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Kenneth Hooper

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Résumé de l'article

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DISTRIBUTION OF FORAMINIFERIDA SOUTH OF SHERBROOKE, NOVA SCOTIA

KENNETH HOOPER
Department of Geology, Carleton University, Ottawa, CANADA

Bottom sediment samples (depths to 25m) from St. Mary's River, Gegogan, Wine Bay, Indian and Holland's Harbours, Nova Scotia, identified for the Foraminiferida by Habbishaw in 1970, were factor-vector analyzed. Based on 'total' populations 4 benthonic foraminiferal assemblages, not strictly biocenoses, are recognized. Assemblage 1, dominated by Miliammina fusca, *has a mean diversity of 4.75, a mean depth of 1.85 m, a mean pH (substrate) of 6.7, and the substrate is coarse-grained. This assemblage is found in the Upper Estuarine (intertidal) Zone in St. Mary's River, south of Sherbrooke. Assemblage 2, dominated by* Eggerella advena, *has a mean diversity of 12.5, a mean depth of 7 m, a mean pH (substrate) of 8.16, and the substrate is very fine-grained. It is found in the Lower Estuarine Zone in the lower reaches of St. Mary's River, Wine Harbour Bay, the western and northern areas of Gegogan Harbour, and the eastern shore south of Port Bickerton. Assemblage 3, dominated by* Elphidium clavatum, *has a mean diversity of 14.3, a mean depth of 9m, a mean pH (substrate) of 7.2, and the substrate is coarse- to fine-grained sand. It occurs in the Marginal Marine Zone (Scott) or Nearshore Biofacies (Bartlett) in St. Mary's River (3 to 5 km from the mouth) and at the head and near the mouth of Indian Harbour. Assemblage 4 dominated by* Cibicides lobatulus, Eggerella advena *and* Elphidium clavatum, *has a mean diversity of 19.9, a mean depth of 12.2m, a mean pH (substrate) of 7.16, and the substrate is medium- to fine-grained sand. It occurs in the Open Ocean-Nearshore Zone (Scott) or the Open Bay Biofacies (Bartlett), inside and outside Holland's Harbour, the southwest and central area of Indian Harbour, at the mouth of St. Mary's River, on the eastern side of Gegogan Harbour, and east of Crook Point.*

INTRODUCTION

In 1959 C.T. Dunlop using a drag sampler from a small motorboat, obtained 59 bottom sediment samples from the shallow water (1.3 to 24.6 m) of the eastern shore of Nova Scotia in the immediate area of St. Mary's River between Liscombe Island and Cape Mocodome including Gegogan Harbour, Wine Harbour, Indian Harbour and Holland's Harbour (Fig. 1).

In addition to the collection of sediment samples readings were made to station position, depth of water and pH, but temperatures and salinities were not recorded because of equipment failure.

Foraminiferida from the sediments were studied by Habbishaw (1970), and 76 forms were recognized. Sixty-five species were identified and named. Fifty-three taxa were hyaline and constituted 55% of the total number of specimens counted. Six taxa were porcelaneous constituting only 2% of the total number of specimens counted. Seventeen taxa were arenaceous (agglutinating) constituting 43% of the total number of specimens counted. The specimens were not stained to reveal protoplasm so that no differentiation could be made between living and non-living, and thus only 'total' populations could be analyzed. Therefore, it is unlikely that the distributions reveal biocenoses in the precise sense because the foraminiferal tests tend to be transported and deposited by current action in these generally high energy shallow water intertidal to subtidal zones. Of the 17 arenaceous species identified, *Eggerella advena*, *Trochamminella atlantica* and *Trochammina inflata* were most abundant in number of individuals in the arenaceous fauna. The species showed no significant limitations with regard to depth, pH or sediment type. *Miliammina fusca* was found to be abundant in very shallow water of depth less than 30 m. *Ammotium cassis* was restricted to depths less than 9 m and pH of 8 or more. *Reophax scottii* was only found in mud and ooze and preferred a pH of 8. *Psammosphaera fusca* was restricted to depths greater than 19.5 m. Porcelaneous foraminifers comprised a small percentage of the total fauna. They preferred sandy sediment with pH 7.0 to 7.5. Arenaceous forms preferred coarse-grained sediments with pH 6.5 to 7.2 and mud and ooze with pH 7.8 to 8.5. Hyaline forms were the most abundant and widespread group, favouring medium to fine sand with pH 7.0 to 7.5. *Elphidium clavatum*, *Protelphidium orbiculare* and *Buccella frigida* were common in most environments. Hyaline forms were rarely found in conditions with pH greater than 8 or less than 7. Planktonic foraminifers were rare; only one species *Globigerina bulloides* was identified. Habbishaw (*op cit*) noted that the fauna corresponded well with that reported by Bartlett (1962) from southeastern Nova Scotia.

The purpose of the present study is to establish benthonic foraminiferal assemblages for the area south of Sherbrooke, Nova Scotia.

METHOD

Habbishaw's basic data on counts per species has been subjected to factor-vector analysis using modified COVAP (Manson and Imbrie 1964) in the Q-mode. The Zerox 9 computer was used.

RESULTS

The results of factor analysis on four rotated factors, and other data are shown in Table 1. The samples fall into four assemblages whose distribution in the study area is shown in Figure 2. The

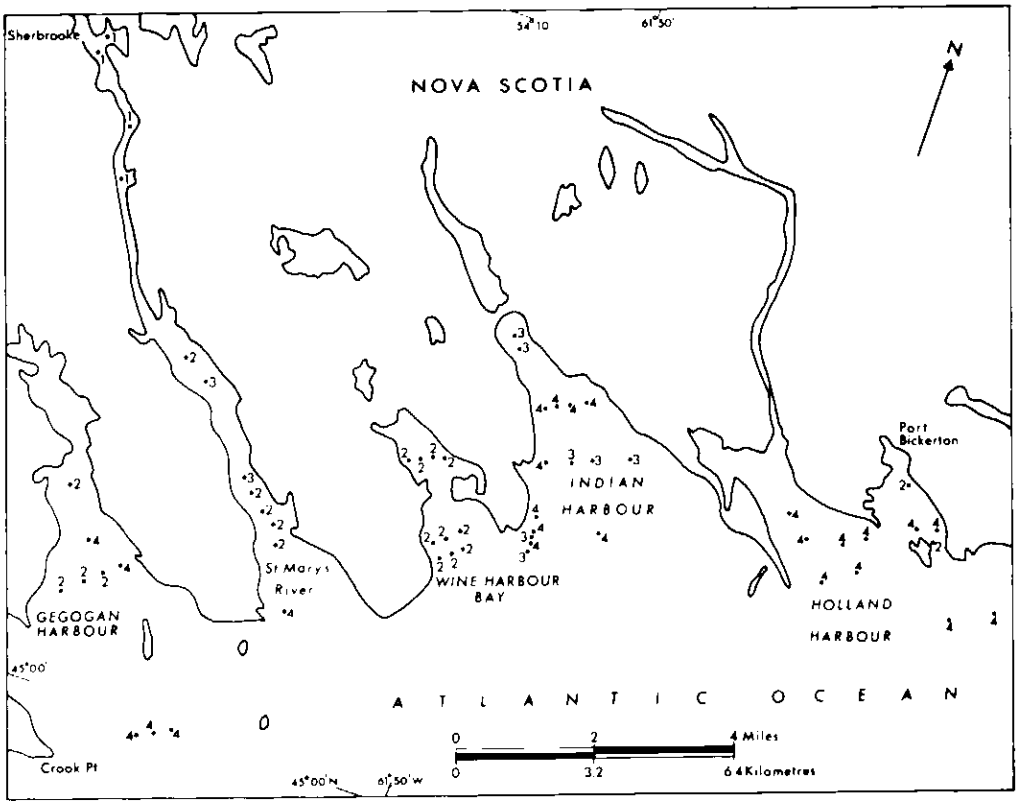

FIG. 1 Locality of the area south of Sherbrook, Nova Scotia showing sediment sampling stations 1–59.

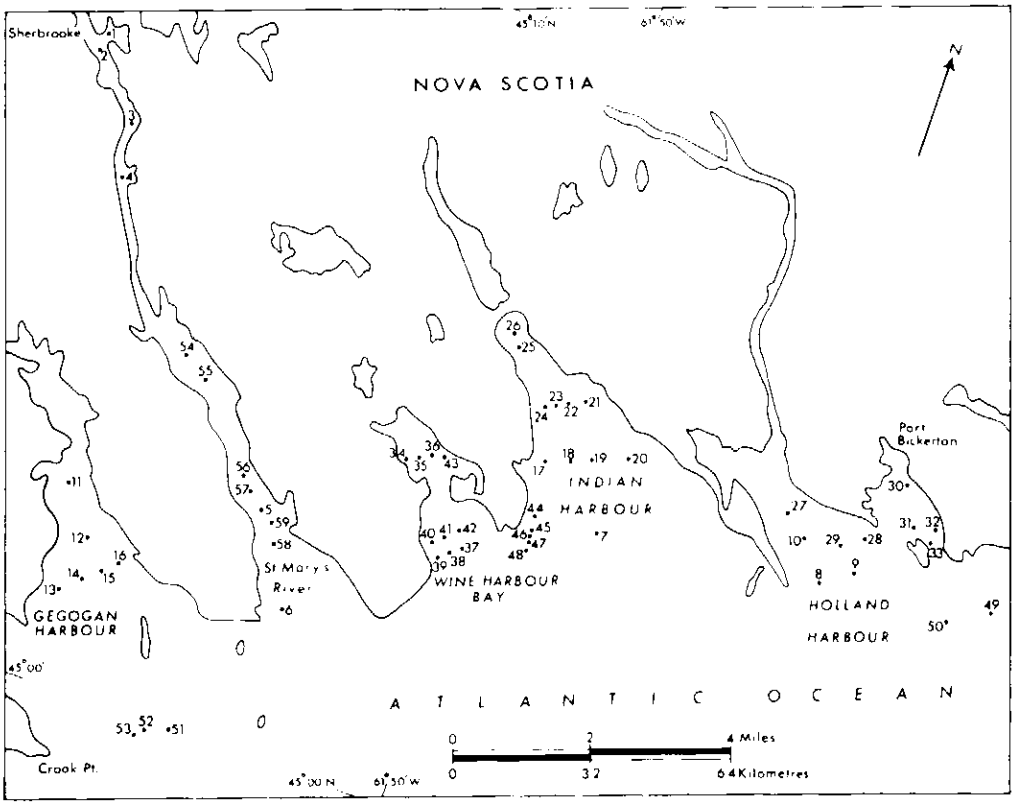

FIG. 2 distribution of benthonic foraminiferal assemblages 1–4.

sample of station 7 is unique and has a very low coefficient of similarity with all other samples. It is therefore removed from the assemblages and treated as a special case. Assemblage 1, the *fusca*, consists of the four samples of stations 1, 2, 3 and 4 on the upper reaches of St. Mary's River, south of Sherbrooke. Agglutinating (arenaceous) taxa account for 97 to 100% of the fauna, hyaline taxa account for up to 3% and there are no porcelaneous forms. Coefficients of similarity are high, ranging from 1.0 to 0.883. The dominant (most abundant) species is *Miliammina fusca* which ranges from 54% in sample 4 to 100% in sample 3.

Common agglutinating forms include *Proteonina atlantica, P. difflugiformis, Eggerella advena* and *Trochammina inflata*. Hyaline forms are rare but include *Elphidium clavatum, Buccella frigida, Islandiella islandica* and *Cibicides lobatulus*. Diversity (number of species) is low, the mean diversity is 4.75, the range is 1 to 6, and N = 4. Substrate data are lacking except for station 3 which is very coarse-grained (cobbles). Mean pH is low at 6.7 the range is 6.5 to 7.2, and N = 3. Depth of water is very shallow; mean depth is 1.85 m and the range is 1.3 to 3.0 m.

Assemblage 2, the ad *advena*, consists of 21 samples representing the stations indicated on Table 1. Coefficients of similarity range from 1.0 to 0.716. Agglutinating (arenaceous) taxa predominate (99.8 to 51%) especially in samples with the highest coefficients of similarity. Samples with lower similarity coefficients tend to have lower percentages of agglutinating taxa but higher percentages of hyaline taxa (0.2 to 49%). Procelaneous forms are rare being present in only two samples (0.1 to 1.0%). The most abundant species in all samples is *Eggerella advena* with percentages ranging from 95 to 39. *Trochammina inflata* is the most abundant species in most samples of high similarity coefficient (1.0 to 0.918). Below 0.918 the Elphidiidae and *Cibicides lobatulus* tend to take over. In sample 11 *Ammotium cassis* is second-most abundant species. In samples 57 and 58 *Miliammina fusca* at 24% occupies this position. Other agglutinating (arenaceous) forms present in the assemblage include *Reophax arctica, R. scottii, Trochamminella atlantica* and *Trochammina rotaliformis*. The hyaline forms *Fissurina marginata, Buccella frigida* and *Protelphidium orbiculare* also are present in moderate amounts.

The mean diversity 12.5, range 4 to 30, N = 21 is more than double that of Assemblage 1. The mean pH 8.16, range 7.0 to 8.5 is the highest of the 4 assemblages. The substrates associated with Assemblage 2 are mostly ooze, mud and fine sand. Only one is medium-grained sand. The mean depth is 6.98 m, and the range is 1.8 to 12.9 m.

Assemblage 3, the *clavatum* consists of 9 samples representing stations 25, 26, 48, 55, 56, 19, 20, 18, 46, in order of similarity co-efficients from 1.0 to 0.585 (Table 1). Hyaline forms predominate ranging from 95.9% to 74%. Agglutinating (arenaceous) species range from 0.5% to 26%. Porcelaneous taxa range from zero to 13%. The most abundant species *Elphidium clavatum* is dominant in all samples and ranges from 86% of sample 25 to 27% of sample 18. Other Elphidiidae are present in minor amounts. *Cibicides lobatulus*, which is present in low amounts in the samples of high similarity coefficient and high percentage of *E. clavatum*, becomes more abundant in samples of lower similarity coefficient and lower percentage of *E. clavatum*. Common hyaline forms include *Elphidium bartletti, E. incertum, E. subarcticum, Buccella frigida* and *Fissurina marginata*. *Quinqueloculina seminulum* is a common procelaneous form and the agglutinating form *Eggerella advena* is also common. The mean diversity 14.3, range 5 to 36, N = 9, is higher than that of Assemblage 2. The mean pH 7.2, range 7.0 to 7.5 is lower than that of Assemblage 2, but higher than that of Assemblage 1. Substrates range from coarse-grained sand to fine-grained sand with one sample a mixture of sand and ooze (sample 18). The mean depth is 9 m, and the range is 3.6 to 18.6 m.

Assemblage 4, the *lobatulus - clavatum - advena*, consists of 24 samples excluding the unique sample of station 7. Coefficients of similarity range from 1.0 to 0.497. Hyaline forms range from 86% of sample 60, to 53% of sample 31. Agglutinating (arenaceous) species range from 36% (sample 31) to 6% (sample 8). Porcelaneous species are present in all samples, the percentages ranging from 23% in sample 8 to 0.1% in sample 10. The most abundant species in the samples of high similarity coefficients)i.e. samples 6, 16, 44, 22, 52, 50, 57, 27, 49, 45 and 53) is *Cibicides lobatulus* with percentages ranging from 43 to 27. In samples with lower similarity coefficients *Elphidium clavatum* commonly takes over the premier place with percentages ranging from 39 to 25. However, the percentage for *C. lobatulus* commonly is only slightly lower than that of *E. clavatum* in each sample. *Eggerella advena*, present in all samples of Assemblage 4, is abundant in most and is the most abundant species in sample 32, 12 and 31 with 40%, 29% and 35% respectively. Other species that occur commonly in Assemblage 4 include *Elphidium incertum, E. bartletti, Islandiella islandica, Buccella frigida, Fissurina marginata, Trochamminella atlantica* and *Quinqueloculina seminulum*.

The mean diversity is 19.9, the range is 9 to 24 and N = 24 (excluding station 7). This is the highest diversity of the four assemblages. The mean pH 7.16, with a range of 7.0 to 7.6 is comparable to that of assemblage 3. Substrates range from fine gravel (sample 8) through medium-grained sand to very fine-grained sand. They are thus very similar to those of Assemblage 3.

The 3 rotated factors solution of the data was also considered. The trace of the original matrix = 59.00, the communality over 59 factors is 58.99, over 3 factors it is 52.61. This compares with a communality of 55.08 for the 4 factor solution. Assemblage A of the 3 rotated factor solution consists of the same 4 samples (1, 2, 3 and 4) that comprise Assemblage 1, the *fusca* assemblage, of the 4 toated factor solution. Sample 32 (coefficient of similarity - 0.700) was placed with all the Assemblage 2 samples to form Assemblage B. However, sample 32, also has a coefficient of similarity of 0.548 with Assemblage C, and thus its position is somewhat borderline. Assemblage C (3 rotated factors) consists of all Assemblage 3

and Assemblage 4 samples (4 rotated factors) except sample 32. Assemblage 3 appears to be generally recognizable on the basis of its high percentage of *Elphidium clavatum* and therefore the 4 rotated factor solution is preferred.

DISCUSSION

Temperature and salinity data covering the study area are not available from the Marine Environmental Data Service (pers. comm., King, July 1978). However, some general comments concerning these parameters in relation to foraminiferal distribution can be made by comparison with neighboring areas. At Chezzetcook Inlet, approximately 110 km west of Sherbrooke, Scott (1977) found bottom temperatures at the head of the estuary ranged from -0.5°C to +20°C over the year. Bottom temperatures at the mouth of the estuary ranged from -0.5°C to +12°C, approximately the same as the ocean. Salinity values varied with the tide but north of the entrance they ranged 26, 27, 29°/oo two hours before high water and 31, 31, 31°/oo one hour after. Maximum tidal range at the mouth was 214 cm. Scott recognized salinity zones based on maxima as follows: (1) Upper Estuarine subzone A with an average salinity of 15.8°/oo and values ranging from 11.6°/oo to 21.1°/oo; (2) Upper Estuarine subzone B with an average salinity of 20.4°/oo and values ranging between 13.1°/oo and 26.4°/oo; (3) Lower Estuarine zone with an average salinity of 29.7°/oo and values ranging between 25°/oo and 31°/oo; (4) Open Bay zone with an average salinity of 31.4°/oo and values between 30.8°/oo and 31.8°/oo; and (5) nearshore zone, identical to the Open Bay zone in terms of salinity.

The Upper Estuarine zone A foraminiferal assemblage is characterized by a high percentage of *Miliammina fusca*, lesser amounts of *Ammotium salsum*, *Ammobaculites foliaceus*, *Trochammina inflata macrescens* (equivalent to *T. macrescens*), *T. inflata* and *Tiphotrocha comprimata* (*Trochammina aquamata*). Agglutinating species account for 99.1% of the fauna. Diversity is 7.5. The Upper Estuarine zone B foraminiferal assemblage is characterized by the high abundance of *Miliammina fusca*, an increase in *Ammotium salsum*, a decrease in *Ammobaculites foliaceus*, and the addition of *Hemisphaerammina bradyi* and *Protelphidium orbiculare*. Agglutinating forms account for 98.2% of the fauna. Diversity is 8.7. South of Sherbrooke the *fusca* assemblage is characterized by *Miliammina fusca* as the most abundant species and it contains *Trochammina inflata*, but Habbishaw did not report the other species mentioned by Scott. Thus the Chezzetcook Upper Estuarine zone intertidal assemblages although not strictly comparable to the shallow water St. Mary's River *fusca* assemblage are similar and are indicative of low salinity environments.

The Lower Estuarine zone assemblage of Chezzetcook shows an increase in the abundance of calcareous species. *Cribroelphidium excavatum* (probably equivalent to *Elphidium incertum* in Habbishaw), *C. excavatum clavatum (Elphidium clavatum)*, *C. excavatum selsevensis* (also included in *Elphidium clavatum* in Habbishaw), and *Ammonia beccarii* make their first sustained appearance. Also, *Eggerella advena*, *Hemisphaerammina bradyi* and *Protelphidium orbiculare* are found here. *Miliammina fusca* and *Ammotium salsum* decrease and *Ammobaculites foliaceus* almost disappears. Agglutinating species account for 59.6% of the fauna. Diversity is 12.8. Habbishaw did not report *Hemisphaerammina bradyi*, *Ammonia beccarii* or *Ammotium salsum* from south of Sherbrooke where the genus *Ammotium* is represented by *Ammotium cassis*. Even so, the Lower Estuarine zone assemblage has many important species in common with the *advena* assemblage of the Sherbrooke Area. The absence of *Ammonia beccarii* in the latter assemblage probably indicates lower summer maximum temperature than at Chezzetcook.

Bartlett (1964) reported that estuarine muds commonly are characterized by low (acidic) pH values. However, high (alkaline) pH value substrates apparently are associated with the *advena* assemblage south of Sherbrooke.

The Open Bay assemblage of Scott is dominated by *Cribroelphidium* species and *Protelphidium orbiculare*. Open ocean species such as *Buccella frigida*, *Cibicides lobatulus*, *Glabratella wrighti* and *Rosalina columbiensis* are common. Estuarine forms *Ammotium salsum*, *Hemisphaerammina bradyi* and *Miliammina fusca* disappear. Agglutinating forms account for 24.6% of the fauna. Habbishaw did not report *Glabratella wrighti* or *Rosalina columbiensis* from south of Sherbrooke but otherwise Scott's Open Bay Assemblage is similar to the Sherbrooke Assemblages 3 and 4 except that tests of *Miliammina fusca* though much reduced have not disappeared completely in these latter. They may have been transported seawards.

The Open Ocean-Nearshore zone assemblage at Chezzetcook Inlet is characterized by the absence of estuarine species and is dominated by *Cribroelphidium excavatum* and *Cibicides lobatulus* with *Quinqueloculina seminulum* and *Rosalina columbiensis* moderately common. The diversity is 12.8 and 0.6% of the fauna is agglutinating. Apart from the presence of *Rosalina columbiensis* this assemblage is also similar to Assemblages 3 and 4 south of Sherbrooke, especially to Assemblage 4 in which *Quinqueloculina seminulum* is common attaining a maximum of 23% of sample 21.

Scott (1977) pointed out that Chezzetcook differs from many described Maritimes estuaries in being intertidal rather than subtidal. In faunas reported from deeper estuaries *Ammotium cassis* dominates at least part of the estuary but it is absent from Chezzetcook. *A. cassis* is present in some of the Sherbrooke samples (24% in sample 11, 5% in sample 38, 11% in sample 39, 3% in sample 40 and 6% in sample 43) but is never dominant.

The foraminiferal ecology of St. Margaret's Bay and Mahone Bay, southeastern Nova Scotia was reported upon by Bartlett (1964). Water depths do not exceed 75 m and are generally less than 20 m. Temperatures at depths less than 3 m vary from 1.32°C to 22°C. Variations from 4°C to 10°C are present in depths to 20 m. From 20 m to 70 m temperatures are less than 6°C, often less than 4°C. Salinities are uniform in the open bay (26°/oo to 32°/oo) but are extremely variable nearshore and in estuaries (6°/00 to 28.42°/oo).

This is attributable to fresh water runoff. Four biofacies were recognized. (1) Intertidal: *Miliammina fusca* and *Trochammina lobata* are the indigenous species, but *Elphidium advenum* and other species of *Trochammina* are common. (2) Back bay and lagoon: *Alveolophragmium crassimargo, Ammotium cassis, Eggerella advena, Elphidium advena, E. incertum, Protelphidium orbiculare, Trochammina* spp. are the characteristic species with tests of *Miliammina fusca* and *Trochammina lobata* transported into this environment from the intertidal. (3) Nearshore: *Alveolophragmium crassimargo, Ammotium cassis, Bulimina exilis, Cibicides lobatulus, Eggerella advena, Elphidium clavatum, Elphidium frigidum, Elphidium subarcticum, Protelphidium orbiculare, Quinqueloculina seminulum, Reophax curtus* are present with *Proteonina atlantica* as the most abundant index species of this environment. (4) Open Bay: *Adercotryma glomeratum, Buccella frigida, B. inusitata, Cassidulina islandica, (Islandiella islandica), Cassidulina teretis (Islandiella helenae), Cibicides lobatulus, Elphidium bartletti, E. clavatum, Fissurina marginata, Globobulimina auriculata, Lagena laevis, Nonion labradoricum (Nonionellina labradorica), Pyrgo subsphaerica, Quinqueloculina stalkeri* and *Robertinoides charlottensis* were named as characteristic of this biofacies.

Bartlett regarded salinity and algal relationships as factors limiting the distribution of living *Miliammina fusca, Elphidium advenum* and *Trochammina lobata* to the intertidal zone. The species survive in salinities of 12°/oo to 31°/oo and temperatures of 1.5°C and 22°C. Living specimens of *T. lobata* and *M. fusca* were not found below the zone although large numbers of tests were found seaward, indicating post-mortem seaward transport. *T. lobata* and *E. advenum* were not recorded from south of Sherbrooke but otherwise the *fusca* assemblage seems similar to Bartlett's intertidal biofacies. The Sherbrooke *advena* assemblage seems similar to Bartlett's Back Bay and Lagoonal biofacies, but with the addition of *Elphidium clavatum* and some other more open ocean species. The Sherbrooke Assemblage 3 (the *clavatum*) has a somewhat similar composition to Bartletts' nearshore biofacies although *Reophax curtus* was not recorded by Habbishaw, and the most abundant (and index) species *Proteonina atlantica* was present in only small amounts south of Sherbrooke. Sherbrooke Assemblage 4 (*Cibicides - advena - clavatum*) is similar to the Open Bay biofacies of Bartlett except that *Globobulimina auriculata, Pyrgo subsphaerica* and *Robertinoides charlottensis* were not recorded in the former.

Bartlett noted that living *Eggerella advena* and *Ammotium cassis* were most abundant below wave induced turbulence at the mouths of most estuaries and the coastal indentations associated with bayhead and pocket beaches. This seems to be borne out in the Sherbrooke area.

In the Lahave Estuary, southeastern Nova Scotia, Allen and Roda (1977) reported little variation in bottom water salinities which range from 26°/oo to 30°/oo. Bottom temperatures varied from 14.8°C to 16.6°C (August). They defined two major faunal assemblage zones - the upper estuarine and the transitional as defined by Scott *et al* (1977) and concluded that the foraminiferal distribution in the study area appeared to be determined by sediment patterns as water temperatures and salinities showed little variation. Their assemblage zone 1 contained a high percentage of *Miliammina fusca* and corresponds to the upper estuarine area. Assemblage zone 2 (upper transitional zone) contains relatively large percentages of *Protelphidium orbiculare, Eggerella advena, Cribroelphidium excavatum* and *Ammotium cassis*. Assemblage zone 3 (lower transitional zone) is dominated by *A. cassis*. The sampling was not carried far enough down stream to establish a marginal marine (open bay) fauna. Assemblage zones 1 and 2 are similar to the *fusca* and *advena* assemblages of the area south of Sherbrooke. *Ammotium cassis* is present in the *advena* assemblage of Sherbrooke but never dominant.

Schafer and Sen Gupta (1969) studied the foraminiferal ecology in polluted estuaries of New Brunswick and Maine. They reported *Miliammina fusca* to be the most abundant species, over 90% of the population in St. John River, 39% to 86% in the Penobscot, and 72% to 2% in the Kennebec. *Trochammina inflata* was reported as often abundant or common, except in the St. John River where the common *Trochammina* is *T. macrescens*. *Elphidium orbiculare* was occasionally present in the river samples, and attained a high of 84% in an algal substrate sample from West Franklin. The above species were regarded as intertidal. Their upstream limit was stated to be the 5°/oo isopleth of salinity. Other species occurring in some samples included *Ammonia beccarii, Ammotium cassis, Eggerella advena, Elphidium incertum, E. clavatum, E. marginitaceum* and *Quinqueloculina seminulum*.

Schafer *et al*. (1975) reported upon foraminifera of Canso Strait, Nova Scotia. The dominant arenaceous foraminifer of Canso Strait is *Eggerella advena* especially near shore. It is often closely associated with the *Elphidium incertum/clavatum* group. *Saccammina atlantica* (=*Proteonina atlantica*), *Ammodiscus catinus* and *Trochammina inflata* are significant near shore co-occurring species. The cold shallow near shore co-occurring species are *Elphidiella arctica* (Sherbrooke assemblages 3 and 4, rare), *Elphidium margaritaceum* (not recorded by Habbishaw perhaps included in *E. incertum/clavatum*) and *Buccella inusitata*. The warm shallow near shore (north of the Canso causeway and the Gulf of St. Lawrence) co-occurring species are *Elphidium subarcticum, Islandiella wrighti* and *Ammonia beccarii*. The last two are not recorded from the area south of Sherbrooke.

The Miramichi River and Bay form an estuary emptying into the Gulf of St. Lawrence on the eastern shore of New Brunswick which was studied by Bartlett (1966) who recognized 2 foraminiferal faunas. (1) *Miliammina fusca* fauna prolific in the river, in association with 4 species of *Trochammina*, which inhabits waters of salinities less than 20°/oo, and (2) *Elphidium* fauna prolific in the central bay and adjoining baymouth barriers composed of *Buccella frigida, Eggerella advena, Elphidium incertum* 'complex', *E. margaritaceum E. orbiculare, E. subarcticum* and other subordinate species which inhabit waters with salinities between 20°/oo and 29°/oo. *Eggerella advena* tends to become most abundant in the baymouth barrier environment.

Scott *et al* (1977) studied the same area using cluster analysis. They distinguished three assemblages. (1) Upper Estuarine: abundant *Miliammina fusca*, *Ammotium salsum*, *Trochammina inflata macrescens* and the thecamoebinid *Pontigulasia compressa*. (2) Lower Estuarine - transition zone: distinguished from the Upper Estuarine principally by comparatively high percentages of *Ammotium cassis* and *Eggerella advena*. (3) Marginal Marine: dominated by *Cribroelphidium excavatum clavatum* and *Protelphidium orbiculare*. Although not identical these 3 assemblages are similar to the Sherbrooke Assemblages 1, 2 and 3 respectively. It seems reasonable to conjecture that salinities and temperatures will be broadly similar also. Scott *et al* (1977) referring to Krauel (1975) reported river zone (Upper Estuarine) mean bottom water salinity as 17.5°/oo, mean variability at each station was 5.4°/oo. The transition zone (Lower Estuarine) had a mean bottom water salinity of 23.9°/oo with mean variability at each station of 1.7°/oo. The open bay zone (Marginal Marine) had a mean bottom water salinity of 24.8°/oo and a mean variability at each station of 2.6°/oo. Bottom water temperatures vary with season from 0°C to 20°C. These values are slightly lower than those reported by Bartlett (1964) for open, ocean-facing areas in St. Margarets' Bay and Mahone Bay, Nova Scotia, where salinities are 26°/oo to 32°/oo and temperatures range from 4°C to 10°C in depths to 20 m which are probably more applicable to the Sherbrooke area.

CONCLUSION

Factor-vector analysis suggests 4 benthonic foraminiferal assemblages characterize the bottom south of Sherbrooke. Assemblage 1 extends for 6 km down the St. Mary's River. The assemblage dominated by *Miliammina fusca* denotes a low diversity, low salinity, low pH, shallow water (intertidal), Upper Estuarine Zone. Assemblage 2, a Lower Estuarine assemblage, extends for much of the lower reaches of St. Mary's River. It is dominated by *Eggerella advena*. This moderately diverse (12.5) assemblage which prefers high pH and very fine-grained substates, also occupies the bottom of Wine Harbour Bay, the western and northern areas of Gegogan Harbour and the eastern shore south of Port Bickerton. Assemblage 3 dominated by *Elphidium clavatum* has some of the characteristics of the Marginal Marine Assemblage as defined by Scott, or the Nearshore Biofacies as defined by Bartlett. Moderately diverse (14.3), mean pH 7.2 and preferring sand, it is found in St. Mary's River approximately 3 to 5 km from the mouth and at the head and near the mouth of Indian Harbour. Assemblage 4, dominated by *Cribrolelphidium excavatum*, *Eggerella advena* and *Elphidium excavatum*, has a high diversity (19.9), mean pH 7.16, and prefers a sand substrate. It is similar but not identical to the Open Ocean-Nearshore zone assemblage of Scott. Also, it has many of the characteristics of the Open Bay Biofacies of Bartlett, but it lacks *Globobulimina auriculata*, *Tyrgo subsphaerica*, and *Robertinoides charlottensis*. It is found outside and inside Holland's Harbour, in the southwest and central area of Indian Harbour, at the mouth of St. Mary's River, on the eastern side of Gegogan Harbour, and east of Crook Point.

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APPENDIX I

FAUNAL REFERENCE LIST

Selected references to the species found in this survey are listed below.

Adercotryma glomeratum (Brady) LOEBLICH and TAPPAN, 1952, Journ. Washington Acad. Sci. Vol. 42, p. 141, figs. 1-4' --- 1953, Smith. Misc. Col. Vol. 121, No. 7, p. 26, pl. 8, figs. 1-4.

Alveolophragmium crassimargo (Norman) LOEBLICH and TAPPAN, 1953, Smithsonian Misc. Coll. Vol. 121, No. 7, p. 29, pl. 3, figs. 1-3. Genus *Cribrostomoides* in LOEBLICH and TAPPAN, 1964, Treatise Invert. Paleo. Protista 2(1), p. C225, fig. 136, 3a, b.

Alveolophragmium jeffreysi (Williamson) LOEBICH and TAPPAN, 1953, Smithsonian Misc. Coll. Vol. 121, No. 7, p. 31, pl. 3, figs. 4-7.

Ammotium cassis (Parker) LOEBLICH and TAPPAN, 1953, Smithsonian Misc. Coll., Vol. 21, No. 7, p. 33, pl. 2, figs. 12-18.

Angulogerina angulosa (Williamson) CUSHMAN, 1927, Contr. Cushman Lab. Foram. Res. v. 3, pt. 1, p. 69.

Angulogerina fluens TODD, 1947, *in* Cushman and Todd, 1947, Contr. Cushman Lab. Foram Res., V. 23, pt. 3, p. 67, pl. 16, figs. 6, 7; --- Cushman and McCulloch 1948, Allan Hancock Pacific Exped., v. 6, no. 5, p. 288, pl. 36, fig. 1.

Astrononion gallowayi LOEBLICH and TAPPAN, 1953, Smithsonian Misc. Coll., Vol. 121, No. 7, p. 90, pl. 16, figs. 4-7.

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Buccella inusitata ANDERSON, 1952, Journ. Washington, Acad. Sci. Vol. 42, no. 5, p. 148, figs. 10a-11c.

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Islandiella helenae FEYLING-HANSSEN and BUZAS, 1976, Jour. Foram. Res. V. 6, p. 155, figs. 1-4.

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Dentalina ittai LOEBLICH and TAPPAN, 1953, Smithsonian Misc. Coll. Vol. 121, No. 7, p. 56, pt. 10. figs. 10-12.

Eggerella advena (Cushman) CUSHMAN, 1937, Cushman Lab. Foram. Res. Spec. Publ. No. 8, p. 15, figs. 12-15.

Elphidiella arctica (Parker and Jones) CUSHMAN, 1939, U.S. Geol. Surv. Prof. Pap. 191, p. 65, pl. 18, figs. 11-14.

Elphidiella nitida CUSHMAN, 1941 Contr. Cushman Lab. Foram. Res., vol. 17, pt. 2, p. 35, pl. 9, fig. 4.

Elphidium bartletti CUSHMAN, 1933, Smithsonian Misc. Coll., Vol. 89, No. 9, p. 4, pl. 1, fig. 9.

Elphidium clavatum Cushman LOEBLICH and TAPPAN, 1953, Smithsonian Misc. Coll. Vol. 121, No. 7, p. 98, pt. 19, figs. 8-10.

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Elphidium incertum sensu CUSHMAN, 1930, U.S. Nat. Mus., Bull. 104, pt. 7, p. 18, pl. 7, figs. 5-9.

Elphidium subarcticum CUSHMAN, 1944, Cushman Lab. Foram. Res. Spec. Publ. 12, p. 27, pl. 3, figs. 34, 35.

Esosyrinx curta (Cushman and Ozawa) LOEBLICH and TAPPAN, 1953, Smith. Misc. Coll. Vol. 121, No. 7, p. 85, pl. 15, figs. 1-5.

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Fissurina cucurbitasema LOEBLICH and TAPPAN, 1953, Smith. Misc. Coll., Vol. 121, No. 7, p. 76, pl. 14, figs. 10, 11.

Fissurina marginata (Montagu), MONTAGU 1803, Testacea Britannica, p. 524.

Fissurina semimarginata (Reuss), VON SCHLICHT, 1870, Die Foraminiferen Septarienthones Pielzpuhl, p. 11, pt. 4, figs. 4-6, 10-12.

Fissurina serrata (Schlumberger) SCHLUMBERGER, 1894, Mem, Soc. Zool. France, Vol. 7, p. 258, pl. 3, fig. 7.

Fissurina submarginata (Boomgart) BOOMGART, 1949, Smaller Foraminifera from Bodjonegoro, Utrecht Univ., doct. diss., p. 107.

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Lagena laevis (Montagu) CUSHMAN and GRAY, 1946, Cushman Lab. Foram. Res. Spec. Publ. 19, p. 18, pl. 3, figs. 21-23.

Lagena meridionalis WIESNER, 1931, Deutsche Sudpolar - Exped., 1901-03, Vol. 20, (Zool. Vol. 12), p. 117, pl. 18, fig. 211.

Lagena mollis CUSHMAN, 1944 Cushman Lab. Foram. Res. Spec. Publ. 12, p. 21, pl. 2, fig. 3.

Lagena parri LOEBLICH and TAPPAN, 1953, Smith. Misc. Coll., Vol. 121, No. 7, p. 64, pl. 11, figs. 11-13.

Lagena semilineata WRIGHT, 1886, Proc. Belfast Nat. Field Club, n.s., Vol. 1, app. 9, p. 320, pl. 26, fig. 7.

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Nonionella auricula HERON-ALLEN and EARLAND, 1930, Journ. Roy. Micr. Soc., Vol. 50, p. 192, pl. 5, figs. 68-70.

Oolina apiculata REUSS, 1863, sitzb. Akad. Wiss Wien, math. nat. Kl., V. 46, Abt. 1 (1862).

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Oolina lineata (Williamson) BRADY, 1884, Rep. Voy. Challenger, V. 9 (Zoology), p. 461, pl. 57, fig. 13.

Oolina melo d'ORBIGNY, 1839, Voy. Amer. Merid., Foraminiferes, Tome 5 pt. 5, p. 20, pl. 5, fig. 9.

Oolina squamosa (Montagu) LOEBLICH and TAPPAN, 1953, Smithsonian Misc. Coll. V. 121, No. 7, p. 73, pl. 13, figs. 9, 10.

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Protelphidium orbiculare (Brady) TODD and LOW, 1961, Contr. Cushman Found. Foram. Res. V. 12, p. 20, pl. 2, fig. 11.

Proteonina atlantica CUSHMAN, 1944, Cushman Lab. Foram. Res. Spec. Publ. No. 12, p. 5, pl. 1, fig. 4.

Proteonina difflugiformis (Brady) BRADY, 1879, Brady, Quart. Journ. Micr. Soc. Lond. n.s., Vol. 19, p. 51, pl. 4, figs. 3a, b.

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Quinqueloculina agglutinata CUSHMAN, 1917, U.S. Nat. Mus. Bull. 71, pt. 6, p. 43, pl. 9, fig. 2.

Quinqueloculina arctica CUSHMAN, 1933, Smithsonian Misc. Coll. Vol. 89, No. 9, p. 2, pl. 1, figs. 3a-c.

Quinqueloculina frigida PARKER, 1952, Bull. Mus. Comp. Zool., Vol. 106, No. 8, p. 406, pl. 3, figs. 20a, b.

Quinqueloculina seminulum (Linne) PARKER, 1952, Mus. Comp. Zool. Bull., V. 106, No. 9, p. 406, pl. 3, figs. 21, 22; pl. 4, figs. 1, 2.

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Reophax fusuliformis (Williamson), emended LOEBLICH and TAPPAN, 1955, Smithsonian Misc. Coll., Vol. 128, No. 5, p. 7, pl. 1, figs. 2, 3.

Spiroplectammina biformis (Parker and Jones) CUSHMAN, 1927, Contr. Cushman Lab. Foram. Res., Vol. 3, pt. 1, p. 23, pl. 5, fig. 1.

Trochammina inflata (Montagu) PARKER and JONES, 1859, Ann. Mag. Nat. Hist. V. 4, ser. 3, p. 347.

Trochammina rotaliformis Wright *in* HERON-ALLEN and EARLAND, 1911, Jour. Roy. Micr. Soc., p. 309.

Trochamminella atlantica PARKER 1952, Bull. Mus. Comp. Zool., Vol. 106, No. 9, p. 409, pl. 4, figs. 17-19.

Turrispirillina arctica (Cushman) CUSHMAN, 1933, Smithsonian Misc. Coll., V. 89, No. 9, p. 6, pl. 2, fig. 1, (not. fig. 2).

APPENDIX 2

TABLE 1

Assemblage Data

Sta.	Coeff. Simil.	Hyaline %	Aren. %	Porc. %	Abundant taxa, per cent	Diver-sity	Sub-strate	pH	Depth M
ASSEMBLAGE 1									
3	1.000	0	100	0	*M. fusca* 100	1	cobbles	--	1.3
2	.996	1	99	0	*M. fusca* 75, *P. atlantica* 18, *P. difflugiformis* 3	6	------	6.5	1.3
1	.989	3	97	0	*M. fusca* 75, *P. difflugiformis* 21, *E. clavatum* 1, *B. frigida* 1	6	-----	6.5	1.8
4	.883	0	100	0	*M. fusca* 54, *E. advena* 25, *T. inflata* 13, *P. atlantica* 4	6	-----	7.2	3.0
ASSEMBLAGE 2									
40	1.000	1	99	0	*E. advena* 74, *T. inflata* 18, *A. cassis* 3,	8	ooze	8.0	5.4
13	.987	2	98	0	*E. advena* 82, *T. inflata* 14, *E. clavatum* 1, *R. arctica* 1, *Plk.* 0.2	10	mud	8.0	10.5
37	.981	0.5	99.5	0	*E. advena* 57, *T. inflata* 32, *R. scottii* 10	7	ooze	8.0	9.0
38	.980	11	88	1	*E. advena* 50, *T. inflata* 26, *R. scottii* 8, *A. cassis* 5, *P. cf. orbiculare* 4	11	ooze	8.0	9.0
33	.979	1.9	98	0.1	*E. advena* 87, *T. inflata* 8, *T. atlantica* 2	14	mud	7.8	10.8
35	.973	26	74	0	*E. advena* 58, *T. inflata* 15, *E. clavatum* 7, *B. frigida* 7, *P. cf. orbiculare* 7	19	ooze	8.0	4.2
34	.970	2	98	0	*E. advena* 90, *T. inflata* 6	14	ooze	8.0	4.5
41	.960	0.5	99.5	0	*E. advena* 57, *T. inflata* 41, *A. cassis* 1	5	ooze	8.0	6.6
30	.957	1	99	0	*E. advena* 95, *T. inflata* 2	7	fine sand + mud	7.5	1.8
57	.950	1	98.5	0	*E. advena* 90, *M. fusca* 8	8	med. sand	7.0	1.8
59	.948	18	82	0	*E. advena* 72, *E. clavatum* 5, *E. bartletti* 4, *T. inflata* 5	30	fine sand + mud	7.5	1.8
58	.933	0.5	99.5	0	*E. advena* 80, *M. fusca* 18	8	fine sand + mud	7.5	3.6
39	.918	0.2	99.8	0	*E. advena* 43, *T. inflata* 38, *A. cassis* 11, *R. scottii* 7	7	ooze	8.0	7.8
14	.897	35	65	0	*E. advena* 59, *B. frigida* 9, *E. clavatum* 7, *E. bartletti* 6, *E. incertum* 2, *C. lobatulus* 6, *T. inflata* 4, *F. marginata* 3, *Plk.* 0.2	28	mud+sand	7.5	12.0

TABLE 1 (continued)

Sta.	Coeff. Simil.	Hyaline %	Aren. %	Porc. %	Abundant taxa, per cent	Diver-sity	Sub-strate	pH	Depth M
16	.989	65	32	3	*C. lobatulus* 43, *E. advena* 32, *E. clavatum* 9, *E. bartletti* 2, *B. frigida* 6, *Q. seminulum* 1, *T. islandica* 3.	11	sand + silt	7.6	9
44	.958	82	17	1	*C. lobatulus* 36, *E. clavatum* 22, *E. bartletti* 10, *E. incertum* 1, *E. advena* 16, *B. frigida* 9, *Plk.*0.2	19	mud+ fine sand	7.2	7.2
22	.954	80	19	1	*C. lobatulus* 40, *E. clavatum* 25, *E. bartletti* 5, *E. incertum* 1, *E. advena* 18, *B. frigida* 5, *Q. seminulum*1, *Plk.*1.	16	very fine sand	7.0	9.6
52	.940	75	21	4	*C. lobatulus* 37, *E. clavatum* 26, *E. bartletti* 4, *E. incertum* 0.4, *E. advena* 13, *T. atlantica* 5, *B. frigida* 4, *Q. seminulum* 4, *Plk.* 0.4	22	Med. sand	7.2	20.4
50	.930	86	9	5	*C. lobatulus* 41, *E. clavatum* 32, *E. frigidum* 4, *E. bartletti* 2, *E. incertum* .01, *E. subarcticum* .01, *E. advena* 6, *Q. seminulum* 4, *Plk.* 0.2	30	med.	7.0	24.6
51	.885	75	23	2	*C. lobatulus* 36, *E. clavatum* 30, *E. bartletti* 3, *E. advena* 15, *B. frigida* 3, *T. atlantica* 4, *Q. seminulum* 1	23	med. sand	7.2	20.4
27	.865	84	13	2	*C. lobatulus* 31, *E. advena* 27, *E. clavatum* 17, *E. bartletti* 8, *E. frigidum* 0.2, *E. incertum* 2, *B. frigida* 5, *F. marginata* 2, *Plk.* 1.	27	very	7.0	1.7
49	.831	84	13	2	*E. clavatum* 35, *E. bartletti* 7, *E. incertum* .1, *C. lobatulus* 35, *E. advena* 8, *B. frigida* 4, *T. atlantica* 4, *Q. seminulum* 2	23	med. sand	7.0	24.6
45	.819	77	15	8	*E. clavatum* 33, *E. bartletti* 6, *E. incertum* 2, *C. lobatulus* 33, *E. advena* 14, *Q. seminulum* 3, *Q.* sp. 5, *B. frigida* 3	9	med. fine sand	7.2	7.5
53	.804	77	18	6	*E. clavatum* 25, *E. bartletti* 16, *E. incertum* .4, *E. frigidum* .1, *C. lobatulus* 27, *E. advena* 16, *B. frigida* 5, *Q. seminulum* 5, *Plk.* 0.2	22	med.	7.2	22.5
47	.767	78	16	6	*E. clavatum* 35, *E. incertum* 1, *E. bartletti* 5, *C. lobatulus* 31, *E. advena* 15, *B. frigida* 5, *Q. seminulum* 3, *Q.* sp. 4	10	med. fine sand	7.2	7.5
32	.752	57	41	2	*E. advena* 40, *C. lobatulus* 29, *E. clavatum* 11, *E. bartletti* 8, *E. incertum* 3, *F. marginata* 3, *Q. seminulum* 2, *Plk.* 0.2	31	mud +sand	7.6	7.5
23	.740	83	16	1	*E. clavatum* 27, *E. bartletti* 10, *E. incertum* 3, *C. lobatulus* 24, *E. advena* 15, *B. frigida* 9, *F. marginata* 6, *Q. seminulum* .1, *Plk.* 0.2	18	very sand	7.0	9.0
12	.731	66	32	2	*E. advena* 29, *C. lobatulus* 22, *E. clavatum* 12, *E. incertum* 8, *E. bartletti* 6, *B. frigida* 14, *Q. seminulum* 2.	22	sand	7-7.5	11.7
10	.728	76	24	0.1	*E. clavatum* 31, *E. bartletti* 8, *E. incertum* .4, *C. lobatulus* 28, *E. advena* 22, *B. frigida* 6.	24	silty	7.2	13.5

TABLE 1 (continued)

Sta.	Coeff. Simil.	Hyaline %	Aren. %	Porc. %	Abundant taxa, per cent	Diver- sity	Sub- strate	pH	Depth M
11	.877	0	100	0	*E. advena* 43, *A. cassis* 24, *T. rotaliformis* 15, *T. inflata* 14	8	ooze	8.5	8.1
42	.867	4	96	0	*T. inflata* 47, *E. advena* 44, *M. fusca* 4, *C. lobatulus* 2	10	ooze	8.0	7.8
43	.866	22	78	0	*E. advena* 55, *C. lobatulus* 11, *E. bartletti* 11, *A. cassis* 6	4	ooze	8.0	7.8
5	.801	40	60	0	*E. advena* 55, *E. clavatum* 24, *E. bartletti* 7, *C. lobatulus* 6, *Plk.* 0.5	16	fine sand	7.5	6.0
54	.798	45	55	0	*E. advena* 55, *E. clavatum* 13, *E. bartletti* 5, *C. lobatulus* 12, *F. marginata* 7, *B. frigida* 4	13	very fine sand	7.0	4.5
36	.779	49	51	0	*E. advena* 39, *E. clavatum* 19, *E. bartletti* 16, *E. incertum* 2, *R. scottii* 5, *T. inflata* 5, *C. lobatulus* 4	29	ooze	8.0	6.6
15	.716	45	55	0	*E. advena* 48, *C. lobatulus* 18, *E. clavatum* 7, *E. incertum* 3, *E. bartletti* 7, *F. marginata* 4, *B. frigida* 5	15	mud+ sand	7.6	12.9
ASSEMBLAGE 3									
25	1.000	95.9	4	0.1	*E. clavatum* 86, *E. bartletti* 2, *E. incertum* 1, *E. advena* 4, *B. frigida* 4, *C. lobatulus* 2, *Plk.* .04	15	fine sand +silt	7.5	3.9
26	.960	91	9	0	*E. clavatum* 72, *E. bartletti* 2, *B. frigida* 10, *E. advena* 9, *C. lobatulus* 5	6	fine	7.0	3.6
48	.824	93.5	0.5	6	*E. clavatum* 60, *E. bartletti* 13, *E. incertum* 1, *C. lobatulus* 18, *Q.* sp. 4, *Q. seminulum* 2	10	coarse sand	7.0	6.0
55	.814	82	5	13	*E. clavatum* 50, *E. bartletti* 8, *E. subarcticum* 3, *C. lobatulus* 16, *Q. seminulum* 8, *Q.* sp. 5, *B. frigida* 5	9	med. sand	7.2	6.0
56	.766	74	26	0	*E. clavatum* 52, *E. bartletti* 6, *E. advena* 20, *C. lobatulus* 16, *M. fusca* 4	6	coarse	7.0	5.7
19	.667	80	15	5	*E. clavatum* 40, *E. bartletti* 7, *E. incertum* 1, *C. lobatulus* 19, *E. advena* 19, *B. frigida* 11, *Q. seminulum* 4, *Plk.* 0.6	30	fine sand	7.0	18.6
20	.653	78	22	0	*E. clavatum* 42, *E. bartletti* 13, *E. incertum* 1, *E. advena* 20, *C. lobatulus* 18, *B. frigida* 3	12	med. sand	7.2	10.2
18	.611	94	5	1	*E. clavatum* 27, *E. bartletti* 20, *E. incertum* 2, *E. advena* 16, *C. lobatulus* 10, *F. marginata* 9, *B. frigida* 4, *Plk.* 1.	36	sand +ooze	7.5	19.5
46	.585	80	20	0	*E. clavatum* 40, *C. lobatulus* 20, *E. advena* 20, *B. frigida* 13, *F. marginata* 7.	5	med.	7.2	7.5
ASSEMBLAGE 4									
6	1.000	72	18.5	9.5	*C. lobatulus* 33, *E. clavatum* 17, *E. bartletti* 5, *E. incertum* 4, *E. advena* 16, *Q. seminulum* 8, *B. frigida* 7, *Plk.* 0.6	22	sand	7.6	9

TABLE 1 (continued)

Sta.	Coeff. Simil.	Hyaline %	Aren. %	Porc. %	Abundant taxa, per cent	Diver- sity	Sub- strate	pH	Depth M
28	.700	66	28	6	*E. clavatum* 26, *E. bartletti* 4, *E. incertum* 2, *E. advena* 27, *C. lobatulus* 25, *B. frigida* 4, *Q. seminulum* 4, *Plk.* 1.0	20	fine sand	7.2	5.7
17	.662	71	27	2	*E. clavatum* 27, *E. bartletti* 11, *E. incertum* .4, *E. advena* 26, *C. lobatulus* 23, *B. frigida* 9.	12	fine sand	7.0	13.8
9	.643	60	20	20	*E. clavatum* 28, *E. bartletti* 7, *E. incertum* .4, *C. lobatulus* 20, *Q. seminulum* 17, *E. advena* 13, *T. atlantica* 4	17	med. sand	7.2	19.5
8	.635	71	6	23	*E. clavatum* 30, *E. bartletti* 14, *E. incertum* .7, *C. lobatulus* 23, *Q. seminulum* 23, *E. advena* 3, *T. inflata* 3.	12	fine gravel	7.0	18.0
21	.610	79	10	11	*E. clavatum* 39, *E. bartletti* 8, *E. incertum* 2, *C. lobatulus* 24, *E. advena* 8, *Q. seminulum* 7, *B. frigida* 4.	25	fine sand	7.0	9.0
24	.597	84	15.6	0.4	*E. clavatum* 33, *E. bartletti* 12, *E. incertum* 3, *C. lobatulus* 20, *E. advena* 14, *B. frigida* 12, *Plk.*	22	very fine sand	7.0	9.0
31	.569	53	36	11	*E. advena* 35, *E. clavatum* 21, *E. bartletti* 6, *E. incertum* 1, *C. lobatulus* 20, *Q. seminulum* 9, *Plk.* 0.2	18	med. sand	7.2	6.0
29	.497	66	31	2	*E. clavatum* 28, *E. bartletti* 8, *E. incertum* 3, *E. advena* 24, *C. lobatulus* 17, *B. frigida* 4, *T. inflata* 5, *marginata* 4, *Plk.* 0.6.	24	med. fine sand	7.2	5.4
7	.180	92	4	4	*E. curta* 77, *C. lobatulus* 8, *E. bartletti* 8, *Q. stalkeri* 4, *T. atlantica* 4	5	very coarse sand	7.0	21.6