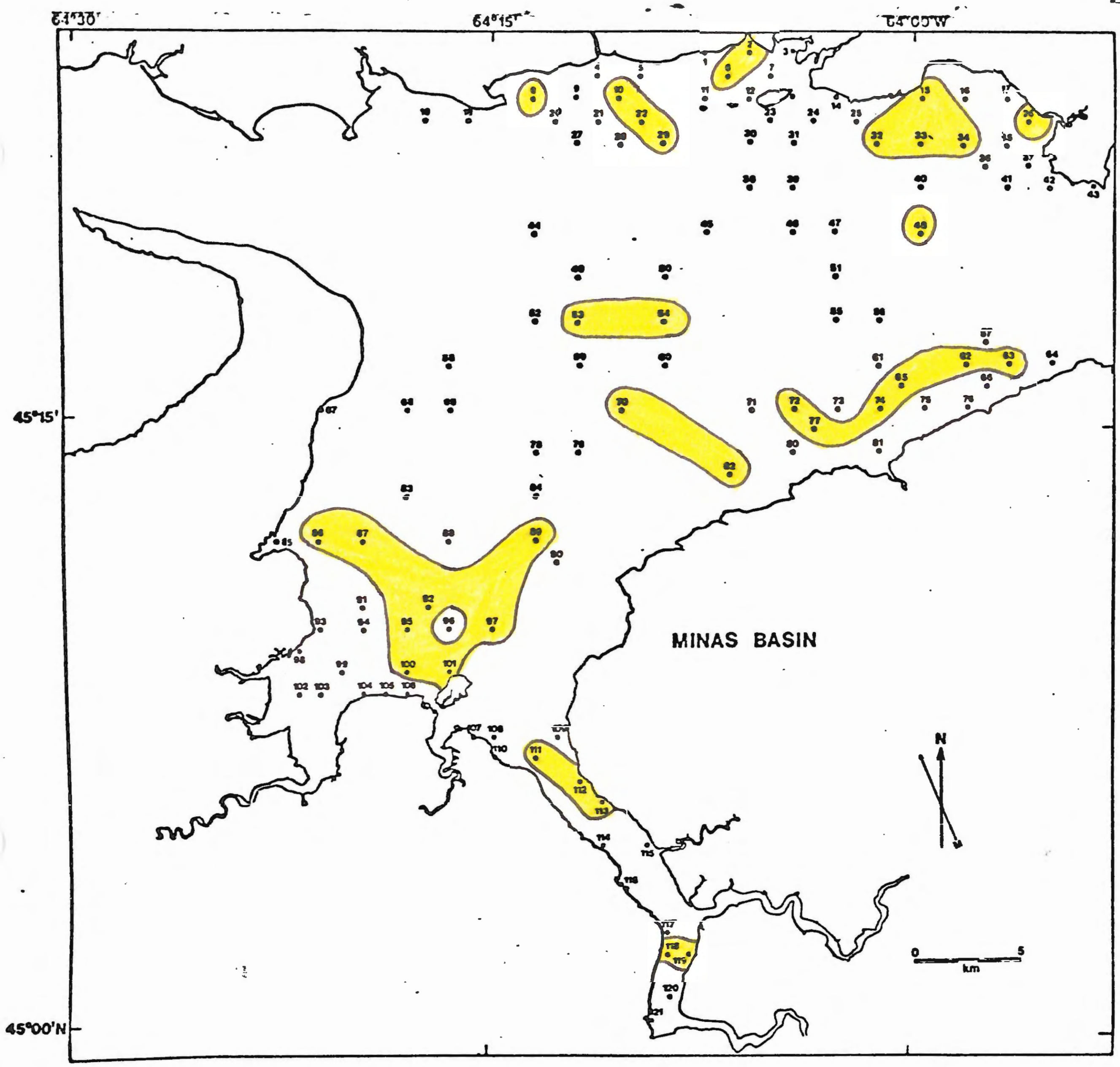

Fig. 16. Distribution of Genus Islandiella.

(including Islandiella sp.)

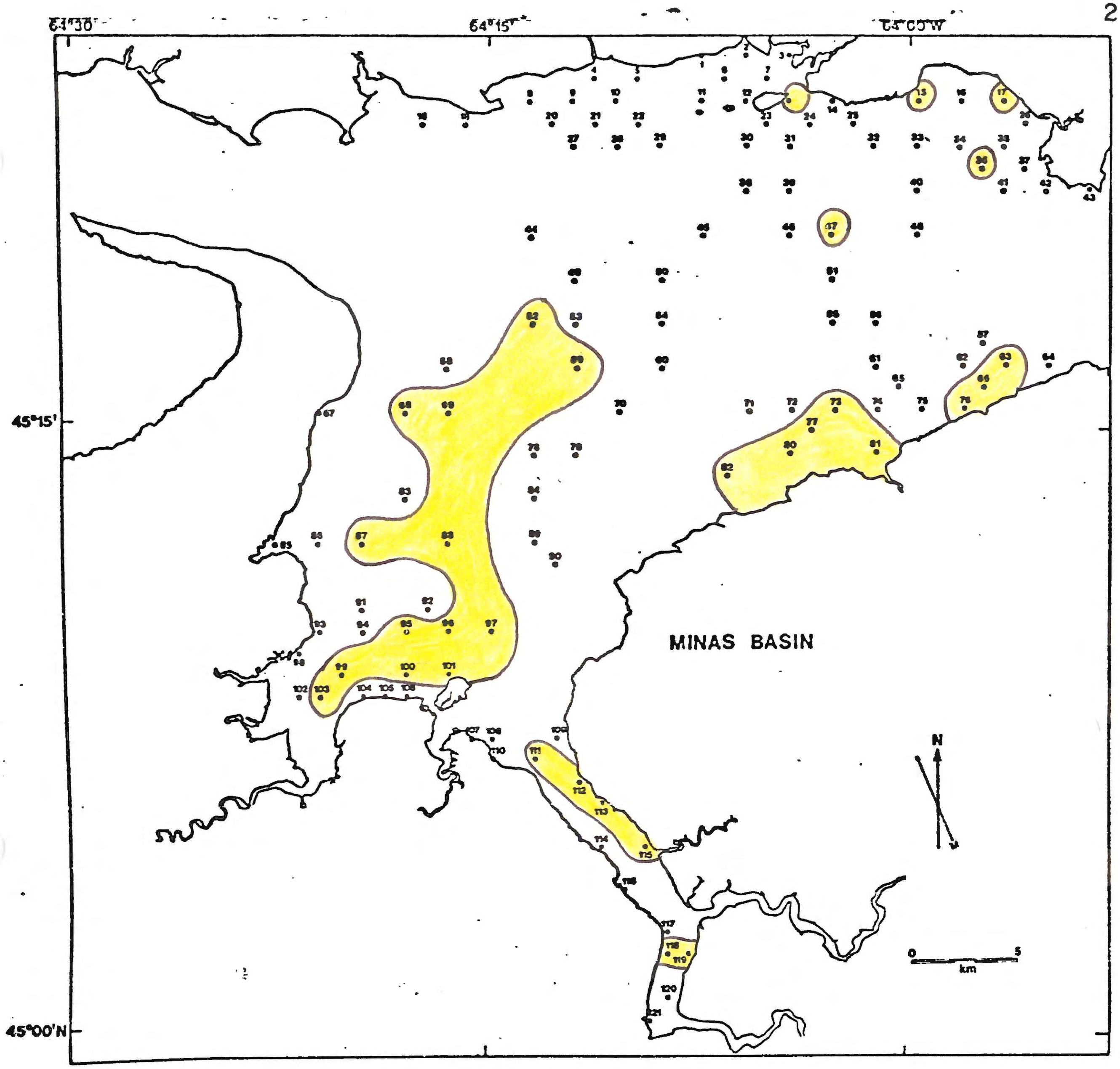

Fig. 17. Distribution of <u>Trifarina angulosa</u>.

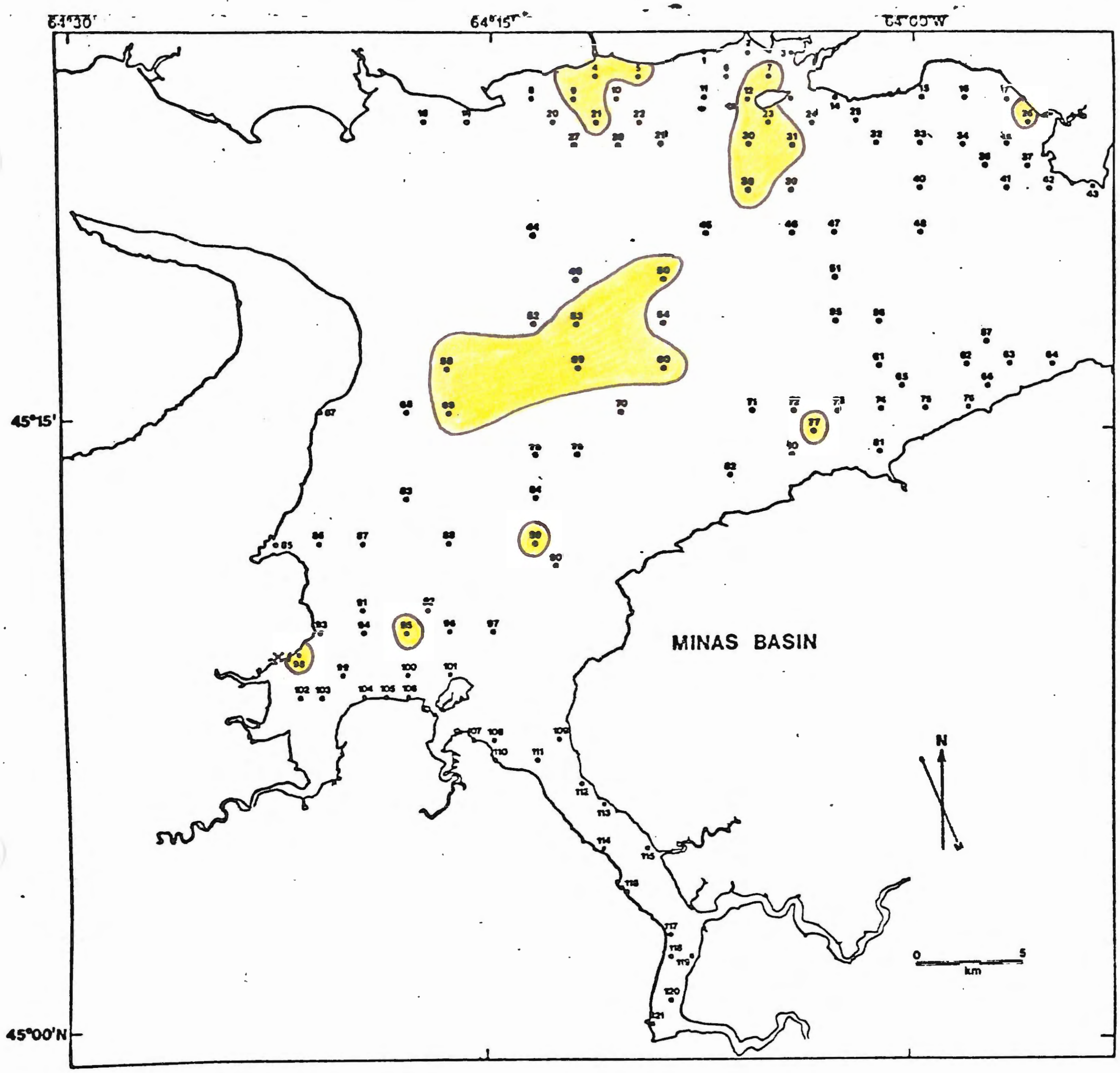

Fig. 18. Distribution of Rosalina columbiensis.

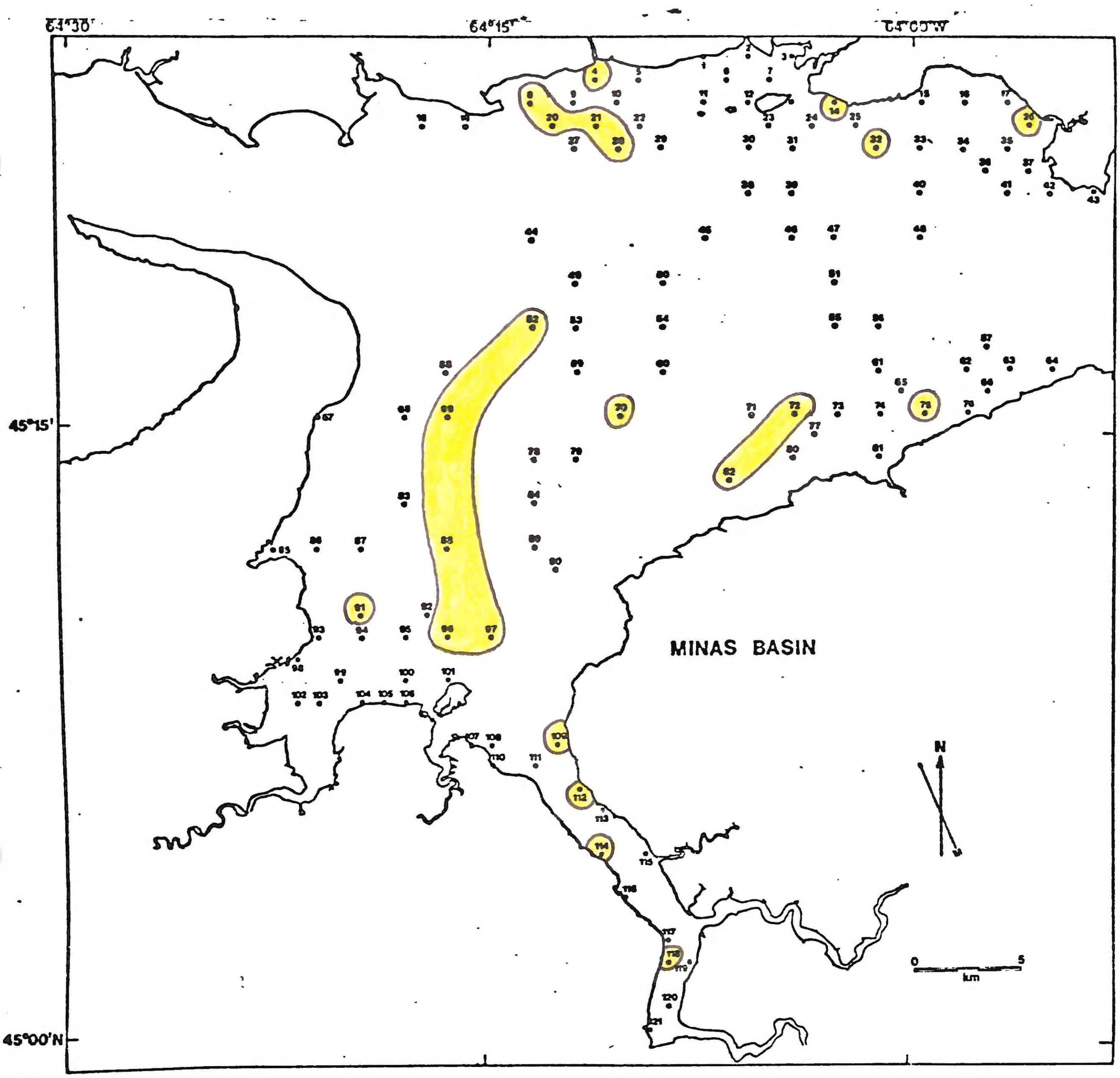

Fig. 19. Distribution of Bucella frigida.

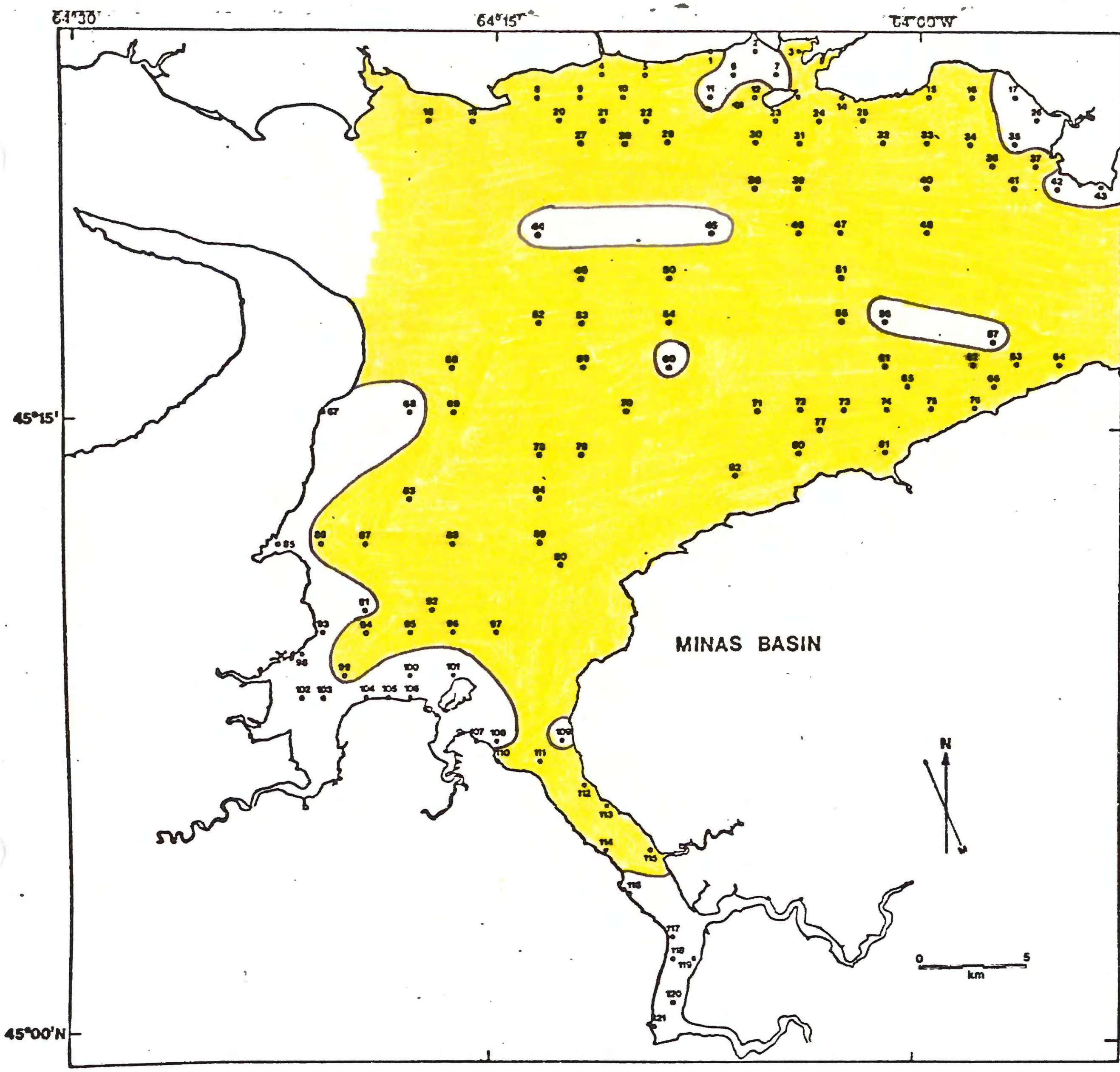

Fig. 20. Distribution of Ammonia beccarii.

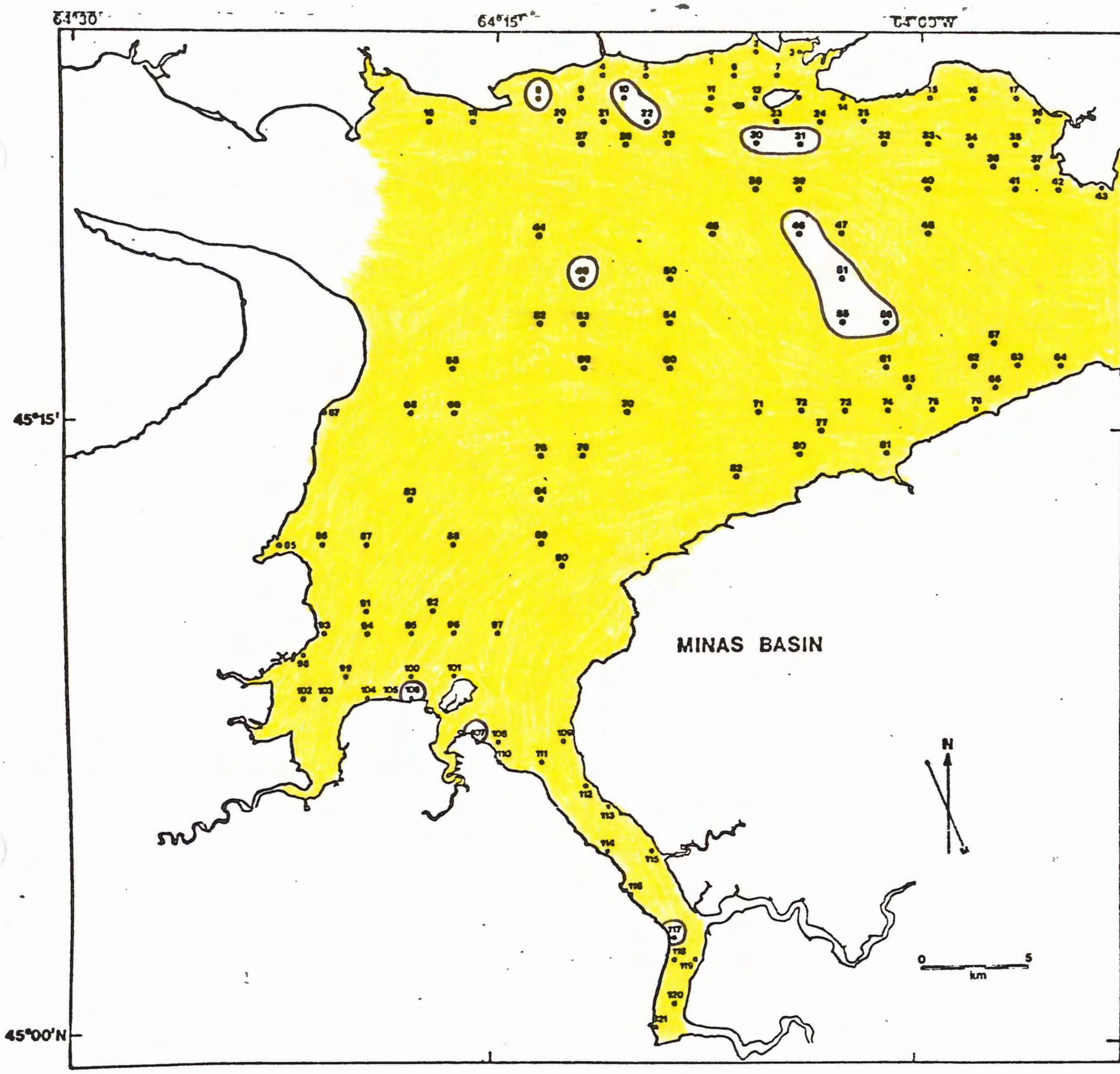

Fig. 21. Distribution of Elphidium clavatum "complex".

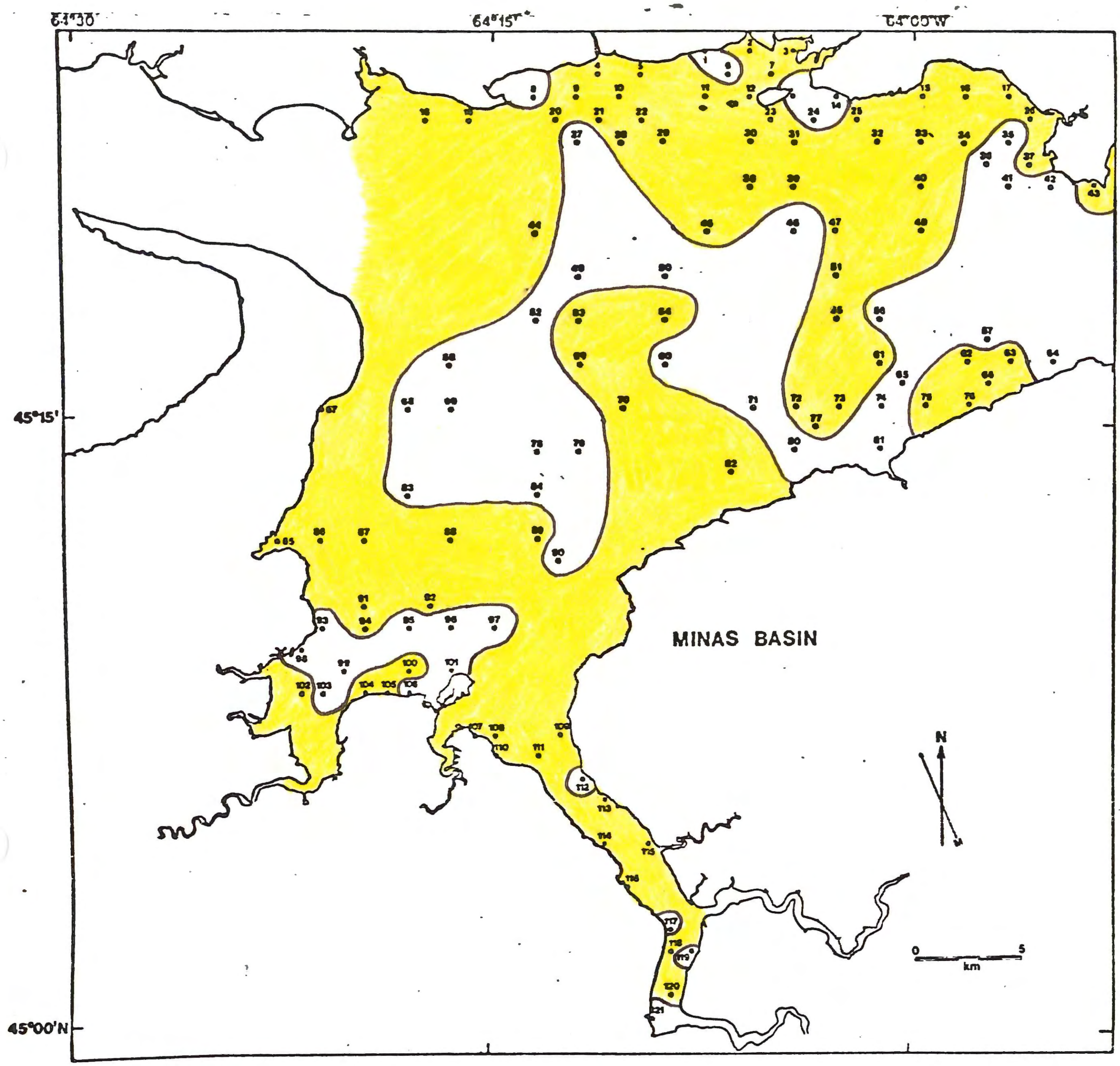

Fig. 22. Distribution of <u>Elphidium frigidum</u>.

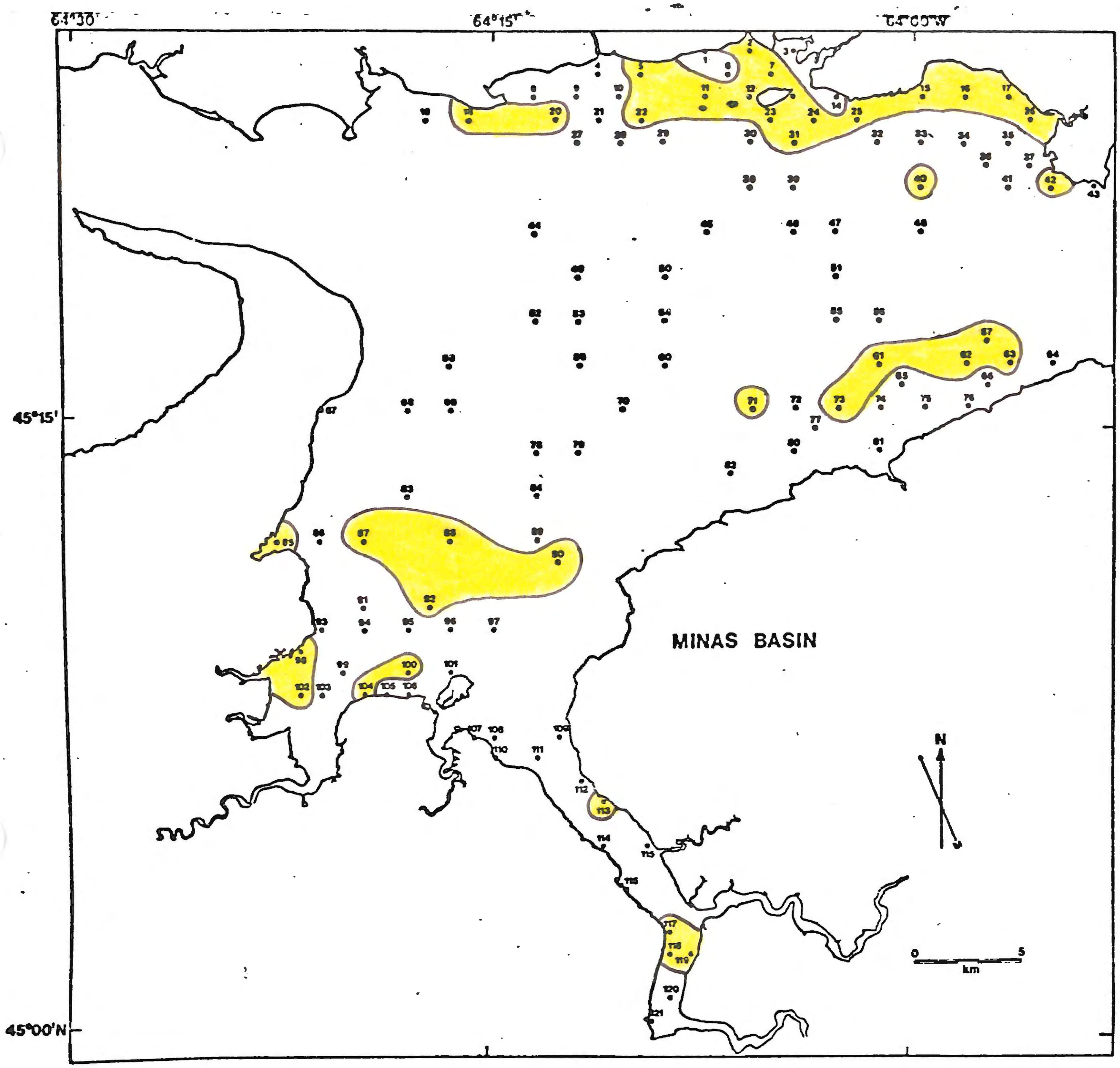

Fig. 23. Distribution of Elphidium margaritaceum.

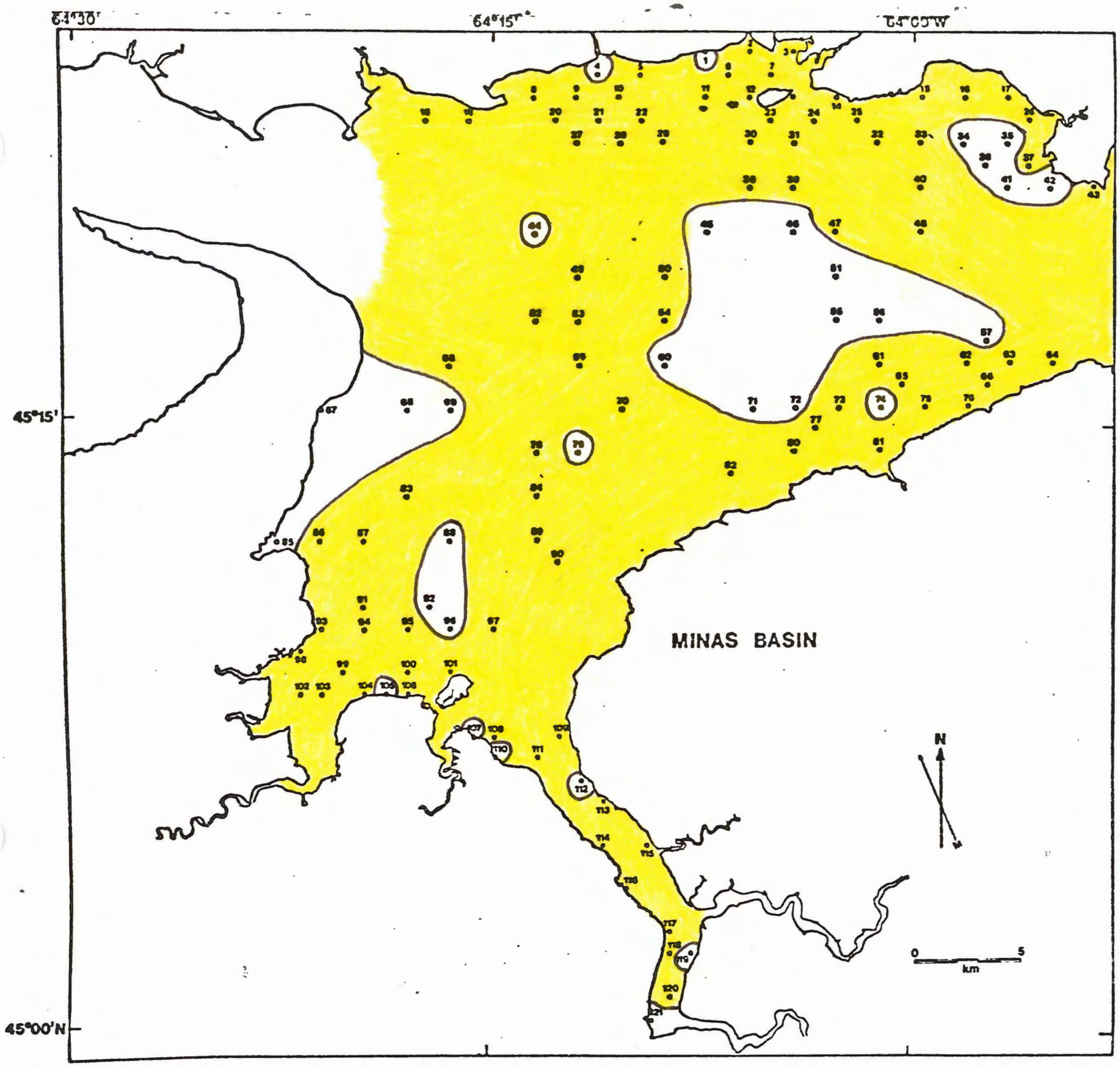

Fig. 24. Distribution of Elphidium subarcticum.

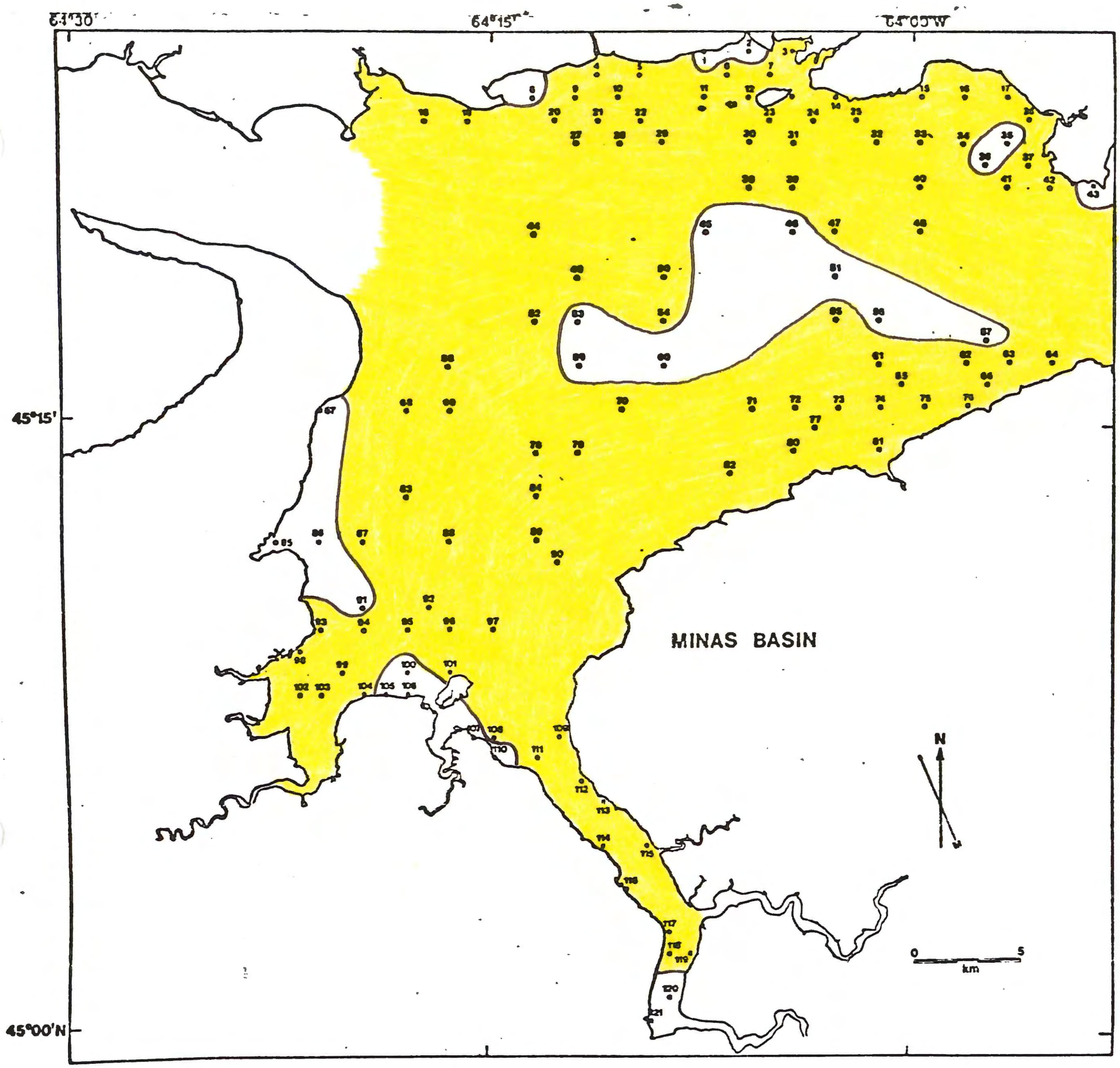

Fig. 25. Distribution of Cibicides lobatulus.

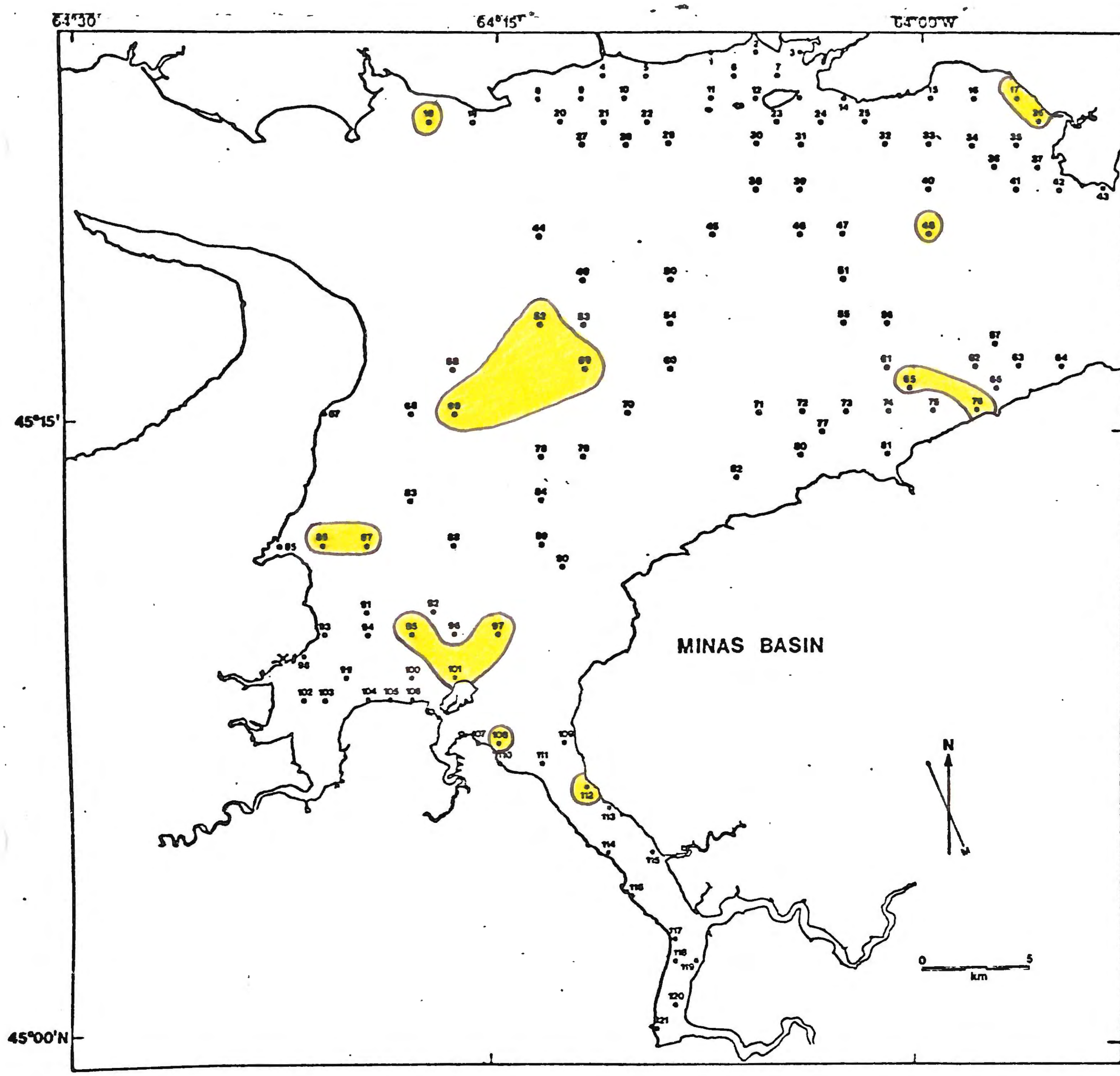

Fig. 26. Distribution of Planktonic Foraminifera.

Conclusions

The distributions observed for the foraminifera in the Minas Basin (and the condition of many of the tests observed) lead to two distinct hypotheses regarding the provenance of these species.

The first hypothesis would be that benthic foraminifera are produced and live in all areas of the Basin, but that the empty tests of dead foraminifera in the central areas are either removed or destroyed as they become available. The net sediment loss through the Minas Passage observed by Amos and Joice (1977) supports this idea.

The second and perhaps more likely hypothesis is that most forms at least are produced near the shore and die there. Tidal currents could then move these tests slowly out to the central area of the Basin during a prolonged period of back-and-forth saltation. Fragile forms such as members of the genus *Lagena* do not survive much abrasion and so are not found very far from shore. Small forms may be carried up into upper water layers and so reach even the center of the Basin, even though they may be rather fragile, such as *Elphidium frigidum*. The heavier, more robust tests of such forms as *Ammonia beccarii*, *Elphidium clavatum* "*complex*", *Quinqueloculina seminulum* and others can survive even the prolonged period of abrasion endured during transport to the central parts of the study area, and so are found there also.

The origin of the few planktonic forms in the samples studied is difficult to assess, but perhaps the simplest explanation is that some planktonic foraminifera are flushed into the Minas Basin from the Bay of Fundy with each rising tide. There they encounter rather unfavourable conditions and die, leaving the empty tests to be distributed at the caprice of the tides.

Systematics

BENTHONIC SPECIES

Family SACCAMMINIDAE Brady, 1884

Subfamily SACCAMMININAE Brady, 1884

Genus SACCAMMINA M. Sars in Carpenter, 1869

SACCAMMINA ATLANTICA (Cushman)

Reophax difflugiformis Brady, 1884 (part), p. 289, pl. 30, fig. 5 (not figs. 1 - 4).

Proteonina difflugiformis (in part) of authors, e.g. Hoglund, 1947, p. 53, pl. 4, fig. 18.

Proteonina atlantica Cushman, 1944, p. 5, pl. 1, fig. 4; - Parker, 1952 a, p. 393, pl. 1, fig. 2; - 1952 b, p. 454, pl. 1, figs. 1,2; - Cooper, 1964, p. 92, pl. 5, fig. 1.

Saccammina atlantica (Cushman) Todd and Bronniman 1957, p. 22, pl. 1, fig. 14; - Vilks, 1969, p. 43, pl. 1, fig. 13; - Gregory, 1970, pp. 162 - 163, pl. 1, fig. 4; - Hume, 1972, p. 69, pl. 1, fig. 1; - Sen Gupta, 1971, p. 83, pl. 1, fig. 1.

Ref. Slide I # 1 - 5 Plate I, fig. 1.

Test of medium size, consisting of a single oval or nearly spherical chamber, no separate neck, but with a slight tapering toward the apertural end. Test composed of fairly coarse, tightly packed grains (largely quartz) and often with a very rough surface.

Distribution very limited, found in only three locations, one near the northwestern shore of the Basin, the other two in the area to the southwest of the mouth of the Avon River. All three samples were taken in shallow water.

Family RZEHAKINIDAE Cushman, 1933

Genus MILIAMMINA Heron - Allen and Earland, 1930

MILIAMMINA FUSCA (Brady)

Quinqueloculina _fusca_ Brady, 1870, p. 47, pl. 11, figs. 2,3.

Miliammina _fusca_ (Brady) Phleger and Walton, 1950, p. 280, pl. 1, figs. 19a, b; - Gregory, 1970, p. 172, pl. 2, fig. 8; - Scott et al., 1977, p. 1579, pl. 2, figs. 8,9.

Ref. Slide I # 6 - 10 Plate I fig. 2.

Test small, elliptical and composed of small, well-sorted mineral grains, usually quartz. Chambers arranged in a _Quinqueloculina_ - like pattern, with sutures distinct and depressed. Aperture terminal, often with a large tooth.

Recorded from 19 stations from many parts of the Basin, and may comprise up to nearly 10% of the total forominiferal assemblage.

Family TEXTVLARIIDAE Ehrenberg, 1838

Sub Family SPIROPLECTAMMININAE Cushman, 1927

Genus SPIROPLECTAMMINA Cushman, 1927

SPIROPLECTAMMINA BIFORMIS (Parker and Jones)

<u>Textularia</u> <u>agglutimans</u> d'Orbigny var. biformis Parker and Jones, 1865, p. 370, pl. 15, figs. 23, 24.

<u>Spiroplecta</u> <u>biformis</u> (Parker and Jones) Brady, 1878, p. 376, pl. 45, figs. 25-27; - Cushman, 1922 b, p. 4.

<u>Spiroplectammina</u> <u>biformis</u> (Parker and Jones) Cushman, 1927, p. 23, pl. 5, fig. 1; - 1944, p. 13, pl. 2, figs. 4,5; - 1948, p. 30, pl. 3, figs. 7,8; - Hoglund, 1947, p. 163, pl. 12, fig. 1, text-figs. 140, 141; - Parker, 1952 a, p. 402, pl. 3, figs. 1,2; - 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. 20 a,b; - Gregory, 1970, p. 178, pl. III, fig. 6; - Sen Gupta, 1971, p. 85, pl. 1, fig. 13.

Ref. Slide I # 36 - 40 Plate I, fig. 3.

Test small, agglutinated, using mostly very small grains of quartz. Planispiral, compressed, with early portions coiled, later chambers uncoiling and somewhat flattened, periphery rounded. Sutures slightly depressed, aperture terminal at the peripheral end of the last chamber.

Not common in the study area, recorded in very small numbers from eight stations on both sides of the Basin.

Family TROCHAMMINIDAE Schwager, 1877

Sub Family TROCHAMMININAE Schwager, 1877

Genus TROCHAMMINA Parker and Jones, 1859

TROCHAMMINA INFLATA (Montagu)

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

Trechammina inflata (Montagu). Parker and Jones, 1859, p. 347; - Brady, 1884, p. 338, pl. 41, figs. 4 a-c; - Cushman, 1920, p. 73; - Phleger and Walton, 1950, p. 280, pl. 2, figs. 1-3; - Parker, 1952 a, p. 407, pl. 4, figs. 6,10; - 1952 b, p. 459, pl. 3, figs. 2 a,b; - Todd and Low, 1961, p. 15, pl. 1, figs, 22, 23; - Buzas, 1965, p. 57, pl. 1, figs. 27-29; - - Gregory, 1970, p. 180, pl. IV, figs. 3,4; - Scott et al. 1977, p. 1579.

Ref. Slide I # 16 - 20 Plate I figs. 5,6.

Test large, free, trochospiral, low, with last whorl consisting of 6 - 8 chambers. Arenaceous, but with very plentiful cement so that wall appears to have a fairly smooth, shiny surface. Chambers inflated, sutures depressed and at nearly right angles to the periphery. Aperture a small slit at the base of the chamber. Specimens of *T. inflata* are often seen in a badly damaged condition in Minas Basin samples.

This species is quite common in the study area, appearing in more than 30 samples from all over the Basin (though less frequently in deeper water), but in only one instance comprising more than 10% of the foraminiferal assemblage.

TROCHAMMINA LOBATA Cushman

Trochammina lobata Cushman, 1944, p. 18, pl. 2, fig. 10;
- Parker, 1952 a, p. 408, pl. 4, figs. 7 a,b; - 1952 b, p. 459, pl. 3, figs. 2 a,b; - Cooper, 1964, p. 94, pl. 5, fig. 10; - Buzas, p. 57, pl. 1, fig. 10, pl. 2, fig. 1; - Gregory, 1970, pp. 180-1, pl. IV, figs. 5,6. Scott et al., 1977, p. 1579, pl. 4, figs. 1,2.

Ref. Slide I, # 26 - 30 Plate I, figs. 4,7.

Test of a moderate size, wall quite smooth and finely arehaceous, often stained a brownish-yellow colour. 6 - 8 chambers in the last whorl, the last chamber somewhat inflated. Sutures distinct, depressed and curved. Periphery broadly rounded and on the ventral side the last chamber forms a lobe to cover the unbilical region. Quite often the test wall is broken near the center on the dorsal side, where the test is thinnest (as in specimen shown).

Distribution rather similar to that of T. inflata but is sometimes found to comprise a larger part of a sample assemblage than T. inflata.

TROCHAMMINA MACRESCENS Brady

Trochammina inflata (Montagu) var. macrescens Brady, 1870, p. 290-1, pl. 11, figs. 5 a-c; Scott et al. 1977, p. 1579, pl. 4, figs. 6, 7.

Trochammina macrescens Brady Phleger and Walton, 1950, p. 281, pl. 2, figs. 6,7; - Parker, 1952 a, p. 408, pl. 4, figs. 8 a,b; - 1952 b, p. 460, pl. 3, figs. 3 a,b; - Todd and Low, 1961, p. 16, pl. 1, fig. 16; - Gregory, 1970, p. 181-2, pl. IV, fig. 7.

Jadammina macrescens (Brady) Murray, 1971, p. 41, pl. 13, figs. 1 - 5.

Ref. Slide I, # 21 Plate I, figs. 8, 9.

(I have chosen to retain T. macrescens as a name for this species over J. macrescens simply because the former is by far the more commonly used.)

Description as for T. inflata except that all chambers appear "collapsed".

Found in very small numbers in only two samples, one from an intertidal zone from the extreme northern part of the study area, the other from an intertidal zone near the mouth of the Avon River.

TROCHAMMINA OCHRACEA (Williamson)

Rotalina ochracea Williamson, 1858, p. 55, pl. 4, fig. 112, pl. 5, fig. 113.

Trochammina ochracea (Williamson) Cushman, 1920, p. 75, pl. 15, fig. 3; - 1944, p. 19, pl. 2, figs. 12,13; - Hoglund, 1947, p. 211, pl. 16, fig. 2, text - fig. 190; - Todd and Low, 1961, p. 16, pl. 1, fig. 18; - Gregory, 1970, pp. 182-3, pl. IV, figs. 8,9; Scott et al., 1977, p. 1580, pl. 4, figs. 5,8.

Ref. Slide I # 31-35 Plate I, figs. 11, 12

Test very small, thin and concave-convex, made of very fine arenaceous material. 9 - 12 chambers in the final whorl, sutures distinct, somewhat depressed, nearly straight on dorsal side, sharply curved on ventral side. Markedly umbilicate. Often the test is stained a dark reddish-brown colour.

Distribution much like that of T. lobata though found in slightly more samples, sometimes making up as much as 20% of the foraminiferal assemblage in a sample.

Family ATAXOPHRAGMIIDAE Schwager, 1877

Sub Family GLOBOTEXTULARIINAE Cushman, 1927

Genus EGGERELLA Cushman, 1933

EGGERELLA ADVENA (Cushman)

Verneuilina advena Cushman, 1922 a, p. 141; - (not Hoglund, 1947, p. 185, pl. 13, fig. 11, text - fig. 16a).

Eggerella advena (Cushman) Cushman, 1937, p. 51, pl. 5, figs. 12-15; - 1944, p. 13, pl. 2, figs. 6,7; - 1948, p. 32, pl. 3, fig. 12; - Parker, 1952 a, p. 404, pl. 3, figs. 12, 13; - 1952 b, p. 447, pl. 2, fig. 3; - Loeblich and Tappan, 1953, p. 36, pl. 3, figs. 8 - 10; - Ronai, 1955, p. 143, pl. 20, fig. 6; - Todd and Low, 1961, p. 14, pl. 1, fig. 4; - Cooper, 1964, p. 94, pl. 5, fig. 5; - Buzas, 1965, p. 55, pl. 1, figs. 4, 5; - Sen Gupta, 1971, p. 85, pl. 1, fig. 18; - Leslie, 1965, p. 159, pl. 2, figs 4 a,b; - Barbieri and Medioli, 1969, p. 855; - Vilks, 1969, p. 46, pl. 2, fig. 3; Scott et al. 1977, p. 1579, pl. 2, fig. 7.

Eggerella arctica Hoglund, 1947, p. 193, pl. 16, fig. 4, text - figs. 262, 263.

Ref. Slide I, # 11 - 15 Plate I, fig. 10.

The description given by Loeblich and Tappan (1953) is fully adequate for the specimens found in the Minas Basin.

One of the most widespread species found in the study area. E. advena appears in some numbers in most of the samples, though rarely comprising more than 15% of any given sample assemblage.

Family MILIOLIDAE Ehrenberg, 1839

Sub Family QUINQUELOCULININAE Cushman, 1917

Genus QUINQUELOCULINA d'Orbigny, 1826

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.

Quinqueloculina seminula (Linne), Cushman, 1929, p. 59, pl. 9, figs. 16-18; - 1944, p. 13, pl. 2, fig. 14; - 1948, p. 34, pl. 3, figs. 14, 15; - Parker, 1952a, p. 406, pl. 3, figs. 21 a,b, 22 a,b, pl. 4, figs. 1, 2; - 1952b, p. 456, pl. 2, figs. 7 a,b.

Quinqueloculina seminulum (Linné) Todd and Bronniman, 1957, p. 27, pl. 3, figs. 9, 10; - Todd and Low, 1961, p. 15, pl. 1, fig. 14; - Adams and Frampton, 1965, p. 55, pl. 5, fig. 16; - Buzas, 1965, p. 56, pl. 1, fig. 7;

- Leslie, 1965, p. 168, pl. 3, figs. 2 a-c; - Vilks, 1969, p. 47, pl. 2, figs. 10 a, b; - Barbieri and Medioli, 1969, p. 855; - Gregory, 1970, p. 187, pl. VI, fig. 1; - Sen Gupta, 1971, p. 85, pl. 1, figs. 25 - 27; - Iqbal, 1973, p. 202, pl. VII, figs. 5, 6.

Ref. Slide I, #46 - 50 Plate II, fig. 1,2.

Test large, free, porcellanous with thick walls. Large individuals tend to be quite rounded in outline, smaller ones being narrower and more elongate. Sutures distinct. Aperture large, terminal with a simple tooth.

Q. seminulum is found in samples from most parts of the Basin, but is most common near the northern shore. In sample # 56, from the central part of the Basin, *Q. seminulum* is the only foraminifer found, and is represented by only one specimen.

Genus PYRGO DeFrance, 1824

PYRGO WILLIAMSONI (Silvestri)

Bileculina ringens (Lamarcke) typica Williamson, 1858, (not Miliolites ringens Lamarcke, 1804), p. 79, pl. 6, figs. 169 - 170, pl. 7, fig. 171.

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, pp. 189, 190, pl. VI, fig. 5; - Sen Gupta, 1971, p. 85, pl. 1, fig. 21; - Iqbal, 1973, p. 199, pl. VI, fig. 3.

Ref. Slide I, # 41 - 45 Plate II, fig. 3.

Test oval, inflated; chambers oval, the last overlapping the previous on all sides. Sutures distinct, depressed. Wall calcareous and porcellanous. Aperture terminal with a large bifid tooth projecting from the lower margin.

A widespread species in the study area, P. williamsoni occurs in almost half the samples, though in only one instance comprising more than 10% of the foraminiferal assemblage. As Q. seminulum, it seems more common on the northern shore of the Basin.

Family NODOSARIIDAE Ehrenberg, 1838

Sub Family NODOSARIINAE Ehrenberg, 1838

Genus ASTACOCUS Montfort, 1808

ASTACOLUS HYALA CRULUS Loeblich and Tappan

Astacolus hyalacrulus Loeblich and Tappan, 1953, p. 52, pl. 9, figs. 1 - 4; - Leslie, 1965, p. 156, pl. 5, figs. 1 a - b; Gregory, 1970, pp. 191 - 192; - Sen Gupta, 1971, p. 86.; - Iqbal, 1973, p. 144, pl. VI, fig. 9.

Ref. Slide 2, # 1 Plate II, figs. 4,5.

Description closely corresponds to Loeblich and Tappan's (1953) of juvenile form, and to Iqbal's (1973) figured specimen.

Occurrence is limited to one specimen at station # 25, near the north shore of the Basin.

Genus LAGENA Walker and Jacob, 1798

LAGENA MERIDIONALIS Weisner

Lagena caudata (d'Orbigny) Parker and Jones, 1865, p. 352, pl. 16, fig. 7.

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

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

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

Lagena meridionalis Weisner, Loeblich and Tappan, 1953, pp. 62 - 63, pl. 12, fig. 1; - Vilks, 1969, pl. 2, fig. 19; - Sen Gupta, 1971, p. 86; - Iqbal, 1973, p. 17, Pl. III, fig. 6.

Ref. Slide 2, #6 Plate II, fig. i.

Closely resemples the description given by Loeblich and Tappan, (L953), except that in Minas Basin forms, abrasion has partially erased the costae, especially near the middle of the test, as the figured specimen clearly shows.

Distribution restricted to only two samples, both from close to the northern shore of the Basin.

LAGENA MOLLIS Cushman

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

Lagena millis Cushman, Loeblich and Tappan, 1953, pp. 63 - 64, pl. 11, figs. 25 - 27; - Vilks, 1969, pl. 2, fig. 20; - Sen Gupta, 1971, p. 86; - Iqbal, 1973, p. 181, pl. III, fig. 1.

Ref. Slide 2, #1 Plate II, fig. 10

Test free, composed of one chamber, elongate and fusiform in outline, with a basal spine and a very long neck, sides mostly parallel with fine longitudinal ribs, aperture terminal often with a flared lip. In Minas Basin forms both the basal spine and the neck may be missing their tips (through abrasion, perhaps) as in the specimen shown.

Occurs in very small numbers in six samples, three of which are in the lower portion of the Avon River.

LAGENA SEMILINEATA Wright

Lagena semilineata Wright, 1886, p. 320, pl. 26, fig. 7; - Cushman and McCulloch, 1950, p. 345, pl. 46, fig. 11; - Loeblich and Tappan, 1953, p. 65, pl. 11, figs. 14 - 22; - Todd and Bronniman, 1957, p. 31, pl. 5, fig. 16; - Leslie, 1965, p. 164, pl. 5, fig. 12; - Gregory, 1970, p. 196, pl. VII, fig. 8; - Sen Gupta, 1971, p. 86.

Lagena caudata (d'Orbigny) Cushman, 1948, p. 46, pl. 5, figs. 8, 9.

Ref. Slide 2, # 16 Plate II, fig. 9.

Test of medium size, flask-shaped, unilocular, with numerous fine costae extending one-third to one-half the length of the test. Aperture at the end of a long neck, with a well-developed lip. Basal spine always absent, probably broken as a result of abrasion.

Found only in sample # 112, at the mouth of the Avon River, in very small numbers.

Family POLYMORPHINIDAE d'Orbigny, 1839

Genus PSEUDOPOLYMORPHINA Cushman and Ozawa, 1928

PSEUDOPOLYMORPHINA NOVANGLIAE (Cushman)

Polymorphina lactea (Walker and Jacob) var. *novangliae*, Cushman, 1927, p. 146, pl. 79, figs. 6 - 8.

<u>Pseudopolymorphina</u> <u>novangliae</u> (Cushman) Parker, 1952a, p. 410, pl. 5, fig. 1; - 1952b, p. 455, pl. 3, figs. 11, 12; - Todd and Low, 1961, p. 16, pl. 1, fig. 26; - Cooper, 1964, p. 95, pl. 5, figs. 18, 19; -Buzas, 1965, p. 58, pl. 2, fig. 4; - Gregory, 1970, p. 197, pl. VIII, fig. 1; - Sen Gupta, 1971, p. 87, pl. 2, figs. 1 - 3.

Ref. Slide 2, # 21 - 25 Plate II, fig. 6, 7.

Test very large, free, white, biserially arranged, calcareous, porcellanous. Chambers large, elongate, sutures slightly depressed. Aperture terminal at the end of a short, tapering neck. Aperture complex, with several small holes surrounded by many radiating lines of other holes between raised ridges of calcitic material (See enlarged apertural view).

Found at seven sample sites, one from near the northern shore of the Basin, the rest from deeper water in the southeastern part of the Basin.

Family GLANDULINIDAE Reuss, 1860

Sub Family OOLININAE Loeblich and Tappan, 1961

Genus OOLINA d'Orbigny, 1839

OOLINA COSTATA (Williamson)

<u>Entosolenia</u> <u>costata</u> Williamson, 1858, p. a, pl. 1, fig. 18.

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

<u>Oolina costata</u> (Williamson) Parker, 1952a, p. 409, pl. 4, figs. 20, 21; - Loeblich and Tappan, 1953, p. 68, pl. 13, figs. 4-6; - Gregory, 1970, pp. 201-2; - Sen Gupta, 1971, p. 87, pl. IX, fig. 3; - Iqbal, 1973, p. 189, pl. III, figs. 13, 14.

Ref. Slide 2, # 26 Plate II, fig. 11.

Test free, ovate, broadening near the base, wall calcareous, smooth, surface ornamentation occurring as 10 - 12 distinct longitudinal ribs of equal length which run from a raised circular area near the base to a similar one surrounding the aperture, which is terminal with an internal tube.

Found in only three samples; one from near the northern shore of the Basin, one from well up the Avon River, and one nearer the mouth of that same river.

OOLINA LINEATA (Williamson)

<u>Entosolenia lineata</u> Williamson, 1858, p. 18, pl. 2, fig. 18.

Lagena lineata (Williamson) Brady, 1884, p. 461, pl. 57, fig. 13; - Cushman, 1923, p. 31, pl. 5, fig. 10, pl. 6, figs. 5 - 8.

Oolina lineata (Williamson) Loeblich and Tappan, 1953, p. 70, pl. 13, figs. 11 - 13; - Gregory, 1970, pp. 203, 204, pl. IX, figs. 1 - 2.

Ref. Slide 2, # 31 Plate II, fig. 14.

Loeblich and Tappan's (1953) description is quite adequate for the forms encountered in this survey.

O. lineata occurs in very small numbers only in Sample # 108, from an intertidal area near the mouth of the Avon River.

OOLINA MELO d'Orbigny

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

Entosulenia hexagona Williamson var. _scalariformis_. Williamson, Cushman, 1948, p. 64, pl. 7, fig. 6.

Oolina melo d'Orbigny, Loeblich and Tappan, 1953, pp. 71 - 72, pl. 12, figs. 8 - 15; - Vilks, 1969, pl. 2, fig. 29; - Sen Gupta, 1971, p. 88; - Iqbal, 1973, p. 192, pl. III, figs. 11, 12.

Ref. Slide 2, # 36 Plate II, fig. 13.

The specimens of _O. melo_ encountered in this survey agree very well with those described by Loeblich and Tappan (1953), except that the double form noted by those authors was not encountered in the Minas Basin.

O. melo occurs in very small numbers in three samples, two from the northern shore of the Basin, and one from the southeastern shore.

OOLINA SP.

Ref. Slide 2, # 41 Plate II, fig. 13

Test free, unilocular, ovate, tapering to an abrupt end containing the aperture. A series of 15 - 20 well-developed costae run the length of the test. These costae are quite high and narrow near the base, flattening out towards the aperture.

Found in very small numbers in only one sample site (#52), almost in the middle of the Basin.

Genus FISSURINA Reuss, 1850

FISSURINA MARGINATA (Montagu)

Vermiculum marginatum Montagu, 1803, p. 524.

Lagena marginata (Walker and Boys) Cushman, 1913, p. 37, pl. 22, figs. 1 - 7.

<u>Entosolenia marginata</u> (Montagu)? Cushman, 1948, p. 65, pl. 7, fig. 7.

<u>Fissurina marginata</u> (Montagu) Loeblich and Tappan, 1953, p. 77, pl. 14, figs. 6 - 9; - Vilks, 1969, pl. 2, figs. 24 a-b; - Sen Gupta, 1971, p. 87, pl. 2, figs. 4 - 5; - Iqbal, 1975, p. 166, Pl. V, figs. 4, 5.

Ref. Slide 2, # 46 Plate II, fig. 15.

Test ovate, slightly protruding near apertural end; wall hyaline to translucents; aperture terminal with an entosolenian tube extending part way down the length of the test. The marginal keel described by some authors is absent or much reduced in Minas Basin specimens, perhaps as a result of abrasion.

<u>F. marginata</u> appears in one sample near the northern shore of the Basin, one in the estuary of the Avon River, and two in the area to the southwest of the mouth of that river.

Family BOLIVINITIDAE Cushman, 1927

Genus BOLIVINA d'Orbigny, 1839

BOLIVINA PSEUDOPLICATA Heron - Allen and Earland

<u>Bolivina pseudoplicata</u> Heron - Allen and Earland, 1930, p. 81, pl. 3, figs. 36-40; - Parker, 1952a, p. 414, pl. 5, fig. 17; - 1952b, p. 444, pl. 4, fig. 11;

- Hoglund, 1947, p. 263, pl. 24, fig. 2, pl. 32, figs. 8 - 11; - Gregory, 1970, p. 212, pl. X, figs. 7 - 9; - Cole and Ferguson, 1975, p. 32, pl. 6, fig. 5.

Ref. Slide 3, # 1 - 5 Plate III, fig. 1.

Test is characteristically small, white, biserially arranged, flat and increasing rapidly in width toward the apertural end. Perforations appear as small round holes covering much of the test. As shown by the figured specimen, most Minas Basin forms exhibit some degree of abrasion.

Distribution rare, limited to only a few stations, and never appearing in large numbers.

BOLIVINA PSEUDOPUNCTATA Hoglund

Bolivina pseudopunctata Hoglund, 1947, p. 273, pl. 24, fig. 5, pl. 32, figs. 23, 24, text - figs. 280, 281, 287; - Loeblich and Tappan, 1953, p. 111, pl. 20, figs. 13, 14; - Gregory, 1970, p. 213, pl. X, fig. 10; - Iqbal, 1973, p. 146, pl. VI, fig. 4.

Ref. Slide 3, # 6 - 10 Plate III, figs. 2,3.

Test small, free, white biserially arranged, with pores rarely visible. Surface often very rough and pitted in appearance. Often the first few chambers are broken off as in the specimen shown. Many specimens are reduced to mere relics, and sometimes identification becomes quite tentative.

Occurs in small numbers in eight samples from widely scattered sites in the Basin, and can only be considered common in one of these.

Family ISLANDIELLIDAE Loeblich and Tappan, 1964

Genus ISLANDIELLA Nørvang, 1958

ISLANDIELLA ISLANDICA (Nørvang)

Cassidulina islandica Nørvang, 1945, p. 41, text - figs. 7, 8 d-f; - Cushman, 1948, p. 75, pl. 8, fig. 13; -Loeblich and Tappan, 1953, p. 118, pl. 24, fig. 1.

Islandiella islandica (Nørvang) Loeblich and Tappan, 1964, p. C556, text - figs. 439, 1 - 3; - Barbieri and Medioli, 1969, p. 857; - Vilks, 1969, p. 4a, pl. 3, fig. 3; - Gregory, 1970, pp. 213 - 214, pl. XI, fig. 1; - Sen Gupta, 1971, p. 88, pl. 2, figs. 11-12, text - figs. 11; - Iqbal, 1973, p. 169, pl. VII, fig. 12.

Ref. Slide 3, # 11 - 15 Plate III, figs. 4,5.

Test free, of medium size, slightly compressed, periphery rounded; chambers inflated, with 3 to 4 pairs in the last whorl, alternate chambers extending to the umbilicus on only one side with merely a portion visible on the other side. Wall opaque, white and smooth. Aperture is seen as an elongate triangular slit appearing alternately on each side of the periphery.

Some writers (Loeblich and Tappan, 1953, Vilks, 1969) have described the test of I. islandica as being translucent. The Minas Basin forms are quite opaque, probably as a result of frosting by abrasion.

I. islandica appears in twelve samples in this survey from widely scattered localities, and never in large numbers.

ISLANDIELLA TERETIS (Tappan)

Cassidulina laevigata d'Orbigny, Brady, 1884 (not d'Orbigny, 1826), p. 428, pl. 54, figs. 1 - 3; - Cushman, 1948, p. 73, pl. 8, fig. 8.

Cassidulina norcrossi Cushman, Phleger, 1952 (not Cushman, 1935), p. 83, pl. 14, fig. 22.

Cassidulina teretis Tappan, 1951, p. 7, pl. 1, figs. 3 a - c; - Loeblich and Tappan, 1953, pp. 121 - 122, pl. 24, figs. 3, 4.

Islandiella teretis (Tappan), Vilks, 1969, pl. 3, fig. 5; - Sen Gupta, 1971, pl. 2, figs. 13 - 14; - Iqbal, 1973, p. 171, pl. VII, fig. 10.

Ref. Slide 3, # 16 - 20 Plate III, figs. 6-8.

The description given by Loeblich and Tappan (1953) is fully adequate for this species, except for, as in _I. islandica_, the frosting apparent in Minas Basin forms.

I. teretis has a slightly more widespread distribution than _I. islandica_, appearing in sixteen samples from various parts of the Basin.

? ISLANDIELLA SP.

Ref. Slide 3, # 21 Plate III, fig. 9.

This grouping is used to cover specimens which appear to be some sort of Islandiella species, but are damaged in such a way as to make identification inconclusive. As the figured example shows, they are often damaged in such a way that the aperture is no longer visible, and frosting action on the surface of the test precludes the possibility of study of arrangement of the chambers. Often these forms are reduced to mere relics.

The distribution of this group is limited to ten samples from various parts of the Basin, and they are never represented by more than one or two specimens in any sample.

Family UVIGERINIDAE Haeckel, 1894

Genus TRIFARINA Cushman, 1923

TRIFARINA ANGULOSA (Williamson)

Uvigerina angulosa Williamson, 1858, p. 67, pl. 5, fig. 140; - Cushman, 1923, p. 170, pl. 141, figs. 17 - 20.

Angulogerina angulosa (Williamson) Cushman, 1944, p. 30, pl. 4, fig. 9; - 1948, p. 66, pl. 7, fig. 8; - Hoglund, 1947, p. 283, pl. 23, fig. 8, text - figs. 305 - 308; - Parker, 1952a, p. 413, pl. 5, figs 18, 19; - Uchio, 1960, pl. 7, fig. 18; - Adams and Frampton, 1965, p. 57, pl. 5, fig. 3; - Leslie, 1965, p. 155, pl. 8, figs. 13 a-c.

Angulogerina flueus Todd, in Cushman and Todd, 1947, p. 67, pl. 16, figs. 6, 7; - Loeblich and Tappan, 1953, p. 112, pl. 20, figs. 10, 12.

Trifarina angulosa (Williamson) Barbieri and Medioli, 1969, p. 857; - Gregory, 1970, pp. 217 - 218, pl. XI, fig. 5; ' Sen Gupta, 1971, p. 89, pl. 2, fig. 16 - 17.

Ref. Slide 3, # 26 - 30 Plate III, fig. 10.

Test elongate, fusiform; several chambers, sets of three comprising each whorl; walls calcareous, finely perforate, ornamentation consisting of vertical costae which curve with the chambers, aperture terminal sometimes with a small lip.

Specimens from the Minas Basin show a continued range of form with some resembling the form decidedly triangular in cross section described by Hoglund (1947) with other, more similar to the more rounded _T. fluens_ of Loeblich and Tappan (1953).

This species often shows a great deal of abrasion and quite often is reduced to an artifact only barely recognizable.

Found in over thirty samples from most areas of the Basin, less common in samples from deeper water. In only one sample does it comprise more than 10% of the population.

Family DISCORBIDAE Ehrenberg, 1838

Sub Family DISCORBINAE Ehrenberg, 1838

Genus ROSALINA d'Orbigny, 1826

ROSALINA COLUMBIENSIS (Cushman)

Discorbis columbiensis Cushman, 1925, p. 43, pl. 6, figs 13 a-c; - Parker, 1952a, p. 418, pl. 6, figs. 7 a,b, 8 a,b, 9 a,b; - 1952b, p. 446, pl. 4, figs. 17 a,b, 18 a,b, 19 a,b, 20 a,b.

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

"<u>Discorbis</u>" <u>sp</u> <u>cf</u>. <u>D</u>. <u>columbiensis</u> Cushman - Gregory, 1970, pp. 218, 219, pl. XI, figs. 6, 7.

<u>Rosalina</u> <u>columbiensis</u> (Cushman) Sen Gupta, 1971, p. 89; - Hume, 1973, p. 111, pl. 6, figs. 15, 16.

Ref. Slide 3, # 31 - 35 Plate III, figs. 11, 12.

Test small, translucent, trochospiral, periphery sub-angular, slightly lobate. 6 - 8 chambers visible in last whorl, last chamber somewhat inflated. Numerous pores on dorsal surface except where sutures lie. Ventral surface exhibits some pores, and each chamber forms a small lobe growing in to the umbilicus, which is depressed. Aperture never seen clearly as last one or two chambers are always missing (i.e. broken off).

Found in twenty-two samples from all parts of the Basin (shallow water as well as deep), but in only one does it comprise more than 10% of the assemblage.

Genus BUCCELLA Anderson, 1952

BUCCELLA FRIGIDA (Cushman)

<u>Pulvinulina frigida</u> Cushman, 1922a, p. 12.

<u>Eponides frigida</u> (Cushman) Cushman, 1931, p. 45.

<u>Buccella frigida</u> (Cushman) Anderson, 1952, p. 144, figs. 4 a-c, 5, 6 a-c; - Loeblich and Tappan, 1953, p. 115, pl. 22, figs. 2, 3; - Gregory, 1970, p. 220, pl. 12, figs. 1 - 3; - Sen Gupta, 1971, p. 89, pl. 2, figs. 18, 19; - Scott et. al., 1977, p. 1578.

Ref. Slide 3, # 36 - 40 Plate IV, figs. 1, 2.

Specimens usually agree quite closely with the descriptions given by Loeblich and Tappan (1953), except that, as in the specimen shown, the periphery is often slightly keeled, as in Loeblich and Tappan's description of <u>B</u>. <u>inusitata</u> (1953, p. 116). (I agree with Gregory's hypothesis (1970, p. 221) that <u>B</u>. <u>frigida</u> and <u>B</u>. <u>inusitata</u> can be considered varieties of one highly variable species.) As in the specimen shown, the last chamber is often broken off in Minas Basin specimens, and other signs of abrasion are quite common.

Distribution of <u>B</u>. <u>frigida</u> in the Minas Basin is sporadic. The species occurs rarely in several samples and can be considered common in only one or two.

Family GLABRATELLIDAE Loeblich and Tappan, 1964

Genus GLABRATELLA Loeblich and Tappan, 1964

GLABRATELLA WRIGHTII (Brady)

Discorbina wrightii Brady, 1881 b, p. 413, pl. 21, fig. 6.

Glabratella wrightii (Brady) Leslie, 1965, p. 161, pl. 10, fig. 7; - Cole and Ferguson, 1975, pl. 8, figs. 10, 11.

Ref. Slide 3, # 41 Plate IV, figs. 3, 4.

Test small, trochospiral and opaque. Periphery broadly rounded, five to seven chambers in the last whorl. Sutures indistinct on dorsal side but marked by patches of growth of calcitic "bumps" on ventral surface. Distinctly umbilicate, aperture not clearly visible.

Occurs in six widely scattered samples all from fairly shallow water.

Family ROTALIIDAE Ehrenberg, 1838

Sub Family ROTALIINAE Ehrenberg, 1838

Genus AMMONIA Brunnich, 1772

AMMONIA BECCARII (Linne)

Nautilus beccarii Linne, 1758, p. 710.

<u>Rotalia</u> <u>beccarii</u> (Linne) var. <u>tepida</u> Cushman, 1926, p. 79, pl. 1; - 1931, p. 61, pl. 13, figs. 3 a-c; - Ronai, 1955, p. 148, pl. 21, fig. 17.

<u>Rotalia</u> <u>beccarii</u> (Linne) and variants Parker, 1952b, pp. 457 - 458, pl. 5, figs. 5 a,b, 7 a,b, 8 a,b.

"<u>Rotalia</u>" <u>sp</u>. <u>cf</u>. "<u>R</u>." <u>beccarii</u> (Linne) Miller, 1953, p. 59, pl. 10, fig. 2.

"<u>Rotalia</u>" <u>beccarii</u> (Linne) variants A, B, C, Parker et al., 1953, p. 13, pl. 4, figs. 20 - 22, 25 - 30.

<u>Streblus</u> <u>beccarii</u> (Linne) and <u>Streblus</u> <u>beccarii</u> <u>tepida</u> (Cushman) Todd and Low, 1961, p. 18, pl. 2, figs. 16 - 19.

<u>Ammonia</u> <u>beccarii</u> (Linne) Frizzell and Keen, 1949, p. 106; - Cifelli, 1962, p. 119, et sequ., text - figs. 6, 7; - Buzas, 1965, p. 62, pl. 4, figs. 1 a,b; - Bartlett, 1966, p. 91, pl. 1, figs. 15 a,b; - Haman, 1966, p. 69, pl. 7, figs. 17 - 19; - Gregory, 1970, pp. 222 - 223, pl. XII, figs. 4, 5 and 6.

Ref. Slide 3, # 46 - 50 Plate IV, figs. 5, 6.

<u>A</u>. <u>beccarii</u> is a species showing a high degree of variability in morphology in its distribution around the world, but in the Minas Basin most specimens are much the

same. The test is very large, free, robust and quite opaque. Chambers are arranged in a trochospiral pattern. The dorsal side is convex with sutures usually plainly visible, except for the smaller chambers near the center. Sutures are often stained a dark reddish colour in Minas Basin forms. The ventral side is umbilicate with many small nodules and other growths of calcite projecting into it, as is characteristic of this species. Some specimens exhibit a large calcite plug partly infilling the umbilicus.

The specimens in this study differ from those of Gregory primarily in being of a much larger size and of a more rounded periphery, with sutures less indented. Most specimens in this study show varying degrees of abrasion on the tests; some being reduced to near artifacts. Often some of the later chambers have been broken off, as in the specimen shown. "Monstrous" specimens of abnormal shape were encountered not infrequently.

This species has a wide range of occurence over the study area and was quite common in many samples.

Family ELPHIDIIDAE Galloway, 1933

Sub Family ELPHIDIINAE Galloway, 1933

Genus ELPHIDIUM de Montfort, 1808

ELPHIDIUM CRISPUM (Linne)?

<u>Nautilus</u> <u>crispus</u> Linne, 1758, p. 709.

<u>Elphidium</u> <u>crispum</u> (Linne) Phleger, Parker and Pierson, 1947, pp. 31 - 32, pl. 6, fig. 17.

Ref. Slide 4, # 1 Plate IV, fig. 10.

The description given by Phleger, Parker and Pierson (1947) is hardly adequate for this species, nor is their figured specimen. The species in the Minas Basin has fewer chambers in the final whorl and a much less pronounced umbilical plug. Also, this form is larger and more carinate than Phleger, Parker and Pierson's.

Occurring only as a very few specimens in four samples, a positive identification of this species appears impossible, particulary since the specimens are all rather abraded. Three of these four samples are from sites clustered near the northern shore of the Basin, with the last from in the estuary of the Avon River.

ELPHIDIUM CLAVATUM Cushman "COMPLEX"

This grouping, as in Gregory's (1970) work, represents the <u>Elphidium</u> <u>incertum</u> "<u>complex</u>" as recognized by Bartlett (1965). No attempt was made by this author to differentiate between them for the purposes of this work simply because it would have been a major undertaking by itself and as such would be quite beyond the scope of this thesis.

A synonymy list of the forms in the literature which I have included under this grouping is as follows:

Elphidium incertum (Williamson) var. clavatum Cushman, 1930, p. 20, pl. 7, fig. 10.

Elphidium clavatum Cushman Loeblich and Tappan, 1953, p. 98, pl. 19, figs. 8 - 10; - Sen Gupta, 1971, p. 89, Pl. 2, figs. 28- 29.

Elphidium subclavatum Gudina, 1964, p. 69, pl. 1, fig. 4 - 10q, text. - fig. 1.

Elphidium excavatum (Terquem) forma clavata Cushman. Feyling - Hanssen, 1972, p. 339 - 40, pl. 1, fig. 1 - 9, pl. 2, figs. 1 - 9.

Polystomella excavata Terquem, 1876, p. 429, pl. 2, fig. 2 a-d.

Polystomella striatopunctata (Fichtel and Moll) var. selseyensis Heron - Allen and Earland, 1911, p. 448.

Elphidium (Polystomella) excavatum (Terquem) Heron - Allen and Earland, 1932, p. 439, pl. 16, figs. 22 - 23.

Elphidium incertum selseyensis (Heron - Allen and Earland) Brand, 1941, p. 65 - 66.

Elphidium excavatum (Terquem) forma selseyensis (Heron - Allen and Earland) Feyling - Hanssen, 1972, p. 341 - 2, pl. 4, figs. 1 - 7, pl. 5, figs. 1 - 7.

<u>Cribroelphidium excavatum clavatum</u> (Cushman) Scott et al., 1977, p. 1578, pl. 5, figs. 1, 2.

<u>Cribroelphidium excavatum selseyensis</u> (Heron - Allen and Earland) Scott et al., 1977, p. 1579, pl. 5, fig. 3.

Ref. Slide 4, # 6 - 10 Plate IV, figs. 7-9.

For descriptions of the various forms of this grouping the reader is referred to Buzas, (1966), Loeblich and Tappan (1953) and Bartlett (1965); though it must be remembered that the Minas Basin forms as often as not represented forms intermediate between any two of the "species" listed above. Of course, with this group as in many others, the effects of abrasion are quite commonly seen, and often specimens are reduced to mere artifacts.

The distribution of <u>E. clavatum</u> "<u>complex</u>" in the Minas Basin is very widespread, appearing in almost all samples, and usually comprising a relatively large percentage of the assemblage.

ELPHIDIUM FRIGIDUM Cushman

<u>Elphidium frigidum</u> Cushman, 1933, p. 5, pl. 1, fig. 8; - 1939, p. 64, pl. 18, fig. 8; - 1948, p. 57, pl. 6, figs. 9 - 11; - Loeblich and Tappan, 1953, pp. 99 - 100, pl. 18, figs. 4 - 9; - Gregory, 1970, pp. 227 - 228,

pl. 14, fig. 3; - Hume, 1972, p. 115, pl. 7, fig. 7.

Ref. Slide 4, # 11 - 15 Plate IV, figs. 11,12, Plate V, fig. 1.

The description given by Hume (1972) applies very well to the specimens from the Minas Basin (as does that of Loeblich and Tappan, 1953) except for the matter of size. Most individuals encountered in this work were quite small, only a few approaching 0.3 mm in diameter. This could possibly be a result of repeated breaking off of chambers, a phenomenon that occurred frequently when handling these very fragile forms. (The figured specimen, an unusually large individual, has its final chamber missing - though this was not due to handling.)

One of the most widespread and abundant species in the Minas Basin, E. frigidum is reported from almost all stations, and is usually one of the most numerous species in the samples.

ELPHIDIUM MARGARITACEUM Cushman

Polystomella odvena Cushman, 1922a, p. 56, pl. 9, figs. 11, 12.

Elphidium advenum (Cushman) var. margaritaceum Cushman, 1930, p. 25, pl. 10, fig. 3; - Parker, 1952b, p. 447, pl. 3, fig. 10.

Elphidium advenum (Cushman) Phleger, Parker and Pierson, 1947, p. 31, pl. 6, fig. 15.

Elphidium margaritaceum Cushman, Todd and Low, 1961, p. 19, pl. 2, fig. 3; - Gregory, 1971, p. 228, pl. XIV, fig. 4.

Cribroelphidiam excavatum (Tarquem) Scott et al., 1977, p. 1578, pl. 5, fig. 4.

Ref. Slide 4, # 16 - 20 Plate V, figs. 2-4.

For the most part, Gregory's description is fairly accurate and under the binocular microscope specimens from the Minas Basin resemble Gregory's figured specimen quite closely. Under the scanning electron microscope, however, Minas Basin specimens show a remarkable tendency towards the growth of numerous small papillae of calcite over most of their surface area. This phenomenon shows up quite clearly in the specimen figured in this work.

The distribution of this species in the study area is quite widespread, and often it is one of the more common species in a sample.

ELPHIDIUM SUBARCTICUM Cushman

Elphidium subarcticum Cushman, 1948, p. 58, pl. 6, fig. 12; - Loeblich and Tappan, 1953, p. 105, pl. 19, figs. 5-7;

- Gregory, 1970, pp. 229 - 230, pl. XIV, fig. 7; - Sen Gupta, 1971, p. 89, pl. 2, figs. 30 - 31; - Hume, 1972, pp. 116 - 117, pl. 7, fig. 9; - Iqbal, 1973, p. 162, pl. VIII, figs. 10, 11.

Ref. Slide 4, # 21 - 25 Plate V, fig. 5.

For a description of this species the reader is referred to Loeblich and Tappan's (1953) comprehensive work, as there is no visible difference in Minas Basin specimens compared to those of Loeblich and Tappan.

E. subarcticum is another very common form in this study area, appearing at almost all sample sites, and being quite numerous in most.

Family EPONIDIDAE Hofker, 1951

Genus EPONIDES de Montfort, 1808

EPONIDES UMBONATUS (Reuss)

Rotalina umbonatus Reuss, 1851, p. 75, pl. 5, figs. 35 a-c.

Eponides umbonatus (Reuss) and variants Phleger, Parker and Pierson, 1947, p. 42, pl. 9, figs. 9, 10.

Ref. Slide 4, # 26 Plate V, figs. 6,7.

Test small, translucent and trochospiral. Periphery rounded, very slightly lobate, inflated final chamber; umbilicus depressed. Sutures visible, especially on ventral side. Aperture appears as small slit on base of final chamber, often obscured by overgrowths of calcite (as on specimen figured).

Distribution limited to four widely scattered sites in the northern portion of the Minas Basin; two in intertidal zones, two in deeper water.

Family CIBICIDIDAE

Sub Family 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 lobatulus (Walker and Jacob) Perker, 1952b, p. 446, pl. 5, figs. 11 a,b; - Todd and Low, 1961, p. 27, pl. 2, fig. 20; - Barbieri and Medioli, 1969, p. 860; - Vilks, 1969, pl. 3, figs. 17 a-b; - Sen Gupta, 1971, p. 89, pl. 2, figs. 34 - 36; - Iqbal, 1973, p. 150, pl. IV, figs. 13, 16, 17.

Ref. Slide 4, # 31 - 35 Plate V, figs. 8, 9.

Description agrees quite closely with that given by Izbal, (1973). However, abrasion is quite prevalent in Minas Basin specimens, and some are reduced to artifacts just barely recognizable as C. lobatulus. Quite often the entire dorsal surface is removed so that the interior of most of the chambers is visible. The figured specimen shows roughly the usual degree of abrasion encountered in this species.

Distribution is widespread, occuring in most samples (even in those samples containing very few foraminifer of any species), and is common in many of these.

PLANKTONIC SPECIES

Family HANTKENINIDAE Cushman, 1927

Sub Family HASTIGERININAE Bolli, Loeblich and Tappan 1957

Genus HASTIGERINA Bollis, Loeblich and Tappan, 1957

HASTIGERINA AEQUILATERALIS (Brady)

Globigerina aequilateralis Brady, 1879, p. 71 (figs. in Brady, 1884, pl. 80, figs. 18 - 21).

Hastigerina aequilateralis (Brady) Postuma, 1971, pp. 366 - 367.

Ref. Slide 4, # 36 Plate V, figs. 10, 11.

Test very small, almost planispiral, somewhat evolute, chambers spherical, $4\frac{1}{2}$ in the final whorl. Wall coarse, perforate. Umbilicate, aperture large, partially filled by earlier chamber.

One specimen encountered in deep water at station # 48.

Family GLOBIGERINIDAE Carpenter, Parker and Jones 1862

Sub Family 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 (Globorotalia?) pachyderma (Ehrenberg) Barbieri and Medioli, 1969, p. 860.

Globigerina pachyderma (Ehrenberg) Be, 1960, p. 66, text-fig. 1; - Hume, 1972, pp. 122 - 123, pl. 8, figs. 11, 12.

Ref. Slide 4, # 41 - 45 Plate V, fig. 12.

(Included under this heading are a few very small planktonic forms which are probably juveniles of G. pachyderma but may include one or two G. bulloides, and cannot be positively identified).

Test small, trochospiral, chambers spherical, 4 to 5 chambers in the final whorl; wall calcareous, final chamber smooth, others somewhat rough, perforate; aperture umbilical, with a small lip. All specimens are the left-coiling form, *G. pachyderma sinistralis*, indicative of colder water.

Found at 15 stations from both deep-water and near-shore environments, never present in numbers greater than 5 or 6 individuals and usually only one or two.

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APPENDICES

APPENDIX I

Table showing original station numbers, the station numbers adapted for this study, weight of each sample in grams (Dry, >63 microns), total number of Foraminifera in each sample and Foraminifera/gm sediment (dry, >63 microns)

Original Station Number	Station Number for This Study	Weight of Sample (dry, >63) in grams	Total Number Foraminifera	Foraminifera per gram sediment (Dry, > 63 microns)
128-112	1	65.00	40	0.62
128-114	2	31.54	2072	65.69
128-116	3	95.00	61	0.64
127-107	4	85.56	54	0.63
127-109	5	57.72	1392	24.12
127-113	6	67.53	54	0.80
127-115	7	75.87	83	1.09
126-104	8	54.41	49	0.90
126-106	9	53.22	60	1.13
126-108	10	47.66	101	2.12
126-112	11	59.01	35	0.59
126-114	12	84.81	976	11.51
126-116	13	49.82	61	1.22
126-118	14	58.20	15	0.26
126-122	15	75.90	171	2.25
126-124	16	79.52	71	0.89
126-126	17	70.00	3362	48.03
125-099	18	72.53	195	2.69
125-101	19	23.15	356	15.38
125-105	20	83.13	1824	21.94
125-107	21	64.42	1960	30.42
125-109	22	56.49	256	4.53
125-115	23	52.80	1360	25.76
125-117	24	74.70	50	0.66
125-119	25	75.66	37	0.49
125-127	26	64.81	4096	63.20
124-106	27	58.06	127	2.19
124-108	28	31.66	125	3.95
124-110	29	69.48	261	3.76
124-114	30	59.86	339	5.66
124-116	31	25.39	323	12.72
124-120	32	68.37	99	1.49
124-122	33	66.52	98	1.47
124-124	34	73.43	25	0.34

Original Station Number	Station Number for This Study	Weight of Sample (dry, >63) in grams	Total Number Foraminifera	Foraminifera per gram sediment (Dry, >63 microns)
124-126	35	70.61	2424	34.89
123-125	36	75.52	9	0.12
123-127	37	30.80	52	1.69
122-114	38	94.16	292	5.34
122-116	39	50.27	180	3.58
122-122	40	90.48	211	2.33
122-126	41	80.00	6	0.08
122-128	42	89.00	39	0.49
122-130	43	100.00	7	0.07
120-104	44	80.85	39	0.48
120-112	45	53.06	2	0.04
120-116	46	61.79	3	0.05
120-118	47	37.21	161	4.33
120-122	48	75.23	45	0.60
118-106	49	29.61	17	0.57
118-110	50	45.27	117	2.58
118-118	51	38.49	3	0.07
116-104	52	56.47	166	2.94
116-106	53	78.80	330	4.19
116-110	54	67.31	45	0.67
116-118	55	49.80	4	0.08
116-120	56	41.70	1	0.02
115-125	57	4.28	10	2.37
114-100	58	89.93	32	2.68
114-106	59	70.99	140	1.97
114-110	60	74.44	8	0.11
114-120	61	45.56	35	0.77
114-124	62	42.20	47	0.90
114-126	63	43.95	70	1.59
114-128	64	65.13	19	0.29
113-121	65	64.35	12	0.18
113-125	66	47.55	385	8.10
112-094	67	61.56	21	2.93
112-098	68	2.78	48	17.26
112-100	69	57.17	89	1.56
112-108	70	36.02	64	1.78
112-114	71	55.78	452	8.10
112-116	72	65.89	4704	71.39
112-118	73	59.70	1952	32.69
112-120	74	61.72	48	0.78
112-122	75	28.42	98	3.49
112-124	76	77.79	1840	23.65
111-117	77	8.87	93	10.49
110-104	78	43.66	59	1.35
110-106	79	74.41	112	1.51
110-116	80	50.37	1320	26.21
110-120	81	78.21	133	1.70
109-113	82	67.52	546	8.09
108-098	83	58.53	232	3.96
108-104	84	68.34	3	0.04

Original Station Number	Station Number for This Study	Weight of Sample (dry, >63) in grams	Total Number Foraminifera	Foraminifera per gram sediment (Dry, >63 microns)
106-093	85	62.33	6	0.09
106-094	86	21.08	37	1.75
106-096	87	54.74	489	8.93
106-100	88	55.53	746	13.44
106-104	89	76.12	106	1.39
105-105	90	55.90	55	0.98
103-096	91	10.75	9088	845.39
103-099	92	54.92	68	1.24
102-094	93	65.11	54	0.83
102-096	94	47.53	408	8.58
102-098	95	50.82	412	8.11
102-100	96	67.26	103	1.53
102-102	97	64.79	299	4.61
101-093	98	70.82	166	2.34
100-095	99	60.03	65	1.08
100-098	100	46.025	10,944	237.28
100-100	101	31.284	105	3.36
099-093	102	40.48	11,008	271.97
099-094	103	42.15	382	9.06
099-096	104	43.83	36	0.82
099-097	105	49.98	269	6.14
099-098	106	59.88	6	0.10
097-101	107	78.01	1	0.01
097-102	108	58.93	1480	25.11
097-105	109	29.99	9024	300.86
096-102	110	78.26	12	0.15
096-104	111	51.88	277	5.39
095-106	112	46.96	1119	23.81
094-107	113	51.78	15682	302.88
092-107	114	66.27	3425	51.69
092-109	115	53.12	1054	19.84
090-108	116	31.78	2752	86.58
088-110	117	61.99	23	0.37
087-110	118	40.55	33,600	828.50
087-111	119	47.16	94	1.99
085-110	120	56.34	656	11.64
084-109	121	49.74	1	0.02

Appendix II

Table showing original station numbers, the station numbers adapted for this study, weight of each sample in grams (Dry, 63u), total number of Foraminifera in each sample and Foraminifera/gm sediment (dry, 63u).

Original Station Number	Station Number for this Study	Weight of sample (dry 63) in grams	Total Number Foraminifera	Foraminifera per gram sediment (Dry, 63u)
128-112	1	65.00	40	0.62
128-114	2	31.54	2072	65.69
128-116	3	95.00	61	0.64
127-107	4	85.56	54	0.63
127-109	5	57.72	1392	24.12
127-113	6	67.53	54	0.80
127-115	7	75.87	83	1.09
126-104	8	54.41	49	0.90
126-106	9	53.22	60	1.13
126-108	10	47.66	101	2.12
126-112	11	59.01	35	0.59
126-114	12	84.81	976	11.51
126-116	13	49.82	61	1.22
126-118	14	58.20	15	0.26
126-122	15	75.90	171	2.25
126-124	16	79.52	71	0.89
126-126	17	70.00	3362	48.03
125-099	18	72.53	195	2.69
125-101	19	23.15	350	15.38
125-105	20	83.13	1824	21.94
125-107	21	64.42	1960	30.42
125-109	22	56.49	256	4.53
125-115	23	52.80	1360	25.76
125-117	24	74.70	50	0.66
125-119	25	75.66	37	0.49
125-127	26	64.81	4096	63.20
124-106	27	58.06	127	2.19
124-108	28	31.66	125	3.95
124-110	29	69.48	261	3.76
124-114	30	59.86	339	5.66
124-116	31	25.39	323	12.72
124-120	32	68.37	99	1.49
124-122	33	66.52	98	1.47
124-124	34	73-43	25	0.34

Original Station Number	Station Number for this Study	Weight of sample (dry 63) in grams	Total Number Foraminifera	Foraminifera per gram sediment (Dry, 63u)
124-126	35	70.61	2424	34.89
123-125	36	75.52	9	0.12
123-127	37	30.80	52	1.69
122-114	38	94.16	292	5.34
122-116	39	50.27	180	3.58
122-122	40	90.48	211	2.33
122-126	41	80.00	6	0.08
122-128	42	85.00	39	0.49
122-130	43	100.00	7	0.07
120-104	44	80.85	39	0.48
120-112	45	53.06	2	0.04
120-116	46	61.79	3	0.05
120-118	47	37.21	161	4.33
120-122	48	75.23	45	0.60
118-110	50	45.27	117	2.58
118-118	51	38.49	3	0.07
116-104	52	56.47	166	2.94
116-106	53	78.80	330	4.19
116-110	54	67.31	45	0.67
116-118	55	49.80	4	0.08
116-120	56	41.70	1	0.02
115-125	57	4.28	10	2.37
114-100	58	85.93	32	2.68
114-106	59	70.99	140	1.97
114-110	60	74.44	8	0.11
114-120	61	45.56	35	0.77
114-124	62	42.20	47	0.90
114-126	63	43.95	70	1.59
114-128	64	65.13	19	0.29
113-121	65	64.35	12	0.18
113-125	66	47.55	385	8.10
112-094	67	61.56	21	2.93
112-098	68	2.78	48	17.26
112-100	69	57.17	89	1.56
112-108	70	36.02	64	1.78
112-114	71	55.78	452	8.10
112-116	72	65.89	4704	71.39
112-118	73	59.70	1952	32.69
112-120	74	61.72	48	0.78
112-122	75	28.42	98	3.49
112-124	76	77.79	1840	23.65
111-117	77	8.87	93	10.49
110-104	78	43.66	59	1.35
110-106	79	74.41	112	1.51

Original Station Number	Station Number for this Study	Weight of sample (dry 63) in grams	Total Number Foraminifera	Foraminifera per gram sediment (Dry, 63u)
110-116	80	50.37	1320	26.21
110-120	81	78.21	133	1.70
109-113	82	67.52	546	8.09
108-098	83	58.53	232	3.96
108-104	84	68.34	3	0.04
106-093	85	62.33	6	0.09
106-094	86	21.08	37	1.75
106-096	87	54.74	489	8.93
106-100	88	55.53	746	13.44
106-104	89	76.12	106	1.39
105-105	90	55.90	55	0.98
103-096	91	10.75	9088	845.39
103-099	92	54.92	68	1.24
102-094	93	65.11	54	0.83
102-096	94	47.53	408	8.58
102-098	95	50.82	412	8.11
102-100	96	67.26	103	1.53
102-102	97	64.79	299	4.61
101-093	98	70.82	166	2.34
100-095	99	60.03	65	1.08
100-098	100	46.025	10944	237.78
100-100	101	31.284	105	3.36
099-093	102	40.48	11008	271.97
099-094	103	42.15	382	9.06
099-096	104	43.83	36	0.82
099-097	105	49.98	269	6.14
099-098	106	59.88	6	0.10
097-101	107	78.01	1	0.01
097-102	108	58.93	1480	25.11
097-105	109	29.99	9024	300.86
096-102	110	78.26	12	0.15
096-104	111	51.88	277	5.39
095-106	112	46.96	1119	23.81
094-107	113	51.78	15682	302.88
092-107	114	66.27	3425	51.69
092-109	115	53.12	1054	19.84
090-108	116	31.78	2752	86.58
088-110	117	61.99	23	0.37
087-110	118	40.55	33600	828.50
087-111	119	47.16	94	1.99
085-110	120	56.34	656	11.64
084-109	121	49.74	1	0.02

Appendix III

Table showing Relative Abundances of Each Species in Every Sample.

(A number in brackets appearing below the station number indicates number of foraminifera in the sample, if less than 50.)

SAMPLE NO.	1 (40)	2	3	4	5	6	7	8 (49)	9	10	11 (35)	12
Ammonia beccarii	22.5		4.9	3.6	2.3			55.1	18.3	11.9		1.6
Astaculus hyalacrulus												
Bolivina pseudoplicata		0.7		1.2								
B. pseudopunctata												
Bucella frigida				5.4				2.0				
Cibicides lobatulus		0.8		9.9	12.6	22.2	8.4		16.7	12.9	22.8	8.2
Eggerella advena		7.7		3.6	5.7		14.5			9.9		6.5
Elphidium "complex"	22.5	4.7	18.0	55.5	13.8	27.8	6.0	20.4		24.7		22.9
E. crispum											2.8	
E. frigidum		76.8	16.4	1.8	17.2		7.2		20.0	26.7	11.4	22.9
E. margaritaceum		1.8			11.5		12.0				5.7	1.6
E. subarcticum		3.9	31.8		16.1	22.2	28.9	8.2	21.7	4.9	25.7	24.6
Eponides umbonatus												
Fissurina marginata												
Glabratella wrightii					4.6							1.6
Globigerina pachyderma												
Hastigerina aecquilateralis												
Islandiella islandica		0.7				7.4						
Islandiella teretis								2.0				
?Islandiella? sp.										2.0		
Lagena meridionalis					1.2				1.7			
Lagena mollis												
Lagena semilineata												
Milliammina fusca					1.2		9.6			2.0	8.6	
Oolina costata												
Oolina lineata												
Oolina melo												
Oolina sp.												
Pseudo polymorphina novangliae												
Pyrgo williamsoni						7.4		2.0			2.8	1.6
Quinqueloculina seminulum	55.0		3.2	1.8	1.2	11.1				2.0	14.3	
Rosalina columbiensis				10.9	5.7		6.0		8.3			1.6
Saccammina atlantica												
Spiroplectammina biformis				1.8								
Trifarina angulosa												
Trochammina inflata			8.2	1.8		1.8					5.7	1.6
Trochammina lobata		1.5	6.5		1.2		3.7	8.2		3.0		1.6
Trochammina macrescens												
Trochammina ochracea		1.5	9.8	3.6	4.6		3.7	2.0	13.3			3.3

13	14 (15)	15	16	17	18	19	20	21	22	23	24
19.7	26.6	9.4	15.5		6.2	6.7	1.7	1.6	12.2	1.2	22.0
	13.3						0.9	5.7			
16.4	13.3	5.3	23.9	5.7	13.8	7.8	1.7	4.9	8.6	5.3	10.0
		7.6		10.5	8.7	5.6	1.7	5.3	19.2		
44.2	20.0	15.8	14.0	22.5	21.0	15.7	28.1	3.7		27.1	14.0
									1.0		
		8.8	11.3	14.3	18.5	32.6	29.5	43.6	24.6	31.7	20.0
		9.9	2.9	16.8		3.4	1.7		2.4	1.2	4.0
14.8	20.0	19.3	21.1	15.9	17.9	21.3	30.7	26.1	16.0	28.8	6.0
				1.9							
		4.6									
				1.9	1.1						
									15.2		
		1.2									
				1.0							
			2.9								4.0
							0.9	0.7			
	6.6	0.7		1.0		1.2	0.9	0.7	4.3	2.3	4.0
		1.7	8.4	1.9	4.1	3.4	0.9	0.7	5.5	1.2	6.0
								2.4		1.2	
						1.2					
				1.0							
3.3		1.7		1.0							
		4.1					0.9	0.7	1.9		
1.6				1.9		1.2		0.7	1.9		
				1.0							
		9.9		1.9	8.7			3.3			10.0

25	26	27	28	29	30	31	32	33	34	35	36
(37)									(25)		(9)
8.1		78.2	2.4	25.3	16.5	11.4	8.0	7.1	44.0		22.2
2.7											
	0.8				1.2						
					1.2						
	0.8		4.0				3.0				
8.1	12.5	5.5	16.8	14.6	8.0	5.9	15.0	8.1	8.0		
	8.6	1.0	11.2		6.2	3.4	17.0	11.2			
32.4	11.7	4.7	9.6	7.7			12.0	16.3	20.0	100.0	11.1
					1.2						
	25.8		1.6	6.5	11.8	48.3	8.0	22.4	8.0		
8.1	3.9					1.5					
13.5	25.0	6.3	46.4	41.4	32.7	13.0	15.0	17.3			
					8.8						
					1.5						
	1.6										
	0.8								4.0		
							2.0	1.2			
				0.3							
	0.8										
	0.8					1.0		4.1			
				0.3							
				0.7							
16.2	0.8		1.6	4.2	3.8	2.5	3.0	5.1			
10.8	0.8	2.0		2.3	1.5	3.4	9.0	9.2	16.0		55.5
	0.8				4.7	3.1					
	0.8				0.9						
											11.1
	1.5			0.3							
	1.5					1.5					
	0.8	2.0	6.4				7.0				

37	38	39	40	41	42	43	44	45	46	47	48
				(6)	(39)	(7)	(39)	(32)	(3)		(45)
7.7	2.5	7.8	6.2	16.6					33.3	5.6	13.3
							2.5	3.1			
[illegible]	9.7	7.2	8.5	33.3	17.9		5.1			7.4	8.9
	4.7	10.0	7.1				7.7	3.1		6.2	2.7
19.2	6.3	26.1	24.2	50.0	38.5	28.6	15.4	15.7		27.3	17.8
15.4	34.1	10.0	20.4			28.6	46.4	46.9		23.0	22.2
			5.7		10.3						
15.4	29.7	28.3	16.6			28.6				26.1	17.8
											2.7
											2.7
											2.7
											2.7
	0.3		1.6								
	0.6	1.8	2.4		12.8			3.1			
9.6	3.4	8.8	3.3		20.5			9.4	66.6	3.1	6.7
	2.8										
										1.3	
						14.3					
3.8	0.6										
	5.3		4.0				20.4	18.7			

49 (17)	50	51 (3)	52	53	54 (45)	55 (4)	56 (1)	57 (10)	58 (32)	59	60 (8)
11.7	15.4	33.3	6.0	2.7	20.0	25.0			32.2	8.6	
			0.6							3.5	
			0.6								
47.1	20.5		22.3		13.3	25.0			48.4		
	4.4		3.6	6.4				50.0		7.9	
	14.5		14.5	22.1	17.8			30.0	9.6	7.1	62.5
		66.6		25.4	2.3	25.0				20.7	
								20.0			
29.4	23.9		36.1	27.9	33.3				6.6	29.3	
			0.6							2.1	
				1.5							
					2.3						
	9.4										
			0.6								
				3.3							
11.8			10.8	2.1	2.3	25.0	100.0			3.0	
	4.1			3.9					3.2	11.4	25.0
			0.7							1.4	
				0.8	2.2						
	6.8		3.6	3.9	6.7					5.0	12.5

61 (35)	62 (47)	63	64 (19)	65 (12)	66	67 (21)	68 (48)	69	70	71	72
14.3	10.6	7.1	15.9	8.3	4.9			1.9	28.1	10.9	6.6
					4.1						0.2
											0.2
								1.2	3.1		0.2
17.1	19.1	10.0	21.0	33.3	5.2		16.7	19.1	15.6	17.7	0.7
		8.6			5.2		12.5	2.2			42.0
22.9	27.6	21.4	42.1	16.6	21.3	4.7	41.7	58.4	9.4	69.0	42.8
14.3	21.2	18.6			35.3	95.3			1.6		4.7
4.7	2.1	11.4								5.3	
11.4	12.0	15.7	10.5	16.6	16.6				31.2		
				8.3				1.1			
	2.1										0.2
		2.8									0.2
				8.3					1.6		
8.6					4.1						
		2.8								3.5	0.3
5.7			10.5	8.3			4.2	1.1	7.8	1.8	0.7
								1.2			
		1.6			3.1		4.2	1.2			
					4.1						
								1.1		1.8	0.2
					4.1		20.8	5.6			

73	74	75	76	77	78	79	80	81	82	83	84
	(48)										(3)
3.3	16.7	10.2	1.7	21.5	59.3	57.1	1.2	39.8	3.3	22.5	
		2.0									
		4.1							1.6		
9.8	18.8	12.2	2.6	16.1	13.5	7.1	43.6	29.3	25.8	28.5	33.3
3.3			1.7						4.8	8.6	
19.7	45.8	31.6	30.4	16.1	15.2	14.3	50.3	15.0	53.4	33.7	33.3
26.2		21.4	27.8	32.2					1.5		
1.6											
29.5		15.3	29.6	5.4	8.4		3.6	7.5		4.7	33.3
			0.9								
1.6											
			0.9								
									0.5		
	4.2										
				1.1					0.5		
									0.4		
									0.2		
						7.1			0.2	0.8	
1.6		1.0	0.9	2.2		7.1	0.6	1.5	1.5	0.4	
	14.6		0.9		3.6	7.1		4.5	1.1	0.8	
				1.1							
1.6			0.9	2.2			0.6	0.9	4.8		
		1.0	0.9	2.2				1.5			
1.6		1.0							0.4		
			0.9								

85	86	87	88	89	90	91	92	93	94	95	96
(6)	(37)										
	2.7	21.3	15.0	4.7	16.3		5.8		8.8	2.7	7.8
				1.0							
			1.5			0.8					1.9
		14.5	23.6	9.4	9.1		19.1	1.9	16.7	16.7	9.7
	10.8	9.0	2.7	4.7			10.3		3.4	7.8	
	43.2	20.0	40.5	20.7	56.4	3.5	41.2	57.4	29.4	34.2	76.7
	10.8	7.6	2.7	17.0		71.1	7.4		19.6		
53.7		4.9	0.5		1.9		4.4				
	16.2	10.6		22.6	9.1	17.2		14.8	17.8	23.1	
							1.6		1.0		
										1.2	
	2.7	0.4								0.5	
							2.9				
	2.7	1.0		1.9						1.9	
		2.5									
		0.4	0.5							0.3	
		0.6	1.5							1.2	
	2.7		4.4	5.7	7.2		4.4	24.1	1.0	1.2	
				4.7						2.2	
								1.9	1.0		
		0.6									1.0
		2.5	4.0							2.4	2.9
	8.1	2.0	2.0	1.9			2.9		1.0	4.6	
16.6	5.4	2.0	1.1								
				5.7		7.4					

97	98	99	100	101	102	103	104 (36)	105	106 (6)	107 (1)	108
6.7		16.9									
			0.3								
								11.9			
1.3											
33.4	9.0	20.0		15.2	0.6	13.1	8.3				17.3
0.4		12.3	1.5	3.8	4.7	4.2	22.2	11.5			13.0
44.8	4.8	26.2	30.4	56.0	1.2	44.0	11.1	8.9			15.1
			0.3								
			31.0		36.6		27.8	55.8		100.0	34.6
	56.6		1.0		0.6		13.9				
1.7	13.3	9.2	29.2	11.4	37.2	34.5	16.7		100.0		17.3
			0.3								
0.7				1.8							0.5
0.3			0.3	1.9							
0.7											
					0.6						
0.3	3.6										
1.3			0.6								
1.0		7.7	0.6								
	1.9										
			0.3								
4.0		4.6	0.3	1.9		4.2					
2.7	6.0	7.1	1.2	2.9							
0.4	4.8		1.5								
				1.9							
			1.5	3.8	18.6		11.	11.9			0.6

109	110 (12)	111	112	113	114	115	116	117 (23)	118	119	120	121 (1)
	16.7	2.9	0.4	1.0	1.9	3.0						
0.7						0.3						
1.4			1.8		2.8				0.4			
14.2		11.6	24.5	20.8	8.4	10.7	2.4	21.7	5.7	13.8		
2.8		22.0	0.9		28.0	6.3	5.8		9.5	11.7	36.6	
51.1	41.7	29.2	64.2	31.4	27.1	33.4	25.7		28.5	57.4	14.6	100.0
22.7	41.7	8.3		5.2	12.2	15.2	11.6		18.8		12.3	
				3.1				65.2	0.7	5.3		
5.7		19.5		30.7	10.3	14.7	39.5	4.4	19.2		21.9	
			1.1									
				0.3								
		1.9							0.2	3.4		
			0.4									
			0.2			0.2			0.2			
			0.2									
				0.2								
			0.2						0.2			
1.4			0.4	1.1					0.2			
			0.7	0.2					0.2			
						1.5						
		2.1	2.1	2.3		3.2			5.7	4.2		
		2.5	1.8	1.0	1.9	3.1	5.8		0.4			
						1.6	9.3		0.4	4.2		
				0.3	7.5	6.2		8.7	9.5		14.6	

Plates

Plate I

Fig.

1 Saccammina atlantica (x60)

2 Milliammina fusca (x148)

3 Spiroplectammina biformis (x166)

4 Trochammina lobata - dorsal view (x110)

5 Trochammina inflata - ventral view (x88)

6 Trochammina inflata - dorsal view (x88)

7 Trochammina lobata - ventral view (x110)

8 Trochammina macrescens - dorsal view (x80)

9 Trochammina macrescens - ventral view (x70)

10 Eggerella advena (x255)

11 Trochammina ochracea - dorsal view (x147)

12 Trochammina ochracea - ventral view (x147)

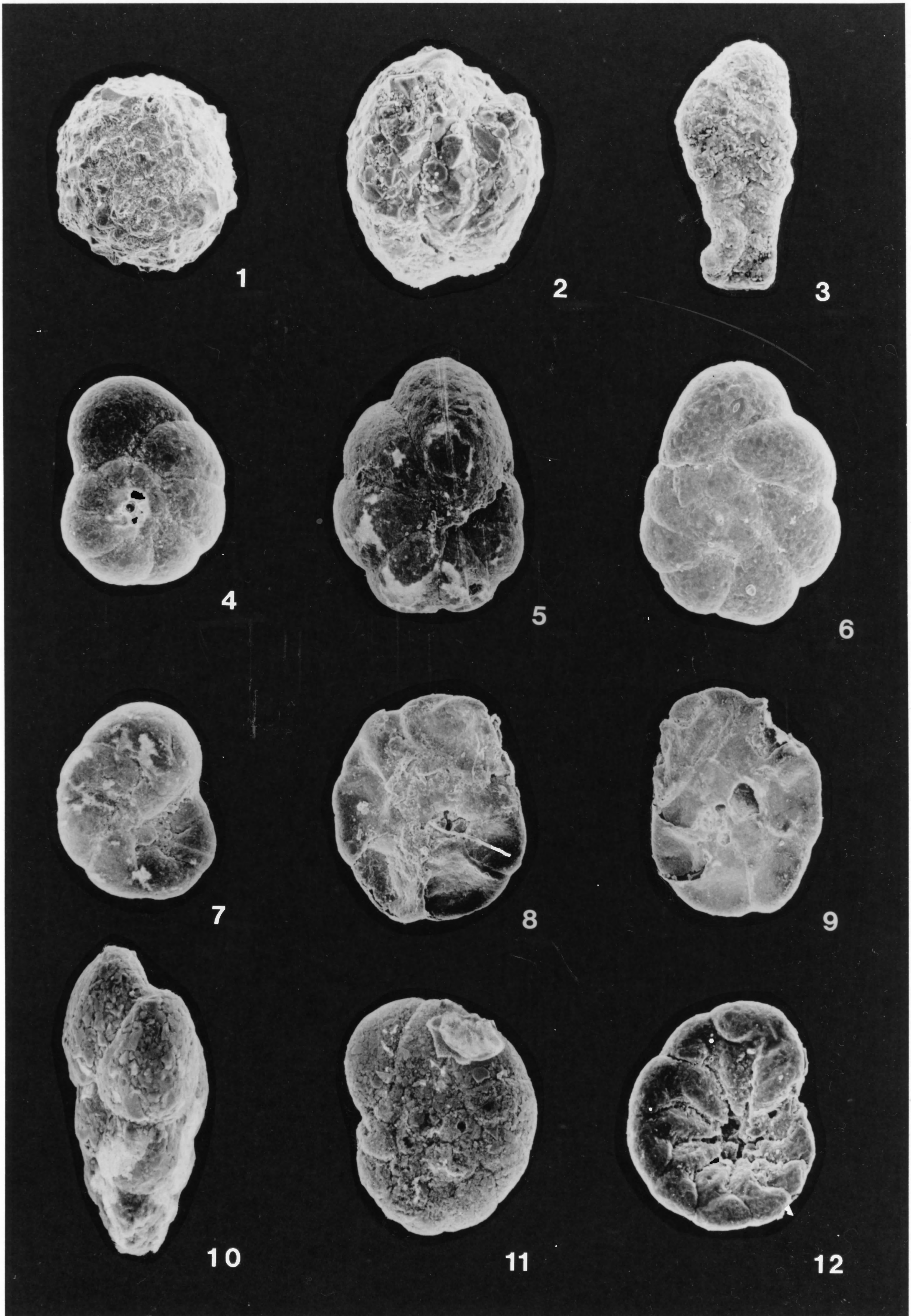
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Plate II

Feg.

1 Quinqueloculina seminulum (x138)

2 Quinqueluculina seminulum - apertural view (x155)

3 Pyrgo williamsoni (x64)

4 Astacolus hyalacrulus (x105)

5 Astacolus hyalacrulus - apertural view (x105)

6 Pseudopolymorphina novangliae (x28)

7 Pseudopolymorphina novangliae - apertural view (x73)

8 Lagena meridionalis (x225)

9 Lagena semilineata (x92)

10 Lagena mollis (x84)

11 Oolina costata (x97)

12 Oolina sp. (x270)

13 Oolina melo (x90)

14 Oolina lineata (x152)

15 Fissurina marginata (x180)

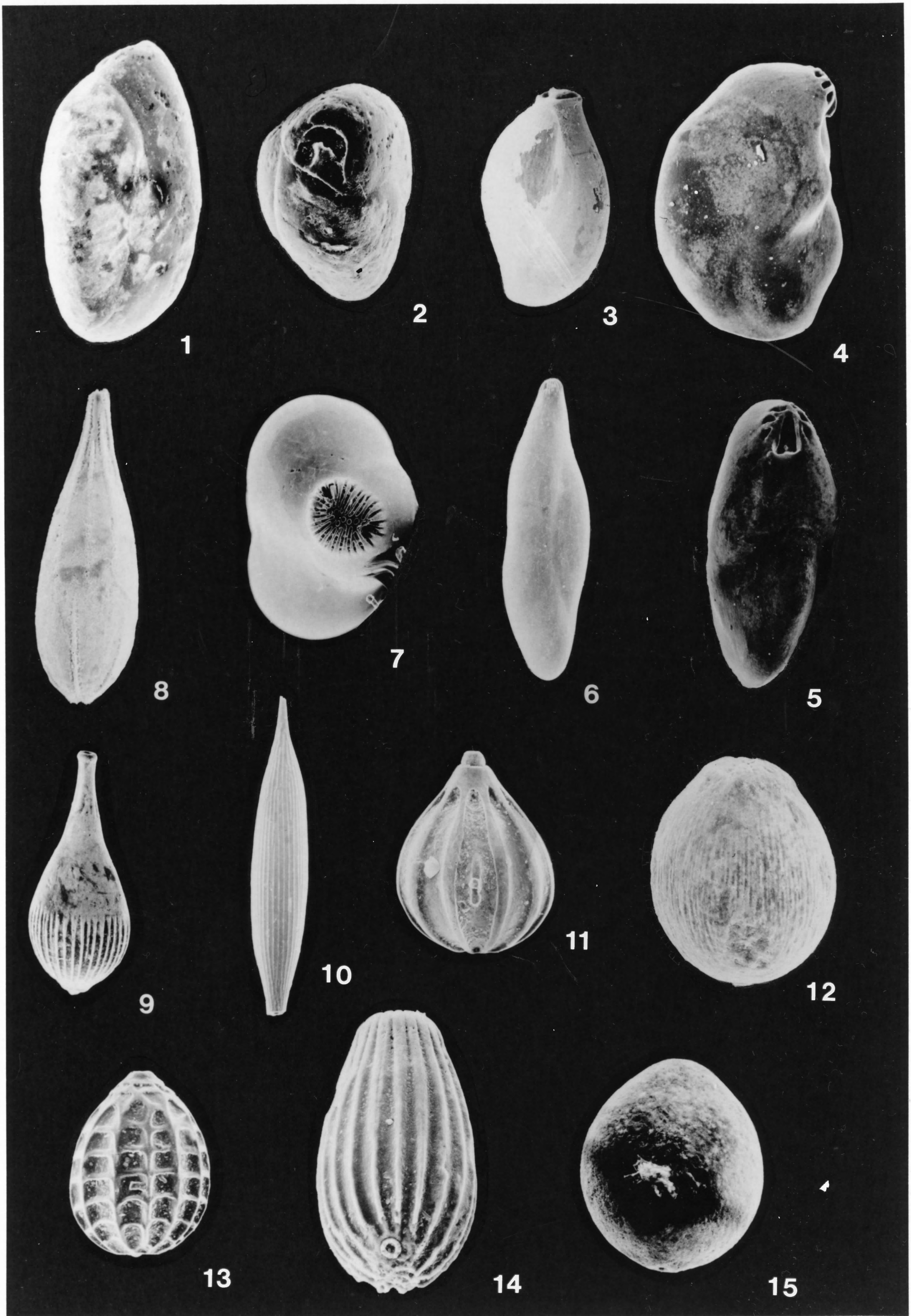
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Plate III

Fig.

1. *Bolivina pseudoplicata* (x335)
2 *Bolivina pseudopunctata* (x240)
3 *Bolivina pseudopunctata* (x121)
4 *Islandiella islandica* - ventral view (x130)
5 *Islandiella islandica* - dorsal view (x130)
6 *Islandiella teretis* - dorsal view (x120)
7 *Islandiella teretis* - ventral view (x97)
8 *Islandiella teretis* - apertural view (x109)
9 *?Islandiella sp.* (x105)
10 *Trifarina angulosa* (x104)
11 *Rosalina columbiensis* - dorsal view (x165)
12 *Rosalina columbiensis* - ventral view (x165)

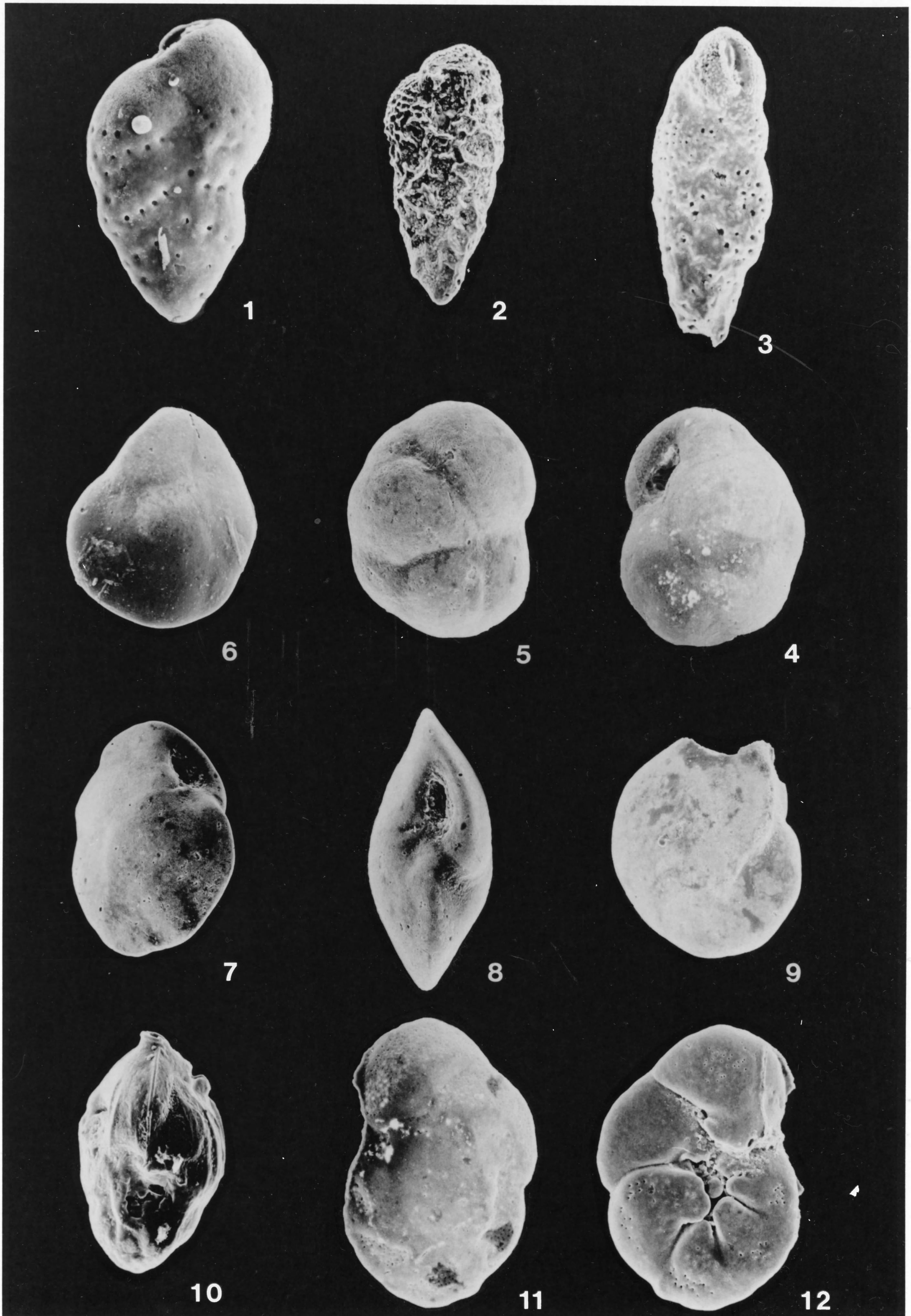
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Plate IV

Fig.

1 Bucella frigida - dorsal view (x110)

2 Bucella frigida - ventral view (x134)

3 Glabratella wrightii - dorsal view (x215)

4 Glabratella wrightii - ventral view (x195)

5 Ammonia beccarii - ventral view (x48)

6 Ammonia beccarii - dorsal view (x48)

7 Elphidium clavatum "Complex" (x148)

8 Elphidium clavatum "complex" (x111)

9 Elphidium clavatum "complex" (x111)

10 Elphidium crispum (x73)

11 Elphidium frigidum (x156)

12 Elphidium frigidum (x156)

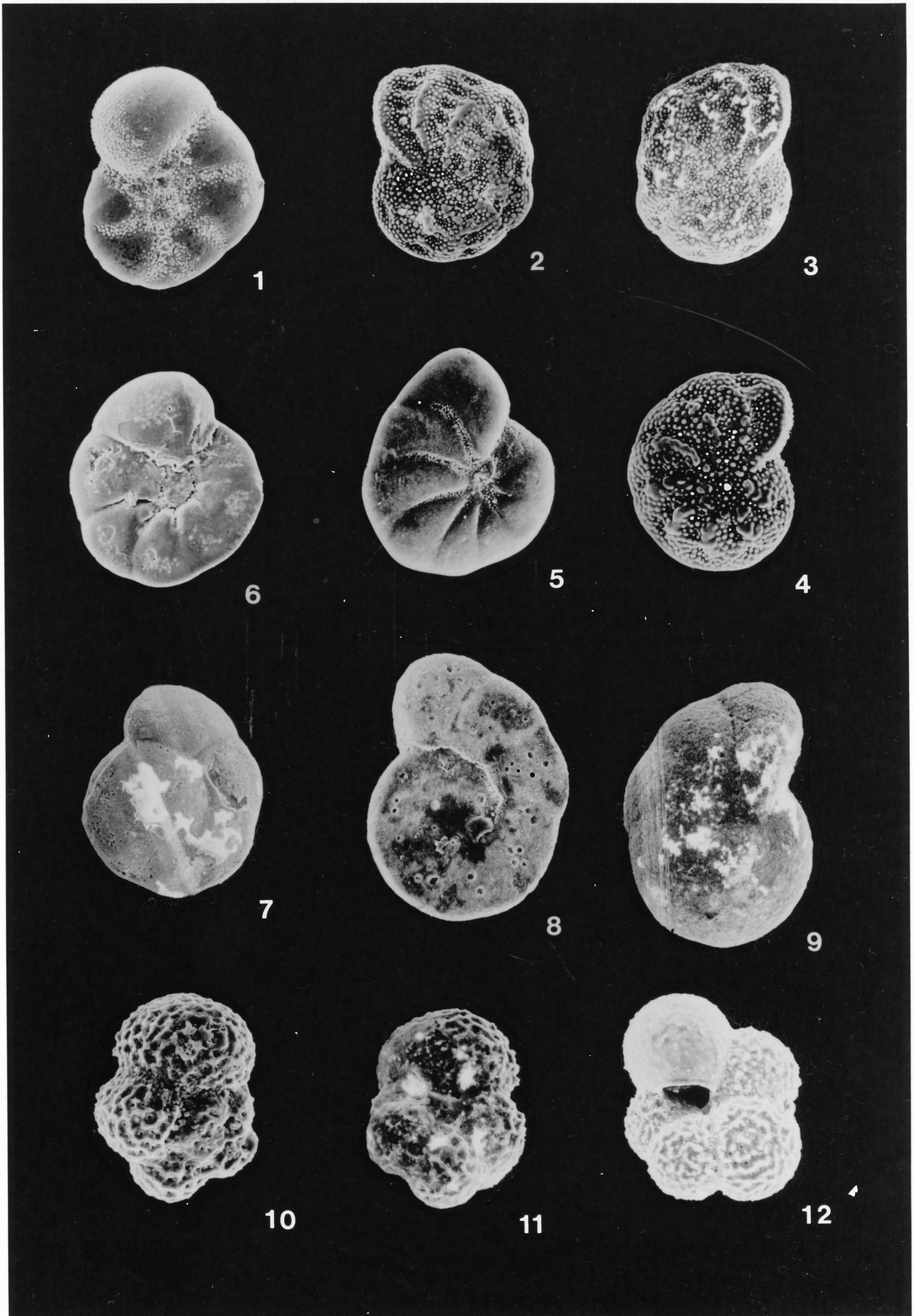
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Plate V

Fig.

1 <u>Elphidium frigidum</u> (x195)

2 <u>Elphidium margaritaceum</u> (x112)

3 <u>Elphidium margaritaceum</u> (x112)

4 <u>Elphidium margaritaceum</u> (x167)

5 <u>Elphidium subarcticum</u> (x89)

6 <u>Eponides umbonatus</u> - ventral view (x146)

7 <u>Eponides umbonatus</u> - dorsal view (x146)

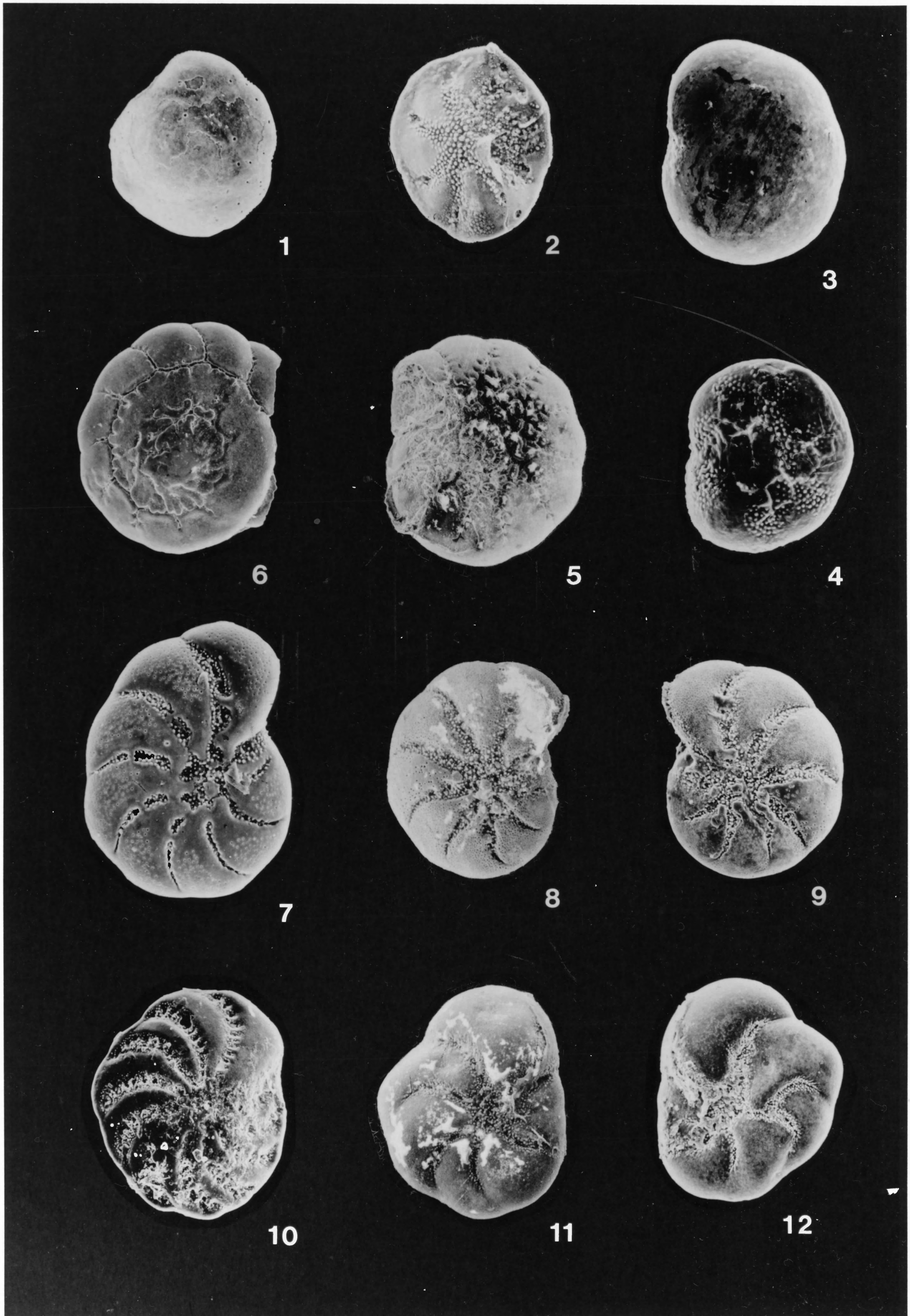
8 <u>Cibicides lobatulus</u> - ventral view (x140)

9 <u>Cibicides lobatulus</u> - dorsal view (x140)

10 <u>Hastigerina aecquilateralis</u> (x245)

11 <u>Hastigerina aecquilateralis</u> (x245)

12 <u>Globigerina pachyderma</u> - ventral view (x215)



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