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POPULATION DYNAMICS AND FACIES ASSOCIATION OF RECENT FORAMINIFERA FROM A NEARSHORE MARGINAL MARINE ENVIRONMENT: PLYMOUTH SOUND

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CHAPTER NINE

9.0 THE DEAD ASSEMBLAGE

9.1. Location 1

9.1.1. Introduction

The foraminiferal assemblage is diverse. The condition of foraminiferal tests was moderate to poor as breakage and abrasion was commonly observed. Foraminifera were generally small in this fine sand facies

9.1.2. Species Abundance

The most abundant species at Location 1 was *A. beccarii batavus*, closely followed by *Cibicides lobatulus*. Other important species were *H. germanica, E. scabrum, T. truncata, A. beccarii limnetes Cibicides pseudoungerianus* and *E. williamsoni* (Table 9.1).

	Absolute	**%**
Ammonia beccarii batavus	850	22
Cibicides lobatulus	540	14
Elphidium crispum	279	7
Haynesina germanica	231	6
Eggerelloides scabrum	214	6
Textularia truncata	182	5
Ammonia beccarii limnetes	150	4
Cibicides pseudoungerianus	146	4
Elphidium williamsoni	144	4
Rosalina globularis	103	3
Elphidium cuvillieri	98	3
Quinqueloculina seminulum	97	3
Asterigerinata mamilla	79	2
Quinqueloculina lata	55	1
Rosalina williamsoni	53	1
Bulimina elongata	36	1
Massilina secans	35	1

Brizalina spathulata	30	1
Quinqueloculina aspera II	30	1
Spiroplectammina wrightii	29	1
Quinqueloculina auberiana	27	1
Bulimina gibba	26	1
Planorbulina mediterranensis	25	1
Quinqueloculina spp.	25	1
Elphidium earlandi	23	1
Elphidium margaritaceum	23	1
Quinqueloculina oblonga var. *lata*	22	1
Quinqueloculina cliarensis	21	1

Table 9.1 All species ≥1% abundance recorded at Location 1, shown in absolute (Abs.) and percentage (%) amount.

9.1.3. Species Distribution

The most common species (*A. beccarii batavus* and *C. lobatulus*) exhibited a high degree variation in abundance; the former attained its highest percentage in August while *C. lobatulus* attained its maximum abundance in July (Fig. 9.1).

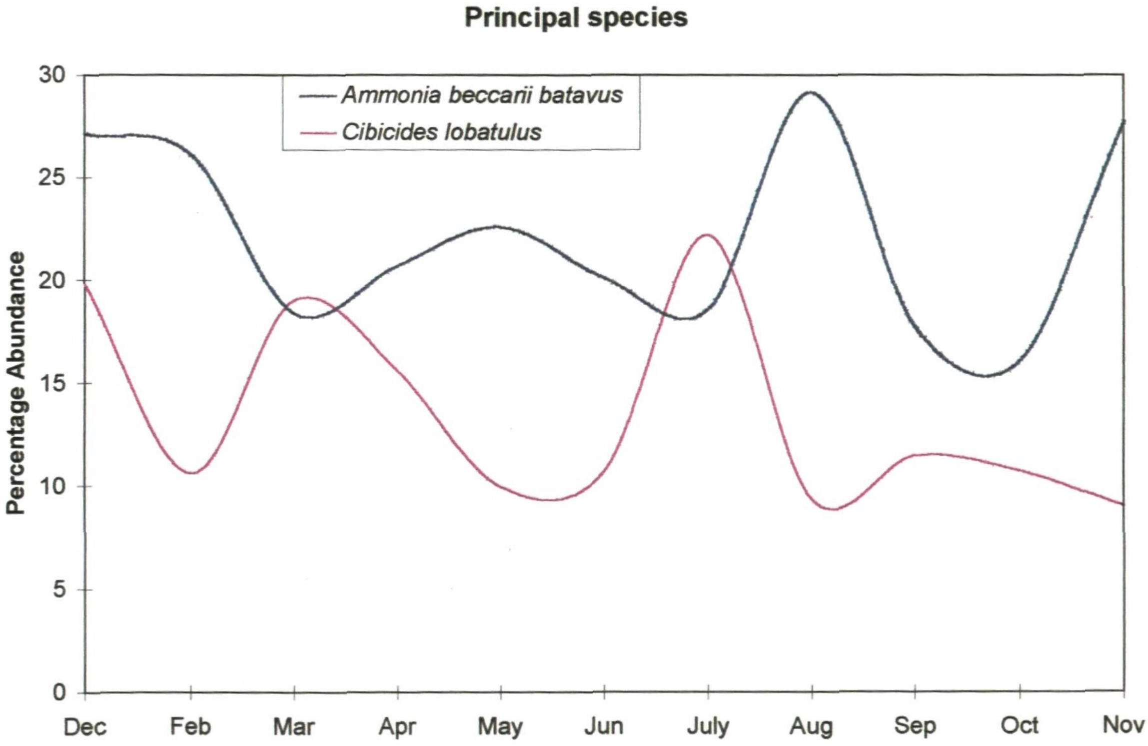


Figure. 9.1. Percentage abundance of *A. beccarii batavus* and *C. lobatulus* at Location 1 throughout the year. No data for January.

The subordinate species show a very variable distribution throughout the year, which is probably influenced by a range of factors such as production of live foraminifera, transport and other post-mortem affects. There is very little correlation between minor species throughout the year. The species which exhibits the greatest fluctuation in abundance was *T. truncata*. This species was virtually absent from the beginning and end of the year, but attained an abundance of 8% of the assemblage during July, this coincides with the period when live *T. truncata* was most abundant. *Haynesina germanica* was rare for most of the year but constituted nearly 10% of the assemblage during the autumn (Fig. 9.2).

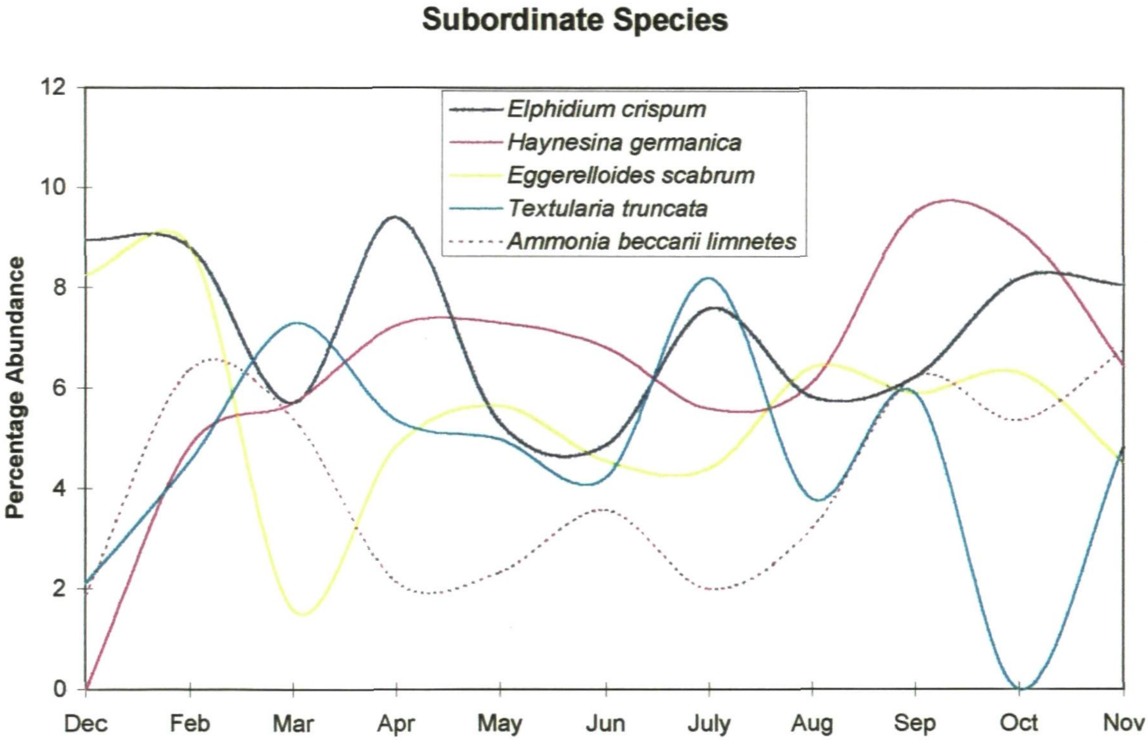


Figure. 9.2. Percentage abundance of *E. crispum, H. germanica, E. scabrum, T. truncata* and *A. beccarii limnetes* at Location 1 throughout the year. No data for January.

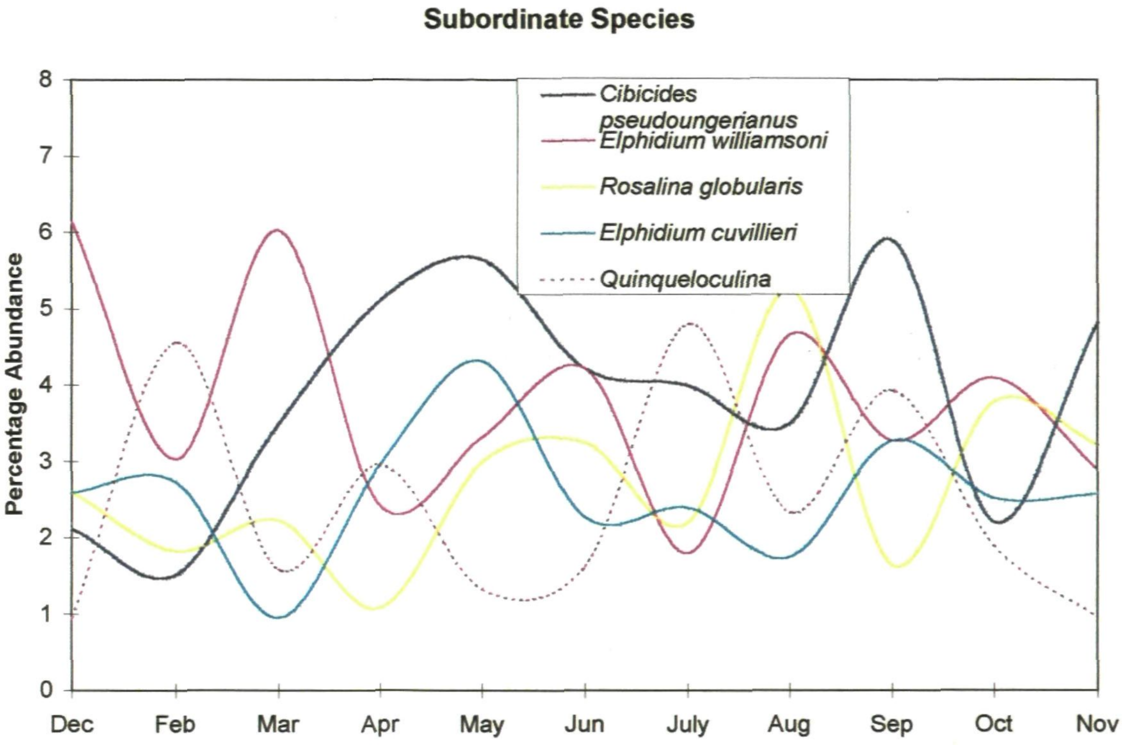


Figure. 9.3. The percentage abundance of *C. pseudungeranius, E. williamsoni, R. globularis, E. cuvillieri* and *Q. seminulum* throughout the year at Location 1. No data for January.

Other subordinate species show less variability. No trends in distribution are discernible apart from the higher abundance of *E. williamsoni* in winter and early spring (Fig. 9.3).

9.1.4. Diversity

A total of 80 species were recorded from 3800 individuals throughout the year, which results in a Fisher Alpha index of approximately 14. The highest diversity of 32 species was recorded in June. The periods of highest diversity were in March, June and October. Lowest diversity occurred in July and August (Fig. 9.4).

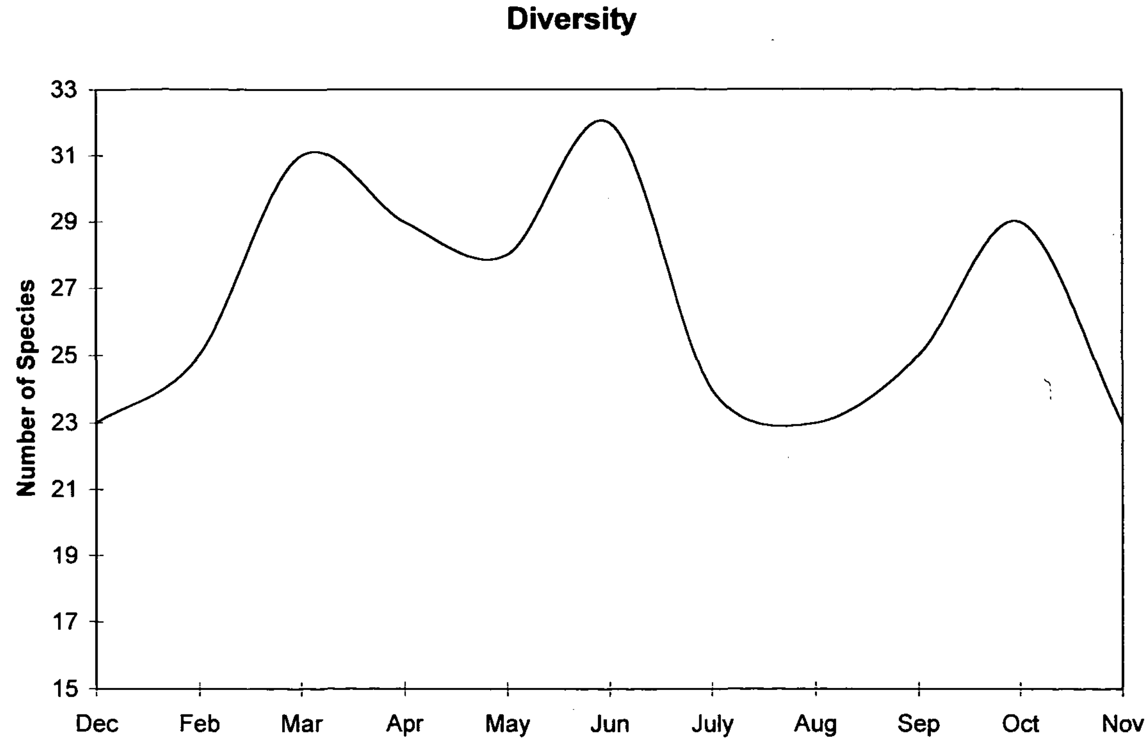


Figure. 9.4 Diversity of the dead assemblage throughout the year at Location 1. No data for January.

9.1.5. Morphogroups

The most common group were the rounded planispirals/ low trochospirals (H1) which accounted for 40% of the assemblage. Also common were the plano-convex group (H3) which accounted for 24%. Other important groups were the lenticular group (H3) which accounted for 7% and was composed entirely of *E. crispum* (Table 9.2).

MG		Abs.	%
H1	*A beccarii batavus*	850	22
H1	*Haynesina germanica*	231	6
H1	*Ammonia beccarii limnetes*	150	4
H1	*Elphidium williamsoni*	144	4
H1	*Elphidium cuvillieri*	98	3
H1	*Elphidium earlandi*	23	1
H1	*Elphidium margaritaceum*	23	1
H10	*Brizalina spathulata*	30	1
H3	*Elphidium crispum*	279	7
H3	*Lenticulina orbiculatis*	3	0
H4	*Cibicides lobatulus*	540	14
H4	*Cibicides pseudoungerianus*	146	4

MG		Abs.	%
A6	*Eggerelloides scabrum*	214	6
A7	*Textularia truncata*	182	5
A7	*Spiroplectammina wrightii*	29	1
	Others	34	1
	Total	**459**	**12**
P8	*Quinqueloculina seminulum*	97	3
P8	*Quinqueloculina lata*	55	1
P8	*Quinqueloculina aspera* II	30	1
P8	*Quinqueloculina auberiana*	27	1
P8	*Quinqueloculina* spp.	25	1
P8	*Quinqueloculina oblonga* var. *lata*	22	1

H4	*Rosalina globularis*	103	3
H4	*Rosalina williamsoni*	53	1
H4	*Planorbulina mediterranensis*	25	1
H5	*Asterigerinata mamilla*	79	2
H6	*Bulimina elongata*	36	1
H6	*Bulimina gibba*	26	1
	Others	134	4
	Total	**2973**	**78**

P9	*Massilina secans*	35	1
P9	*Quinqueloculina cliarensis*	21	1
	Others	80	2
	Total	**392**	**10**

Table 9.2. Morphogroup distribution for species at Location 1. Foraminifera are separated into three general groups (hyaline, porcellaneous and agglutinated) and allocated morphogroups (columns labelled MG). Both the absolute (Abs.) and percentage (%) values of each species are shown. Species which account for less than 1% are grouped under 'Others'.

9.1.6. Condition of foraminiferal tests

Many of the empty tests collected from this location were small, the majority being generally between 63µm and 250µm. Few individuals exceeded this size, which suggests that many of the tests may be transported into the area. This is certainly true of *C. lobatulus, H. germanica* and *E. williamsoni* none of which were observed living. Those species accounted for 1/4 of the entire assemblage. Foraminifera where most common within the 125µm fraction. Many of the tests (in general perhaps 50%) showed signs of abrasion and breakage, which was most commonly observed as broken or missing chambers (usually the ultimate chamber). General scratching also suggests that the tests had suffered some transportation, as abrasion rarely occurs without at least a small degree of transport.

9.1.7. Discussion

The species distribution throughout the year show a large degree a variability, this is probably the result of many factors :-

> Natural variation of species abundance throughout the sediment (patchiness) which is must be present to some degree.
>
> Production of live foraminifera and subsequent contribution of their tests to the sediment certainly influence the dead assemblage. Some examples of this are the

maxima of *A. beccarii batavus* and *T. truncata* in the dead assemblage just after these species attain their maximum abundance in the live assemblage.

Transport of tests into and out of adjacent areas which may explain the high abundance of estuarine species in the winter when production of these species was low. They where probably transported form the estuaries during periods of high river out flow and storms.

Variation in the position from which samples are collected. If a sample is collected from a slightly different area the sediment grainsize may be different. Some species have predominantly small or large test sizes, sampling a coarser sediment may result in a comparative enrichment of large tests at the expense of smaller tests which are not as abundant within the sediment

Biases introduced through the processing and particularly the picking of foraminifera e. g. destruction of fragile species when washing sediment or the workers tendencies to select large or striking individuals.

The abundance of a particular species will be the result of its abundance in the live assemblage, its rate of production, the durability of its test and its susceptibility to transportation into or out of an area. The large abundances of *A. beccarii batavus* and *C. lobatulus* suggest that these species are common in the live assemblage (true of *A. beccarii batavus*), have a high productivity, have strong tests resistant to destruction (true of both species) and have been transported into the area (true of *C. lobatulus*).

The variations in foraminiferal diversity throughout the year probably result from the increased diversity of the live assemblage and subsequent transfer to the dead assemblage. If this is true then the decrease of diversity of the dead assemblage (when few tests are contributed from the live assemblage) may show that the influx of new tests to the dead assemblage are rapidly dispersed and destroyed (fragile species) until the assemblage is closer to equilibrium in terms of the sedimentary facies it occurs in.

Just as the abundance of species may vary due to their patchiness of distribution within the sediment, so diversity may also vary due to such patchiness.

The high abundance of the rounded planispiral morphogroup (H1) was mainly due to *A. beccarii batavus* and the estuarine species *H. germanica* and *E. williamsoni.* These two species must have been transported into the area as they are rarely observed living outside the estuarine environment. These morphologies suggest a soft sand, mud or mixed sediment substrate to which these forms are adapted (generally low to moderate energy conditions). The plano-convex group (24%) was composed mainly of *C. lobatulus* which was never observed living in any abundance within the Sound, although unstained tests were abundant adhering to rocks and infrequently observed attached to marine plants which were occasionally retrieved from the various locations. This group comprised one quarter of the assemblage and indicate the presence or nearness of epiphytal, coarse sediment, shell, or rock substrates to which these forms adhere.

The dead assemblage results from the interaction of abundance and production of (indigenous) species and is mediated by a range of post-mortem processes.

9.2. Location 3

9.2.1. Introduction

The dead assemblage within this high energy shell gravel exhibits a high degree of species evenness and low dominance. Diversity is high. The tests are generally in good condition but show some signs of damage. The majority of tests are surprisingly small in size.

9.2.2. Species Abundance

The most important species at Location 3 were *C. lobatulus* and *E. crispum.* Other important species were *T. truncata, A. beccarii batavus* and *Q. seminulum.* The assemblage showed high species evenness and low dominance (Table 9.3).

	Abs.	%
Cibicides lobatulus	519	18
Elphidium crispum	297	11
Textularia truncata	258	9
Ammonia beccarii batavus	213	8
Quinqueloculina seminulum	210	7
Planorbulina mediterranensis	115	4
Eggerelloides scabrum	106	4
Haynesina germanica	104	4
Cibicides pseudoungerianus	78	3
Miliolinella subrotunda	69	2
Rosalina williamsoni	66	2
Quinqueloculina spp.	62	2
Ammonia beccarii limnetes	59	2
Rosalina globularis	57	2
Massilina secans	56	2
Elphidium williamsoni	51	2
Quinqueloculina bicornis	35	1
Elphidium cuvillieri	34	1
Asterigerinata mamilla	31	1
Cribrostomoides jeffreysii	27	1
Quinqueloculina auberiana	24	1
Miliolinella circularis	21	1
Brizalina spathulata	16	1
Quinqueloculina lata	16	1
Brizalina pseudopunctata	15	1
Quinqueloculina aspera II	15	1
Quinqueloculina williamsoni	15	1

Table 9.3 Faunal list for all species ≥1% abundance recorded at Location 3, shown in absolute (Abs.) and percentage (%) amount.

9.2.3. Species distribution

Many of the important species exhibit moderate variation in abundance throughout the year. *Cibicides lobatulus, E. crispum, Q. seminulum* and to a lesser degree *A. beccarii batavus* exhibit abundance maxima from March to July. *Textularia truncata* exhibits its highest abundance during July (Fig. 9.5.).

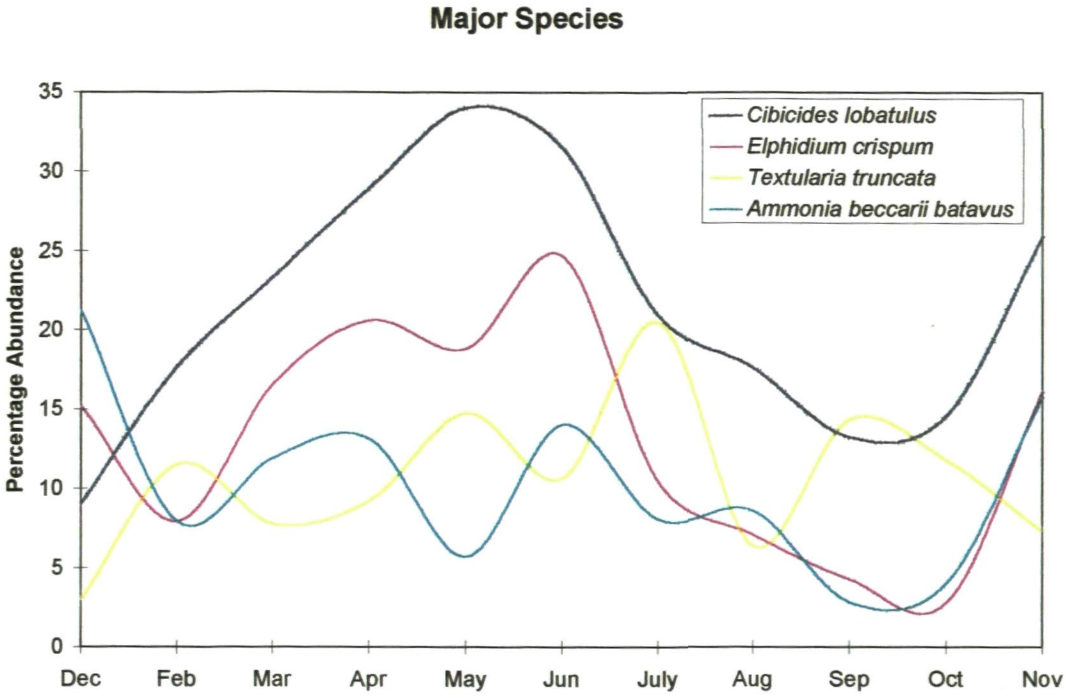


Figure. 9.5 Percentage abundance of *C. lobatulus, E. crispum, A. beccarii batavus* and *T. truncata* from Location 3 throughout the year. No data for January.

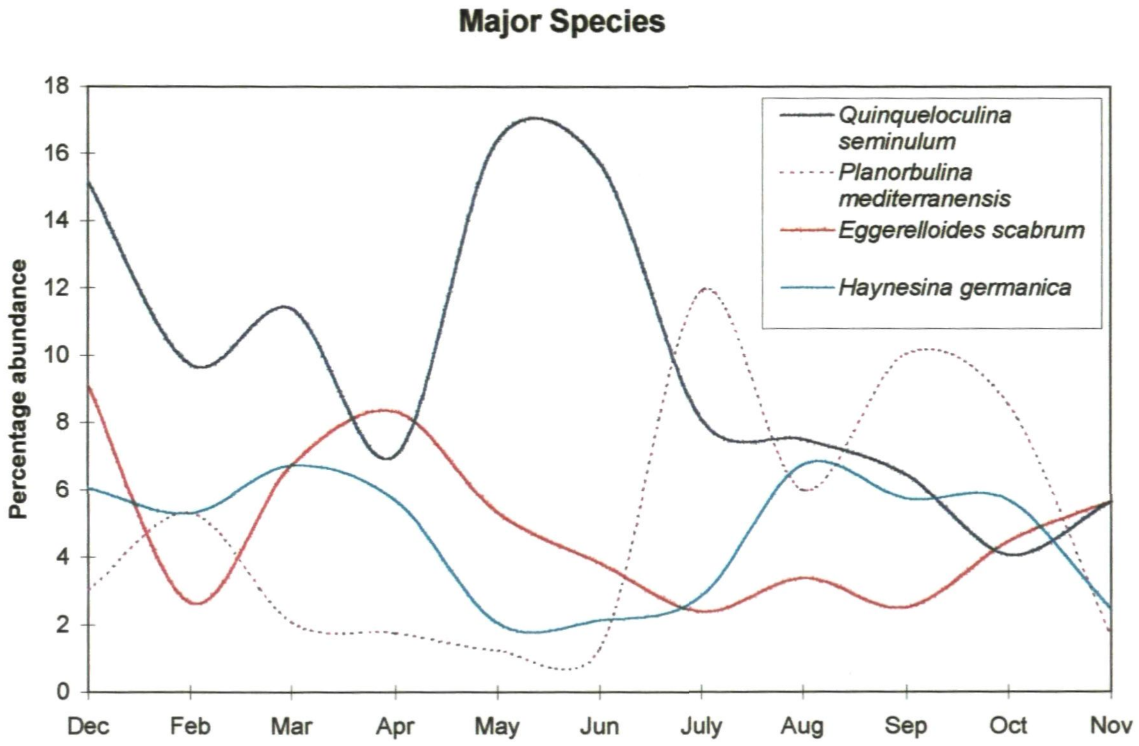


Figure.. 9.6 Percentage abundance of *Q. seminulum, P. mediterranensis, E. scabrum* and *H. germanica* from Location 3 throughout the year. No data for January.

Trends in abundance distribution throughout the year become less discernible as foraminiferal abundance decreases, although *P. mediterranensis* can be seen to be most common during the summer and autumn (Figure 9.6).

9.2.4. Diversity

A total of 78 species were recorded at Location 3 throughout the year from 2695 individuals resulting in a Fisher Alpha diversity index of 14 or 15. Diversity throughout the year exhibited a large degree of variation being low during January, moderate from February to June and highest during August, September and October (maximum diversity of 49 species was recorded in October). See Figure 9.7.

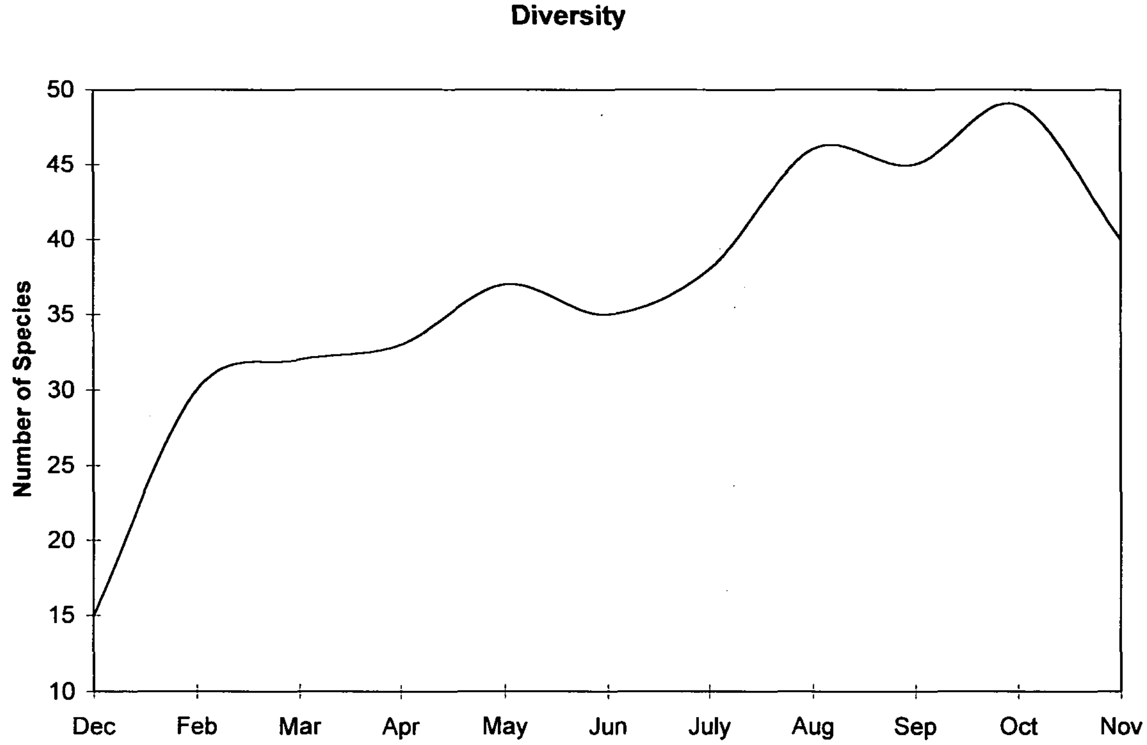


Figure. 9.7 Diversity of the dead assemblage throughout the year at Location 3. No data for January.

9.2.5. Morphogroups

The most abundant morphogroup are the hyaline, plano-convex group which account for nearly one third of the assemblage (30%). The rounded planispiral/ low trochospiral group (H1) and fusiform porcellaneous group (P8) are both common accounting for 17% and 16% respectively. The lenticular group (H3) was composed mainly of *E. crispum* (11%).

MG		Abs.	%
H1	*Ammonia beccarii batavus*	213	8
H1	*Haynesina germanica*	104	4
H1	*Ammonia beccarii limnetes*	59	2
H1	*Elphidium williamsoni*	51	2
H1	*Elphidium cuvillieri*	34	1
H3	*Elphidium crispum*	297	11
H4	*Cibicides lobatulus*	519	18
H4	*Planorbulina mediterranensis*	115	4
H4	*Cibicides pseudoungerianus*	78	3
H4	*Rosalina williamsoni*	66	2
H4	*Rosalina globularis*	57	2
H5	*Asterigerinata mamilla*	31	1
H10	*Brizalina spathulata*	16	1
H10	*Brizalina pseudopunctata*	15	1
	Others	140	5
	Total	**1795**	**65**

MG		Abs.	%
A1	*Cribrostomoides jeffreysii*	27	1
A6	*Eggerelloides scabrum*	106	4
A7	*Textularia truncata*	258	9
	Others	43	1.5
	Total	**435**	**15**
P9	*Massilina secans*	56	2
P9	*Miliolinella subrotunda*	69	2
P8	*Quinqueloculina* spp.	62	2
P8	*Quinqueloculina seminulum*	210	7
P8	*Quinqueloculina bicornis*	35	1
P8	*Quinqueloculina auberiana*	24	1
P8	*Miliolinella circularis*	21	1
P8	*Quinqueloculina lata*	16	1
P8	*Quinqueloculina aspera* II	15	1
P8	*Quinqueloculina williamsoni*	15	1
	Others	61	1
	Total	**584**	**21**

Table 9.4 Morphogroup distribution for species at Location 3. Foraminifera are divided into three general groups; hyaline, porcellaneous and agglutinated and allocated morphogroups (columns labelled MG). Both the absolute (Abs.) and percentage (%) values of each species are shown. Species which account for less than 1% are grouped under 'Others'.

9.2.6. Test condition

Foraminiferal tests were mainly small, often most common in the 63μm and 125μm fractions. The tests were in reasonably condition although many exhibited minor breakage of the ultimate chamber and apertural face. Agglutinated foraminifera often exhibited missing or damaged ultimate chambers. In addition to these small foraminifera a distinctly different assemblage was present within the 250μm and ≥500μm fractions. This assemblage was sparse and composed large species such as *Q. seminulum*, *Vaginulina linearis* and *C. lobatulus*. These individuals displayed many signs of breakage and damage, except the tests of *Q. seminulum* which almost always occurred in perfect condition or slightly abraded. Whilst some have suffered a high degree of transportation, many others are indigenous to the area. The disparity between the condition of tests of small and large individuals maybe due to very different hydrodynamic behaviour of these different sized tests.

9.2.7. Discussion

The assemblage exhibits a high species evenness and low dominance which suggest a high diversity marine environment. The small size of the majority of tests is largely a reflection of the live assemblage which is also dominated by small tests. The coarse sediment at this location certainly should support and hold large tests at least as well as small tests, although very few are present. Normally coarse grained sediments in high energy environments loose small foraminifera through winnowing and destruction leaving behind a remnant or lag of large tested foraminifera.

The variation in diversity throughout the year (highest from August to October) suggests a close link to live foraminiferal rates of production which were highest during July to September (Figure 8.5).

The fact that 40% of the assemblage is composed of attached plano-convex foraminifera and a further 10% of clinging foraminifera in the form of *T. truncata* and *C. jeffreysii* and porcellaneous forms are common (20%) all suggest a very high energy environment in which foraminifera must secure themselves to the substrate to survive.

9.3. Location 4

9.3.1. Introduction

The assemblage at Location 4 was highly diverse. Individuals exhibited a wide range of sizes and generally showed little sign of damage within this muddy sand.

9.3.2. Species Abundance

The two dominant species were *E. crispum* and *A. beccarii batavus*, both accounted for 20% of the assemblage. Other important species at this location were *C. lobatulus* (8%), *Q. seminulum* (6%) and *E. scabrum* (5%). The estuarine species *H. germanica* was also reasonably abundant (3%). See Figure 9.5.

	Abs.	%
Elphidium crispum	778	20
Ammonia beccarii batavus	775	20
Cibicides lobatulus	302	8
Quinqueloculina seminulum	246	6
Eggerelloides scabrum	205	5
Haynesina germanica	134	3
Textularia truncata	105	3
Ammonia beccarii limnetes	71	2
Elphidium williamsoni	63	2
Elphidium cuvillieri	61	2
Rosalina globularis	60	2
Massilina secans	59	2
Planorbulina mediterranensis	57	1
Quinqueloculina oblonga	50	1
Quinqueloculina cf. *cliarensis*	46	1
Asterigerinata mamilla	43	1
Quinqueloculina aspera II	40	1
Cibicides pseudoungerianus	36	1
Rosalina williamsoni	36	1
Quinqueloculina lata	35	1
Textularia sagittula	31	1
Quinqueloculina auberiana	29	1
Quinqueloculina spp.	28	1
Brizalina spathulata	26	1
Brizalina pseudopunctata	23	1
Bulimina elongata	23	1
Elphidium gerthi	21	1
Textularia earlandi	20	1

Table 9.5 All species ≥1% abundance recorded at Location 4, shown in absolute (Abs.) and percentage (%) amount.

9.3.3. Species distribution

The two principal species; *E. crispum* and *A. beccarii batavus* exhibited variation in abundance throughout the year. *Elphidium crispum* attained its maximum abundance in February and *A. beccarii batavus* in August, see Figure 9.8. The trends of both species correlate well with each other. Their gradual decline in abundance throughout the year may be due to biases in picking, or a general decline in abundance of these species at this location throughout the year.

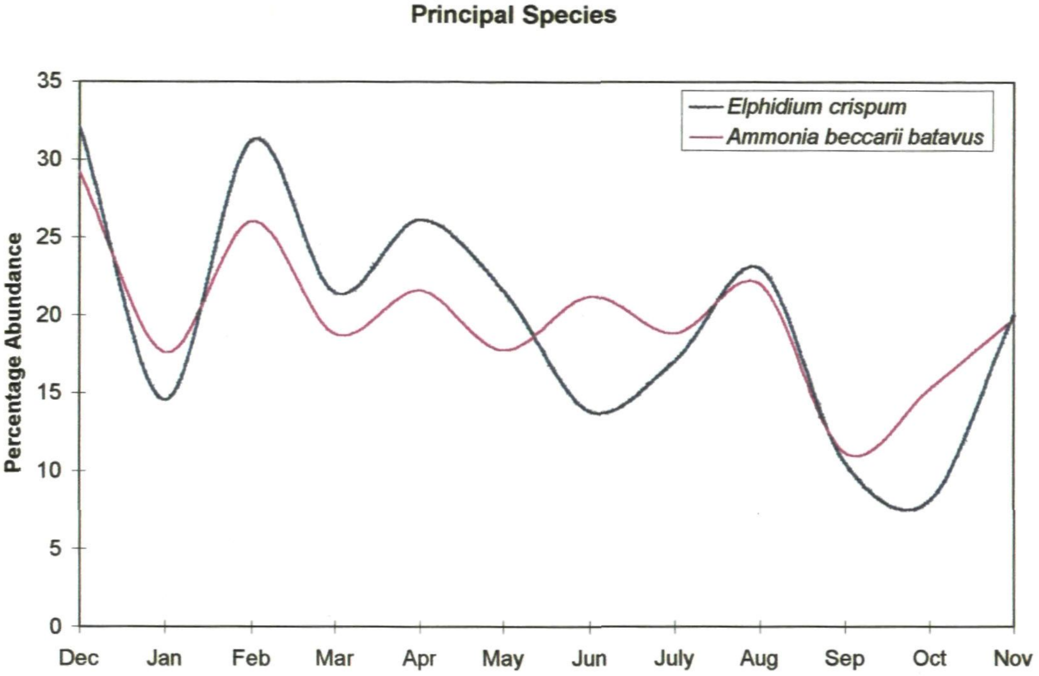


Figure. 9.8. Percentage abundance of *E. crispum* and *A. beccarii batavus* throughout the year from Location 4

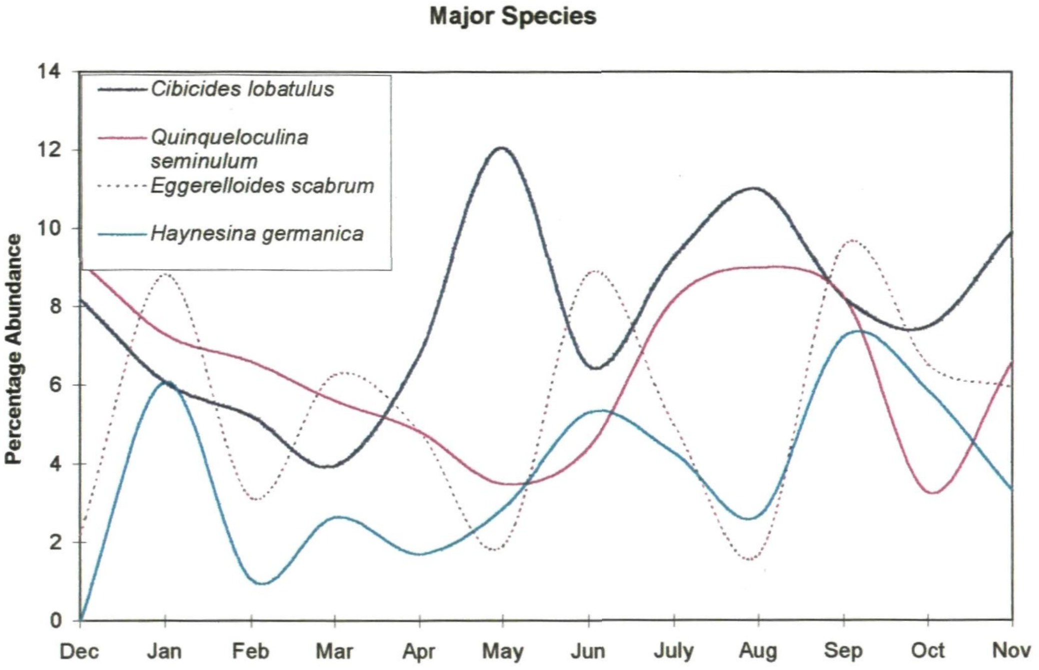


Figure. 9.9 Percentage abundance of *C. lobatulus, Q. seminulum, E. scabrum* and *H. germanica* throughout the year from Location 4.

Other species exhibited a more variable distribution, *C. lobatulus* attained its maximum abundance in May while *Q. seminulum* attained its maximum in July/August/September. *Eggerelloides scabrum* and *H. germanica* exhibited a high degree of variability in abundance (Figure 9.9).

9.3.4. Diversity

A total of 99 species were recorded from Location 4 throughout the year from 3836 individuals resulting in a Fisher Alpha diversity index of 19.

The diversity of the assemblage varied throughout the year, being low in February and August/September (See Figure 9.10). The highest monthly diversity of 58 species was reached in April and May giving a Fisher Alpha index of over 20 for those months. Diversity was also high in January and November.

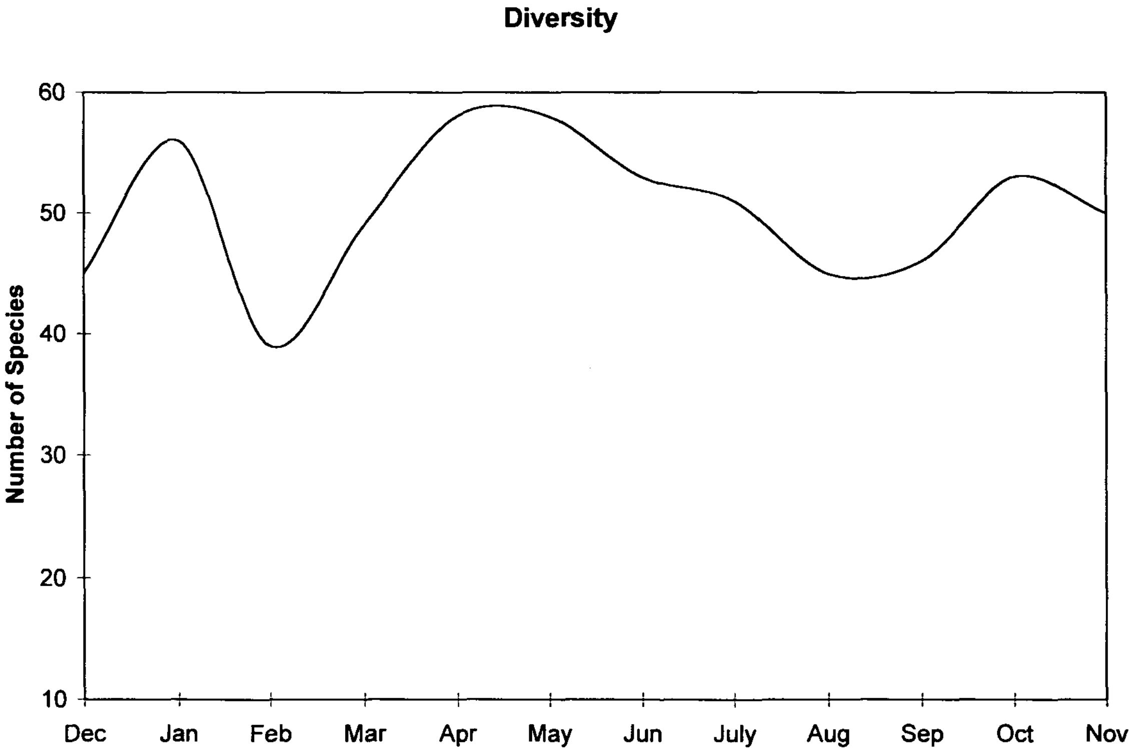


Figure. 9.10 Diversity of the dead assemblage throughout the year at Location 4.

9.3.5. Morphogroups

The most abundant morphogroup at Location 4 was the planispiral/low trochospiral group (H1) which accounted for one third of the assemblage (32%). Also common was the lenticular group (H3) composed almost entirely of *E. crispum,* which accounted for 20% of the assemblage (Table 9.6).

MG		Abs.	%
H1	*Ammonia beccarii batavus*	775	20
H1	*Haynesina germanica*	134	3
H1	*Ammonia beccarii limnetes*	71	2
H1	*Elphidium williamsoni*	63	2
H1	*Elphidium cuvillieri*	61	2
H1	*Elphidium gerthi*	21	1
H10	*Brizalina spathulata*	26	1
H10	*Brizalina pseudopunctata*	23	1
H3	*Elphidium crispum*	778	20
H4	*Cibicides lobatulus*	302	8
H4	*Rosalina globularis*	60	2
H4	*Planorbulina mediterranensis*	57	1
H4	*Cibicides pseudoungerianus*	36	1
H4	*Rosalina williamsoni*	36	1
H5	*Asterigerinata mamilla*	43	1
H6	*Bulimina elongata*	23	1
	Others	196	5
	Total	**2703**	**70**

MG		Abs.	%
P8	*Quinqueloculina seminulum*	246	6
P8	*Quinqueloculina oblonga*	50	1
P8	*Quinqueloculina aspera* II	40	1
P8	*Quinqueloculina lata*	35	1
P8	*Quinqueloculina auberiana*	29	1
P8	*Quinqueloculina* spp.	28	1
P9	*Massilina secans*	59	2
P9	*Quinqueloculina* cf. *cliarensis*	46	1
	Others	163	4
	Total	**700**	**18**
A6	*Eggerelloides scabrum*	205	5
A6	*Textularia earlandi*	20	1
A7	*Textularia truncata*	105	3
A7	*Textularia sagittula*	31	1
A1	Others	72	2
	Total	**433**	**11**

Table 9.6 Morphogroup distribution for species at Location 4. Foraminifera are divided into three general groups; hyaline, porcellaneous and agglutinated and allocated to morphogroups (columns labelled MG). Both the absolute (Abs.) and percentage (%) values of each species are shown. Species which account for less than 1% are grouped under 'Others'

9.3.6. Condition of Tests

Foraminifera at Location 4 showed a complete range in size, with foraminifera being common in the 63µm, 125µm, 250µm and 500µm sieve fractions. Often juveniles and adults of the same species were present. The tests were generally in good condition and showed little sign of abrasion or breakage although occasional worn individuals both small and large in size were observed.

9.3.7. Discussion

The large range of test sizes and low energy nature of the deposit imply that few tests are transported out of the area. In such low energy areas small tests may be transported into the area in suspension during storms. The absence of size sorting, abrasion and breakage of tests testify to little transportation and alteration having occurred.

The high diversity of the assemblage is a function of the live assemblage which is generally more diverse in mud rich areas (Murray, 1986) and the fact that few specimens are transported out of the area, while an allocthanous element of small foraminifera may potentially have enriched the assemblage.

The rounded planispiral/low trochospiral morphogroups are most abundant and well represented. Both tend to be herbivorous although the later is epifaunal whilst the former may be both epi- and infaunal. The rounded planispiral/low trochospiral group are most abundant in mud rich facies.

9.4. Location 8

9.4.1. Introduction

This coarse sand facies contained a foraminiferal fauna of moderate diversity. Few small or large specimens were present and the assemblage exhibited good size sorting. Test damage through abrasion and breakage was very abundant.

9.4.2. Species Abundance

Cibicides lobatulus was the dominant species accounting for nearly half of the total assemblage (48%). *Ammonia beccarii batavus* and *E. crispum* were also important species accounting for 13% and 11% of the assemblage respectively (Table 9.11).

	Abs.	%
Cibicides lobatulus	1741	48
Ammonia beccarii batavus	480	13
Elphidium crispum	404	11
Massilina secans	134	4
Textularia truncata	111	3
Quinqueloculina bicornis	79	2
Eggerelloides scabrum	62	2
Rosalina globularis	58	2
Haynesina germanica	58	2
Quinqueloculina lata	45	1
Elphidium williamsoni	40	1
Quinqueloculina seminulum	37	1
Cibicides pseudoungerianus	35	1
Quinqueloculina spp.	34	1
Quinqueloculina auberiana	31	1
Planorbulina mediterranensis	22	1
Asterigerinata mamilla	21	1
Rosalina williamsoni	20	1

Table 9.7 All species ≥1% abundance recorded at Location 8, shown in absolute (Abs.) and percentage (%) amounts.

9.4.3. Species Distributions

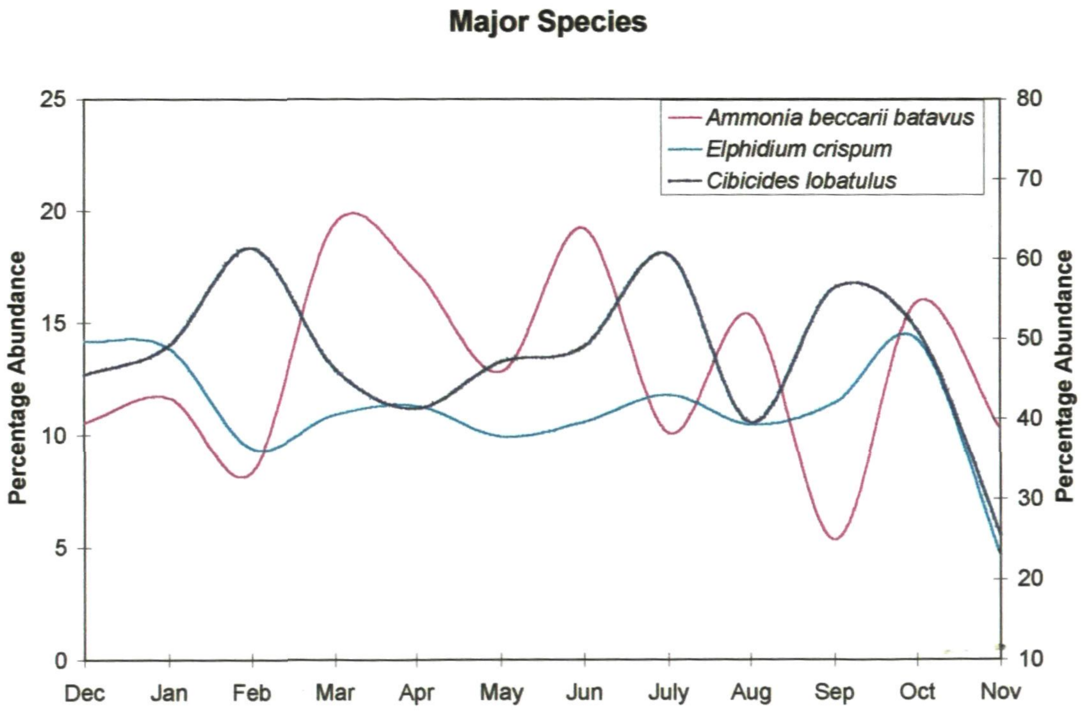


Figure. 9.11 Percentage abundance of *A. beccarii batavus, E. crispum* and *C. lobatulus* from Location 8 throughout the year.

Cibicides lobatulus shows three abundance maxima in February, July and September. *Ammonia beccarii batavus* exhibits a variable distribution, attaining maximum abundance in March with another period of similar abundance in June. The distribution of *E. crispum* is less variable and remains constant at approximately 10% of the assemblage for most of the year (Figure 9.11).

9.4.4. Diversity

A total of 69 species were recorded from Location 8 throughout the year from 3651 individuals, resulting in a Fisher Alpha diversity index of between 12 and 13. The diversity of the assemblage, although variable throughout the year, ranges between approximately 20 to 35 species per sample (301 count), but this was superseded in November when the highest diversity of 42 species was recorded resulting in a Fisher Alpha diversity index of 12 (Figure 9.12).

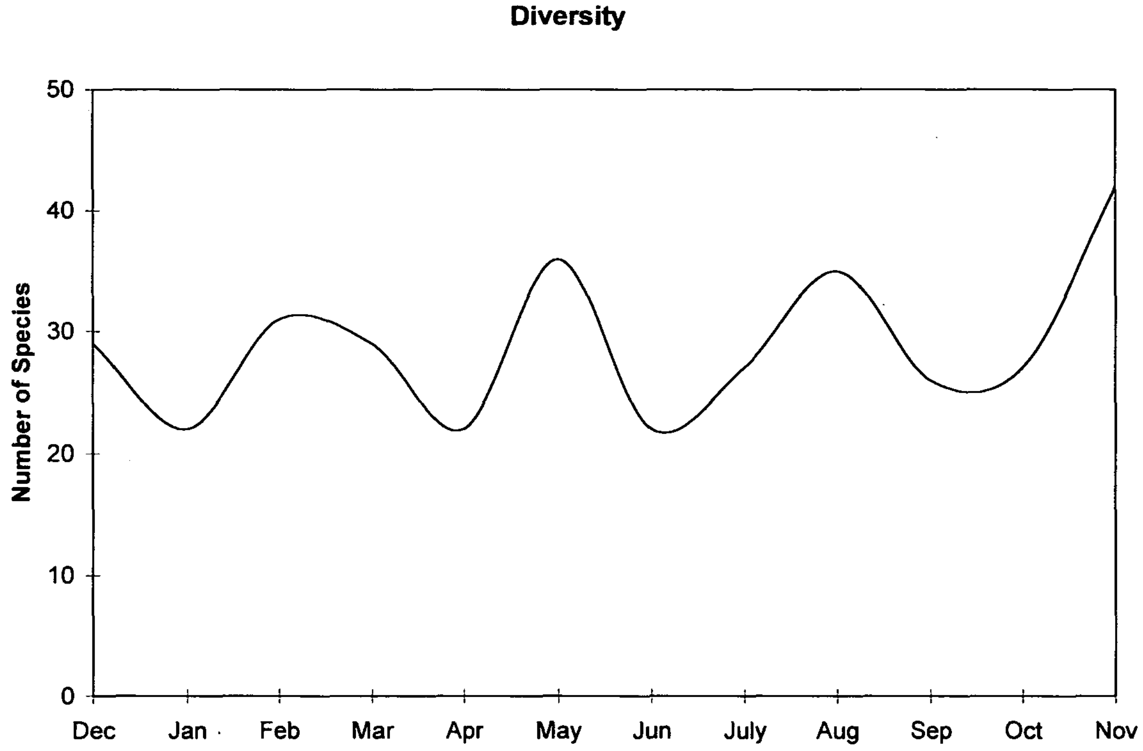


Figure. 9.12 Diversity of the dead assemblage throughout the year from Location 8.

9.4.5. Morphogroups

The plano-convex morphogroup (H4) dominates the assemblage (Table 9.8) accounting for 52% of the fauna (48% of *C. lobatulus* alone). The planispiral/low trochospiral group (H1) contributes 17% of the assemblage, mainly due to the abundance of *A. beccarii batavus*. The lenticular group (H3) accounts for 11% due entirely to *E. crispum*. Other important groups are the porcellaneous fusiform groups P8 and P9 which account for 11% in total (6% and 5% respectively).

MG		Abs.	%
H1	*Ammonia beccarii batavus*	480	13
H1	*Haynesina germanica*	58	2
H1	*Elphidium williamsoni*	40	1
H3	*Elphidium crispum*	404	11
H4	*Cibicides lobatulus*	1741	48
H4	*Rosalina globularis*	58	2
H4	*Cibicides pseudoungerianus*	35	1
H4	*Planorbulina mediterranensis*	22	1
H4	*Rosalina williamsoni*	20	1
H5	*Asterigerinata mamilla*	21	1
	Others	143	4
	Total	**3022**	**83**

MG		Abs.	%
P8	*Quinqueloculina bicornis*	79	2
P8	*Quinqueloculina lata*	45	1
P8	*Quinqueloculina seminulum*	37	1
P8	*Quinqueloculina* spp.	34	1
P8	*Quinqueloculina auberiana*	31	1
P9	*Massilina secans*	134	4
	Others	67	2
	Total	**427**	**12**
A6	*Eggerelloides scabrum*	62	2
A7	*Textularia truncata*	111	3
	Others	29	1
	Total	**202**	**6**

Table 9.8 Morphogroup distribution for species at Location 8. Foraminifera are divided into three general groups; hyaline, porcellaneous and agglutinated and allocated morphogroups (columns labelled MG). Both the absolute (Abs.) and percentage (%) values of each species are shown. Species which account for less than 1% are grouped under 'Others'

9.4.6. Condition of Tests

The foraminiferal assemblage was dominated by medium size tests in particularly foraminifera from the 250μm fraction. Foraminifera from the 63μm fraction and below were virtually absent as were those of the 500μm fraction. This bias towards medium size specimens is reflected in species such as *C. lobatulus, E. crispum, A. beccarii batavus, M. secans, Q. seminulum* and *Q. bicornis* which commonly attain these dimensions, being most abundant at Location 8. The tests of *C. lobatulus, E. crispum,* and *A. beccarii batavus* often displayed eroded peripheries, missing or punctured chambers as well as general scratching. The porcellaneous species *M. secans, Q. seminulum* and *Q. bicornis* tended to display abrasion damage through breakage of the exterior chambers. In general most of the specimens examined were damaged. *Cibicides lobatulus* exhibited less than average damage, perhaps its tests are a relatively new addition to the assemblage, or they may simply be more resistant to damage. The tests of *Globulina gibba* and *Globulina gibba* var. *myristiformis* showed some polishing but were unique in being the only species to be in near perfect condition at this location.

9.4.7. Discussion

The bias towards medium size specimens and the nature of the sediment (coarse sand) suggest that winnowing and loss of small specimens is prevalent. The abundant damage visible on nearly all tests, also suggest that these specimens may have suffered a high degree of transport. Some may have come from other areas and been transported as bedload, while others were probably indigenous (see Chapter 8 Section 8.5) and form a residual or lag deposit of medium to large tests.

The moderate diversity of the assemblage may indicate loss of small individuals and thus probably some species from the location, as well as reflecting a relatively low diversity live assemblage. The fluctuations in diversity throughout the year shows little correlation with either diversity of the live assemblage (see Figure. 8.14) or the abundance of the live assemblage (Figure. 8.12). The fluctuations in diversity may therefore simply reflect a patchy distribution of species.

The species trend of *A. beccarii batavus* exhibits its lowest abundance during September (Figure. 9.11) while within the live assemblage (Figure. 8.13) *A. beccarii batavus* attains its maximum abundance during the same month. This relationship highlights an relationship between the live and dead assemblages.

The major morphogroup distributions are not typical for this sand facies because over half of the assemblage is composed of plano-convex forms (52%) which are usually only abundant in shell gravel facies or on hard substrates such as rocks or plants etc.. The planispiral/low trochospiral (17%) and lenticular (11%) groups are well represented. Within the live assemblage of Location 8 plano-convex forms are virtually absent; this further indicates an assemblage which has undergone severe alteration.

9.5. Location 9

9.5.1. Introduction

The assemblage at this location exhibits the highest diversity of foraminifera. Most of the tests are small and, in general, the tests are in good condition, exhibiting few signs of abrasion and damage. Exotic tests exhibited higher amounts of damage.

9.5.2. Species Abundance

The two most common species at this location were *R. williamsoni* and *H. germanica* both accounting for 6% of the assemblage. *Eggerelloides scabrum* accounted for 5% of the assemblage. Other important species were *B. pseudopunctata* (4%), *B. spathulata* (4%), *A. beccarii batavus* (4%), *A. beccarii limnetes* (3%), and *C. jeffreysii* (3%).

	Abs.	**%**
Rosalina globularis	224	6
Haynesina germanica	217	6
Eggerelloides scabrum	192	5
Brizalina pseudopunctata	157	4
Brizalina spathulata	150	4
Ammonia beccarii batavus	129	4
Ammonia beccarii limnetes	119	3
Cribrostomoides jeffreysii	92	3
Planorbulina mediterranensis	85	2
Miliolinella subrotunda	82	2
Rosalina williamsoni	79	2
Cibicides pseudoungerianus	77	2
Quinqueloculina oblonga	76	2
Clavulina obscura	75	2
Quinqueloculina seminulum	74	2
Bolivina pseudoplicata	70	2
Brizalina striatula	70	2
Cibicides lobatulus	66	2
Elphidium williamsoni	66	2
Stainforthia concava var. *loeblichi*	66	2
Textularia earlandi	62	2
Elphidium cuvillieri	61	2
Lenticulina crepidula	60	2
Nodosaria pyrula	59	2

Quinqueloculina spp.	59	2
Elphidium gerthi	58	2
Fissurina lucida	55	2
Elphidium crispum	53	1
Fissurina marginata	49	1
Fursenkoina fusiformis	49	1
Ammoscalaria pseudospiralis	48	1
Textularia truncata	42	1
Cyclogyra involvens	36	1
Bulimina gibba	33	1
Trifarina angulosa	33	1
Fissurina orbignyana	32	1
Deuterammina (Lepidodeuterammina) ochracea var. *sinuosa*	31	1
Buliminella elegantissima	30	1
Quinqueloculina cliarensis	30	1
Brizalina variabilis	29	1
Cornuspirella diffusa	27	1
Asterigerinata mamilla	26	1
Bulimina elongata	26	1
Elphidium earlandi	24	1
Miliolinella circularis	21	1

Table 9.9 All species equal or greater than ≥1% abundance recorded at Location 9, shown in absolute (Abs.) and percentage (%) amount.

9.5.3. Species Distribution

The distribution of the two most abundant species show little variation throughout the year (Figure. 9.13). *Eggerelloides scabrum,* which usually has an abundance of approximately 5% of the assemblage throughout the year, attains its maximum of 20% during February (the highest abundance of any species at Location 9).

Brizalina spathulata exhibits high abundance in January and maximum abundance in October (See Figure. 9.14). Abundance of this species is unusually low for the period from April to August. *Brizalina spathulata* exhibits a variable abundance. The distribution of *A. beccarii batavus* is very variable accounting for over 10% of the fauna during January (maximum abundance) but is virtually absent for the period from May to August.

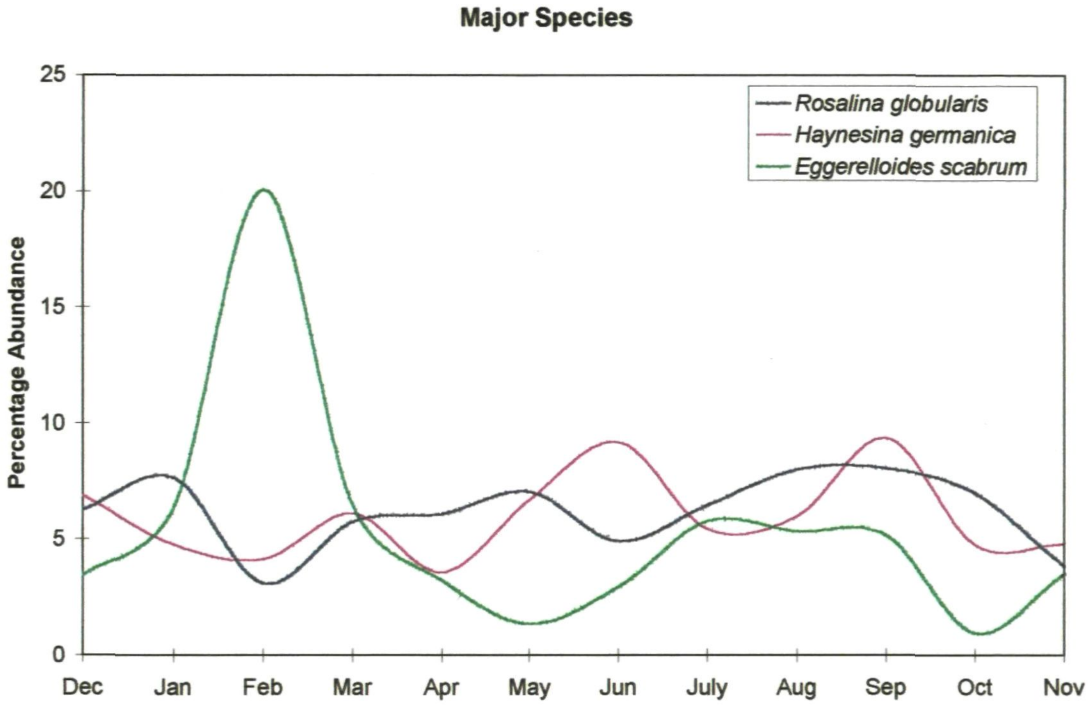


Figure. 9.13 Percentage abundance of *R. globularis, H. germanica* and *E. scabrum* from Location 9 throughout the year.

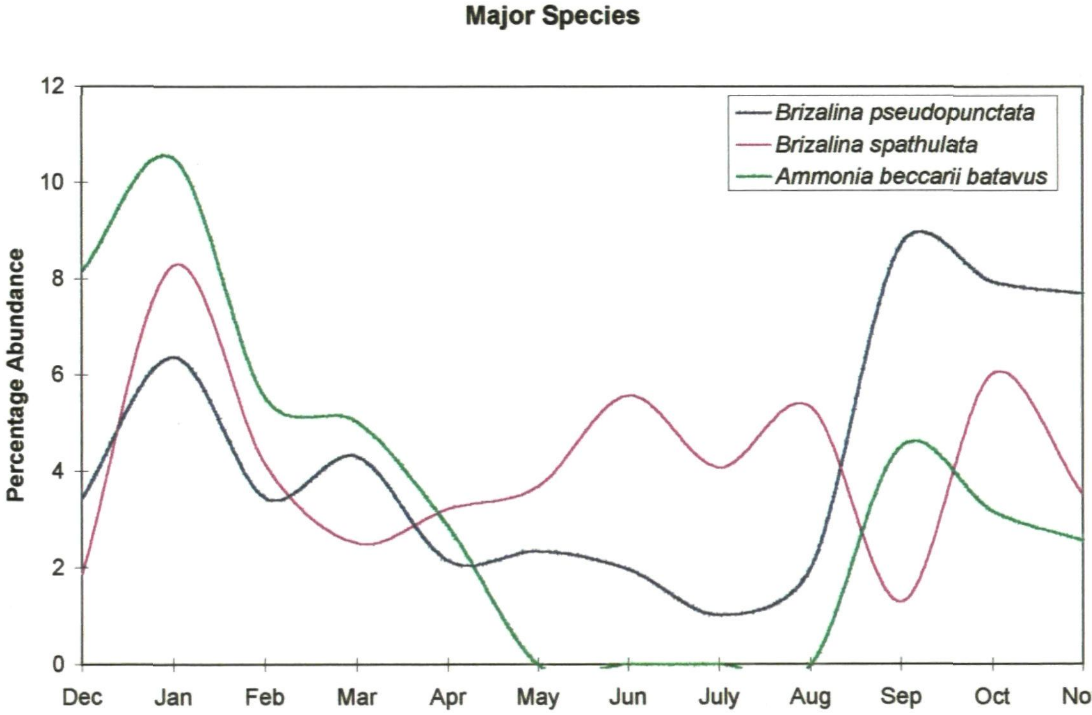


Figure. 9.14 Percentage abundance of *B. pseudopunctata, B. spathulata* and *A. beccarii batavus* from Location 9 throughout the year.

Ammonia beccarii limnetes exhibits the opposite trend to *A. beccarii batavus* being least abundant at the beginning of the year and attaining maximum abundance during July (Figure. 9.15). Maximum numbers of *C. jeffreysii* were recorded in March/April. This species exhibits a period of very low abundance (similar to that of *A. beccarii* batavus) between April to August. *Planorbulina mediterranensis* shows a relatively even distribution.

9.5.4. Diversity

A total of 109 species were recorded from Location 9 throughout the year from 3613 individuals resulting in a Fisher Alpha diversity index of greater than 20. Diversity throughout the year remained reasonably constant between 60 to 70 species each month. A maximum diversity of 71 species was attained during April giving a Fisher Alpha diversity in excess of 20 (Figure. 9.16).

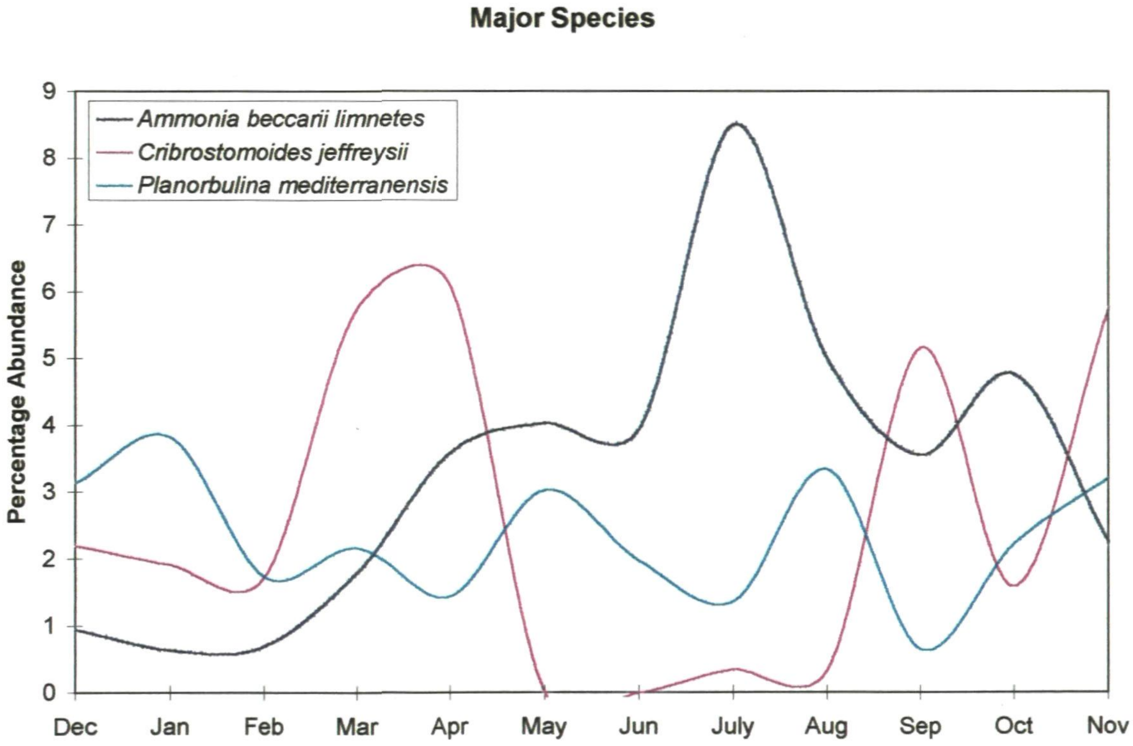


Figure. 9.15 Percentage abundance of *A. beccarii limnetes, C. jeffreysii* and *P. mediterranensis* from Location 9 throughout the year

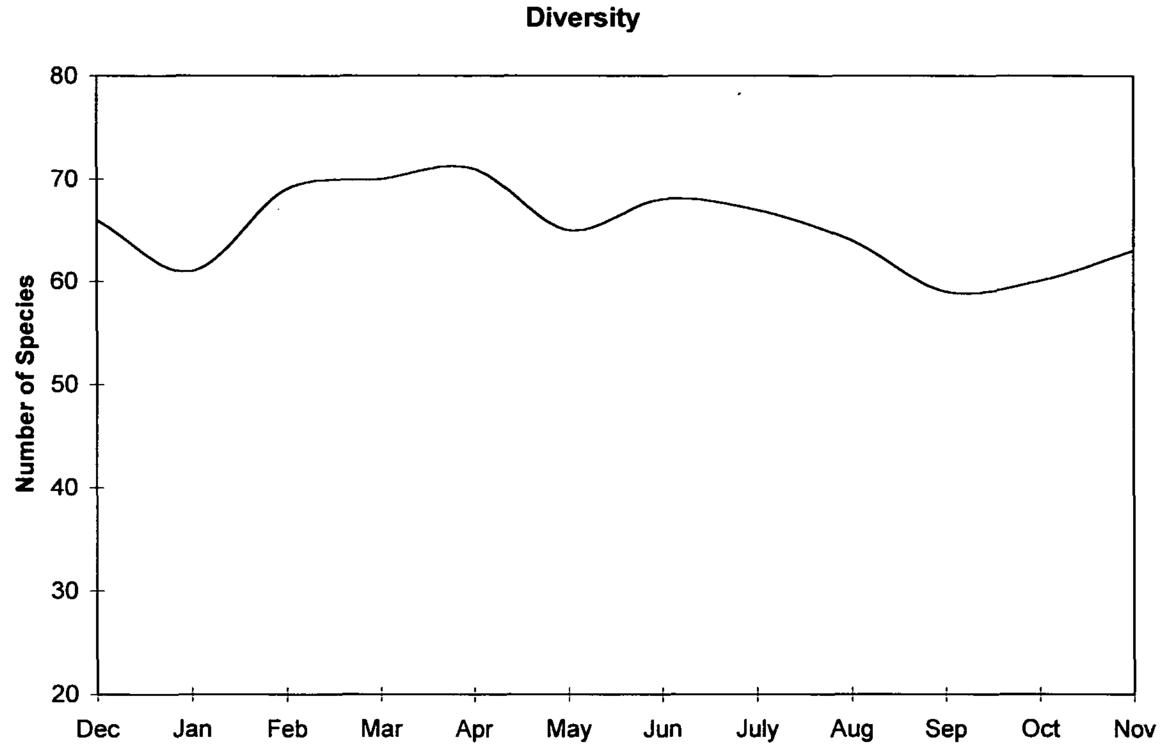


Figure. 9.16 Diversity of the dead assemblage throughout the year at Location 9.

9.5.5. Morphogroups

All of the main morphogroups are represented at this location (Table 9.10). Foraminiferal species are distributed relatively evenly throughout the morphogroups. The most common morphogroup was the planispiral/low trochospiral group (H1) which accounted for 21% of the fauna. The plano-convex group (H4) was also well represented with 15% of the assemblage.

The flattened tapered group (H10) was also reasonably abundant with 13% of the fauna. The cylindrical (5), conical (6), tapered (7) and fusiform (8) groups accounted for approximately 11% each of hyaline, porcellaneous and agglutinated test types and 32% in total. Many species belonging to this series of groups are free living, well adapted to burrowing and probably infaunal.

H1	*Haynesina germanica*	217	6
H1	*Ammonia beccarii batavus*	129	4
H1	*Ammonia beccarii limnetes*	119	3
H1	*Elphidium williamsoni*	66	2
H1	*Elphidium cuvillieri*	61	2
H1	*Lenticulina crepidula*	60	2
H1	*Elphidium gerthi*	58	2
H1	*Elphidium earlandi*	24	1
H10	*Brizalina pseudopunctata*	157	4
H10	*Brizalina spathulata*	150	4
H10	*Bolivina pseudoplicata*	70	2
H10	*Brizalina striatula*	70	2
H10	*Brizalina variabilis*	29	1
H11	*Fissurina lucida*	55	2
H11	*Fissurina marginata*	49	1
H11	*Fissurina orbignyana*	32	1
H3	*Elphidium crispum*	53	1
H4	*Rosalina globularis*	224	6
H4	*Planorbulina mediterranensis*	85	2
H4	*Rosalina williamsoni*	79	2
H4	*Cibicides pseudoungerianus*	77	2
H4	*Cibicides lobatulus*	66	2
H5	*Nodosaria pyrula*	59	2
H5	*Asterigerinata mamilla*	26	1
H6	*Bulimina gibba*	33	1
H6	*Bulimina elongata*	26	1
H8	*Stainforthia concava* var. *loeblichi*	66	2
H8	*Trifarina angulosa*	33	1
H8	*Buliminella elegantissima*	30	1
H9	*Fursenkoina fusiformis*	49	1
	Others	228	6
	Total	**2480**	**68**

A7	*Textularia truncata*	42	1
A6	*Eggerelloides scabrum*	192	5
A6	*Textularia earlandi*	62	2
A5	*Clavulina obscura*	75	2
A4	*Trochammina ochracea*	31	1
A1	*Cribrostomoides jeffreysii*	92	3
A1	*Ammoscalaria pseudospiralis*	48	1
	Others	69	2
	Total	**611**	**17**
P2	*Cyclogyra involvens*	36	1
P9	*Miliolinella subrotunda*	82	2
P9	*Quinqueloculina cliarensis*	30	1
P8	*Quinqueloculina oblonga*	76	2
P8	*Quinqueloculina seminulum*	74	2
P8	*Quinqueloculina* spp.	59	2
P8	*Miliolinella circularis*	21	1
P12	*Cornuspirella diffusa*	27	1
	Others	124	4
	Total	**529**	**15**

Table 9.10 Morphogroup distribution for species at Location 9. Foraminifera are divided into three general groups; hyaline, porcellaneous and agglutinated and allocated morphogroups (columns labelled MG). Both the absolute (Abs.) and percentage (%) values of each species are shown. Species which account for less than 1% are grouped under 'Others'.

9.5.6. Condition of Tests

The tests observed are generally small (125μm or less) although a wide size range is present. The predominance of small tests may be due to two factors. Firstly the small tests may be indigenous (either small species or juveniles), secondly, the areas of low energy (such as this location) allow the deposition and accumulation of small tests which are transported into the area in suspension. The energy is often not great enough to transport larger tests into the area. Most species exhibited damage regardless of size, the estuarine species *H. germanica* and *E. williamsoni* exhibited more abundant damage than other species.

The tests of most individuals were in good condition and show little or no evidence of damage. Rare isolated individuals did, however, exhibit abundant abrasion and breakage; these tended to be of medium or large size (>125µm to 500µm).

Most of the medium to large tests present were probably accumulated *in situ* or from nearby, as they consist mainly of indigenous species such as *A. beccarii batavus*, *Q. seminulum, E. scabrum,* etc.. There is little evidence for the transportation of large tests into this area.

9.5.7. Discussion

The dead assemblage at Location 9 shows a high degree of species evenness and low species dominance. The abundance of small tests is due either to an abundance of small tests within the live assemblage, enrichment of small tests by transport in suspension or a combination of both.

The high diversity (total and monthly) is a result of high diversity in the live assemblage (see Chapter 8, Section 8.6.5.) and probably an element of allochthonous fauna. The low variation of diversity throughout the year reflects the stability and homogenous nature of the site.

Foraminifera are evenly distributed within morphogroups with all the major groups being represented. The plano-convex group (H4) probably represent individuals which have been transported into the area they are generally small, ≤125µm. The abundance of flattened tapered, elongate, cylindrical and conical groups is characteristic of mud rich facies as these forms are likely to be infaunal detritivores.

9.6. Location 11

9.6.1. Introduction

The assemblage is characterised by a lack of small tests and an abundance of medium to large tests. Most tests exhibit a high degree of damage. Diversity is low to moderate.

9.6.2. Species Abundance

Cibicides lobatulus was the most abundant species at Location 11, where it accounted for 40% of the assemblage. *Elphidium crispum* and *A. beccarii batavus* were also abundant accounting for 16% and 10% of the assemblage respectively. *Textularia truncata* (6%), *M. secans* (4%) and *E. scabrum* (4%) were significant species.

	Abs.	**%**
Cibicides lobatulus	1579	40
Elphidium crispum	630	16
Ammonia beccarii batavus	403	10
Textularia truncata	252	6
Massilina secans	176	4
Eggerelloides scabrum	152	4
Quinqueloculina seminulum	109	3
Quinqueloculina auberiana	47	1
Elphidium williamsoni	42	1
Quinqueloculina lata	42	1
Cibicides pseudoungerianus	34	1
Asterigerinata mamilla	31	1
Haynesina germanica	31	1
Quinqueloculina bicornis	31	1
Quinqueloculina aspera II	26	1
Quinqueloculina cliarensis	25	1
Elphidium cuvillieri	24	1
Ammonia beccarii limnetes	22	1
Globulina gibba var. *myristiformis*	21	1

Table 9.11 All species ≥1% abundance recorded at Location 11, shown in absolute (Abs.) and percentage (%) amount.

9.6.3. Species Distribution

Cibicides lobatulus and *E. crispum* exhibited low abundances during April (Figure. 9.17). *Cibicides lobatulus* attained its maximum abundance during December 1993, while *E. crispum* attained its maximum abundance during January. *Ammonia beccarii batavus* exhibited a trend which displayed a negative correlation with the two former species, attaining its maximum abundance in February (See Figure. 9.17).

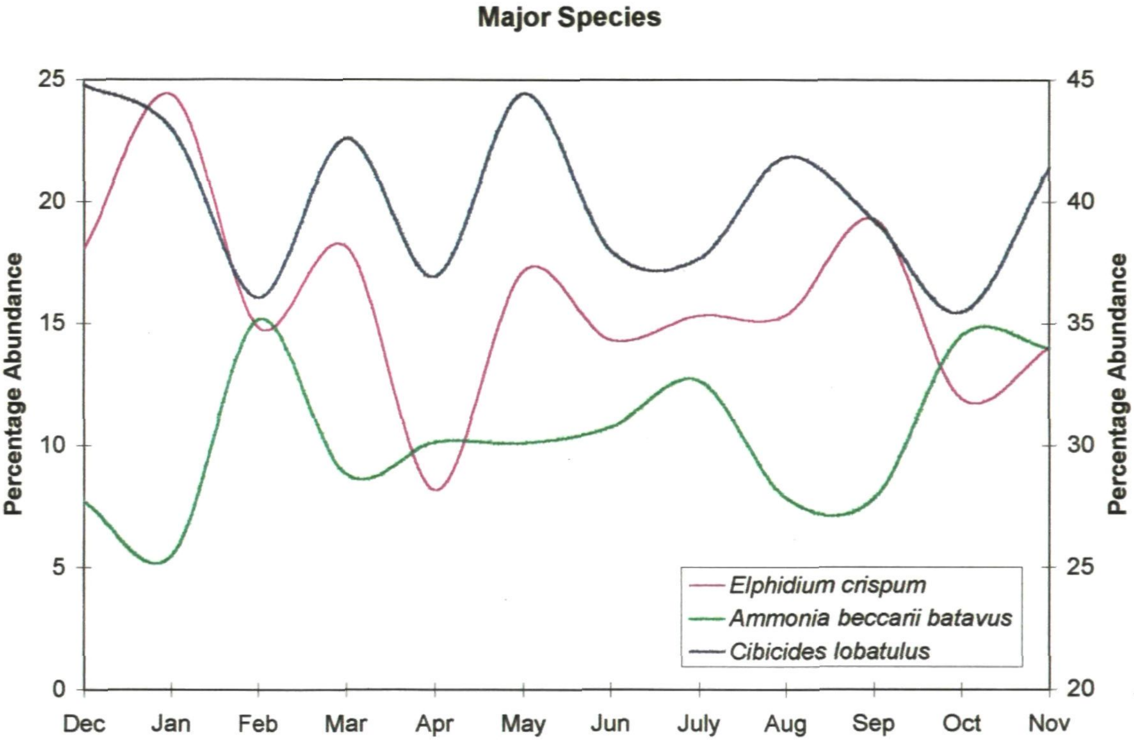


Figure. 9.17. Percentage abundance of *E. crispum, A. beccarii batavus* and *C. lobatulus* from Location 11 throughout the year. Note that *Cibicides lobatulus* is plotted on the right axis.

The maximum abundance of *T. truncata* occurred during August and September, after which it declined rapidly exhibiting its lowest abundance during November. The distributions of *M. secans* and *E. scabrum* were quite variable, both attaining their maximum numbers during the summer (Figure. 9.18).

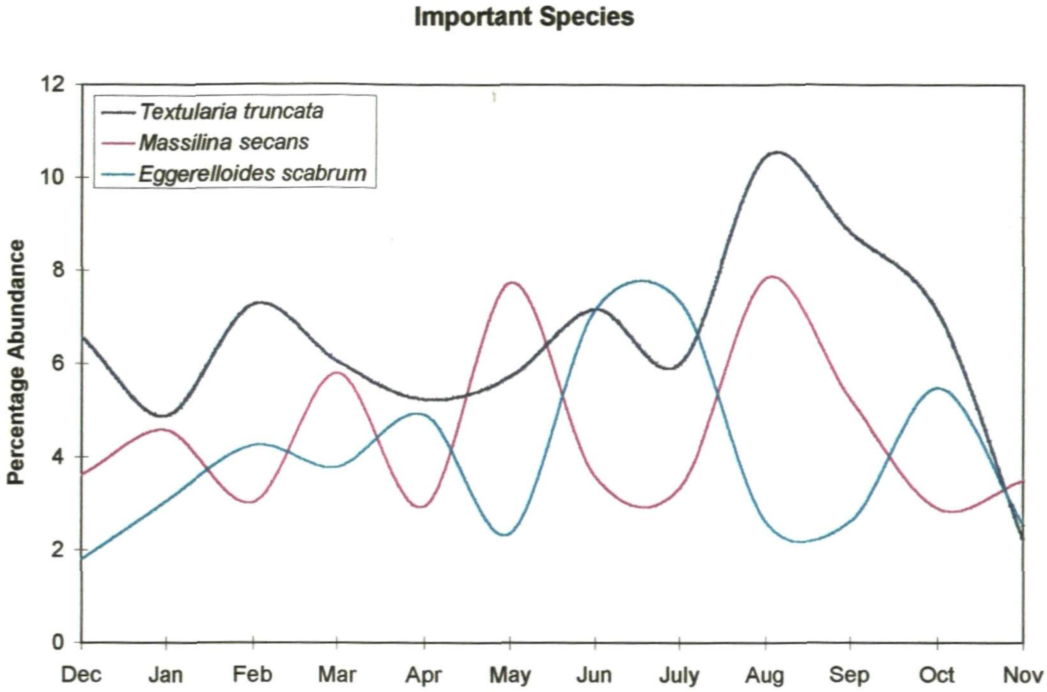


Figure. 9.18 Percentage abundance of *T. truncata, M. secans* and *E. scabrum* from Location 11 throughout the year.

9.6.4. Diversity

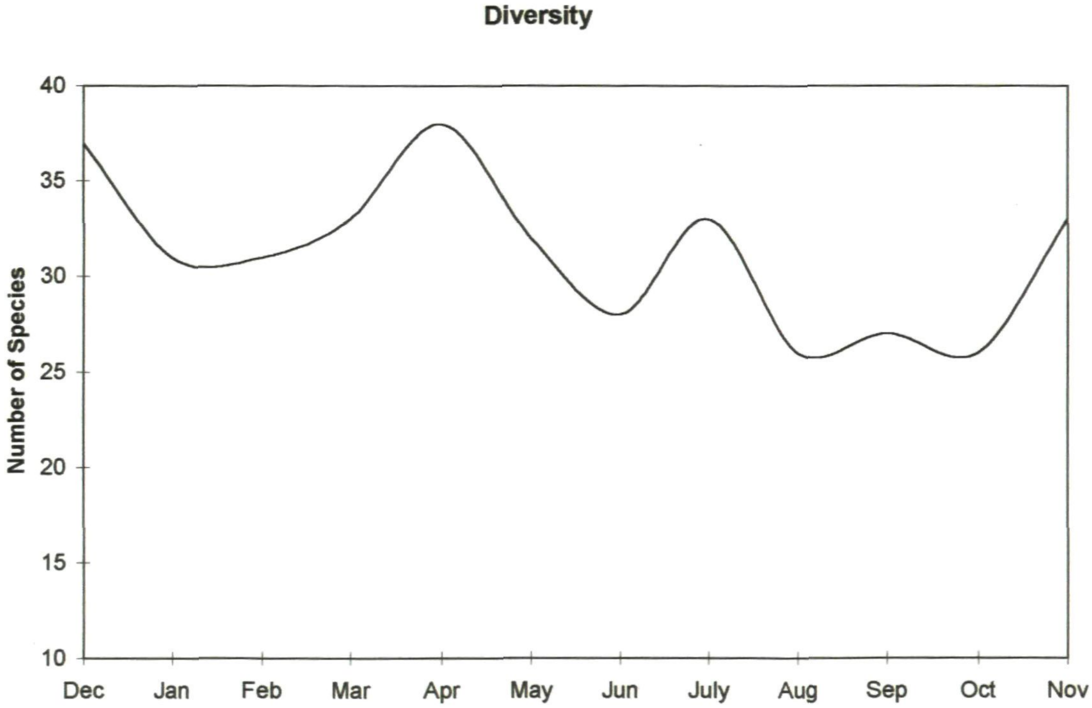


Figure. 9.19 Diversity of the dead assemblage throughout the year from Location 11.

A total of 63 species were recorded from 3915 individuals throughout the year resulting in a Fisher Alpha diversity index of 11 for Location 11. Diversity was variable throughout the year but remained above 25 and below 40 species per month (301 count). The highest diversity was attained during April with 39 species resulting in a Fisher Alpha diversity index of 12. The lowest diversities were recorded from August to October (Figure. 9.18).

9.6.5. Morphogroups

MG		Abs.	%
H1	*Ammonia beccarii batavus*	403	10
H1	*Elphidium williamsoni*	42	1
H1	*Haynesina germanica*	31	1
H1	*Elphidium cuvillieri*	24	1
H1	*Ammonia beccarii limnetes*	22	1
H11	*Globulina gibba* var. *myristiformis*	21	1
H3	*Elphidium crispum*	630	16
H4	*Cibicides lobatulus*	1579	40
H4	*Cibicides pseudoungerianus*	34	1
H5	*Asterigerinata mamilla*	31	1
	Others	116	3
	Total	**2933**	**75**

MG		Abs.	%
P9	*Massilina secans*	176	4
P8	*Quinqueloculina seminulum*	109	3
P8	*Quinqueloculina auberiana*	47	1
P8	*Quinqueloculina lata*	42	1
P8	*Quinqueloculina bicornis*	31	1
P8	*Quinqueloculina aspera* II	26	1
P9	*Quinqueloculina cliarensis*	25	1
	Others	102	2
	Total	**554**	**14**
A6	*Eggerelloides scabrum*	152	4
A7	*Textularia truncata*	252	6
	Others	24	1
	Total	**428**	**11**

Table 9.12 Morphogroup distribution for species at Location 11. Foraminifera are divided into three general groups; hyaline, porcellaneous and agglutinated and allocated morphogroups (columns labelled MG). Both the absolute (Abs.) and percentage (%) values of each species are shown. Species which account for less than 1% are grouped under 'Others'.

The most abundant morphogroup at Location 11 was the plano-convex (H4) group which accounted for 43 % of the assemblage (*Cibicides lobatulus* accounted for 40% of this group). The lenticular group (H3) accounted for 16% of the assemblage and was composed solely of *E. crispum*. The planispiral/ low trochospiral (H1) group was also well represented accounting for 14% of the assemblage. The porcellaneous groups P8 fusiform and P9 flattened fusiform accounted for 8% and 6% respectively (Table 9.12).

9.6.6. Condition of Tests

The tests exhibited abundant evidence of abrasion, breakage and perhaps possible dissolution (Murray, 1989). Nearly all the tests of *E. crispum* and the miliolids were damaged and broken. Tests were dominated by medium to large specimens and were most abundant within the 250µm and 500µm fractions. Foraminiferal tests belonging to the 125µm, and in particular the 63µm fraction, were very sparse or absent from the assemblage. This suggests that the fine fractions have been removed by winnowing whilst the larger tests remain.

9.6.7. Discussion

The assemblage observed at this location has been significantly altered by post-mortem processes, which is exhibited in the removal of small tests and the damage (perhaps by bedload transport) of larger tests.

The abundance of test throughout the year is probably influenced by the patchiness of the site and variability caused by sampling. *Textularia truncata* exhibits a positive correlation with its live assemblage, being common living during July and August (Figure. 8.21) and most abundant within the dead assemblage during August and September (Figure. 9.18). The poor correlation between the major species within the live and dead assemblage may be due to the dynamic environment in which post-mortem transport is prevalent.

The highest diversities during the first half of the year contradicts the diversity within the live assemblage (Figure. 8.22). The reason for this is not known and will be discussed in Chapter 10.

The morphogroups are dominated (43%) by the plano-convex group (H4) which suggests the presence of suitable rock, shell or plant substrates for attachment although no suitable substrates were observed. The occurrence of the lenticular group (H3) and the low trochospiral/planispiral groups (H1) with 16% and 14% respectively is to be expected.

9.7. Location 12

9.7.1. Introduction

The assemblage at this location shows a good range of test sizes, in good condition. Evidence for transport and damage is moderate to low although a component of the fauna (small tests) is likely to have been transported into the area after death.

9.7.2. Species Abundance

	Abs.	%
Ammonia beccarii batavus	949	26
Eggerelloides scabrum	411	11
Haynesina germanica	311	8
Cibicides lobatulus	247	7
Ammonia beccarii limnetes	224	6
Elphidium williamsoni	127	3
Rosalina globularis	101	3
Cribrostomoides jeffreysii	89	2
Cibicides pseudoungerianus	87	2
Elphidium crispum	71	2
Elphidium gerthi	71	2
Brizalina pseudopunctata	67	2
Brizalina spathulata	58	2
Elphidium cuvillieri	56	2
Quinqueloculina seminulum	49	1
Planorbulina mediterranensis	47	1
Nodosaria pyrula	45	1
Rosalina williamsoni	44	1
Fissurina lucida	40	1
Quinqueloculina spp.	36	1
Clavulina obscura	35	1
Bulimina gibba	33	1
Bolivina pseudoplicata	32	1
Bulimina elongata	31	1
Elphidium margaritaceum	24	1
Fissurina marginata	23	1
Miliolinella subrotunda	21	1
Quinqueloculina oblonga	19	1

Table 9.13 All species ≥1% abundance recorded at Location 12, shown in absolute (Abs.) and percentage (%) amount.

The most abundant species at Location 12 was *A. beccarii batavus,* constituting 26% of the assemblage. *Eggerelloides scabrum* accounted for 11% of the assemblage. *Haynesina germanica* (8%), *Cibicides lobatulus* (7%) and *A. beccarii limnetes* (6%) were all significant within the assemblage (Table 9.13).

9.7.3. Species Trends

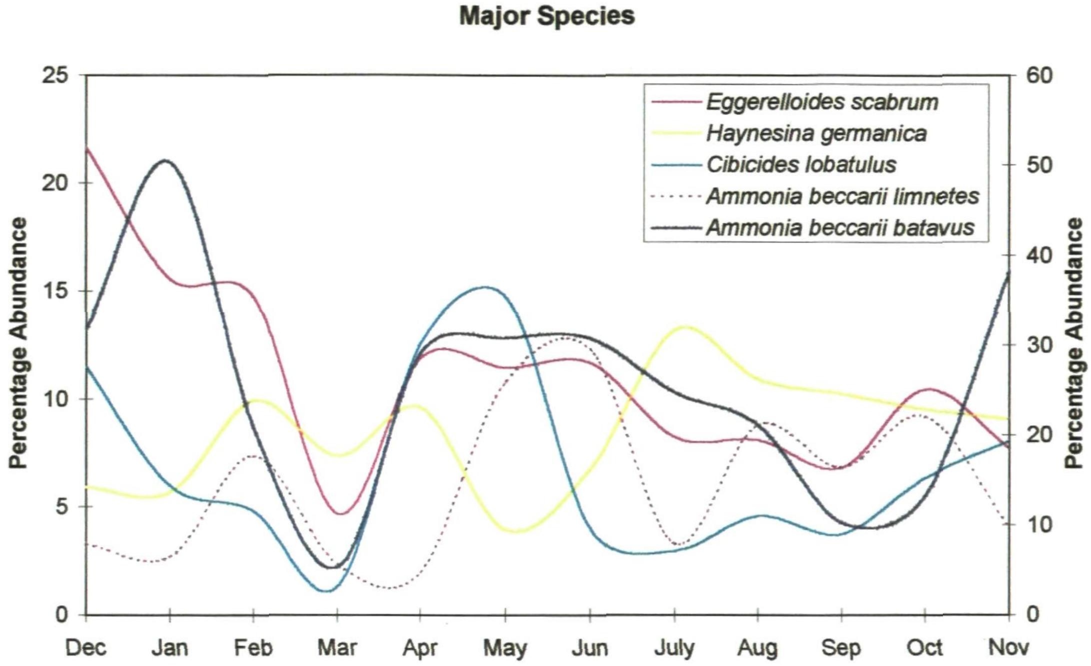


Figure. 9.20 Percentage abundance of *E. scabrum, H. germanica, C. Lobatulus, A. beccarii limnetes* and *A. beccarii batavus* from Location 12 throughout the year. NB *A. beccarii batavus* is plotted on the right axis.

Maximum numbers of *A. beccarii batavus* was attained during January, while its lowest abundance was reached in March. *Eggerelloides scabrum* reached its maximum abundance during December 1993 and, like *A. beccarii batavus* it exhibited its lowest abundance during March. All the marine species (excluding the euryhaline *H. germanica*) exhibited their lowest abundance during March/April. *Cibicides lobatulus, H. germanica* and *A. beccarii limnetes* attained there greatest numbers during the spring and summer (Figure 9.20).

9.7.4. Diversity

A total of 87 species were recorded from 3675 individuals throughout the year resulting in a Fisher Alpha Diversity Index of approximately 17. The highest diversity was recorded in February at 53 species, resulting in a Fisher Alpha diversity index of 19. Foraminiferal diversities varied throughout the year being generally high from February to October. The lowest diversities were in January and November (Figure 9.21).

Diversity varied throughout the year, lowest diversity was recorded in January at 30 species (per 301 individuals). The highest diversity occurred in March at 54 species (per 301 individuals). Monthly samples exhibited a Fisher Alpha diversity range of between 8 to 19

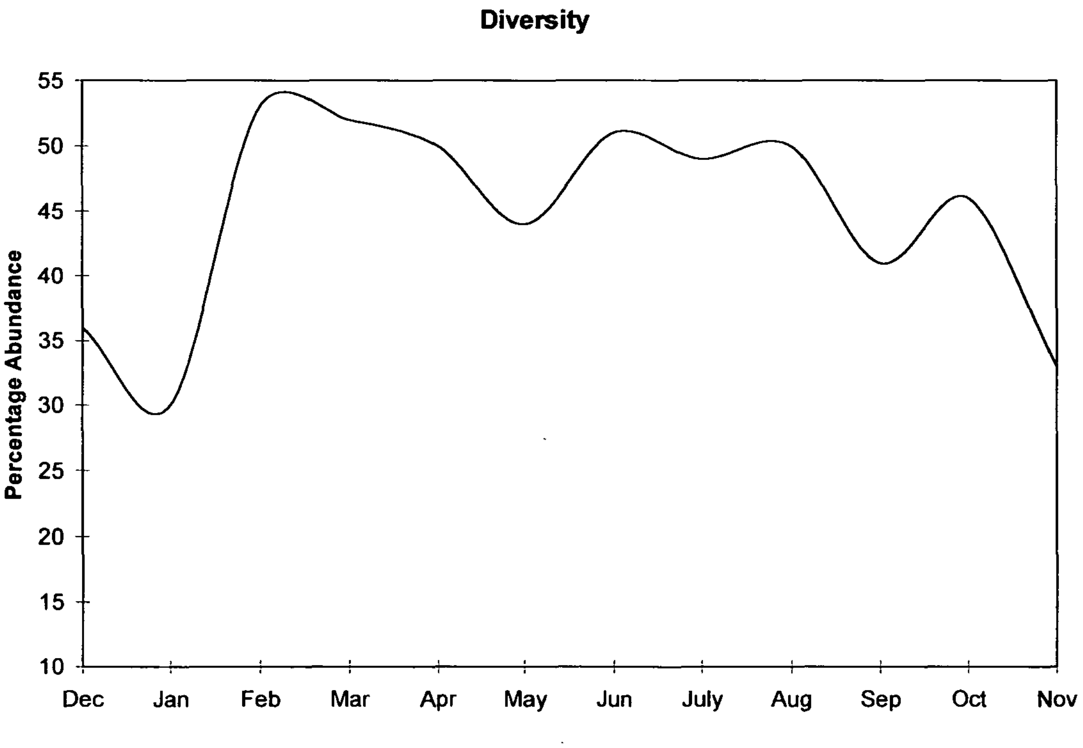


Figure. 9.21 Diversity of the dead assemblage throughout the year at Location 12.

9.7.5. Morphogroups

By far the most abundant group was the planispiral/low trochospiral group (H1) which accounted for 48% of the assemblage. The plano-convex group (H4) which have an attached life position accounted for 14% of the fauna. Also abundant was the conical, agglutinated group (A6) which accounted for 11% of the assemblage.

MG		Abs.	%
H1	*Ammonia beccarii batavus*	949	26
H1	*Haynesina germanica*	311	8
H1	*Ammonia beccarii limnetes*	224	6
H1	*Elphidium williamsoni*	127	3
H1	*Elphidium gerthi*	71	2
H1	*Elphidium cuvillieri*	56	2
H1	*Elphidium margaritaceum*	24	1
H10	*Brizalina pseudopunctata*	67	2
H10	*Brizalina spathulata*	58	2
H10	*Bolivina pseudoplicata*	32	1
H11	*Fissurina lucida*	40	1
H11	*Fissurina marginata*	23	1
H3	*Elphidium crispum*	71	2
H4	*Cibicides lobatulus*	247	7
H4	*Rosalina globularis*	101	3
H4	*Cibicides pseudoungerianus*	87	2
H4	*Planorbulina mediterranensis*	47	1
H4	*Rosalina williamsoni*	44	1
H5	*Nodosaria pyrula*	45	1
H6	*Bulimina gibba*	33	1
H6	*Bulimina elongata*	31	1
	Others	174	5
	Total	**2862**	**78**

MG		Abs	%
A1	*Cribrostomoides jeffreysii*	89	2
A5	*Clavulina obscura*	35	1
A6	*Eggerelloides scabrum*	411	11
	Others	67	1
	Total	**602**	**16.4**
P8	*Quinqueloculina seminulum*	49	1
P8	*Quinqueloculina* spp.	36	1
P9	*Miliolinella subrotunda*	21	1
P8	*Quinqueloculina oblonga*	19	1
	Others	86	3
	Total	**211**	**6**

Table 9.14 Morphogroup distribution for species at Location 12. Foraminifera are divided into three general groups; hyaline, porcellaneous and agglutinated and allocated morphogroups (columns labelled MG). Both the absolute (Abs.) and percentage (%) values of each species are shown. Species which account for less than 1% are grouped under 'Others'.

9.7.6. Condition of Tests

The tests at Location 12 were generally in good condition showing little sign of transport or damage although the tests of *C. lobatulus* exhibited a very high degree of damage. A wide range of test sizes were present from 63µm to 500µm, although the smaller tests (63µm and 125µm) were the most abundant.

9.7.7. Discussion

The good condition and range of sizes of the tests suggest that post-mortem transport and alteration of the assemblage has been minor. Small tests (63µm and 125µm) are prone to transport in most environments as they act hydrodynamically as a silt-size quartz grains. In the silty sands of Location 12 the assemblage may have been enriched by small tests being deposited during low energy conditions. The presence of the estuarine *H. germanica* and *E. williamsoni* testify to this, as they are generally small, and indigenous as living taxa only to estuaries.

The empty tests of many species show significant variation in abundance throughout the year. This undoubtedly results from the interaction between the live and dead assemblages and other factors such as post-mortem alteration and patchiness of distribution as discussed in Section 9.1. Both the live and dead assemblages exhibit very low abundance during March.

The assemblage displays good species evenness with the most abundant (*A. beccarii batavus*) species accounting for one quarter of the assemblage; other species are considerably less than this.

Morphogroups are dominated by the low trochospiral/planispiral group H1 (48%). This group is most abundant in mud rich sites. The presence of the plano-convex group H4 (14%) is surprising in such an environment this attached group is usually associated with high energy. Their small size suggest that they are an allocthanous component.

9.8. Location 14

9.8.1. Introduction

The assemblage at this location shows signs of transport and abrasion. The estuarine species exhibited less damage. The fauna is generally of low diversity and dominated by *C. lobatulus*.

9.8.2. Species Abundance

The dominant species at this location was *C. lobatulus* which accounted for 40% of the fauna. Also abundant were *A. beccarii batavus* and *E. crispum* with 11% and 10% of the assemblage (Table 9.15). Other important species were *E. scabrum* (6%) and *P. mediterranensis* (5%).

	Abs.	%
Cibicides lobatulus	1489	40
Ammonia beccarii batavus	400	11
Elphidium crispum	383	10
Eggerelloides scabrum	230	6
Planorbulina mediterranensis	178	5
Textularia truncata	126	3
Haynesina germanica	125	3
Elphidium williamsoni	90	2
Massilina secans	65	2
Elphidium cuvillieri	57	2
Ammonia beccarii limnetes	48	1
Rosalina globularis	46	1
Cibicides pseudoungerianus	45	1
Miliolinella subrotunda	44	1
Quinqueloculina seminulum	42	1
Quinqueloculina auberiana	37	1
Asterigerinata mamilla	23	1
Quinqueloculina spp.	22	1
Quinqueloculina cliarensis	22	1

Table 9.15 All species ≥1% abundance recorded at Location 14, shown in absolute (Abs.) and percentage (%) amount.

9.8.3. Species Distribution

Cibicides lobatulus exhibits its highest abundance during February and May where it accounted of over 50% of the assemblage. Its lowest abundance was in September. The abundance of *A. beccarii batavus* was inversely proportional to that of *C. lobatulus* (Figure. 9.22). The greatest abundance of *A. beccarii batavus* occurred in April and from August to October. *Eggerelloides scabrum* exhibits its highest abundances during April while *E. crispum* has a variable trend with abundance maxima in January, March and November.

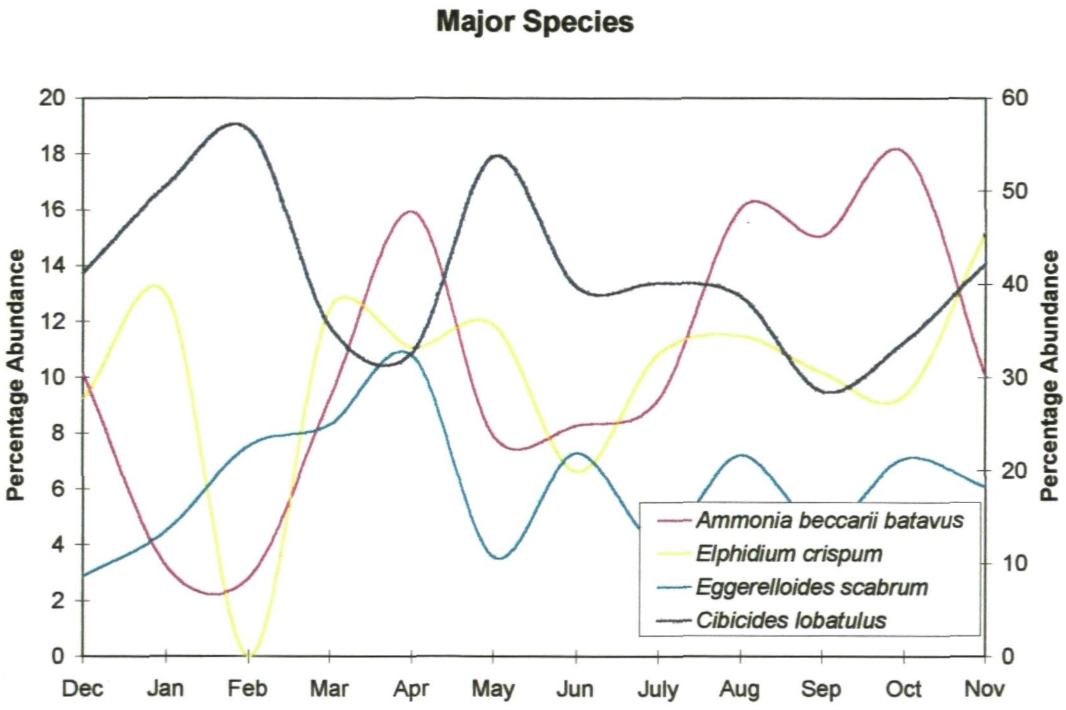


Figure. 9.22 Percentage abundance of *A. beccarii batavus, E. crispum, E. scabrum* and *C. lobatulus* from Location 14 throughout the year. NB *Cibicides lobatulus* is plotted on the right axis.

9.8.4. Diversity

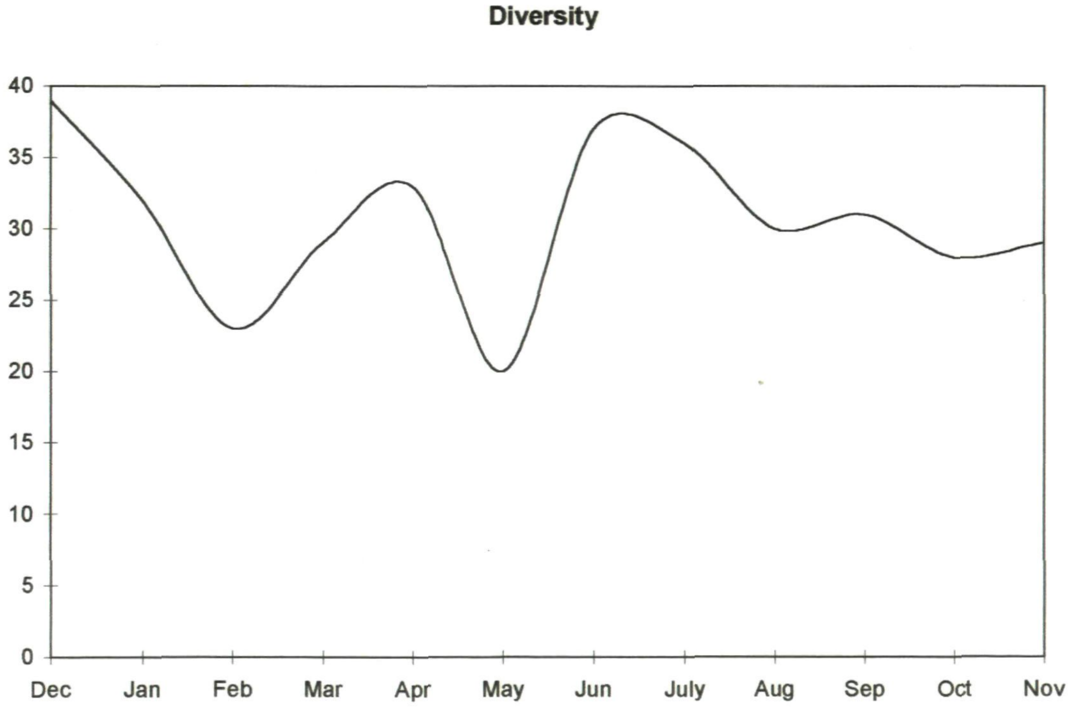


Figure. 9.23 Diversity of the dead assemblage throughout the year Location 14.

A total of 68 species were recorded for Location 14 from 3688 individuals resulting in a Fisher Alpha diversity index of 12. Diversity varied throughout the year, the lowest diversity of 20 species was recorded in May (in a 301 count). The highest diversity occurred in December at 49 species (per 301 count) see Figure. 9.23. Monthly samples exhibited a Fisher alpha diversity range of between 5 to 16 (Table 9.16).

9.8.5. Morphogroups

Only two morphogroups are abundant at this location. The plano-convex (H4) group accounted for 48% of the assemblage (40% of which was contributed by one species: *C. lobatulus*). The other abundant group was the planispiral/low trochospiral group (H1) which accounted for 20% of the assemblage.

MG		Abs.	%
H1	*Ammonia beccarii limnetes*	48	1
H1	*Elphidium cuvillieri*	57	2
H1	*Elphidium williamsoni*	90	2
H!	*Haynesina germanica*	125	3
H1	*Ammonia beccarii batavus*	400	11
H3	*Elphidium crispum*	383	10
H4	*Cibicides pseudoungerianus*	45	1
H4	*Rosalina globularis*	46	1
H4	*Planorbulina mediterranensis*	178	5
H4	*Cibicides lobatulus*	1489	40
H5	*Asterigerinata mamilla*	23	1
	Others	107	3
	Total	2991	81

MG		Abs.	%
A6	*Eggerelloides scabrum*	230	6
A7	*Textularia truncata*	126	3
	Others	10	0
	Total	366	10
P9	*Massilina secans*	65	2
P9	*Miliolinella subrotunda*	44	1
P8	*Quinqueloculina seminulum*	42	1
P8	*Quinqueloculina auberiana*	37	1
P8	*Quinqueloculina* spp.	22	1
P9	*Quinqueloculina* cf. *cliarensis*	22	1
	Others	99	3
	Total	331	9

Table 9.16 Morphogroup distribution for species at Location 14. Foraminifera are divided into three general groups; hyaline, porcellaneous and agglutinated and allocated morphogroups (columns labelled MG). Both the absolute (Abs.) and percentage (%) values of each species are shown. Species which account for less than 1% are grouped under 'Others'.

9.8.6. Condition of Tests

Many tests showed signs of damage and abrasion. Sorting is also believed to have occurred, as tests are rarer within the 63μm fraction and most common in the 250μm fraction.

9.8.7. Discussion

Abraded and broken tests are indicative of an assemblage that has suffered considerable transport. The assemblage is dominated by the plano-convex species *C. lobatulus* (40%). As this species is unlikely to live in medium to fine sandy sediment it is probable that it has been transported into the area. The planispiral/low trochospiral group is reasonably common with 20% of the assemblage. The lower abundance of small tests also indicates post-mortem current sorting. The assemblage at this location may be a lag deposit of medium sized tests.

9.9. Location 15

9.9.1. Introduction

The assemblage at this location exhibits high diversity and a good range of test size. Transport of tests out of the area is believed to be low, although the assemblage may be enriched with small exotic tests.

9.9.2. Species Abundance

Ammonia beccarii batavus is the dominant species accounting for 23% of the assemblage. *Eggerelloides scabrum, C. lobatulus* and *E. crispum* contribute significantly to the assemblage (Table 9.17). Other important species were *Elphidium gerthi* (5%), *E. cuvillieri* (4%), *A. beccarii limnetes* (4%) and *H. germanica* (3%).

	Abs.	%
Ammonia beccarii batavus	848	23
Eggerelloides scabrum	414	11
Cibicides lobatulus	341	9
Elphidium crispum	257	7
Elphidium gerthi	172	5
Elphidium cuvillieri	156	4
Ammonia beccarii limnetes	129	4
Haynesina germanica	112	3
Cibicides pseudoungerianus	88	2
Brizalina spathulata	80	2
Bulimina elongata	79	2

Bulimina gibba	69	2
Clavulina obscura	65	2
Rosalina globularis	61	2
Brizalina pseudopunctata	59	2
Cribrostomoides jeffreysii	55	1
Fissurina lucida	42	1
Elphidium williamsoni	40	1
Quinqueloculina seminulum	40	1
Rosalina williamsoni	31	1
Quinqueloculina aspera III	30	1
Miliolinella subrotunda	27	1
Elphidium margaritaceum	26	1
Quinqueloculina spp.	26	1
Brizalina variabilis	25	1
Bolivina pseudoplicata	24	1
Quinqueloculina oblonga	24	1
Nodosaria pyrula	23	1

Table 9.17 All species ≥1% abundance recorded at Location 15, shown in absolute (Abs.) and percentage (%) amount.

9.9.3. Species Trends

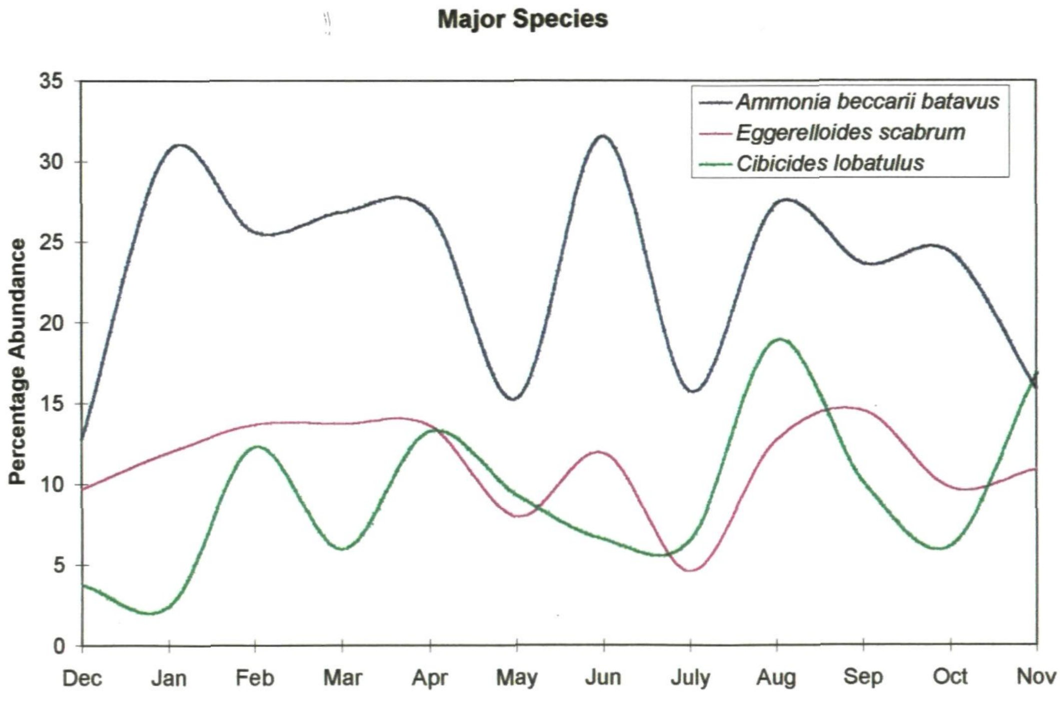


Figure. 9.24 Percentage abundance of *A. beccarii batavus, E. scabrum* and *C. lobatulus* from Location 15 throughout the year.

The principal species, *A. beccarii batavus,* shows a large degree of variation in abundance throughout the year. Its maximum abundance occurred during June. *Cibicides lobatulus* attains its maximum abundance during August. *Eggerelloides scabrum* exhibits the least variable trend (Figure. 9.24).

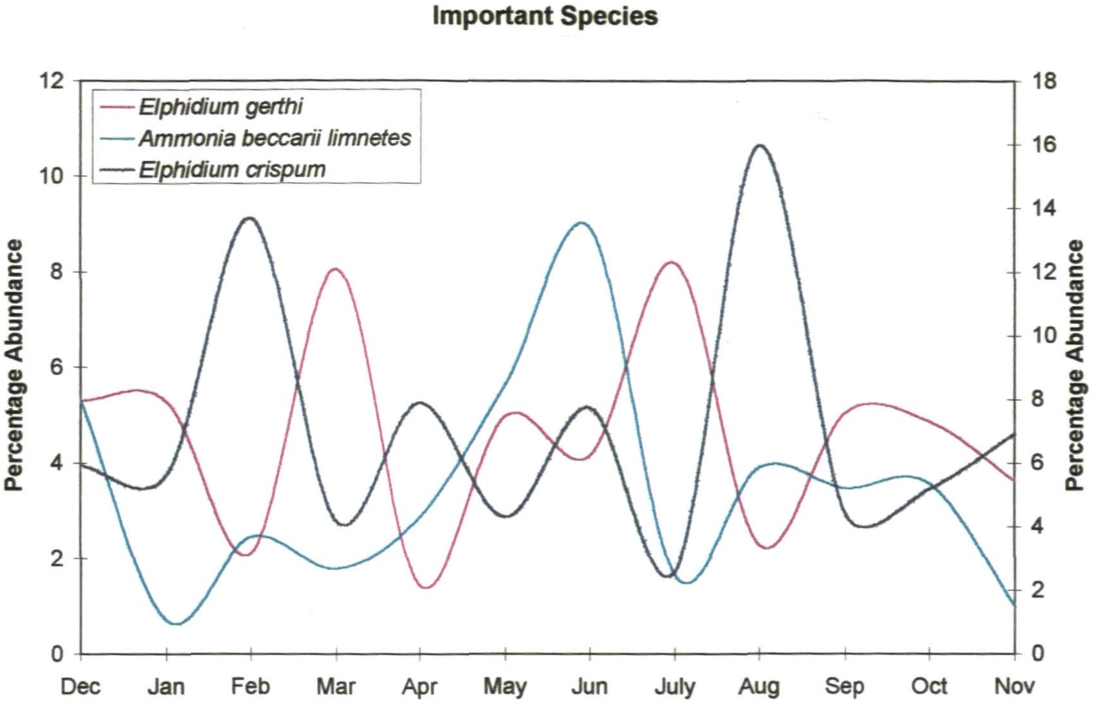


Figure. 9.25 Percentage abundance of *E. gerthi, A. beccarii batavus* and *E. crispum* from Location 15 throughout the year.

Elphidium gerthi and *E. crispum* both show a variable abundance throughout the year although their highest abundances are during February/March and July/August. *Ammonia beccarii limnetes* exhibits its highest abundance during June (Figure 9.25) as did *A. beccarii batavus* (Figure 9.24).

9.9.4. Diversity

The species diversity at Location 15 exhibits a remarkable consistency rarely dropping below 30 species or exceeding 50 species per month. The highest diversity was attained during January and May of 54 species (per 301 count) giving a Fisher alpha diversity index of 20. The lowest diversity occurred during August and October of 37 species (from 301 individuals) giving a Fisher Alpha diversity index of 10.

A total of 95 species were recorded throughout the year from 2832 individuals resulting in a Fisher Alpha diversity index of 20.

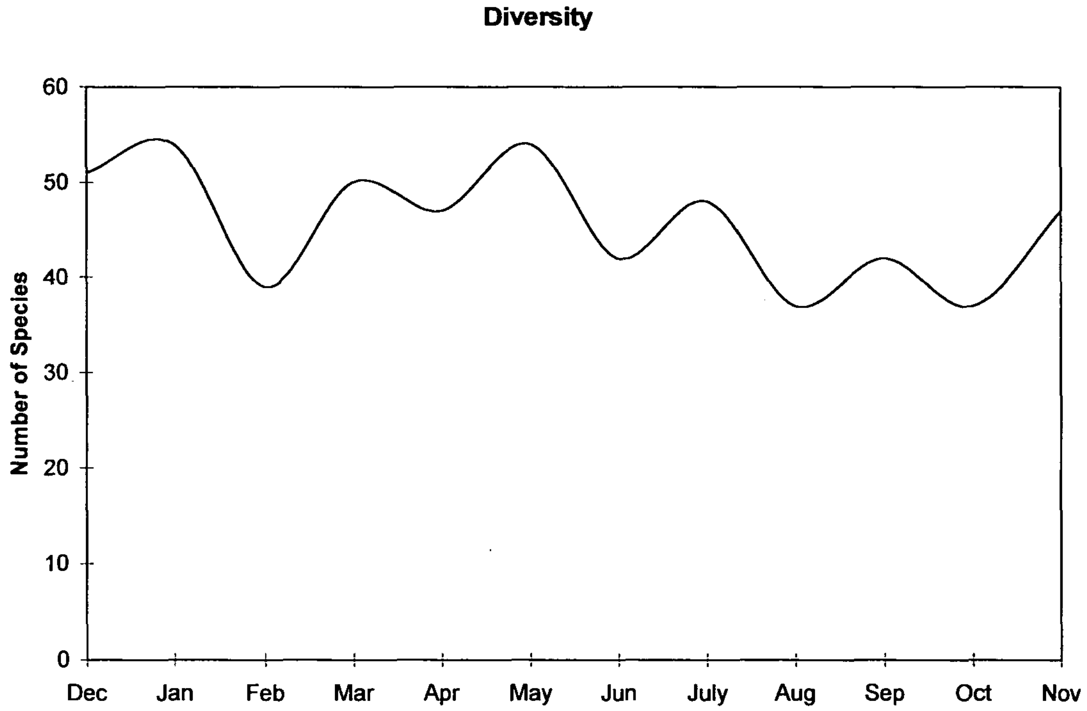


Figure. 9.26 Diversity of the dead assemblage throughout the year at Location 15.

9.9.5. Morphogroups

The dominant morphogroup at Location 15 was the rounded planispiral/low trochospiral group (H1) which accounted for 41% of the assemblage. The plano-convex group H4 accounted for 14% of the fauna, much of which was due to *C. lobatulus*. The agglutinated conical group A6 accounted for 11% of the assemblage, although this was entirely due to one species; *E. scabrum* (Table 9.18).

MG		Abs.	%
H1	*Ammonia beccarii batavus*	848	23
H1	*Elphidium gerthi*	172	5
H1	*Elphidium cuvillieri*	156	4
H1	*Ammonia beccarii limnetes*	129	4
H1	*Haynesina germanica*	112	3
H1	*Elphidium williamsoni*	40	1
H1	*Elphidium margaritaceum*	26	1
H10	*Brizalina spathulata*	80	2
H10	*Brizalina pseudopunctata*	59	2
H10	*Brizalina variabilis*	25	1
H10	*Bolivina pseudoplicata*	24	1
H11	*Fissurina lucida*	42	1
H3	*Elphidium crispum*	257	7
H4	*Cibicides lobatulus*	341	9
H4	*Cibicides pseudoungerianus*	88	2
H4	*Rosalina globularis*	61	2
H4	*Rosalina williamsoni*	31	1
H5	*Nodosaria pyrula*	23	1
H6	*Bulimina elongata*	79	2
H6	*Bulimina gibba*	69	2
	Others	177	5
	Total	**2839**	**77**

MG		Abs.	%
A1	*Cribrostomoides jeffreysii*	55	1
A5	*Clavulina obscura*	65	2
A6	*Eggerelloides scabrum*	414	11
	Others	77	2
	Total	**611**	**17**
P8	*Quinqueloculina seminulum*	40	1
P8	*Quinqueloculina aspera* III	30	1
P9	*Miliolinella subrotunda*	27	1
P8	*Quinqueloculina* spp.	26	1
P8	*Quinqueloculina oblonga*	24	1
	Others	83	2
	Total	**230**	**6**

Table 9.18 Morphogroup distribution for species at Location 15. Foraminifera are divided into three general groups; hyaline, porcellaneous and agglutinated and allocated morphogroups (columns labelled MG). Both the absolute (Abs.) and percentage (%) values of each species are shown. Species which account for less than 1% are grouped under 'Others'.

9.9.6. Condition of Tests

The tests at Location 15 showed few signs of damage or breakage although the tests of *A. beccarii batavus* exhibited a reasonable amount of damage as did the tests of *C. lobatulus* were damaged. A good range of test sizes were present with individuals ranging from the 63μm to 500μm fractions.

9.9.7. Discussion

The silty sediment at Location 15 contains an assemblage of foraminifera which is highly diverse and in good physical condition. The lack of damage suggests little post-mortem alteration, although it is likely that the assemblage has been enriched with respect to small individuals which have been transported from adjacent areas. The tests of *C. lobatulus* and to a lesser extent those of *A. beccarii batavus* may also have been transported into the area.

The assemblage displays good species evenness with the most abundant (*A. beccarii batavus*) species accounting for less than one quarter of the entire assemblage. The dominance of the planispiral/low trochospiral group H1 (41%) reflects the environment at Location 15 (muddy sediments in which infaunal grazers are abundant). The small amount of plano-convex forms H4 (14%) are unlikely to be indigenous to such an environment and have probably been transported to this area.

9.10. Location 16

9.10.1. Introduction

The assemblage in this high energy environment may result in the preferential loss of small specimens and the retention of large tough specimens. Breakage and abrasion is evident mainly in the large specimens.

9.10.2. Species Abundance

Elphidium crispum, A. beccarii batavus and *C. lobatulus* all accounted for 10% of the assemblage (Table 9.19). *Quinqueloculina seminulum* accounted for 9%. Other important species at this location where *T. truncata* (7%), *M. secans* (5%) and *R. williamsoni* (5%).

	Abs.	%
Elphidium crispum	305	10
Ammonia beccarii batavus	280	10
Cibicides lobatulus	280	10
Quinqueloculina seminulum	258	9
Textularia truncata	197	7
Massilina secans	156	5
Rosalina williamsoni	144	5
Haynesina germanica	126	4
Quinqueloculina lata	120	4
Planorbulina mediterranensis	114	4
Cibicides pseudoungerianus	89	3
Miliolinella subrotunda	83	3
Quinqueloculina aspera II	73	3
Ammonia beccarii limnetes	64	2
Quinqueloculina spp.	64	2

Quinqueloculina bicornis	60	2
Rosalina globularis	59	2
Cribrostomoides jeffreysii	57	2
Eggerelloides scabrum	49	2
Elphidium williamsoni	43	1
Quinqueloculina auberiana	43	1
Brizalina spathulata	42	1
Quinqueloculina oblonga var. *lata*	37	1
Elphidium gerthi	31	1
Miliolinella circularis	29	1
Asterigerinata mamilla	28	1
Elphidium cuvillieri	26	1
Quinqueloculina cf. *cliarensis*	23	1
Bolivina pseudoplicata	19	1
Bulimina elongata	17	1
Nodosaria pyrula	16	1
Quinqueloculina oblonga	16	1
Trifarina angulosa	16	1
Brizalina pseudopunctata	15	1

Table 9.19 All species ≥1% abundance recorded at Location 16, shown in absolute (Abs.) and percentage (%) amount.

9.10.3. Species Distribution

Elphidium crispum, A. beccarii batavus and *C. lobatulus* generally show high abundance form December to July and again during November (Figure. 9.27). All three show similar patterns of abundance, exhibiting their lowest abundances during August to October.

Quinqueloculina seminulum shows its highest abundance during April to June and its lowest abundance during March and September. *Textularia truncata* and *R. williamsoni* exhibit their highest abundances during August and September/October respectively (Figure. 9.28)

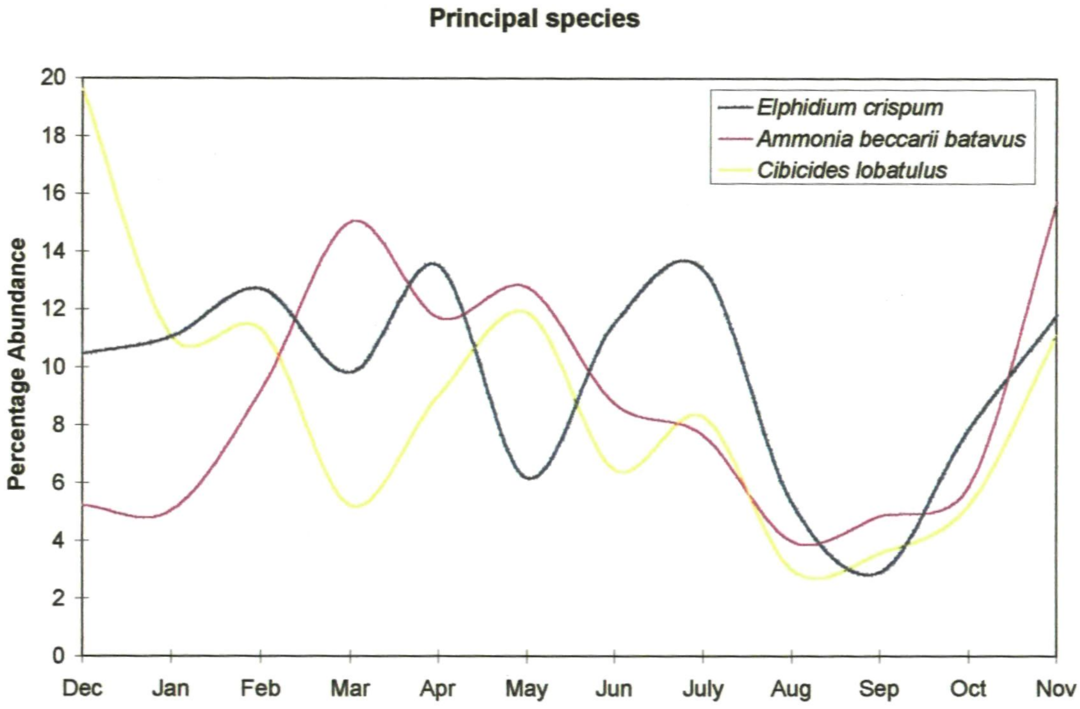


Figure. 9.27 Percentage abundance of *E. crispum, A. beccarii batavus* and *C. lobatulus* from Location 16 throughout the year.

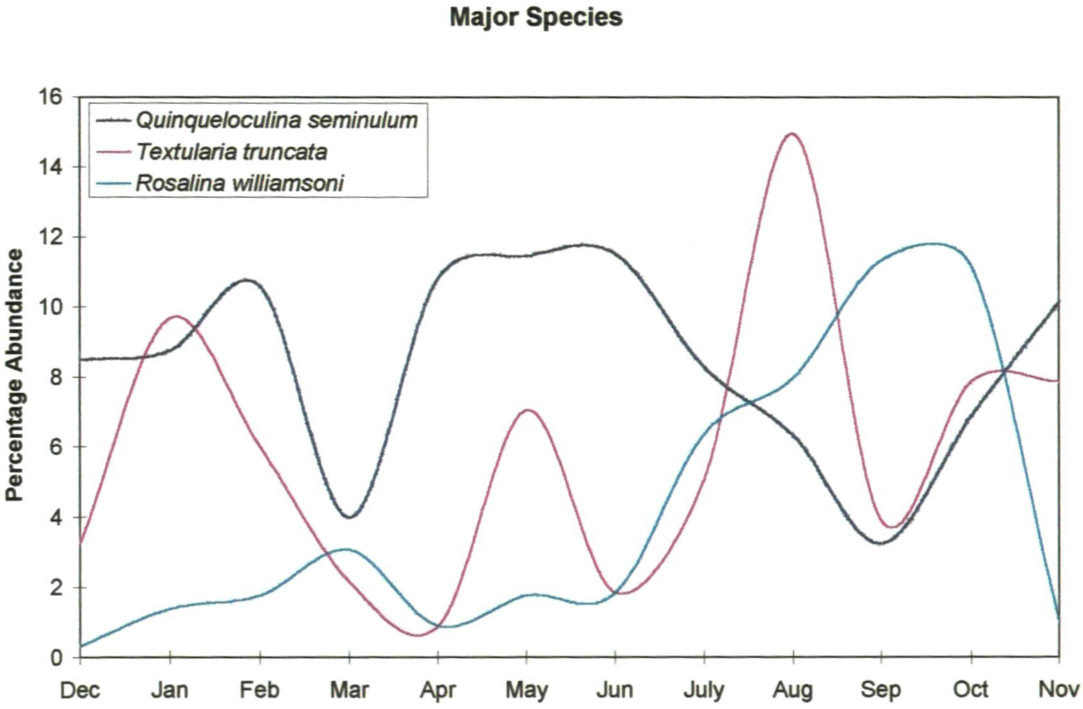


Figure. 9.28 Percentage abundance of *Q. seminulum, T. truncata* and *R. williamsoni* from Location 16 throughout the year.

9.10.4. Diversity

Diversity was lowest in April at 30 species (in 301 individuals) giving a Fisher alpha diversity index of 8 and highest from July to September (the highest diversity of 55 species was recorded from September) giving a Fisher Alpha diversity index of 20 (Figure 9.29).

A total of 86 species were recorded throughout the year from 2917 individuals giving an overall Fisher Alpha diversity index of 17.

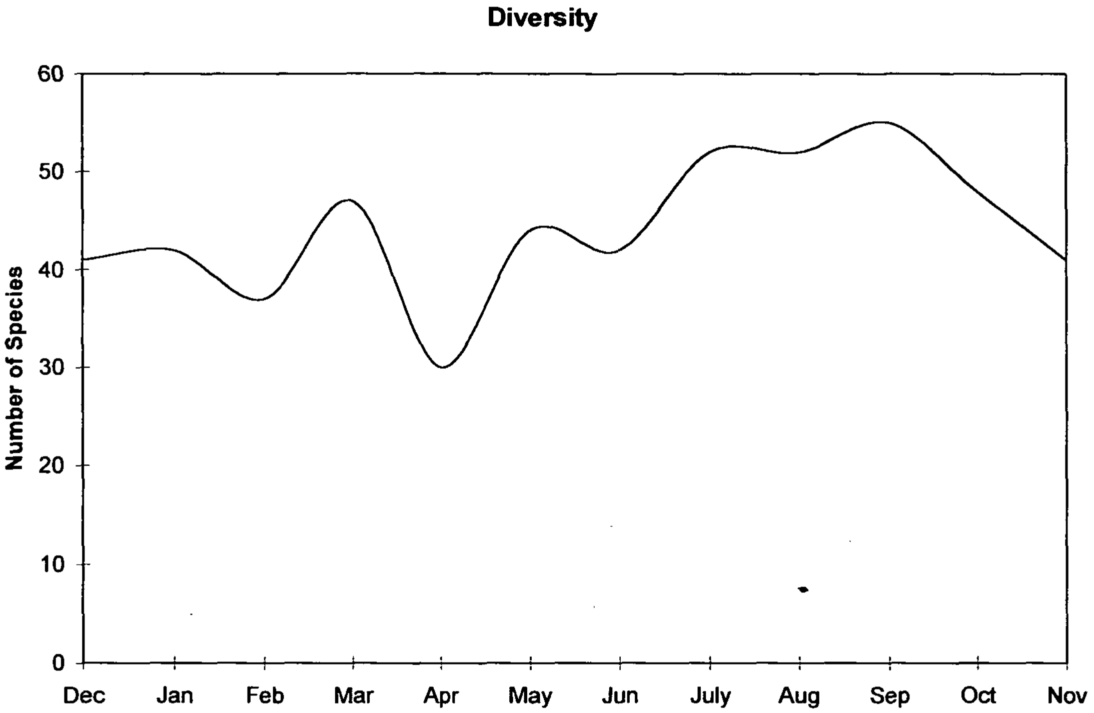


Figure. 9.29 Diversity of the dead assemblage throughout the year Location 16.

9.10.5. Morphogroups

Foraminifera were distributed among several morphogroups and no one group dominated the assemblage. The most abundant groups were the plano-convex (H4) group with 22% of the assemblage and the fusiform porcellaneous group (P8) also with 22% of the assemblage. This latter group, when combined with the flattened fusiform porcellaneous group P9 (which are very similar in morphology), account for nearly one third of the assemblage (30%). Other important morphogroups represented at this location were the rounded planispiral/ low trochospiral group (H1) with 17%. The lenticular group (H3) with 10% and the agglutinated wedge-shape group (A7) with 7% of the assemblage (Table 9.20).

MG		Abs.	%
H1	*Ammonia beccarii batavus*	280	9
H1	*Haynesina germanica*	126	4
H1	*Ammonia beccarii limnetes*	64	2
H1	*Elphidium williamsoni*	43	1
H1	*Elphidium gerthi*	31	1
H1	*Elphidium cuvillieri*	26	1
H10	*Brizalina spathulata*	42	1
H10	*Bolivina pseudoplicata*	19	1
H3	*Elphidium crispum*	305	9
H4	*Cibicides lobatulus*	280	9
H4	*Rosalina williamsoni*	144	4
H4	*Planorbulina mediterranensis*	114	4
H4	*Cibicides pseudoungerianus*	89	3
H4	*Rosalina globularis*	59	2
H5	*Asterigerinata mamilla*	28	1
H6	*Bulimina elongata*	17	1
	Others	176	5
	Total	**1843**	**57**

MG		Abs	%
A1	*Cribrostomoides jeffreysii*	57	2
A6	*Eggerelloides scabrum*	49	2
A7	*Textularia truncata*	197	6
	Others	61	2
	Total	**364**	**11**
P8	*Quinqueloculina seminulum*	258	8
P8	*Quinqueloculina lata*	120	4
P8	*Quinqueloculina aspera* II	73	2
P8	*Quinqueloculina* spp.	64	2
P8	*Quinqueloculina bicornis*	60	2
P8	*Quinqueloculina auberiana*	43	1
P8	*Quinqueloculina oblonga* var. *lata*	37	1
P8	*Miliolinella circularis*	29	1
P9	*Massilina secans*	156	5
P9	*Miliolinella subrotunda*	83	3
P9	*Quinqueloculina cliarensis*	23	1
	Others	69	3
	Total	**1015**	**32**

Table 9.20 Morphogroup distribution for species at Location 16. Foraminifera are divided into three general groups; hyaline, porcellaneous and agglutinated and allocated morphogroups (columns labelled MG). Both the absolute (Abs.) and percentage (%) values of each species are shown. Species which account for less than 1% are grouped under 'Others'.

9.10.6. Condition of Tests

Many of the tests from this location exhibited abundant signs of damage. Many were broken, with general abrasion and scratching on other specimens. Much of this damage is limited to the medium and large tests with many smaller tests (63µm and 125µm) being unaffected. The reason for this may be that the larger tests are part of a remnant or lag deposit and have been subjected to long periods of abrasion. Another reason may be due to their hydrodynamic behaviour and subsequent susceptibility to destruction. The medium to large miliolid species exhibited the highest amount of damage with over half being affected, surprisingly *Q. seminulum* was unaffected by damage. This can only be interpreted as the tests being recent arrivals to the dead assemblage or very resistant to damage.

9.10.7. Discussion

The high energy environment at this location implies that many small tests may be lost, leaving a remnant deposit of large damaged specimens. Post-mortem alteration through damage and transport are high at this location.

The plano-convex group (H4) account for 22% of the assemblage which reflects their dominance at this location within the live assemblage. Although this group is well represented with 22% of the assemblage, this figure may have been higher were it not due to the potential loss of foraminifera (small forms) in this high energy environment. The porcellaneous groups P8 and P9 fusiform and flattened fusiform accounted for over 50% of the assemblage in total. These groups are rare within the live assemblage and their abundance may reflect their resistance to destruction and removal.

The assemblage exhibits the highest species evenness of all the assemblages within the Sound and this is reflective of the live assemblage.

9.11. Location 17

9.11.1. Introduction

The assemblage exhibited moderate to high diversity and a range of tests sizes, although the tests retained in the 250µm fraction were the most abundant. There is abundant evidence of damage to tests and subsequent transport and sorting of the assemblage.

9.11.2. Species Abundance

Cibicides lobatulus is the dominant species at this location, it accounting for 41% of the fauna. Other important species at Location 17 were *A. beccarii batavus* and *E. crispum* which accounted for 15% and 12% respectively (Table 9.21).

	Abs.	%
Cibicides lobatulus	1524	41
Ammonia beccarii batavus	536	15
Elphidium crispum	442	12
Eggerelloides scabrum	143	4

Massilina secans	117	3
Elphidium cuvillieri	115	3
Quinqueloculina lata	94	3
Textularia truncata	75	2
Ammonia beccarii limnetes	49	1
Rosalina globularis	48	1
Cibicides pseudoungerianus	46	1
Elphidium williamsoni	45	1
Haynesina germanica	37	1
Quinqueloculina seminulum	34	1
Quinqueloculina auberiana	33	1
Miliolinella circularis	23	1
Quinqueloculina bicornis	21	1
Asterigerinata mamilla	19	1

Table 9.21 All species equal or greater than 1% abundance recorded at Location 17, shown in absolute (Abs.) and percentage (%) amount.

9.11.3. Species Trends

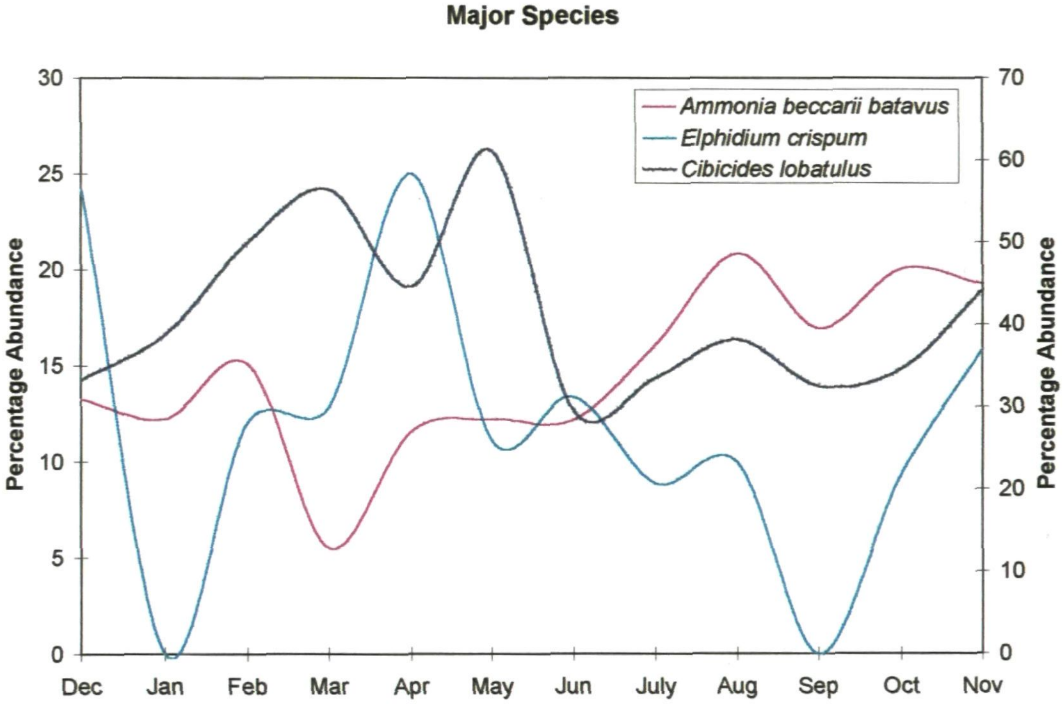


Figure. 9.30 Percentage abundance of *A. beccarii batavus, E. crispum* and *C. lobatulus* from Location 17 throughout the year. Note that *Cibicides lobatulus* is plotted on the right axis.

Cibicides lobatulus generally showed higher abundances during the first half of the year (Figure. 9.30). June represents a marked decrease in abundance during which *C. lobatulus* exhibited its lowest abundance. *Ammonia beccarii batavus* exhibits its highest abundance during the second half of the year, maximum abundance was attained during August. The species trend of *E. crispum* is very distinct, with abundance low for most of the year but with a maximum April.

Eggerelloides scabrum displays its highest abundance during summer and autumn (Figure. 9.31). *Massilina secans* exhibits a gradually diminishing abundance but it does show a distinct peak in abundance during June. The most striking distribution is shown by *E. cuvillieri* which was very abundant during January (accounting for a quarter of the entire assemblage); thereafter it was present in low abundance (a few percent of the fauna).

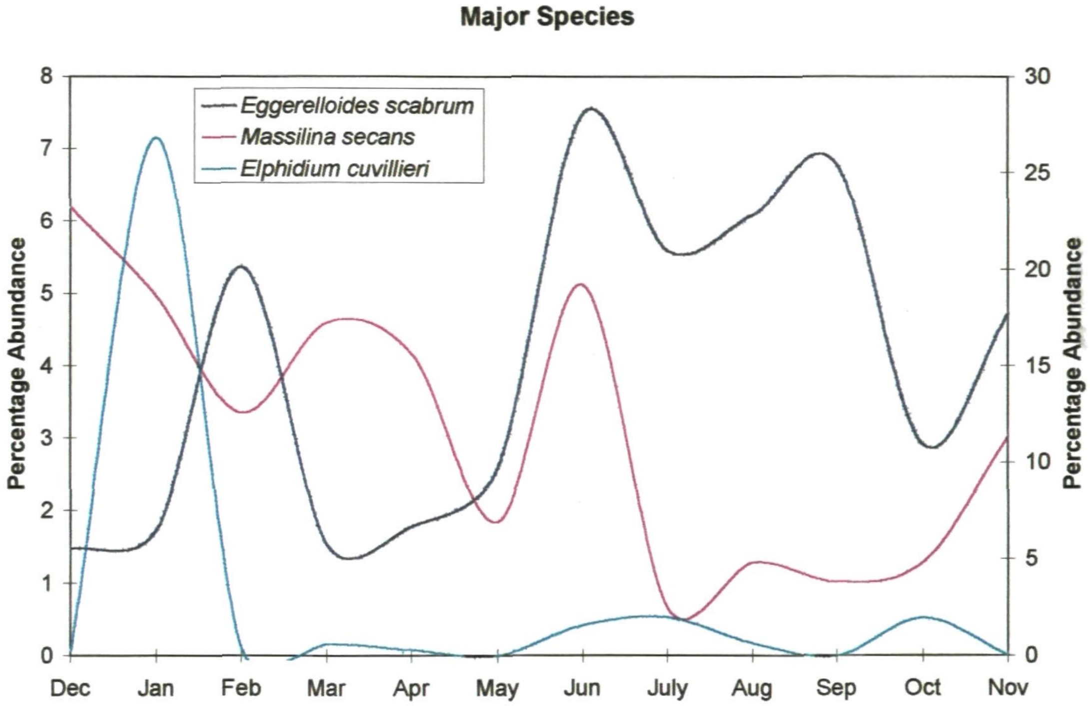


Figure. 9.31 Percentage abundance of *E. scabrum, M. secans* and *E. cuvillieri* from Location 17 throughout the year. Note that *Elphidium cuvillieri* is plotted on the right axis.

9.11.4. Diversity

The highest diversity was recorded in July at 55 species per 301 individuals, giving a Fisher Alpha diversity index of 20. The lowest diversity in November of 17 species per 301 individuals results in a Fisher Alpha diversity index of 4 (Figure 9.32).

A total of 75 species were recorded throughout the year from 3682 individuals giving an overall Fisher Alpha diversity index of 13.

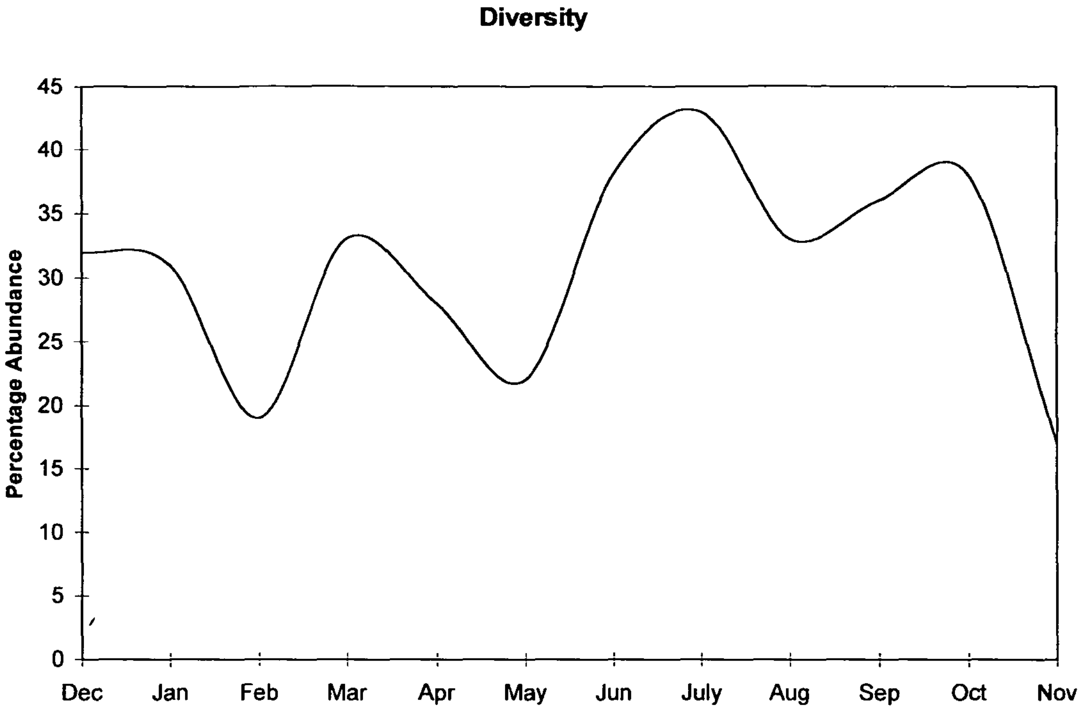


Figure. 9.32 Diversity of the dead assemblage throughout the year at Location 17.

9.11.5. Morphogroups

The foraminiferal morphogroups are dominated by the plano-convex (H4) group which accounted for 45% of the assemblage although this was largely due to the high abundance of *C. lobatulus* (41%). The rounded planispiral/ low trochospiral group (H1) was well represented with 21% of the fauna. Also common was the lenticular group (H3) at 12% of the assemblage which was composed almost entirely of *E. crispum*. The porcellaneous and agglutinated groups were poorly represented although the groups P8 and P9 together accounted for 11% of the assemblage (Table 9.22).

MG		Abs	%
H1	*Ammonia beccarii batavus*	536	15
H1	*Elphidium cuvillieri*	115	3
H1	*Ammonia beccarii limnetes*	49	1
H1	*Elphidium williamsoni*	45	1
H1	*Haynesina germanica*	37	1
H3	*Elphidium crispum*	442	12
H4	*Cibicides lobatulus*	1524	41
H4	*Rosalina globularis*	48	1
H4	*Cibicides pseudoungerianus*	46	1
H5	*Asterigerinata mamilla*	19	1
	Others	141	4
	Total	**3002**	**82**

MG		Abs	%
A6	*Eggerelloides scabrum*	143	4
A7	*Textularia truncata*	75	2
	Others	41	1
	Total	**259**	**7**
P8	*Quinqueloculina lata*	94	3
P8	*Quinqueloculina seminulum*	34	1
P8	*Quinqueloculina auberiana*	33	1
P8	*Miliolinella circularis*	23	1
P8	*Quinqueloculina bicornis*	21	1
P9	*Massilina secans*	117	3
	Others	99	2
	Total	**421**	**11**

Table 9.22 Morphogroup distribution for species at Location 17. Foraminifera are divided into three general groups; hyaline, porcellaneous and agglutinated and allocated morphogroups (columns labelled MG). Both the absolute (Abs.) and percentage (%) values of each species are shown. Species which account for less than 1% are grouped under 'Others'.

9.11.6. Condition of Tests

Many tests showed damage through abrasion and breakage, those species particularly affected were *M. secans* and *C. lobatulus*. There was a normal distribution of test sizes.

9.11.7. Discussion

The dominance of the attached *C. lobatulus* is unusual within a sand/mixed sediment facies. The damage observed on the tests of this species suggests that it has been transported into the area. The lower abundance of small tests indicate alteration of the assemblage probably through current and wave activity.

Location 18

9.12.1. Introduction

The assemblage at this location was diverse exhibiting a wide range of test size. Both juveniles and adults of the same species were present. Damaged tests were observed, but these were rare.

9.12.2. Species Abundance

	Abs.	%
Cibicides lobatulus	784	21
Ammonia beccarii batavus	770	21
Elphidium crispum	498	14
Eggerelloides scabrum	260	7
Quinqueloculina seminulum	106	3
Elphidium gerthi	94	3
Elphidium cuvillieri	92	3
Ammonia beccarii limnetes	72	2
Haynesina germanica	70	2
Elphidium williamsoni	66	2
Rosalina globularis	58	2
Cibicides pseudoungerianus	46	1
Bulimina elongata	45	1
Massilina secans	39	1
Quinqueloculina aspera II	36	1
Miliolinella subrotunda	34	1
Textularia truncata	34	1
Quinqueloculina cliarensis	29	1
Fissurina lucida	27	1
Nodosaria pyrula	24	1
Quinqueloculina spp.	22	1
Quinqueloculina aspera III	22	1
Textularia sagittula	22	1
Brizalina spathulata	21	1
Quinqueloculina auberiana	21	1
Planorbulina mediterranensis	21	1
Bulimina gibba	19	1

Table 9.23 All species ≥1% abundance recorded at Location 18, shown in absolute (Abs.) and percentage (%) amount.

The assemblage is dominated by two species of nearly equal abundance; *C. lobatulus* and *A. beccarii batavus* both accounting for 21% of the fauna. *Elphidium crispum* is also important accounting for 14% of the assemblage as is *E. scabrum* with 7% of the assemblage (Figure 9.23).

9.12.3. Species Distribution

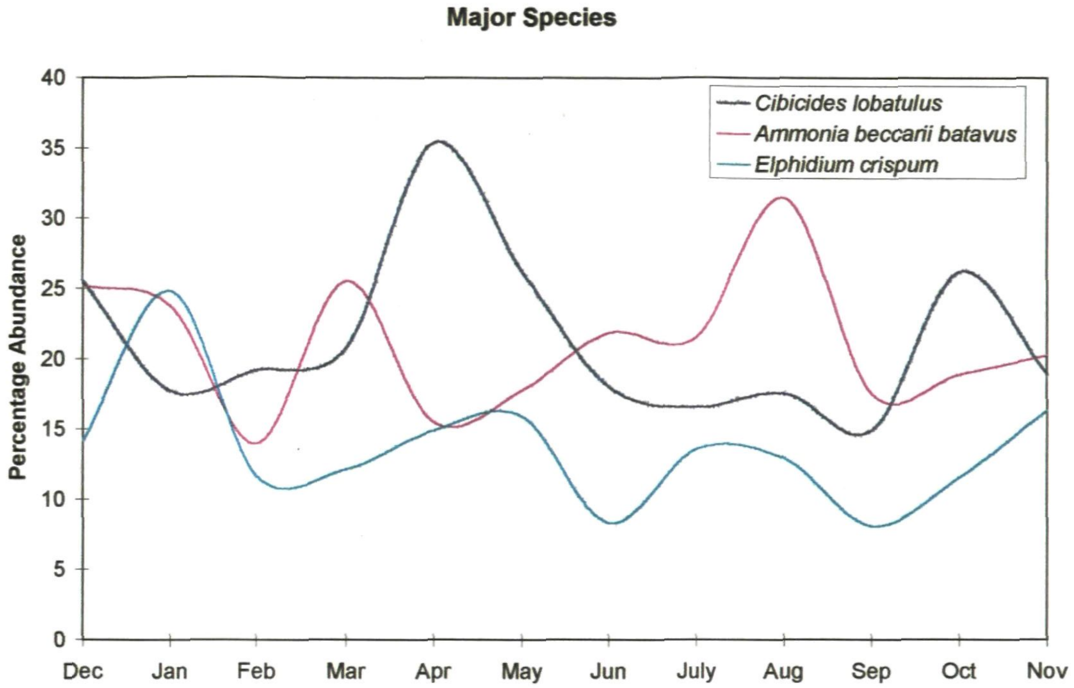


Figure. 9.33 Percentage abundance of *A. beccarii batavus*, *E. crispum* and *C. lobatulus* from Location 18 throughout the year.

The maximum abundance of *C. lobatulus* occurred during April when it accounted for over a third of the assemblage. *Ammonia beccarii batavus* exhibited its maximum abundance during August while *E. crispum* attained its maximum during January (see Figure. 9.33).

Eggerelloides scabrum exhibited its highest abundance during February and March and lowest abundance in April and May. Both species of *Elphidium* in Figure. 9.34 exhibit good correlation and higher abundances during February and September. *Quinqueloculina seminulum* showed remarkable consistency throughout the year.

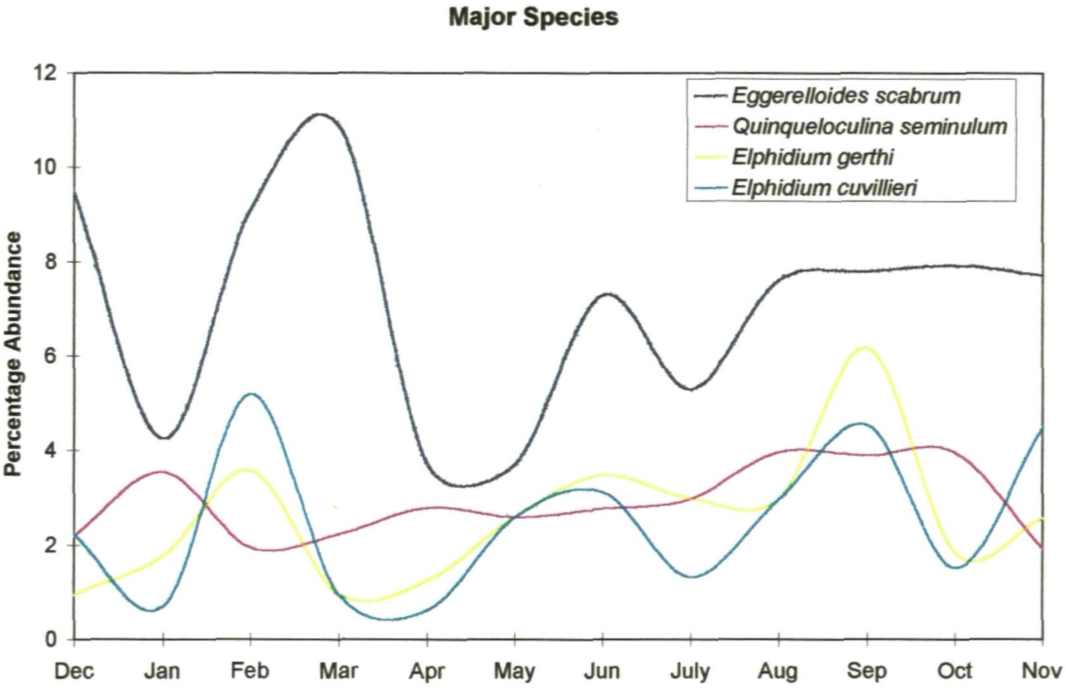


Figure. 9.34. Percentage abundance of *E. scabrum, Q. seminulum, E. gerthi* and *E. cuvillieri* from Location 18 throughout the year.

9.12.4. Diversity

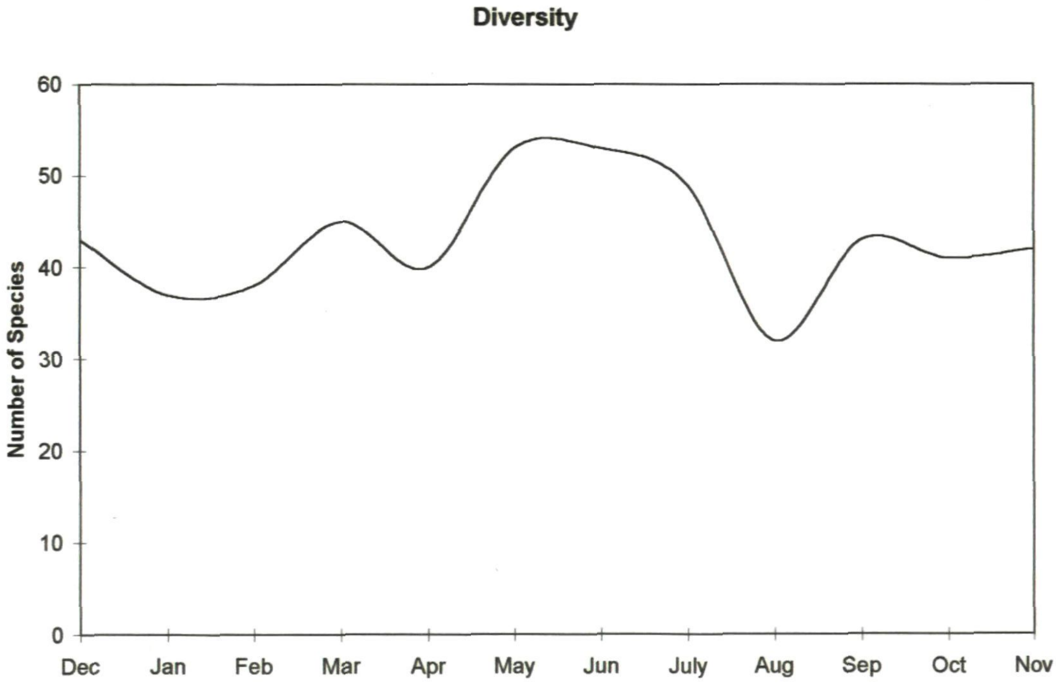


Figure. 9.35 Diversity of the dead assemblage throughout the year Location 18.

The highest diversities of 53 species per 301 individuals were recorded during May and June resulting in a Fisher Alpha diversity index of 19, while the lowest diversity was observed in August at 32 species per 300 individuals giving a Fisher alpha diversity index of 9 (Figure 9.35).

Total of 86 species were recorded from Location 18 throughout the year from 3651 individuals resulting in an overall Fisher Alpha diversity index of 16.

9.12.5. Morphogroups

MG		Abs	%
H1	*Ammonia beccarii batavus*	770	21
H1	*Elphidium gerthi*	94	3
H1	*Elphidium cuvillieri*	92	3
H1	*Ammonia beccarii limnetes*	72	2
H1	*Haynesina germanica*	70	2
H1	*Elphidium williamsoni*	66	2
H10	*Brizalina spathulata*	21	1
H11	*Fissurina lucida*	27	1
H3	*Elphidium crispum*	498	14
H4	*Cibicides lobatulus*	784	21
H4	*Rosalina globularis*	58	2
H4	*Cibicides pseudoungerianus*	46	1
H4	*Planorbulina mediterranensis*	21	1
H5	*Nodosaria pyrula*	24	1
H6	*Bulimina elongata*	45	1
H6	*Bulimina gibba*	19	1
	Others	128	4
	Total	**2835**	**78**

MG		Abs	%
A6	*Eggerelloides scabrum*	260	7
A7	*Textularia sagittula*	34	1
A7	*Textularia truncata*	22	1
	Others	52	1
	Total	**368**	**10**
P8	*Quinqueloculina seminulum*	106	3
P9	*Massilina secans*	39	1
P8	*Quinqueloculina aspera* II	36	1
P9	*Miliolinella subrotunda*	34	1
P9	*Quinqueloculina* cf. *cliarensis*	29	1
P8	*Quinqueloculina* spp.	22	1
P8	*Quinqueloculina aspera* III	22	1
P8	*Quinqueloculina auberiana*	21	1
	Others	139	4
	Total	**448**	**12**

Table 9.24 Morphogroup distribution for species at Location 18. Foraminifera are divided into three general groups; hyaline, porcellaneous and agglutinated and allocated morphogroups (columns labelled MG). Both the absolute (Abs.) and percentage (%) values of each species are shown. Species which account for less than 1% are grouped under 'Others'.

The most common morphogroup at this location was the rounded planispiral/ low trochospiral group (H1) which accounted for 32% of the assemblage. The plano-convex group (H4) was also well represented with 25% of the fauna although much of this was due to the abundance of *C. lobatulus* (21%). The lenticular group was represented by one species; *E. crispum* which accounted for 14% of the assemblage. The porcellaneous fusiform groups P8 (8%) and P9 (9%) combined accounted for 11% of the fauna.

9.12.6. Condition of Tests

A wide range of test sizes are present, which include both juveniles and adults of the same species. This suggest that little transport or sorting has altered the assemblage. The tests of one species; *C. lobatulus* were highly damaged and indicated a large amount of transport.

9.12.7. Discussion

The rounded planispiral/low trochospiral group is well represented with 32% of the assemblage. *Elphidium crispum* accounted for 14% of the assemblage, but unusually the plano-convex group (H4) accounted for 25%, most of which was due to the abundance of *C. lobatulus*. This group is out of place in a muddy sand and must have been transported in from adjacent areas.

The highest diversities were in June and July and may reflect high contributions of tests from the live assemblage.

9.13. Size Fractions

The size of the foraminifera analysed within an assemblage can significantly influence interpretations drawn from that assemblage. Foraminifera species can attain a wide range of adult sizes, for example many brizalinids and lagenids were restricted to the 63µm and perhaps the 125µm fractions while other species, such as *Massilina secans* and *Elphidium crispum,* were common only in the 250µm and 500µm fractions (See Figure 9.37). In an extreme situation analysis of solely the 63µm or 500µm size fractions would exclude many species. Schroder *et al.* (1987) has re-examined other worker's samples taking into account the previously ignored 63µm and 125µm fractions and as a result has arrived at different environmental interpretations for the same assemblage. This emphasises the importance of taking into account the complete range of size fractions.

Location 3	**February and October**						
Sieve fractions (microns)	**63**	**125**	**250**	**500**	**1000**	**Abs**	**%**
Cibicides lobatulus	1	31	80	6		**118**	**13**
Textularia truncata	2	24	34			**60**	**7**
Cibicides pseudoungerianus	25	31	2			**58**	**6**
Rosalina williamsoni	29	24	2			**55**	**6**
Haynesina germanica	27	24				**51**	**6**
Eggerelloides scabrum	3	30	12			**45**	**5**
Ammonia beccarii batavus	4	30	10			**44**	**5**
Quinqueloculina spp.	24	17	2			**43**	**5**
Quinqueloculina seminulum	9	11	4	13		**37**	**4**
Elphidium crispum	1	7	22	5		**35**	**4**
Planorbulina mediterranensis	12	21				**33**	**4**
Gravelinopsis praegeri	17	12	3			**32**	**3**
Elphidium cuvillieri	4	12	9			**25**	**3**
Miliolinella subrotunda	11	10	3			**24**	**3**
Asterigerinata mamilla	2	14	1			**17**	**2**
Brizalina spathulata	16	1				**17**	**2**
Ammonia beccarii limnetes	6	9	1			**16**	**2**
Cribrostomoides jeffreysii	9	6				**15**	**2**
Elphidium williamsoni	4	7	4			**15**	**2**
Quinqueloculina cf. *lata/seminulum*	8	5				**13**	**1**
Brizalina pseudopunctata	12					**12**	**1**
Bolivina pseudoplicata	6	5				**11**	**1**
Nonion depressulus	1	9				**10**	**1**
Fissurina marginata	9					**9**	**1**
Quinqueloculina lata		1	6	2		**9**	**1**
Elphidium gerthi	2	4	1			**7**	**1**
Quinqueloculina bicornis		3	3	1		**7**	**1**
Massilina secans		4	2			**6**	**1**
Bulimina gibba	4	1				**5**	**1**
Clavulina obscura	4	1				**5**	**1**
Miliolinella circularis	3	2				**5**	**1**
Quinqueloculina oblonga	3	2				**5**	**1**
Technitella teivyense			5			**5**	**1**
Trifarina angulosa	2	3				**5**	**1**
Deuterammina (Lepidodenterammina) ochracea var. *sinuosa*	5					**5**	**1**

February and October		
whole sample	**Abs**	**%**
Cibicides lobatulus	**56**	**13**
Textularia truncata	**42**	**10**
Cibicides pseudoungerianus	**10**	**2**
Rosalina williamsoni	**25**	**6**
Haynesina germanica	**20**	**5**
Eggerelloides scabrum	**14**	**3**
Ammonia beccarii batavus	**19**	**5**
Quinqueloculina spp.	**15**	**4**
Quinqueloculina seminulum	**21**	**5**
Elphidium crispum	**16**	**4**
Planorbulina mediterranensis	**27**	**7**
Rosalina globularis	**17**	**4**
Elphidium cuvillieri	**9**	**2**
Miliolinella subrotunda	**16**	**4**
Asterigerinata mamilla	**1**	**0**
Brizalina spathulata	**2**	**0**
Ammonia beccarii limnetes	**14**	**3**
Cribrostomoides jeffreysii	**7**	**2**
Elphidium williamsoni	**9**	**2**
Quinqueloculina cf. *lata/seminulum*	**2**	**0**
Brizalina pseudopunctata	**1**	**0**
absent		
absent		
Fissurina marginata	**1**	**0**
Quinqueloculina lata	**2**	**0**
Elphidium gerthi	**3**	**1**
Quinqueloculina bicornis	**5**	**1**
Massilina secans	**7**	**2**
Bulimina elongata	**6**	**1**
Clavulina obscura	**1**	**0**
Miliolinella circularis	**3**	**1**
Quinqueloculina oblonga	**5**	**1**
absent		
Trifarina angulosa	**1**	**0**
Deuterammina (Lepidodenterammina) ochracea var. *sinuosa*	**1**	**0**

Table 9.25 List of foraminifera for the same months at Location 3. On the left, size fraction samples in absolute (Abs.) and percentage (%) abundance. On the right, a list of foraminifera from whole fraction samples.

When analysing foraminifera, two methods pertaining to their size can be used; firstly foraminifera can be sieved into appropriate size fractions (such as 63µm, 125µm, 250µm and 500µm) and a set number of foraminifera picked from each size fraction. The advantages of this method are that large foraminifera are not inadvertently picked at the expense of small foraminifera (size bias). The effects of mechanical sorting are also eliminated (large foraminifera concentrated at the top of a storage container or receptacle).

The disadvantage is really only the large amount of time required to pick and speciate all the foraminiferal fractions (in particular the 63μm and 125μm fractions).

The second method involves picking a set number of foraminifera from the whole sample i.e. ≥63μm. This method relies on the worker taking a representative sub-sample and picking a range of sizes (of foraminifera) from it. The disadvantage of this method is size bias and other biases (colour, shape, etc.) as well as mechanical sorting, may be introduced and effect the results (Martin and Liddell, 1989). Unlike the sieve fraction method far less time is needed to pick and speciate foraminifera from whole samples. In large studies this can amount to a considerable period of time (several months or more).

Location 15	**Feb, July and October**						
Sieve Fractions (μm)	**63**	**125**	**250**	**500**	**1000**	Abs	%
Ammonia beccarii batavus	11	85	564	478		1138	**34**
Eggerelloides scabrum	6	218	106			330	**10**
Elphidium crispum	2	39	77	201	1	320	**9**
Cibicides lobatulus		36	80	34		150	**4**
Brizalina pseudopunctata	91	1				92	**3**
Clavulina obscura	88	3				91	**3**
Brizalina spathulata	80	10				90	**3**
Elphidium gerthi	37	47				84	**2**
Cibicides pseudoungerianus	30	38	10			78	**2**
Rosalina globularis	60	16	1			77	**2**
Elphidium cuvillieri	10	49	14	1		74	**2**
Haynesina germanica	39	32				71	**2**
Cribrostomoides jeffreysii	22	36	1			59	**2**
Bulimina elongata	24	32				56	**2**
Bolivina pseudoplicata	53	2				55	**2**
Bulimina gibba	26	28	1			55	**2**
Ammonia beccarii limnetes	18	20	9	2		49	**1**
Fissurina lucida	32	9				41	**1**
Rosalina williamsoni	32	6				38	**1**
Quinqueloculina seminulum	7	18	8			33	**1**
Quinqueloculina spp.	22	2		3		27	**1**
Massilina secans		1	4	13	5	23	**1**
Nonion depressulus	10	13				23	**1**
Elphidium margaritaceum	5	17				22	**1**
Quinqueloculina aspera II	4	12	5			21	**1**
Fissurina marginata	17	1				18	**1**
Quinqueloculina aspera III	3	12	3			18	**1**

Feb, July and Oct		
Whole Fraction		%
Ammonia beccarii batavus	196	**22**
Eggerelloides scabrum	83	**9**
Elphidium crispum	63	**7**
Cibicides lobatulus	74	**8**
Brizalina pseudopunctata	20	**2**
Clavulina obscura	24	**3**
Brizalina spathulata	25	**3**
Elphidium gerthi	46	**5**
Cibicides pseudoungerianus	22	**2**
Rosalina globularis	19	**2**
Elphidium cuvillieri	33	**4**
Haynesina germanica	27	**3**
Cribrostomoides jeffreysii	21	**2**
Bulimina elongata	29	**3**
Bolivina pseudoplicata	13	**1**
Bulimina gibba	19	**2**
Ammonia beccarii limnetes	23	**3**
Fissurina lucida	14	**2**
Rosalina williamsoni	10	**1**
Quinqueloculina seminulum	8	**1**
Quinqueloculina spp.	6	**1**
absent		
absent		
Elphidium margaritaceum	9	**1**
Quinqueloculina aspera II	3	**0**
Fissurina marginata	4	**0**
Quinqueloculina aspera III	3	**0**

Table 9.26 List of foraminifera for the same months at Location 15. On the left, size fraction samples in absolute (Abs.) and percentage (%) abundance. On the right, a list of foraminifera from whole fraction samples.

Taking into consideration time available and the size of the study the second method was adopted (picking from the whole sample which incorporated all the size fractions) but in order to evaluate the process, and any errors which may have been introduced, periodically, several sample locations were split and picked using the sieve fraction and whole fraction methods. Locations which are very different sedimentologically (Location 3; a shell gravel, Location 12; a mud, Location 17; a sand sometimes muddy and Location 18; a mixed sediment) were chosen. The results are shown, and discussed, below.

Within the size fraction samples for Location 3 (Table 9.25), 35 species formed 1% or greater of the assemblage. Of these 35 species 3 are absent from the whole fractions samples for the same months, 2 of which are small species (*N. depressulus* and *B pseudoplicata* generally occur within the 63μm to 125μm fraction).

Location 17	**Feb, July and Oct**						
Sieve Fractions (μm)	**63**	**125**	**250**	**500**	**1000**	**Abs**	**%**
Cibicides lobatulus		105	460	209		774	***24***
Elphidium crispum	2	21	92	482	2	599	***18***
Ammonia beccarii batavus	27	125	149	27		328	***10***
Eggerelloides scabrum		161	15			176	***5***
Massilina secans		1	15	120	14	150	***5***
Cibicides pseudoungerianus	49	74	3			126	***4***
Rosalina globularis	49	33	5			87	***3***
Haynesina germanica	42	27	2			71	***2***
Ammonia beccarii limnetes	19	39	4			62	***2***
Quinqueloculina seminulum	10	23	18	4		55	***2***
Brizalina pseudopunctata	50	1				51	***2***
Elphidium williamsoni	11	35	5			51	***2***
Brizalina spathulata	50					50	***2***
Textularia truncata	11	20	10			41	***1***
Miliolinella circularis	19	16	1			36	***1***
Quinqueloculina spp.	27	5	2	2		36	***1***
Quinqueloculina lata		12	21	1		34	***1***
Bolivina pseudoplicata	33					33	***1***
Clavulina obscura	31					31	***1***
Miliolinella subrotunda	21	3	7			31	***1***
Rosalina williamsoni	26	4				30	***1***
Elphidium gerthi	20	9				29	***1***
Elphidium cuvillieri	11	15	2			28	***1***
Bulimina elongata	20	6				26	***1***
Bulimina gibba	23	1				24	***1***
Asterigerinata mamilla	5	16	1			22	***1***
Fissurina lucida	20	1				21	***1***
Cribrostomoides jeffreysii	13	5				18	***1***
Fissurina marginata	18					18	***1***
Quinqueloculina auberiana		13	4			17	***1***

Feb, July and Oct		
Whole (all) fraction	**Abs**	**%**
Cibicides lobatulus	358	**39**
Elphidium crispum	92	**10**
Ammonia beccarii batavus	156	**17**
Eggerelloides scabrum	42	**5**
Massilina secans	16	**2**
Cibicides pseudoungerianus	10	**1**
Rosalina globularis	19	**2**
Haynesina germanica	11	**1**
Ammonia beccarii limnetes	13	**1**
Quinqueloculina seminulum	15	**2**
Brizalina pseudopunctata	1	**0**
Elphidium williamsoni	13	**1**
Brizalina spathulata	5	**1**
Textularia truncata	23	**3**
Miliolinella circularis	9	**1**
Quinqueloculina spp.	2	**0**
Quinqueloculina lata	22	**2**
Absent		
Absent		
Miliolinella subrotunda	7	**1**
Rosalina williamsoni	1	**0**
Elphidium gerthi	1	**0**
Elphidium cuvillieri	13	**1**
Bulimina elongata	3	**0**
Bulimina gibba	3	**0**
Asterigerinata mamilla	10	**1**
Fissurina lucida	2	**0**
Cribrostomoides jeffreysii	4	**0**
Fissurina marginata	1	**0**
Quinqueloculina auberiana	12	**1**

Table 9.27 List of foraminifera for the same months at Location 17. On the left, size fraction samples in absolute (Abs.) and percentage (%) abundance. On the right, a list of foraminifera from whole (all) fraction samples

In total 66 species of foraminifera (922 individuals) were recorded from size fraction samples, while 55 species were recorded from whole fraction samples (415 individuals). In summary some small species may be under-represented within the whole fraction samples but generally both methods gave remarkably similar and consistent results.

Location 17	**Feb, July and Oct**						
Sieve Fraction (µm)	**63**	**125**	**250**	**500**	**1000**	**Abs**	**%**
Elphidium crispum	3	40	134	586	23	786	**22**
Ammonia beccarii batavus	38	325	263	83		709	**20**
Cibicides lobatulus		84	201	61		346	**10**
Eggerelloides scabrum	5	180	55			240	**7**
Quinqueloculina seminulum	26	37	35	1		99	**3**
Elphidium gerthi	36	54				90	**3**
Rosalina globularis	58	24	4			86	**2**
Massilina secans			16	50	8	74	**2**
Clavulina obscura	66					66	**2**
Brizalina spathulata	57	4				61	**2**
Haynesina germanica	30	30	1			61	**2**
Elphidium cuvillieri	13	39	7			59	**2**
Fissurina lucida	52	4				56	**2**
Bulimina gibba	38	15	1			54	**2**
Brizalina pseudopunctata	53					53	**1**
Bulimina elongata	28	23	1			52	**1**
Cibicides pseudoungerianus	24	24	1			49	**1**
Quinqueloculina oblonga	22	20				42	**1**
Bolivina pseudoplicata	39	1				40	**1**
Elphidium williamsoni	7	30	2			39	**1**
Miliolinella circularis	15	20	1			36	**1**
Ammonia beccarii limnetes	13	19	3			35	**1**
Miliolinella subrotunda	11	4	7	1		23	**1**
Nonion depressulus	12	10	1			23	**1**
Quinqueloculina cf. *cliarensis*	1	10	8	4		23	**1**
Quinqueloculina spp.	18	4	1			23	**1**
Textularia truncata	5	15	3			23	**1**
Rosalina williamsoni	15	5				20	**1**
Cribrostomoides jeffreysii	15	4				19	**1**
Textularia earlandi	8	11				19	**1**

Feb, July and Oct.		
Whole (all) fractions	**Abs**	**%**
Elphidium crispum	115	**12**
Ammonia beccarii batavus	170	**18**
Cibicides lobatulus	195	**21**
Eggerelloides scabrum	70	**7**
Quinqueloculina seminulum	28	**3**
Elphidium gerthi	26	**3**
Rosalina globularis	14	**1**
Massilina secans	12	**1**
Clavulina obscura	1	**0**
Brizalina spathulata	10	**1**
Haynesina germanica	20	**2**
Elphidium cuvillieri	25	**3**
Fissurina lucida	10	**1**
Bulimina gibba	6	**1**
Brizalina pseudopunctata	9	**1**
Bulimina elongata	17	**2**
Cibicides pseudoungerianus	11	**1**
Quinqueloculina oblonga	4	**0**
Bolivina pseudoplicata	1	**0**
Elphidium williamsoni	15	**2**
Miliolinella circularis	4	**0**
Ammonia beccarii limnetes	28	**3**
Miliolinella subrotunda	4	**0**
Absent		
Quinqueloculina cf. *cliarensis*	14	**1**
Quinqueloculina spp.	8	**1**
Textularia truncata	10	**1**
Rosalina williamsoni	1	**0**
Cribrostomoides jeffreysii	4	**0**
Textularia earlandi	3	**0**

Table 9.28 List of foraminifera for the same months at Location 18. On the left, size fraction samples in absolute (Abs.) and percentage (%) abundance. On the right, a list of foraminifera from whole fraction samples.

A total of 27 species form 1% or greater of the assemblage from the size fraction samples from Location 15 (Table 9.26). Of these 27 species, 2 are absent from the whole fraction samples one of which is a large species (*M secans*). A total of 81 species (from 3372 individuals) were identified, while from the whole fraction samples a total of 63 species (from 898 individuals) were recorded. In summary there is little evidence from the mud-rich Location 15 of small foraminifera being underrepresented.

A total of 30 species formed 1% or greater of the size fraction assemblage. Of these 30 species, two were absent from the whole fraction sample, both of which were small species. Other small species such as *B. pseudopunctata* and *B spathulata* were also rare which suggests that at Location 17 (Table 9.27) small species may be under-represented. A total of 84 species were identified from 3268 individuals while from the whole fraction sample 52 species were identified from 911 individuals. In summary, a small degree of under representation may been introduced when picking samples from this location (which was usually a clean, medium grained sand, occasionally muddy).

A total of 30 species formed 1% or greater of the size fraction assemblage. Of these 30 species, only one species (*N. depressulus*) is absent from the whole fraction samples for the same months, from Location 18 (Table 9.28). *Nonion depressulus* is a medium to small species. Other small species such as *B. psuedopunctata, B. spathulata* and *B. pseudoplicata* are quite rare and may also be under-represented. A total of 86 species were identified from 3582 individuals from the size fraction samples while 62 species were identified from 938 individuals from the whole fraction samples. In summary, both types of picking have resulted in very similar and consistent results.

In the samples described above, it appears that small species, particularly the brizalinids and bolivinids may be under-represented. These species may be rare in all fractions, but dominate the 63μm fraction, although still sparse. Because a set number of foraminifera must be picked from each fraction (with the size fraction method), these species are over represented as material from the medium to large fractions may be an order or two of magnitude greater in abundance i.e. a sample may contain many 30 000 of *Ammonia beccarii batavus* (in the 250μm fraction) but only 300 *B. pseudopunctata* which are restricted to the 63μm fraction. If 300 individuals are picked from each fraction, *B. pseudopunctata* would appear to have a similar abundance to *A. beccarii batavus* and make up at least 1/5 of the assemblage. Within a whole fraction sample *B. pseudopunctata* will be represented by a few individuals (3, 4, 10, 15 etc.), while *A. beccarii batavus* would be dominant. This is a potential problem when using the sieve fraction method and one species is numerically rare but dominates a size fraction.

9.13.1. Species size

All of the most abundant species are plotted on size fraction charts to show their distribution. By plotting the most abundant species it can be seen that many species are effectively restricted to certain size fractions. The charts below show the sum of individuals from all locations analysed by size fraction (i.e. the sum of Locations 3,15,17 and 18).

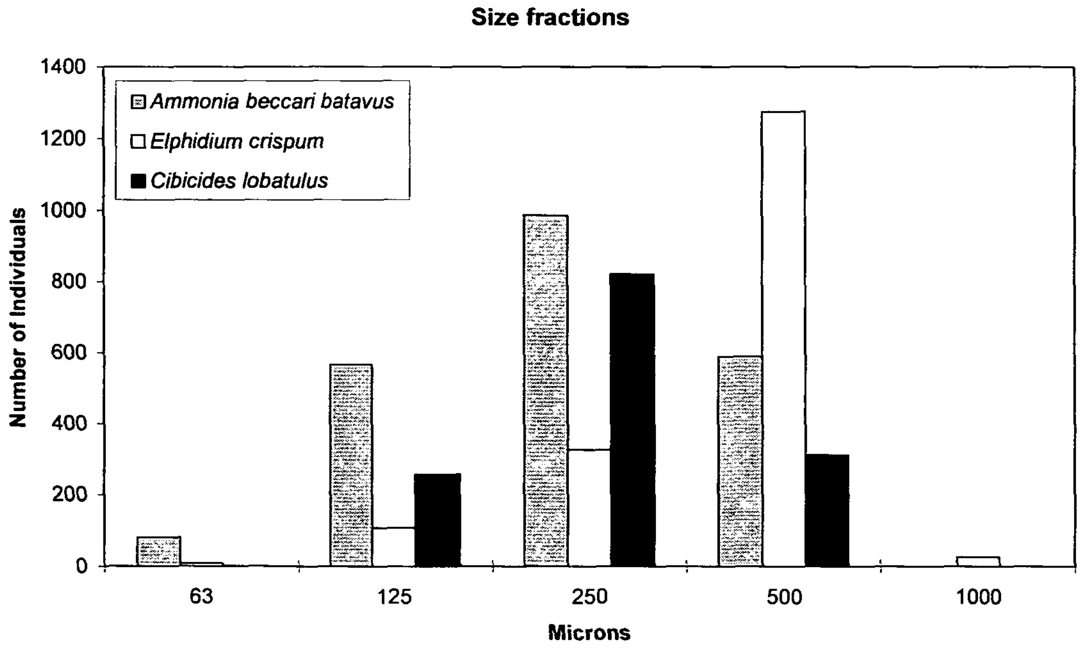


Figure 9.36 The size distribution of the *A. beccarii batavus, E. crispum* and *C. lobatulus* which are the most abundant dead species within the Sound are shown within the 5 size fractions analysed (foraminifera combined from Locations 3, 15, 17 and 18).

Ammonia beccarii batavus is common within the 125μm, 250μm and 500μm fractions which suggests that it is a medium to large species, the same is true of *C. lobatulus. Elphidium crispum* is present in all the size fractions but dominant within the 500μm fraction which implies that the normal adult size is generally large for the Sound. Juveniles (within the 63μm fraction) of *E. crispum* and *C. lobatulus* are virtually absent (Figure 9.36).

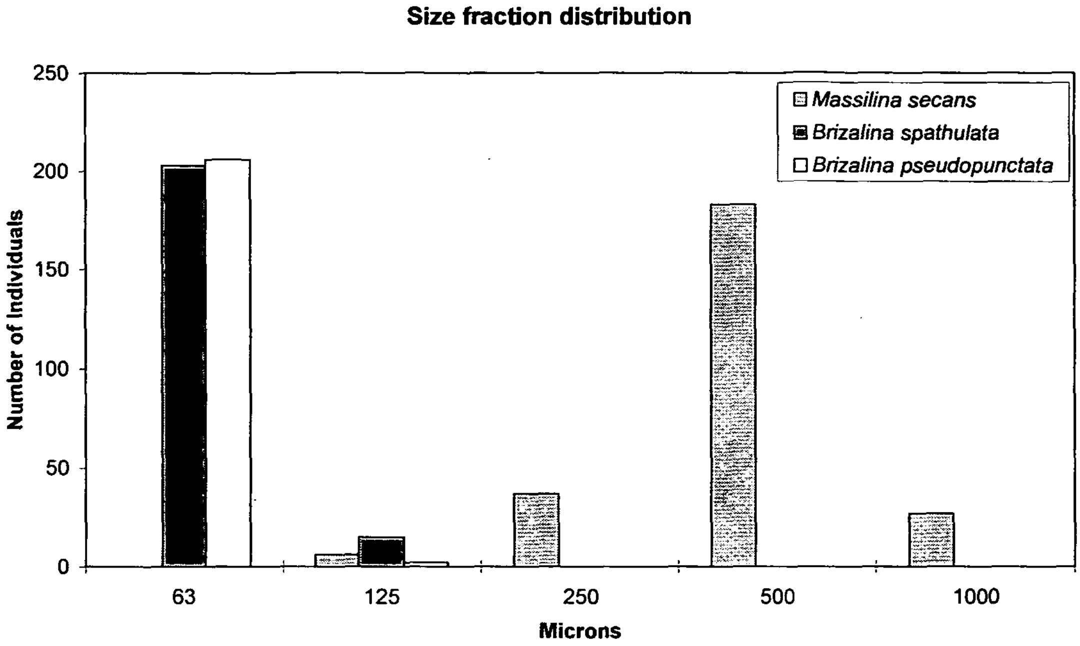


Figure 9.37 The size distribution *M. secans, B. pseudopunctata* and *B. spathulata* are shown within the 5 fractions analysed. (foraminifera combined from Locations 3, 15, 17 and 18).

Brizalina pseudopunctata and *B spathulata* are restricted to the 63μm fraction. Although a few individuals occur in other fractions these species can easily be overlooked if the fine fraction is not analysed. *Massilina secans* has the opposite distribution and commonly occurs as medium to large individuals. The species of *Brizalina* and *Massilina secans* rarely overlap in their size distributions (Figure 9.37).

Eggerelloides scabrum is a medium sized species which is common in the 125μm and 250μm fractions. *Haynesina germanica* is a small species, being generally restricted to the 63μm and 125μm fraction (this species is generally transported from estuaries into the Sound). *Clavulina obscura* is a good example of a very small species being uncommon outside the 63μm fraction (Figure 9.38).

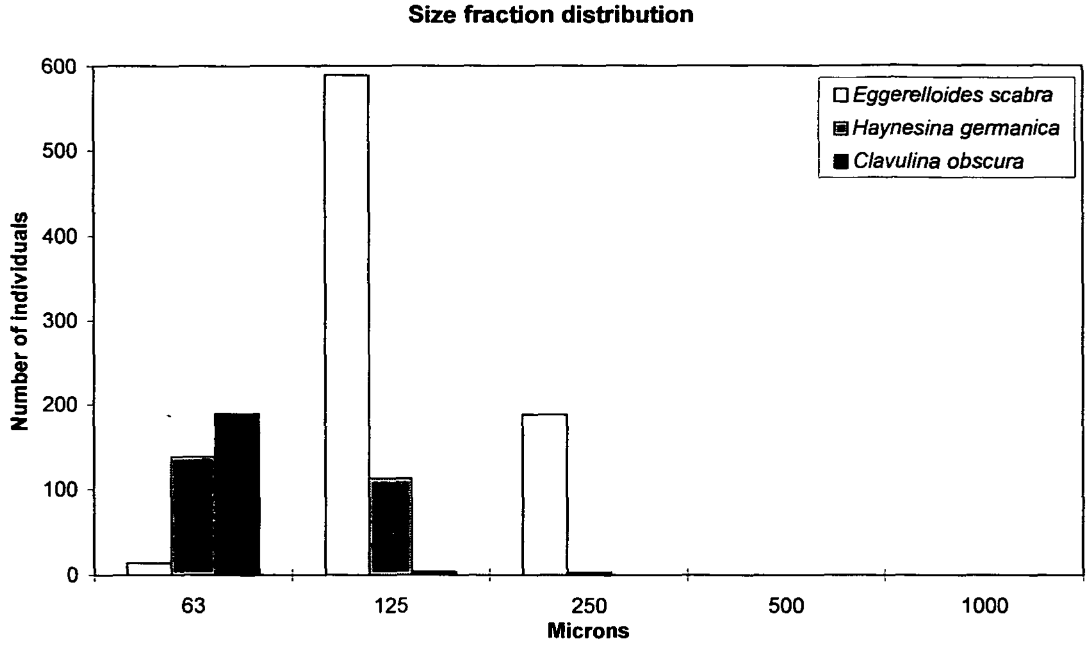


Figure 9.38 The size distribution *E. scabrum, H. germanica* and *C. obscura* are shown within the 5 size fractions analysed (foraminifera combined from Locations 3, 15, 17 and 18).

Foraminiferal species were analysed on the basis of their size to highlight any differences or similarities in their size at different locations. Figure 9.39 shows eight species which were common at all locations. In Figure 9.39B it can be seen that the population of *A. beccarii batavus* is composed of individuals from the 125μm and 250μm fractions (particularly Locations 17 and 18). The fauna at Location 3 is composed of mainly small individuals (125μm) while the fauna at Location 15 is composed of mainly large individuals (250μm and 500μm fractions). This distribution is unlikely to be due to sorting and winnowing of tests because Location 3 is a shell gravel which may be expected to contain large tests, while Location 15 is a mud which commonly contains small foraminiferal tests. This size distribution may reflect the distribution of living foraminifera. At Location 3 (normal marine) this species may reproduce quickly, so attain small sizes, while at Location 15 (hyposaline) this species may attain much larger sizes before reproducing because of the less favourable conditions (Bradshaw, 1951). Large *A. beccarii batavus* were also observed at Location 12 (another hyposaline silty sediment) which further adds to this theory of delayed reproduction.

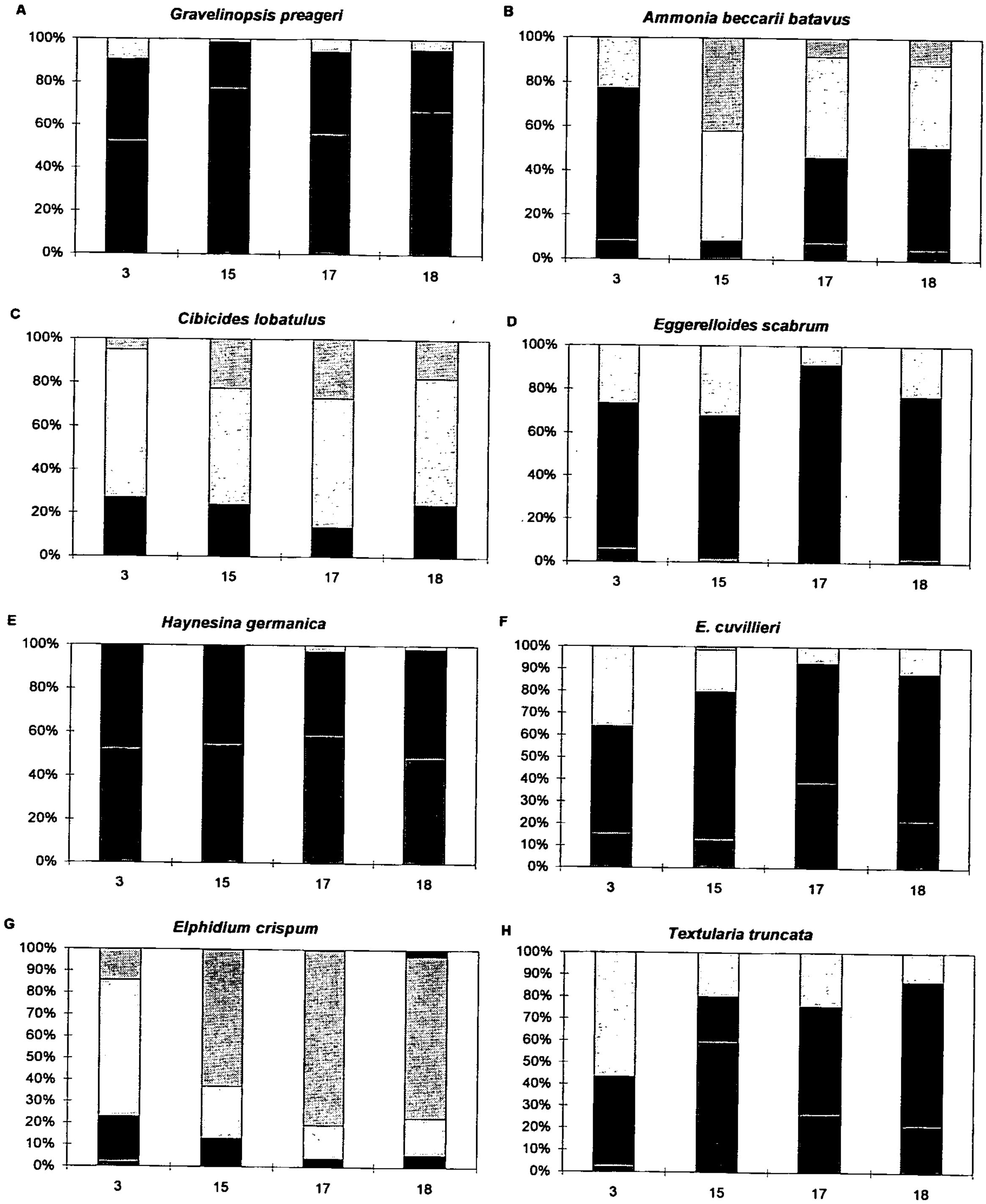


Figure 9.39 Foraminifera from Locations 3, 15, 17 and 18 shown on X axis and their size distribution; ■ = 63µm, ■ = 125µm, ☐ = 250µm, ▨ = 500µm and ■ = 1000µm.

Elphidium crispum (Figure. 9.39g) was most abundant as large individuals at locations 15, 17 and 18 but as small to medium sized individuals at Location 3. This may reflect its living distribution as it occurred living at Locations 15, 17 and 18, but was not observed living at Location 3. The fauna at Location 3 may be predominantly transported (small to medium tests being preferentially transported) while at Locations 15, 17 and 18 the individuals are mainly autochthonous.

The largest individuals of *T. truncata* occurred at Location 3, they were small at Location 15 and medium in sized at locations 17 and 18. This distribution is reflective of the sediment grain size at these locations (coarse at Location 3, medium at Locations 17 and 18 and fine at Location 15) and may be attributed to post-mortem transportation.

Other species represented by Figure 9.39A, C, D, E and F show less variation in size between the four locations.

The results of the comparison of the sieve fraction and whole fraction methods shows good consistency, particularly within sandy (Location 17) and mixed sediments (Location 18). A small degree of under representation of small species may have occurred at Locations 3 and 15. This may be because small species are present only in the fine fractions but generally rare at these locations and may be over represented by the sieve fraction method, or simply that the small rare species at Locations 3 and 15 may have been missed by the worker. Size bias does occur when using the whole fraction method but the consistency of both methods indicate that the size bias is small, in conclusion the results indicate that the use of the whole fraction method is valid and justified.

9.14.0. The Dead Assemblage Discussion

Once foraminifera have died their empty tests are contributed to the sediment. Their distribution is controlled, from then on, by hydrodynamic factors and other post-mortem effects. Post-mortem transportation sorts the tests into sediments appropriate for their mass, shape and traction velocity. Large, heavy, robust tests and plate-like tests tend to reside in sediments subject to high energy and strong currents as smaller tests are destroyed or cannot be deposited there. At the other sedimentological extreme many fine, small, light tests are carried in suspension and deposited in fine silt and clay sediments. The post-mortem redistribution of tests over-prints their original biological distribution. Depending on the type of sediment and post-mortem changes which have occurred, a great deal of the original biological distribution may be preserved or destroyed

Apart from the hydrodynamic redistribution of tests through currents, waves and tides, there are many other taphonomic agencies which generally remove foraminifera either selectively or unselectively. Destruction and subsequent removal of the tests can occur through physical means such as abrasion and breakage (cracks, punctures and loss of chambers) which is particularly prevalent within high energy environments.

Biological destruction can occur due to many organisms such as fish, ophiuroids, scaphopods, gastropods, echinoids, bivalves, polychaetes, nematode worms, crustaceans, (Lipps, 1983) fungi, sponges, bacteria (Boltovskoy, 1991), endolithic algae (Kloos, 1982), etc.. All these organisms ingest, abrade, crush or bore holes and channels into the tests of foraminifera. Some workers believe that borings into empty tests are to utilise $CaCO_3$ (Hickman and Lipps, 1983).

Removal of tests can also occur by dissolution. Dissolution is greatest in areas of low pH and where water is undersaturated with respect to $CaCO_3$. This can effect either the water mass in general, bottom waters or pore waters within the sediment. Even at relatively neutral pH values such as between 6 and 8, dissolution of foraminiferal tests can occur. Dissolution will selectively thin and damage tests of calcareous species and perhaps some agglutinated species which are poorly cemented and do not have an organic membrane. Thin, fragile, tests are most prone to destruction and removal by dissolution. Severe dissolution will result in the removal of all the calcareous tests. Some possible indicators of dissolution are the absence of small tests, transparent tests which have become white and opaque, the thinning of tests, punctures and general breakage (Murray, 1989).

Agglutinated foraminifera are generally unaffected by dissolution but weakly cemented forms may be rapidly fragmented especially during processing. Forms which are held together by an organic membrane may also be destroyed by oxidation of the membrane (Douglas *et al.*, 1980).

Burial does not directly destroy the tests of foraminifera but does remove the tests from the surface. In areas of high sedimentation foraminiferal tests which have recently been contributed to the sediment, either directly from the live assemblage, or through transport are rapidly removed from the surface assemblage and thus unavailable to surface sediment studies.

All or many of these processes may act to various degrees on the assemblages of Plymouth Sound to produce the present dead assemblages.

9.14.1. Association of Foraminifera and Sediment Type

The foraminiferal assemblages were treated statistically to analyse their relationship with each other and the sediment type. The assemblages from the various locations form four broad groups which related to the four basic sediment types; Sand, Gravel, Mud and Mixed

Dendrograms for each location throughout the year show a reasonable to good correlation between locations and sediment type. Locations of similar sediment type are often associated together and exhibit a higher similarity, e.g. Locations 9, 12 and 15 (muds) are often grouped together. A Bray-Curtis Similarity index is shown on the axis at the base of each dendrogram. The assemblages for each month exhibit a range of similarities between approximately 40 to 75, depending on how different or similar the fauna from different sediment types is.

Dead Assemblage

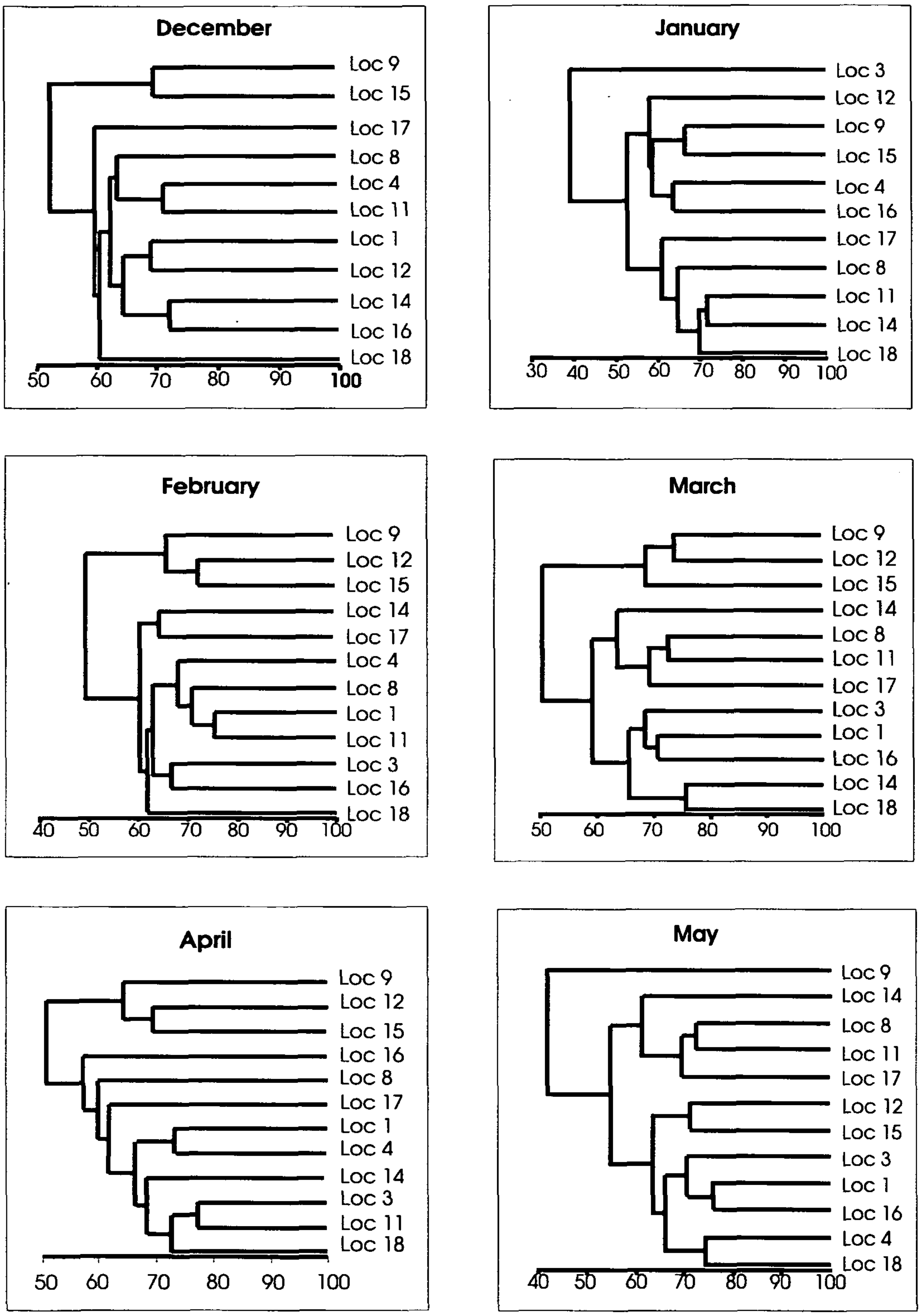


Figure. 9.40 Dendrograms from December 1992 to May 1993

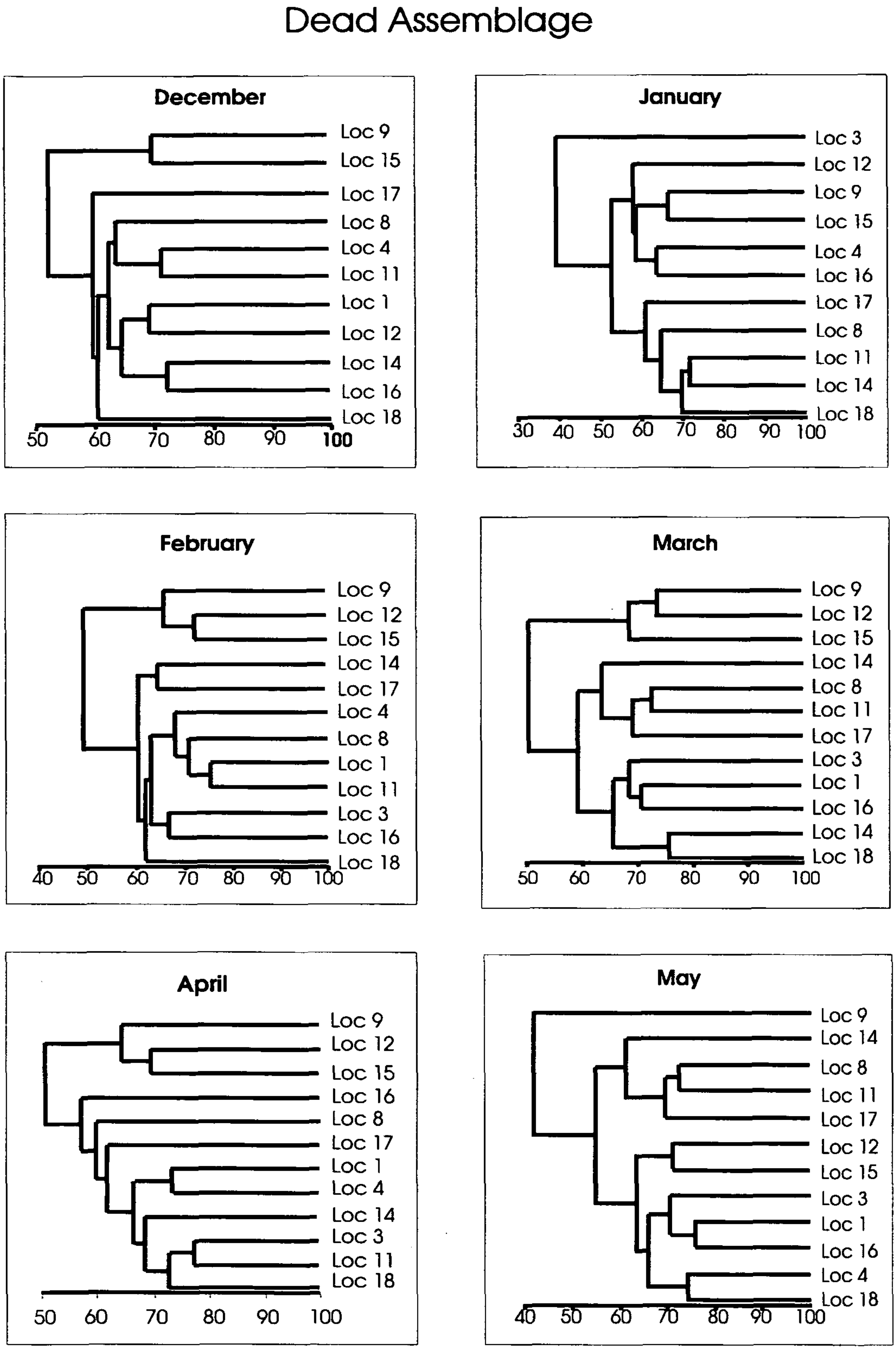


Figure. 9.41 Dendrograms from June 1993 to November 1993.

Individual months samples often show an incomplete or atypical assemblage, by combining monthly assemblages a more complete yearly assemblage is generated. The yearly assemblage exhibits a much higher degree of similarity between all locations, showing similarities of between 70 to 90 on the Bray-Curtis index. The Plym Estuary assemblage is also plotted with the Plymouth Sound assemblage. The dendrogram highlights how different this assemblage is from the more marine assemblages.

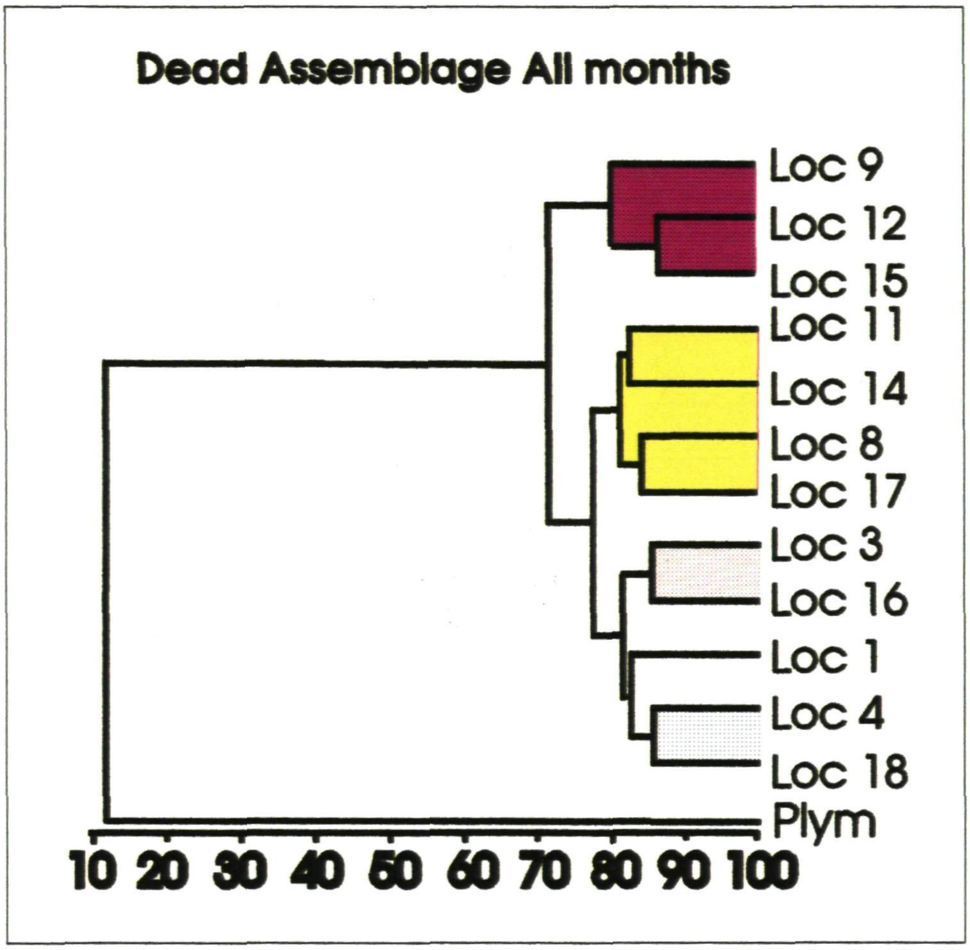


Figure 9.42 Dendrogram for the entire years assemblages. Most of the locations fit into the four sediment types; mud = purple, sand = yellow, gravel = pink and blue = mixed sediment.

Foraminiferal assemblages can be seen to have very strong associations with different sediment types. This is clearly visible in Figure 9.42. where Locations 9, 12 and 15 (muds) form a distinct group, Locations 11, 14, 8, and 17 (sands) form a group, Locations 3 and 16 (gravels) form another group as do the mixed sediments of Locations 4 and 18. Only

Location 1 does not conform to its sediment group (sand) and has an assemblage most similar to those of the gravels and mixed sediments.

Multi Dimensional Scaling maps (MDS) were generated for monthly assemblages throughout the year. Assemblages for each location and month are plotted as dots or points close (similar) or far (dissimilar) from each other according to their similarity. The clusters that often form have been grouped and highlighted with different colours (Figure 9.42). Sometimes the locations form tight clusters of high similarity but at other times similarity between sites is low and clusters do not form. When clusters do form, they often show a gradation from fine to coarse sediments. The direction of coarsening is denoted by an arrow. Stress levels indicate the degree of confidence of the MDS maps, stress levels generally of approximately 2 or below are low and indicate a high level of confidence in the generation of MDS maps.

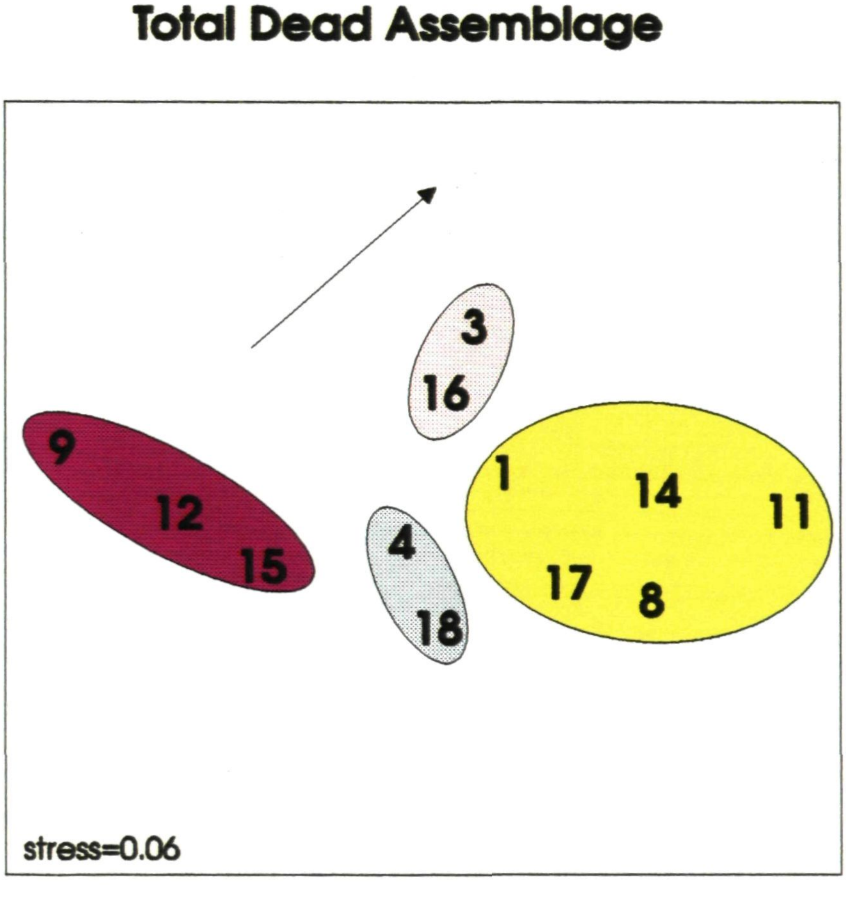


Figure 9.45. Assemblages for the entire year for four distinct cluster on this MDS map. Yellow = sand facies, Blue = mixed facies, Purple = mud facies and pink = gravel facies.

Dead Assemblage

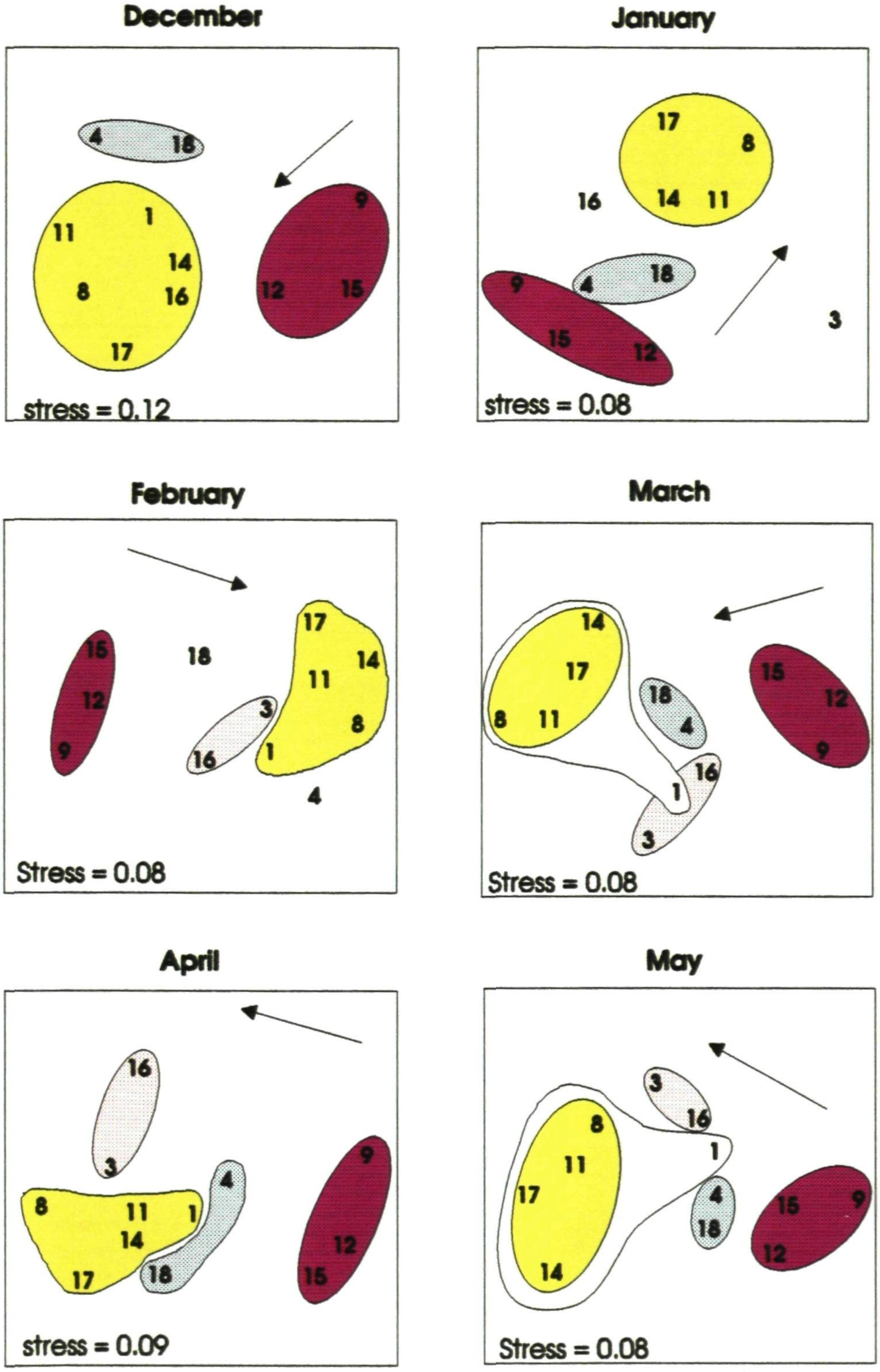


Figure 9.43 MDS maps of assemblages from December 1992 to May 1993. Clusters coloured in yellow denote sand facies, Blue; mixed sediment facies, Purple; mud facies and Pink; gravel facies.

Dead Assemblage continued

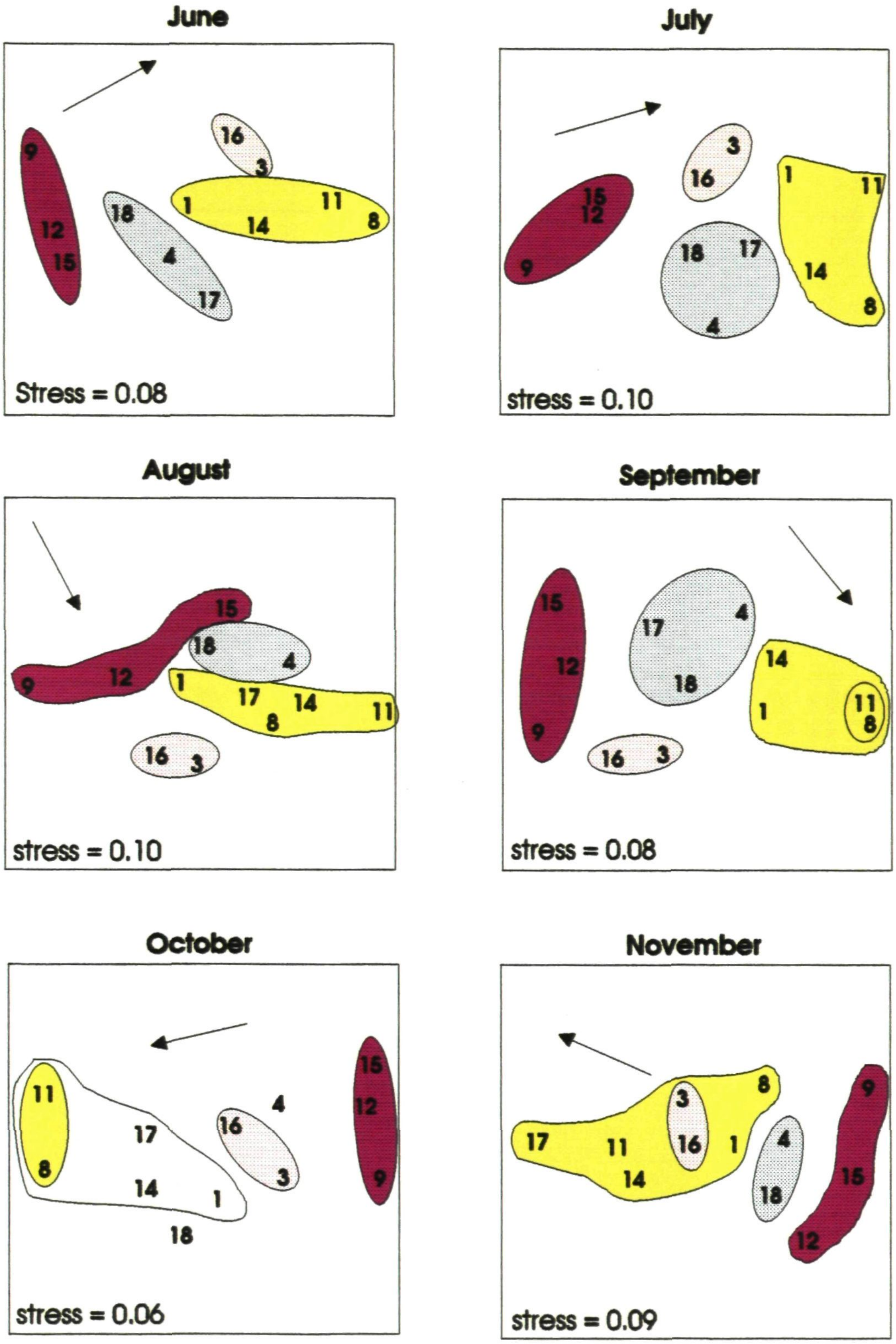


Figure 9.44 MDS maps of assemblages from December 1992 to May 1993. Clusters coloured in yellow denote sand facies, Blue; mixed sediment facies, Purple; mud facies and Pink; gravel facies.

The monthly MDS maps have been combined to form a total or yearly foraminiferal assemblage. The yearly assemblage exhibits four distinct clusters with a high confidence level (stress = 0.06). The gravels, mixed sediments and muds form tight clusters, signifying that the assemblages from those locations are very similar, while the sand facies assemblages have an open cluster signifying lower similarity between the various locations.

9.15.0. Species Association with Sediment Type

9.15.1. Shell Facies

The principal species of the shell gravel facies were *C. lobatulus, A. beccarii batavus, Q. seminulum* and *T. truncata*. These species, together with *E. crispum,* accounted for half of the shell gravel assemblages. *Haynesina germanica, E. williamsoni, P. mediterranensis, M. secans* and *R. williamsoni* were all significant species within the assemblage. Many species of *Quinqueloculina* and *Elphidium* were present, although rare. Surprisingly, for this high energy sediment, many small fragile species were also present. These include several species of *Lagena*, *Brizalina*, *Fissurina*, *Bulimina* and other nodosariids (See Table 9.29).

A total of 95 species were recorded from the shell gravel facies. Species which were absent, were rare within the Sound generally. Absent species belonged to the genera *Ammoscalaria*, *Spirillina*, *Spiroloculina* and several nodosariid species. The absence of some small, and often rare species from gravel facies is not surprising as these are prone to winnowing and destruction in such environments.

Location 3 and 16 (Gravel)	**Abs.**	**%**
Cibicides lobatulus	799	15
Ammonia beccarii batavus	493	9
Quinqueloculina seminulum	468	9
Textularia truncata	455	9
Elphidium crispum	356	7
Haynesina germanica	305	6
Elphidium williamsoni	230	4
Planorbulina mediterranensis	229	4
Massilina secans	212	4
Rosalina williamsoni	210	4
Cibicides pseudoungerianus	167	3
Eggerelloides scabrum	155	3

Absent
Adelosina ribbed
Ammoscalaria pseudospiralis
Ammoscalaria runiana
Amphicoryna cf. *scalaris*
Astacolus crepidulus
Genus 1
Buccella frigida
Genus 2
Cornuloculina balkwilli
Cornuspirella diffusa
Dentalina sp.
Fissurina quadrata

Miliolinella subrotunda	152	3
Quinqueloculina lata	136	3
Quinqueloculina spp.	126	2
Ammonia beccarii limnetes	123	2
Rosalina globularis	116	2
Quinqueloculina bicornis	95	2
Quinqueloculina aspera II	88	2
Cribrostomoides jeffreysii	84	2
Quinqueloculina auberiana	67	1
Asterigerinata mamilla	59	1
Brizalina spathulata	58	1
Miliolinella circularis	50	1
Elphidium cuvillieri	48	1
Quinqueloculina oblonga var. *lata*	47	1
Nonion depressulus	45	1
Elphidium margaritaceum	39	1
Quinqueloculina cf. *cliarensis*	33	1
Elphidium gerthi	31	1
Brizalina pseudopunctata	30	1
Bulimina elongata	28	1
Quinqueloculina oblonga	27	1
Quinqueloculina williamsoni	27	1
Nodosaria pyrula	25	0
Trifarina angulosa	25	0
Bolivina pseudoplicata	23	0
Reophax moniliformis	23	0
Patellina corrugata	20	0
Fissurina marginata	18	0
Clavulina obscura	17	0
Fissurina lucida	17	0
Quinqueloculina aspera III	17	0
Quinqueloculina cf. *lata/seminulum*	16	0
Deuterammina (Lepidodenterammina) ochracea var. *sinuosa*	16	0
Textularia sagittula	15	0
Bulimina gibba	14	0
Vaginulina linearis	14	0
Lagena semistriata	12	0
Acervulina inhaerens	10	0
Globulina gibba	10	0
Psammosphaera bowmani	10	0
Rosalina anomala	10	0
Cyclogyra involvens	9	0
Fissurina orbignyana	9	0
Spiroplectammina wrightii	8	0
Bulimina marginata	8	0
Brizalina striatula	7	0
Quinqueloculina sp. 5	7	0
Deuterammina rotaliformis	7	0
Textularia earlandi	6	0

Genus 3
Gaudryina rudis
Jadammina macresens
Lagena gracilis
Lagena sp.
Lagena substriata
Lamarckina haliotidea
Lagenammina cf. *arenulata*
Nodosariauria pyrula
Elphidium earlandi
Nonionella sp.
Parafissurina malcomsoni
Pateoris haurinoides
Polymorphina cf. *novangliae*
Quinqueloculina cliarensis
Quinqueloculina striated form
Siphogenerinoides sp.
Spirillina runiana
Spirillina wrightii
Spiroloculina sp.
Spirophthalmidium acutimargo var. *emaciatum*
Technitella legumen
Technitella teivyense
Portatrochammina murrayi

Adelosina normal	5	0
Brizalina variabilis	5	0
Fursenkoina fusiformis	5	0
Globulina gibba var. *myristiformis*	5	0
Quinqueloculina mediterranensis	5	0
Lagena sulcata	4	0
Quinqueloculina aspera I	4	0
Remaneica helgolandica	4	0
Lagena perlucida	3	0
Spiroloculina excavata	3	0
Uvigerina sp.	3	0
Technitella sp. 2 (earbud form)	3	0
Buliminella elegantissima	2	0
Lenticulina crepidula	2	0
Lenticulina orbiculatis	2	0
Lagena laevis	2	0
Oolina hexagona	2	0
Oolina melo	2	0
Spiroloculina rotunda	2	0
Stainforthia concava var. *loeblichi*	2	0
Lagena clavata	1	0
Lagena lyellii	1	0
Miliammina fusca	1	0
Nonionella turgida var. *digitata*	1	0
Oolina squamosa	1	0
Polymorphina concava var. *lactea*	1	0
Pyrgo depressa	1	0
Pyrgo williamsoni	1	0
Reophax fusiformis	1	0
Reophax scottii	1	0
Spirillina vivipara	1	0
Spiroloculina grata	1	0
Technitella legumen	1	0
Technitella teivyense	1	0

Table 9.29 Faunal list of species which were recorded from shell gravel facies throughout the year.

9.15.2. Sand Facies

The principal species in the sand facies assemblage were *C. lobatulus,* which alone accounted for over one third, *E. crispum* and *A. beccarii batavus*. Other important species were *T. truncata, H. germanica* and *E. scabrum*. All species of *Quinqueloculina, Elphidium, Fissurina, Brizalina* and *Bulimina* were present. A total of 101 species were recorded in sand facies throughout the year (See Table 9.30).

Several species of *Lagena, Technitella* and *Spirillina* were absent from sand facies. Other absent species were rare generally within the Sound. The absence of several small rare species from sand facies is not surprising as these may be removed by winnowing and destruction in sand facies (See Table 9.30).

Locations 1, 8, 11, 14 (Sand)	**Abs.**	**%**
Cibicides lobatulus	5349	35
Elphidium crispum	1805	12
Ammonia beccarii batavus	1752	12
Haynesina germanica	871	6
Textularia truncata	671	4
Eggerelloides scabrum	658	4
Ammonia beccarii limnetes	619	4
Elphidium williamsoni	445	3
Massilina secans	410	3
Cibicides pseudoungerianus	290	2
Planorbulina mediterranensis	244	2
Rosalina globularis	216	1
Quinqueloculina seminulum	207	1
Elphidium cuvillieri	168	1
Asterigerinata mamilla	154	1
Quinqueloculina williamsoni	132	1
Quinqueloculina spp.	123	1
Quinqueloculina lata	117	1
Quinqueloculina bicornis	105	1
Quinqueloculina auberiana	97	1
Rosalina williamsoni	97	1
Elphidium margaritaceum	68	0
Quinqueloculina cf. *cliarensis*	66	0
Miliolinella circularis	60	0
Bulimina elongata	59	0
Quinqueloculina oblonga var. *lata*	52	0
Quinqueloculina aspera II	49	0
Brizalina spathulata	48	0
Quinqueloculina striated form	48	0
Quinqueloculina oblonga	46	0
Globulina gibba var. *myristiformis*	45	0
Spiroplectammina wrightii	44	0
Elphidium gerthi	43	0
Fissurina quadrata	42	0
Acervulina inhaerens	35	0
Textularia sagittula	34	0
Bulimina gibba	33	0
Miliolinella subrotunda	32	0
Quinqueloculina aspera III	28	0
Elphidium earlandi	27	0
Rosalina anomala	26	0
Fissurina lucida	25	0
Globulina gibba	24	0
Trifarina angulosa	23	0
Quinqueloculina mediterranensis	22	0
Brizalina pseudopunctata	21	0
Cribrostomoides jeffreysii	18	0
Spiroloculina rotunda	18	0

Absent
Ammoscalaria pseudospiralis
Astacolus crepidulus
Genus 1
Buccella frigida
Genus 2
Cornuloculina balkwilli
Cornuspirella diffusa
Genus 3
Gaudryina rudis
Jadammina macresens
Lagena gracilis
Lagena semistriata
Lagena sp.
Lagena substriata
Lamarckina haliotidea
Lagenammina cf. *arenulata*
Miliammina fusca
Nonionella sp.
Parafissurina malcomsoni
Reophax monoliformis
Spirillina wrightii
Spirillina vivipara
Spirophthalmidium acutimargo var. *emaciatum*
Technitella sp. 2 (earbud form)
Technitella legumen
Portatrochammina murrayi
Uvigerina sp.

Nonion depressulus	17	0
Bolivina pseudoplicata	16	0
Quinqueloculina cf. *lata/seminulum*	16	0
Psammosphaera bowmani	15	0
Quinqueloculina sp. 5	14	0
Spiroloculina excavata	12	0
Bulimina marginata	10	0
Clavulina obscura	10	0
Fissurina orbignyana	10	0
Polymorphina concava var. *lactea*	10	0
Buliminella elegantissima	9	0
Spiroloculina sp.	9	0
Adelosina normal	7	0
Brizalina striatula	7	0
Lenticulina orbiculatis	7	0
Patellina corrugata	7	0
Spiroloculina grata	7	0
Lagena sulcata	6	0
Polymorphina cf. *novangliae*	6	0
Pyrgo depressa	6	0
Quinqueloculina cf. *cliarensis*	6	0
Fissurina marginata	5	0
Pyrgo williamsoni	5	0
Quinqueloculina aspera I	5	0
Siphogenerinoides sp	5	0
Brizalina variabilis	4	0
Oolina squamosa	4	0
Stainforthia concava var. *loeblichi*	4	0
Vaginulina linearis	4	0
Lenticulina crepidula	3	0
Cyclogyra involvens	3	0
Oolina melo	3	0
Adelosina ribbed	2	0
Fursenkoina fusiformis	2	0
Lagena clavata	2	0
Lagena laevis	2	0
Lagena perlucida	2	0
Oolina hexagona	2	0
Pateoris hauerinoides	2	0
Reophax scottii	2	0
Ammoscalaria runiana	1	0
Amphicoryna cf. *scalaris*	1	0
Dentalina spp.	1	0
Lagena lyellii	1	0
Nodosaria pyrula	1	0
Nonionella turgida var. *digitata*	1	0
Reophax fusiformis	1	0
Spirillina runiana	1	0
Technitella teivyense	1	0
Textularia earlandi	1	0
Remaneica helgolandica	1	0
Deuterammina (Lepidodenterammina) ochracea var. *sinuosa*	1	0
Deuterammina rotaliformis	1	0

Table 9.30 Faunal list of species which were recorded from sand facies throughout the year.

9.15.3. Mud Facies

The principal species in mud facies were *A. beccarii batavus* and *E. scabrum*. Other important species were *C. lobatulus, H. germanica, A. beccarii limnetes* and *E, crispum*. Within mud facies there is less species dominance and higher species evenness than in other facies (See Table 9.31).

A total of 119 species were recorded from mud facies throughout the year. Virtually all of the small fragile species are represented within the mud facies. Species which were not recorded within the mud facies were either exceptionally rare (known by 1 or few individuals) or large and robust such as *Globulina gibba* d'Orbigny var. *myristiformis* (Williamson) and *V. linearis*.

Location 9, 12, and 15 (Mud)	**Abs.**	**%**
Ammonia beccarii batavus	1926	19
Eggerelloides scabrum	1017	10
Cibicides lobatulus	665	7
Haynesina germanica	640	6
Ammonia beccarii limnetes	472	5
Elphidium crispum	389	4
Elphidium gerthi	296	3
Brizalina spathulata	295	3
Elphidium cuvillieri	278	3
Brizalina pseudopunctata	276	3
Cibicides pseudoungerianus	241	2
Rosalina globularis	241	2
Cribrostomoides jeffreysii	236	2
Rosalina anomala	225	2
Elphidium williamsoni	183	2
Clavulina obscura	175	2
Planorbulina mediterranensis	147	1
Bulimina elongata	143	1
Fissurina lucida	137	1
Bulimina gibba	132	1
Miliolinella subrotunda	130	1
Nodosaria pyrula	127	1
Bolivina pseudoplicata	126	1
Brizalina variabilis	103	1
Quinqueloculina aspera III	95	1
Quinqueloculina aspera II	92	1
Quinqueloculina seminulum	91	1
Stainforthia concava var. *loeblichi*	86	1
Fissurina marginata	84	1
Quinqueloculina aspera I	84	1
Rosalina williamsoni	82	1

Absent
Gaudryina rudis
Globulina gibba var. *myristiformis*
Lamarckina haliotidea
Lagenammina cf. *arenulata*
Parafissurina malcomsoni
Pateoris hauerinoides
Spirillina wrightii
Technitella legumen
Technitella teivyense
Vaginulina linearis

Textularia earlandi	76	1
Elphidium earlandi	75	1
Elphidium margaritaceum	74	1
Fursenkoina fusiformis	69	1
Quinqueloculina spp.	64	1
Lenticulina crepidula	63	1
Ammoscalaria pseudospiralis	61	1
Trifarina angulosa	61	1
Cyclogyra involvens	56	1
Quinqueloculina auberiana	55	1
Textularia sagittula	54	1
Brizalina striatula	52	1
Bulimina marginata	51	1
Fissurina orbignyana	51	1
Asterigerinata mamilla	48	0
Quinqueloculina oblonga	48	0
Miliolinella circularis	39	0
Portatrochammina murrayi	32	0
Textularia truncata	29	0
Cornuspirella diffusa	28	0
Quinqueloculina cf. *cliarensis*	27	0
Massilina secans	26	0
Reophax scottii	26	0
Deuterammina (Lepidodenterammina) ochracea var. *sinuosa*	26	0
Lagena clavata	25	0
Lagena laevis	23	0
Uvigerina sp.	23	0
Psammosphaera bowmani	22	0
Lagena perlucida	20	0
Buliminella elegantissima	19	0
Patellina corrugata	19	0
Dentalina spp.	17	0
Remaneica helgolandica	17	0
Globulina gibba	16	0
Lagena sulcata	16	0
Lagena lyellii	15	0
Quinqueloculina sp. 5	15	0
Quinqueloculina bicornis	15	0
Quinqueloculina cliarensis	15	0
Reophax fusiformis	15	0
Quinqueloculina lata	14	0
Amphicoryna cf. *scalaris*	13	0
Oolina hexagona	13	0
Pyrgo depressa	13	0
Quinqueloculina cf. *lata/seminulum*	13	0
Lagena gracilis	12	0
Lagena semistriata	12	0
Oolina squamosa	12	0
Quinqueloculina mediterranensis	11	0
Spirillina vivipara	11	0
Adelosina normal	10	0

Miliammina fusca	10	0
Reophax monoliformis	10	0
Oolina melo	9	0
Ammoscalaria runiana	7	0
Astacolus crepidulus	7	0
Nonionella turgida var. *digitata*	7	0
Polymorphina cf. *novangliae*	7	0
Siphogenerinoides sp.	7	0
Spiroloculina excavata	6	0
Lagena substriata	5	0
Deuterammina rotaliformis	5	0
Acervulina inhaerens	4	0
Buccella frigida	4	0
Fissurina quadrata	4	0
Lagena sp.	4	0
Nonionella sp.	4	0
Quinqueloculina oblonga var. *lata*	4	0
Quinqueloculina striated form	4	0
Quinqueloculina williamsoni	4	0
Genus 1	3	0
Lenticulina orbiculatis	3	0
Nonion depressulus	3	0
Spiroloculina rotunda	3	0
Pyrgo williamsoni	2	0
Spiroloculina grata	2	0
Spirophthalmidium acutimargo var. *emaciatum*	2	0
Spiroplectammina wrightii	2	0
Adelosina ribbed	1	0
Nodosaria pyrula	1	0
Polymorphina concava var. *lactea*	1	0
Spirillina runiana	1	0
Spiroloculina sp.	1	0
Technitella sp. 2 (ear bud form)	1	0
Cornuloculina balkwilli	1	0
Genus 2	1	0
Genus 3	1	0
Jadammina macresens	1	0

Table 9.31 Faunal list of species which were recorded from mud facies throughout the year.

9.15.4. Mixed Facies

Within the mixed sediment assemblages the principal species, *C. lobatulus*, *A. beccarii batavus* and *E. crispum,* accounted for over half of the entire assemblage. Other important species were *E. scabrum* and *Q. seminulum*. All species of *Quinqueloculina, Brizalina, Fissurina, Bulimina* and *Ammoscalaria* were present. In total 107 species were recorded from mixed sediment facies.

Species which were absent belonged to the genera *Spirillina* and *Technitella*. Some species of nodosarids were absent as were several very rare species.

Locations 4, 17 and 18 (Mixed)	**Abs**	**%**
Cibicides lobatulus	2610	23
Ammonia beccarii batavus	2081	19
Elphidium crispum	1781	16
Eggerelloides scabrum	608	5
Quinqueloculina seminulum	386	3
Elphidium cuvillieri	266	2
Haynesina germanica	241	2
Massilina secans	215	2
Textularia truncata	214	2
Ammonia beccarii limnetes	192	2
Rosalina globularis	166	1
Quinqueloculina lata	145	1
Cibicides pseudoungerianus	128	1
Elphidium williamsoni	122	1
Elphidium gerthi	99	1
Planorbulina mediterranensis	95	1
Quinqueloculina aspera II	85	1
Quinqueloculina auberiana	83	1
Quinqueloculina cf. *cliarensis*	83	1
Bulimina elongata	78	1
Asterigerinata mamilla	75	1
Miliolinella subrotunda	75	1
Quinqueloculina oblonga	74	1
Textularia sagittula	64	1
Fissurina quadrata	63	1
Quinqueloculina spp.	61	1
Quinqueloculina bicornis	57	1
Brizalina spathulata	56	1
Rosalina williamsoni	56	1
Quinqueloculina aspera III	51	0
Miliolinella circularis	48	0
Brizalina pseudopunctata	46	0
Bulimina gibba	46	0
Cribrostomoides jeffreysii	46	0
Elphidium margaritaceum	36	0
Quinqueloculina sp. 5	33	0
Acervulina inhaerens	32	0
Fissurina lucida	32	0
Globulina gibba	28	0
Textularia earlandi	28	0
Clavulina obscura	26	0
Quinqueloculina aspera I	26	0
Ammoscalaria pseudospiralis	25	0
Quinqueloculina williamsoni	24	0

Absent
Astacolus crepidulus
Genus 1
Buccella frigida
Genus 2
Cornuloculina balkwilli
Gaudryina rudis
Jadammina macresens
Lagena gracilis
Lamarckina haliotidea
Lagenammina cf. *arenulata*
Nodosaria pyrula
Nonionella turgida var. *digitata*
Parafissurina malcomsoni
Pateoris hauerinoides
Spirillina runiana
Spirillina wrightii
Spirillina vivipara
Spiroloculina grata
Spirophthalmidium acutimargo var. *emaciatum*
Technitella sp. 2 (ear bud form)
Technitella legumen
Technitella teivyense

Quinqueloculina mediterranensis	23	0
Quinqueloculina oblonga var. *lata*	23	0
Pyrgo depressa	18	0
Bolivina pseudoplicata	15	0
Bulimina marginata	15	0
Trifarina angulosa	15	0
Spiroplectammina wrightii	14	0
Spiroloculina excavata	14	0
Fissurina marginata	13	0
Fissurina orbignyana	12	0
Fursenkoina fusiformis	11	0
Globulina gibba var. *myristiformis*	11	0
Lagena sulcata	11	0
Oolina squamosa	11	0
Rosalina anomala	11	0
Lagena clavata	10	0
Polymorphina cf. *novangliae*	10	0
Psammosphaera bowmani	10	0
Spiroloculina rotunda	9	0
Brizalina striatula	8	0
Brizalina variabilis	8	0
Cyclogyra involvens	8	0
Reophax scottii	8	0
Stainforthia concava var. *loeblichi*	8	0
Adelosina normal	7	0
Lenticulina crepidula	7	0
Patellina corrugata	7	0
Quinqueloculina cliarensis	6	0
Reophax fusiformis	6	0
Nonion depressulus	4	0
Quinqueloculina cf. *lata/seminulum*	4	0
Deuterammina (Lepidodenterammina) ochracea var. *sinuosa*	4	0
Adelosina ribbed	3	0
Amphicoryna cf. *scalaris*	3	0
Lenticulina orbiculatis	3	0
Lagena laevis	3	0
Lagena semistriata	3	0
Lagena substriata	3	0
Pyrgo williamsoni	3	0
Siphogenerinoides sp.	3	0
Spiroloculina sp.	3	0
Uvigerina sp.	3	0
Cornuspirella diffusa	2	0
Dentalina spp.	2	0
Lagena perlucida	2	0
Nonionella sp.	2	0
Oolina hexagona	2	0
Polymorphina concava var. *lactea*	2	0
Quinqueloculina striated form	2	0
Reophax monoliformis	2	0
Portatrochammina murrayi	2	0

Ammoscalaria runiana	1	0
Buliminella elegantissima	1	0
Lagena lyellii	1	0
Lagena sp.	1	0
Miliammina fusca	1	0
Oolina melo	1	0
Remaneica helgolandica	1	0
Deuterammina rotaliformis	1	0
Vaginulina linearis	1	0
Genus 3	1	0

Table 9.32 Faunal list of species which were recorded from mixed facies throughout the year.

The assemblages from the four sedimentary facies show distinct differences in species composition and dominance.

9.15.5. Effects of Salinity

Salinity can affect the structure of living assemblages (see Chapter 8, Table 8.39 and Figure 8.98). The sample locations are arranged from the most hyposaline to the most marine. The number of principal species (greater than 10% of the assemblage), the dominant species and its percentage dominance are shown in Table 9.33. A correlation between salinity and species composition is not apparent.

Site	Salinity	Number of principal species	species name	% abundance of principal species
Location 12	32.88	2	*A. beccarii batavus*	26
Location 14	33.63	3	*C. lobatulus*	40
Location 3	34.39	2	*C. lobatulus*	18
Location 15	34.54	2	*A. beccarii batavus*	23
Location 4	34.66	3	*E. crispum*	26
Location 11	34.70	3	*C. lobatulus*	40
Location 18	34.72	3	*C. lobatulus*	22
Location 17	34.75	3	*C. lobatulus*	41
Location 8	34.82	3	*C. lobatulus*	48
Location 9	34.89	0	*R. globularis*	6
Location 16	35.01	0	*E. crispum*	9
Location 1	35.03	2	*A. beccarii batavus*	22

Table 9.33 Data arranged in order of lowest salinity (top) to highest salinity (bottom). Number of principal species refers to the number of species which form equal or greater than 10% of the assemblage. The right column refers to the percent abundance of the dominant species within the assemblage.

When the salinity and species composition data is plotted on a chart no correlation can be seen (Figure 9.46). This implies that salinity has little affect upon the dead assemblage which is to be expected as the dead assemblage is not influenced by biotic parameters.

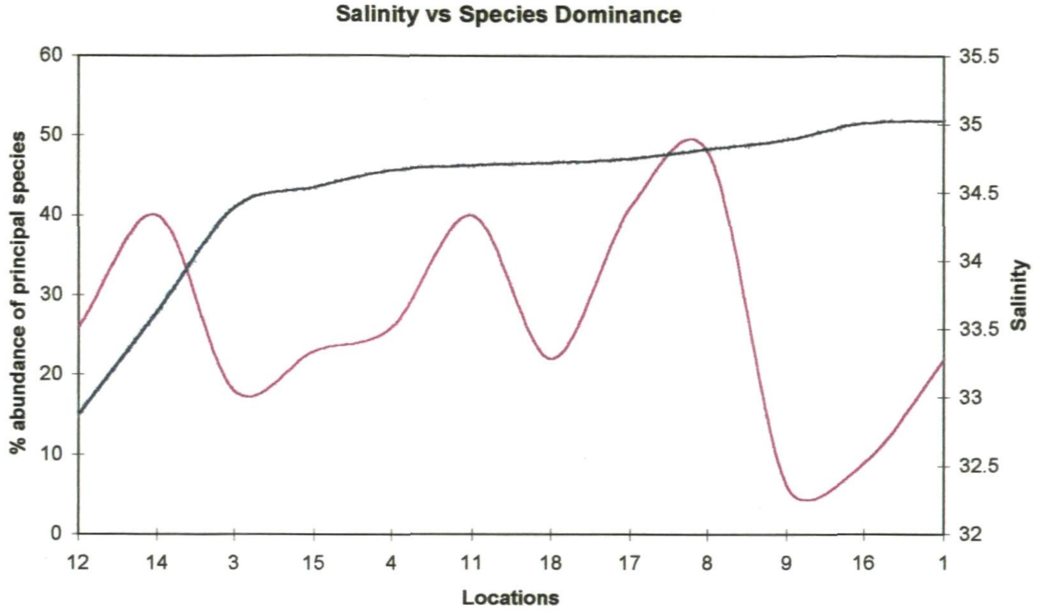


Figure. 9.46 Salinity (blue plotted on right axis) increases from left to right. Species dominance (red) is plotted on the left axis.

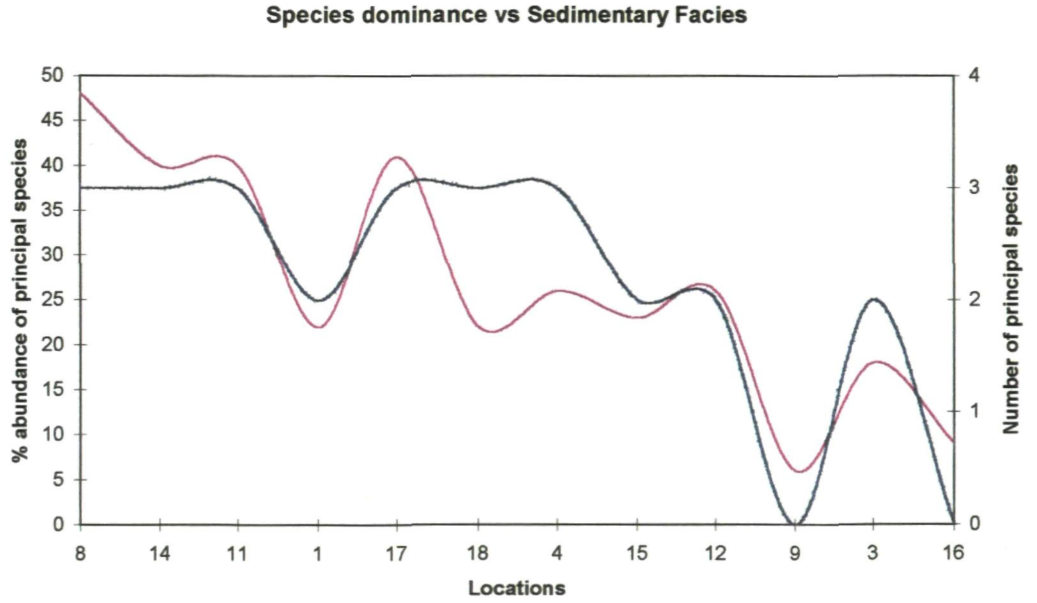


Figure. 9.47 Species dominance (red line plotted on the left axis) and number of principal species (blue plotted on the right axis). The facies are arranged from left to right; sand, mixed, mud and gravel.

When the species composition data (dominance, number of principal species) is plotted on a chart (Figure 9.47) but arranged in order of sedimentary facies rather than salinity it can clearly be seen that a strong correlation exists, indicating that the sediment type is very influential in controlling the assemblage structure and composition.

9.16.0. Important Dead Foraminiferal Species

9.16.1. Cibicides lobatulus

This was the most abundant species within Plymouth Sound. On average it accounted for nearly one quarter of the entire Plymouth Sound assemblages. Its distribution is strongly facies controlled. It accounts for nearly half of many of the sand assemblages and is least abundant in mud facies, accounting for less than 10% of these assemblages (Figure 9.48).

The medium to large size of *C. lobatulus* (most abundant in the 250µm fraction) means that it will behave hydrodynamically similar to sand size mineral grains. The low energy conditions of the silt and clay sediments are not enough to transport this species into those regions and hence its abundance is low in mud facies and mixed facies.

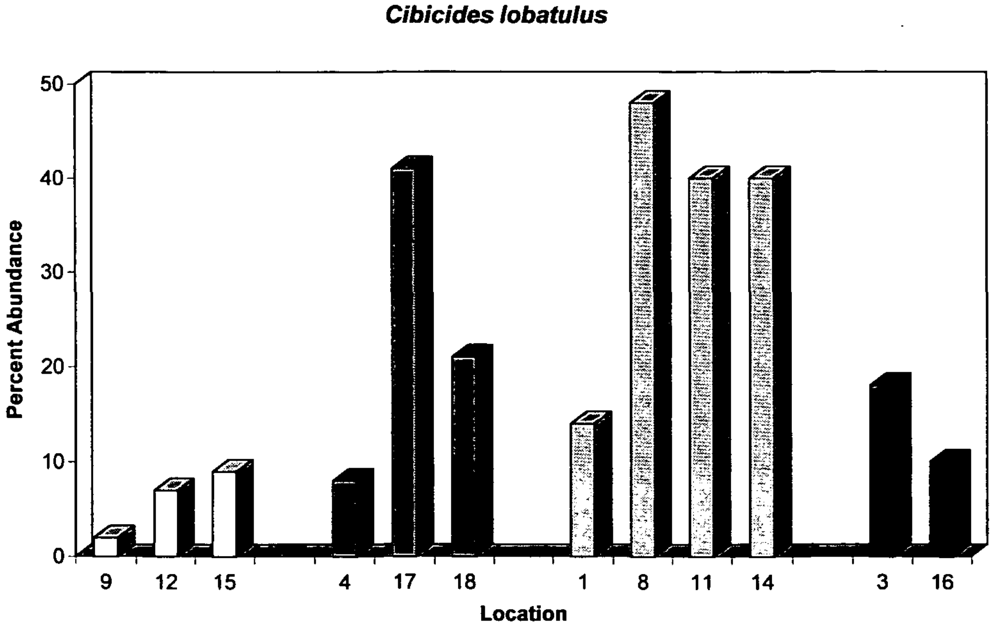


Figure. 9.48 Percentage abundance of *C. lobatulus* within the various locations, which have been grouped into the four basic sediment facies; from left to right muds, mixed, sand and gravels.

The high abundance of this species at Location 17 is probably a reflection of the often clean sandy nature of the sediment at that location. This medium to large species is highly porous and not particularly dense. For these reasons it is most likely to be deposited within medium to coarse sandy facies. Its lower abundance in shell gravels reflects the fact that it cannot easily be deposited within these very high energy environments. The test of this species appears to be of moderate strength although most specimens exhibited damage which may result from excessive transport. Its moderate strength combined with its abundance means that this species is abundant in the dead assemblage and has a good fossil potential.

9.16.2. Ammonia beccarii batavus

This subspecies accounted for a total of 14% of the entire Plymouth Sound assemblage. It is reasonably abundant in most facies. In some mud facies (Locations 12 and 15) it accounts for approximately a quarter of the assemblage, although it is very sparse at Location 9, accounting for only 2% of the assemblage. It is abundant both in mixed and sand facies but occurs in low abundances within the shell gravel facies (Figure 9.49).

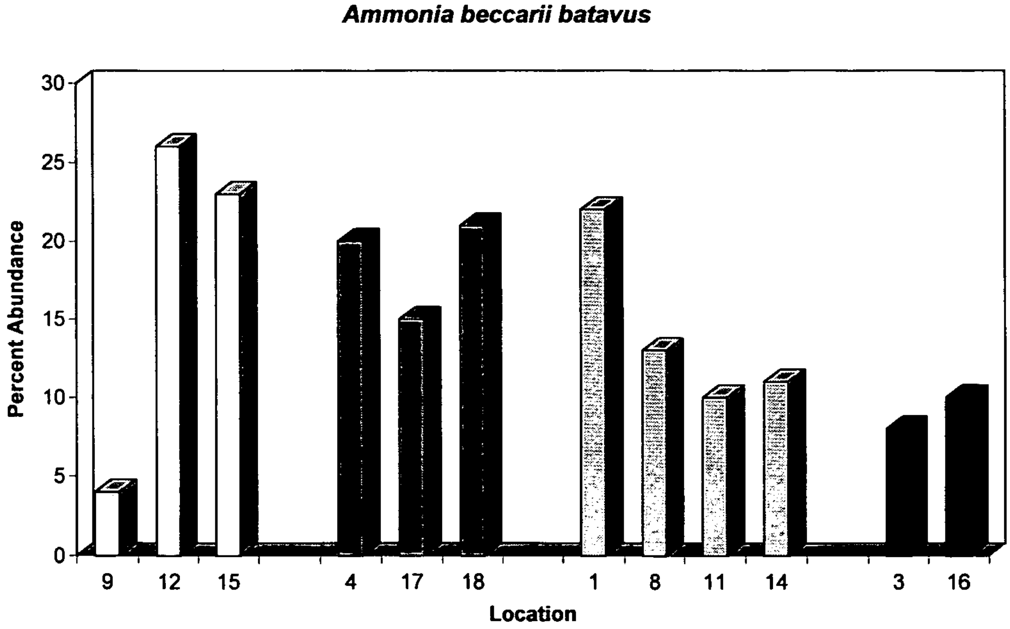


Figure. 9.49 Percentage abundance of *A. beccarii batavus* within the various Locations, which have been grouped into the four basic sediment facies; from left to right muds, mixed, sand and gravels.

Ammonia beccarii batavus is generally medium sized being most common within the 125μm and 250μm fractions. Its distribution within a wide range of facies is a result of perhaps extensive living distribution and post-mortem transport & alteration. The largest specimens of this species occur at Locations 12 and 15 which are low energy environments. These large individuals are probably indigenous and may reflect biological parameters which influence their size when living. Small individuals occur in the shell gravels and this may again reflect biological parameters which influenced their size. The fact that large *A. beccarii batavus* are not common in these high energy environment indicates that transportation of large specimens from their indigenous areas (muddy environments) to the shell gravels does not occur.

This species has a reasonably strong test which is resistant to damage. This combined with its abundance in all facies ensures it has a very good fossil potential.

9.16.3. Elphidium crispum

This species is the third most abundant species within Plymouth Sound accounting for an average of 9 % of the assemblages. It is most abundant within mixed sediment facies where it attains up to 20 % of the assemblage. It is also abundant within sand and gravel facies. It is very sparse in mud facies (with the exception of Location 15) accounting for as little as 1% of these assemblages (Figure 9.50).

Elphidium crispum is a medium to large species being common both in the 250μm and 500μm fractions. It is well calcified and this, combined with its large size and lenticular morphology, suggest that it has a high traction velocity (in adults at least). This may explain its scarcity in mud facies (mainly juveniles) and its moderate abundance in gravel facies, as it does not live in these facies. Its distribution in such facies is due almost entirely to post-mortem transport. Its abundance in sand and mixed facies reflects its biological distribution rather than post-mortem transport. The robust test of this species suggests that it has a good fossil potential, although it is prone to damage (erosion breakage of its periphery) in sand and gravel environments.

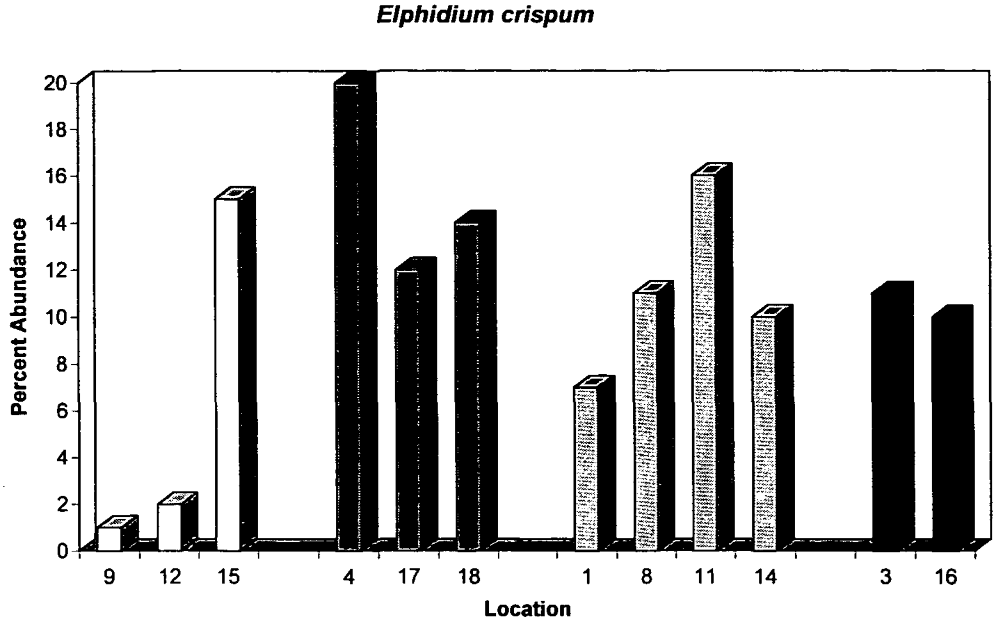


Figure. 9.50 Percentage abundance of *E. crispum* within the various Locations, which have been grouped into the four basic sediment facies; from left to right muds, mixed, sand and gravels.

9.16.4. Eggerelloides scabrum

This species is rarely abundant enough to be a principal species within most assemblages. It is, however, a very important species in many areas of the Sound. It is least common in gravel facies but attains moderate abundance within sand and mixed facies. Its highest abundance occurs within mud facies where it accounts for over 10% of the assemblage (with the exception of Location 9). See Figure 9.51.

Eggerelloides scabrum is generally a medium sized species, being virtually restricted to the 250µm and 125µm fractions. Its medium size and conical morphology indicate that it has a moderate traction velocity, suggesting it may be common within fine to medium sand facies (Locations 1 and 14) and mixed sediment facies. Its high abundance within mud facies may be due to a combination of transport and, particularly, original biological distribution. It is not surprising that this species is rarest within shell gravel facies as the high energy would destroy or transport individuals from this environment. It appears to have a reasonably strong test and as a result may have a moderate fossil potential, as long as the organic membrane is not destroyed by oxidation (Douglass *et al.,* 1980) or the test does not fragment through removal of the cement. Damage within this species manifests itself as broken ultimate chambers.

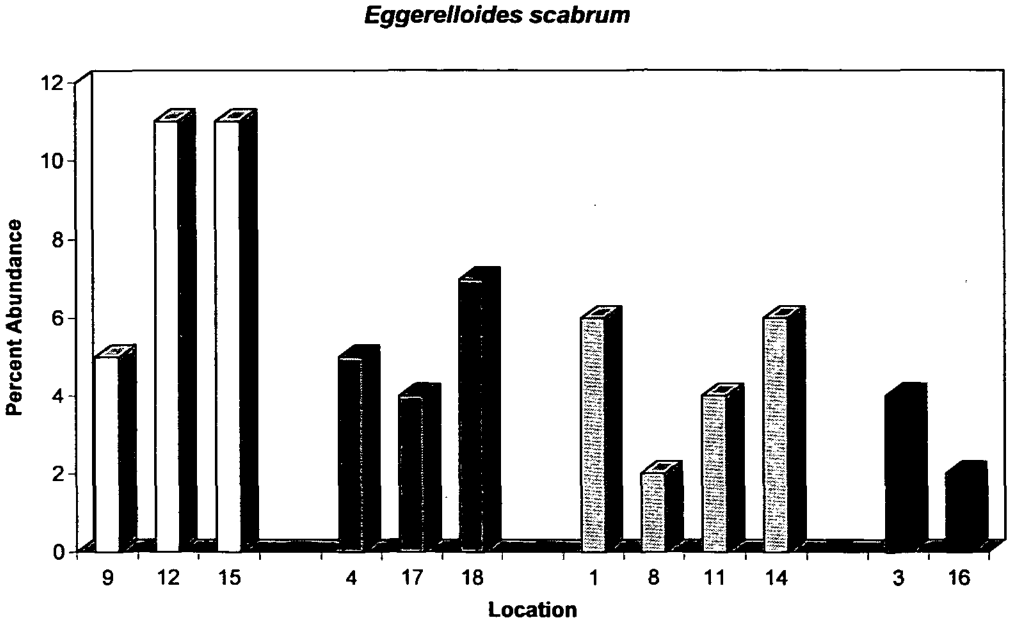


Figure. 9.51 Percentage abundance of *E. scabrum* within the various Locations, which have been grouped into the four basic sediment facies; from left to right muds, mixed, sand and gravels.

9.16.5. Haynesina germanica

This is the fifth most important species within Plymouth Sound. It forms a small but significant proportion of the assemblages at all the Locations. This species is indigenous to the Plym and Tamar estuaries. It is most common within mud facies particularly Location 12 which is adjacent the Tamar estuary. It is also reasonably abundant at Locations 3, 16 and 1 which are all within the southern Sound or outside the Breakwater (Figure 9.52). This distribution is unusual because this species is expected to be most common near the estuaries in the northern Sound. Its distribution within the gravel facies is even more surprising as this species is restricted to the 63μm and 125μm fractions.

Its thin test, which is rounded planispiral in form, further suggests that it has a low traction velocity. It would then be expected to be most abundant with mud and mixed sediment facies and least abundant within sand and particularly within gravel facies.

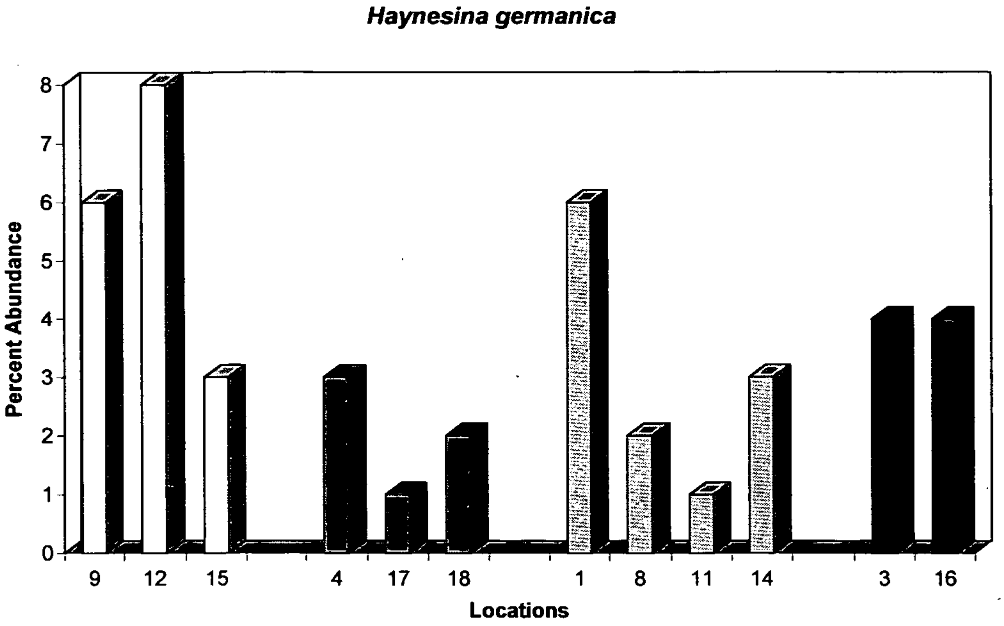


Figure. 9.52 Percentage abundance of *H. germanica* within the various Locations, which have been grouped into the four basic sediment facies; from left to right muds, mixed, sand and gravels.

Its high abundance at Location 1 may be because this assemblage represents a size sorted assemblage in which only small, and to a lesser extent medium sized, foraminifera are abundant. Indigenous species (of the wrong size) may be swept away while exotic species of a small size may be concentrated. *Haynesina germanica*'s relatively high abundance within gravel sediments may be attributed to this small species being trapped between the large plate-like shell fragments which form the sediment as several other small species are also common within the shell gravel facies. It may also reflect original living distribution. The small, thin, test of this species suggests that it has a good fossil potential only in mud rich areas as it is more likely to be destroyed in sands and gravels both at the surface and within the burial environment. A small degree of abrasion results in a broken apertural face and later ultimate chambers.

9.16.6. Elphidium cuvillieri

This species occurs in similar abundances to *H. germanica* within Plymouth Sound. On average it forms only a few percent of an assemblage. It is most common in mud facies and mixed sediment facies. It is less abundant within sand facies although it is relatively abundant at Location 1. It is least abundant within shell gravel facies (Figure 9.53).

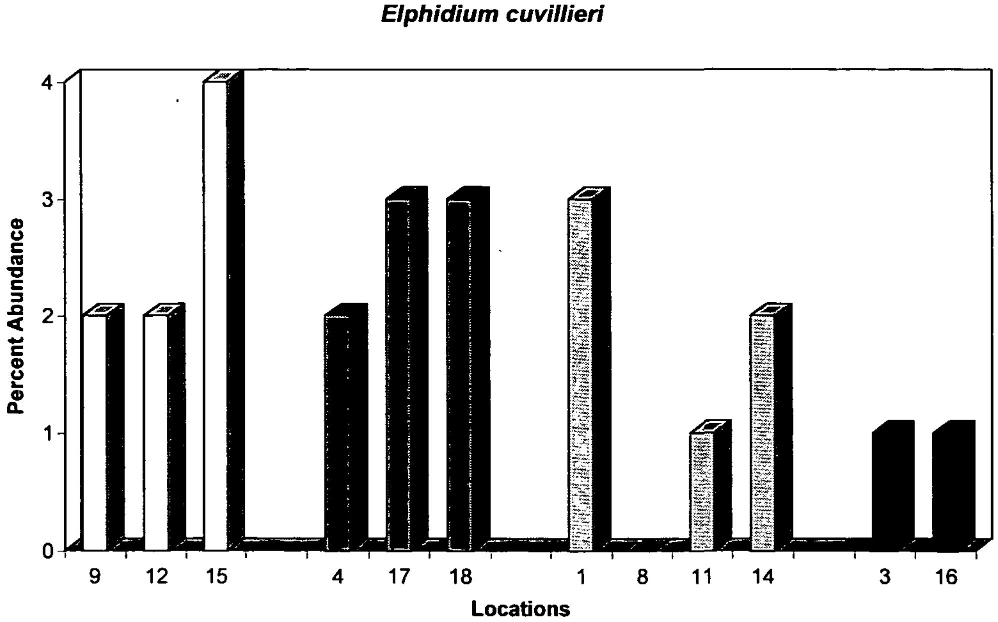


Figure. 9.53 Percentage abundance of *E. cuvillieri* within the various Locations, which have been grouped into the four basic sediment facies; muds = purple, mixed = blue, sand = yellow and pink = gravels. NB It forms less than 1 % of the assemblage at Location 8

Elphidium cuvilleri is a smooth, rounded, planispiral species which is generally small to medium in size, being most abundant within the 125μm fraction. This suggests that it has a low traction velocity and is prone to transportation. Its distribution within the mud, mixed and fine sand (Location 1) facies testify to this. Its small to medium size and moderate thick test means that it has a good fossil potential only in the mud facies where it is most abundant.

9.16.7. Ammonia beccarii limnetes

This subspecies was most common within mud facies and at Location 1 (fine sand facies) and least abundant in sand facies (Figure 9.54). It is most common in the 125μm fraction and to a lesser extent within the 63μm fraction. Its small to medium size and rounded, low trochospiral morphology suggest that this subspecies is prone to transport and hence most abundant in fine sediments. This small to medium subspecies has a reasonably strong test and hence a moderate fossil potential.

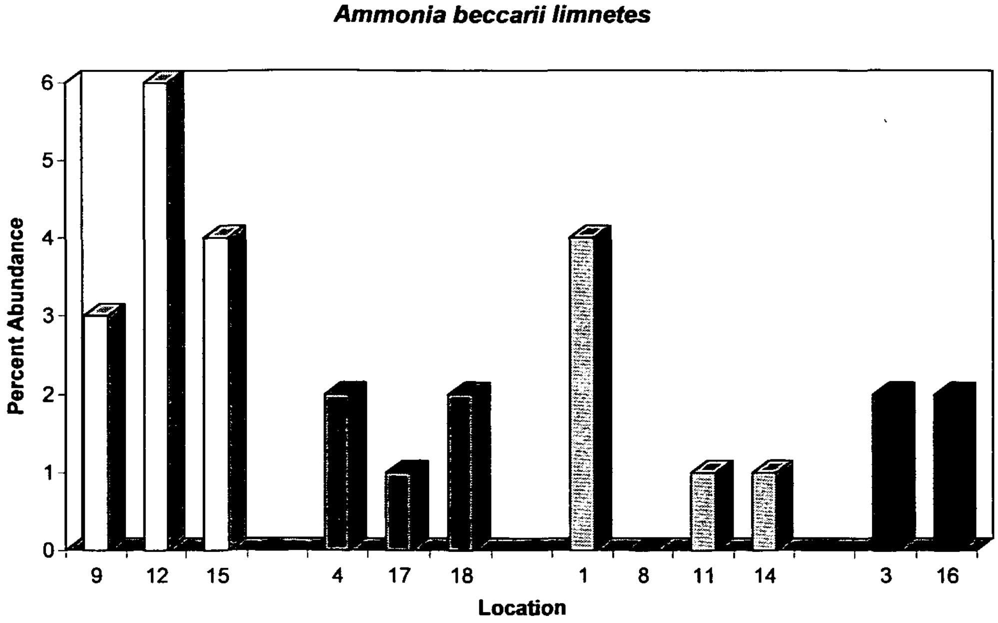


Figure. 9.54 Percentage abundance of *A. beccarii limnetes* within the various Locations, which have been grouped into the four basic sediment facies; muds = purple, mixed = blue, sand = yellow and pink = gravels. NB It forms less than 1 % of the assemblage at Location 8

This subspecies poses a serious taxonomic problem as it is distinguished from the subspecies *batavus* by the lack of umbilical boss, inflections within the ventral sutures and two to three chambers less in the outer whorl. The often small individuals of this species have indistinct ventral sutures and poorly developed umbilical areas. The umbilical boss within *A. beccarii batavus* is particularly prone to damage and removal making the distinction between these two subspecies less clear. Both subspecies exhibit a gradation in taxonomic features with many individuals possessing some features of both subspecies. The small size of *A. beccarii limnetes* suggests that many individuals included within this species may be juveniles and hence taxonomic features are less well developed.

Ammonia beccarii limnetes was never or rarely observed living either within the Sound or the Plym Estuary, although it is principally an estuarine subspecies. This subspecies clearly exists within the dead assemblages but it is quite likely that due to the poor developed and loss of taxonomic features many individuals placed in the *A. beccarii limnetes* subspecies may belong to the subspecies *batavus*. The distinction between these two subspecies may be significantly influenced by their size and state of preservation.

9.16.8. Textularia truncata

This species was irregularly distributed throughout the Sound, being virtually absent from the mud locations, rare in mixed sediment facies, relatively abundant within sand facies and attaining its greatest abundance within gravel facies (Figure 9.55).

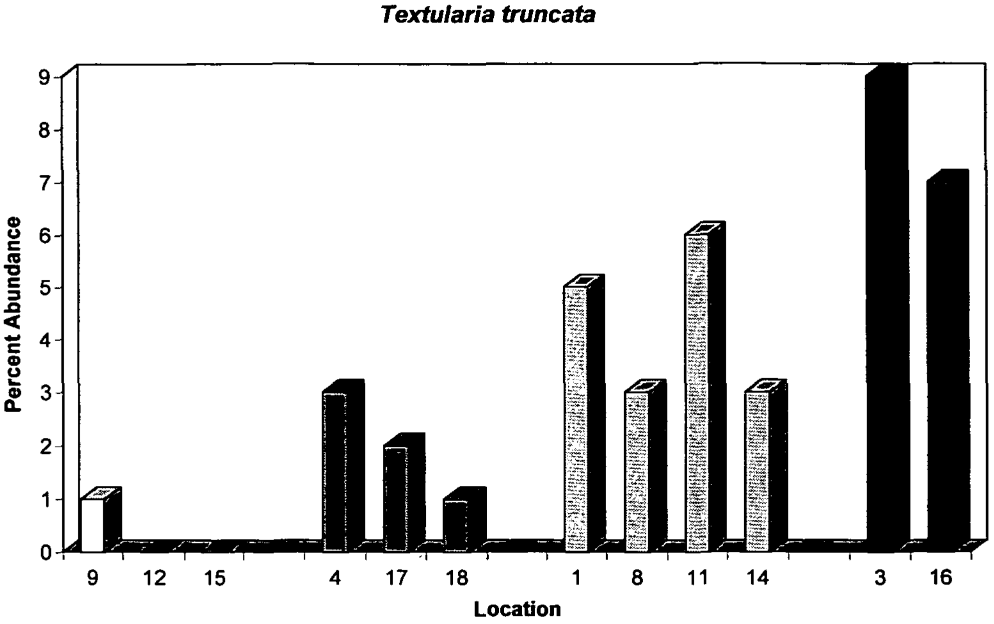


Figure. 9.55 Percentage abundance of *.T. truncata* within the various Locations, which have been grouped into the four basic sediment facies; muds = purple, mixed = blue, sand = yellow and pink = gravels. NB It forms less than 1 % of the assemblage at Locations 12 and 15.

Textularia truncata has a strongly tapered, flattened, pyramidal morphology and is small to medium in size occurring within the 63μm, 125μm and 250μm fractions. This suggests that *T. truncata* has a moderate to high traction velocity depending on size. It may be expected to be most common in sands but may occur in all sediment types. Its lack of abundance within mud, and to a lesser extent mixed sediment, facies suggests that few specimens have been transported into these regions. Its moderate to high abundance in sand facies is not unusual although its highest abundance within shell facies is surprising and is strongly related to its biological distribution. Tests of this species are probably of average strength. They often display cracks and other damage (very often they are missing an ultimate chamber and the pointed proloculus) within the shell gravel facies which suggests that they do not last long in such environments and need replenishing from the live population, as a result the fossil potential of this species is poor.

9.16.9. Quinqueloculina seminulum

This species is well distributed throughout the Sound although it only accounts for a few percent of assemblages. It tends to be least abundant in mud, mixed and sand facies (with the exception of Location 4; mixed). It exhibits its highest and most significant abundance within the shell gravel facies (Figure 9.56).

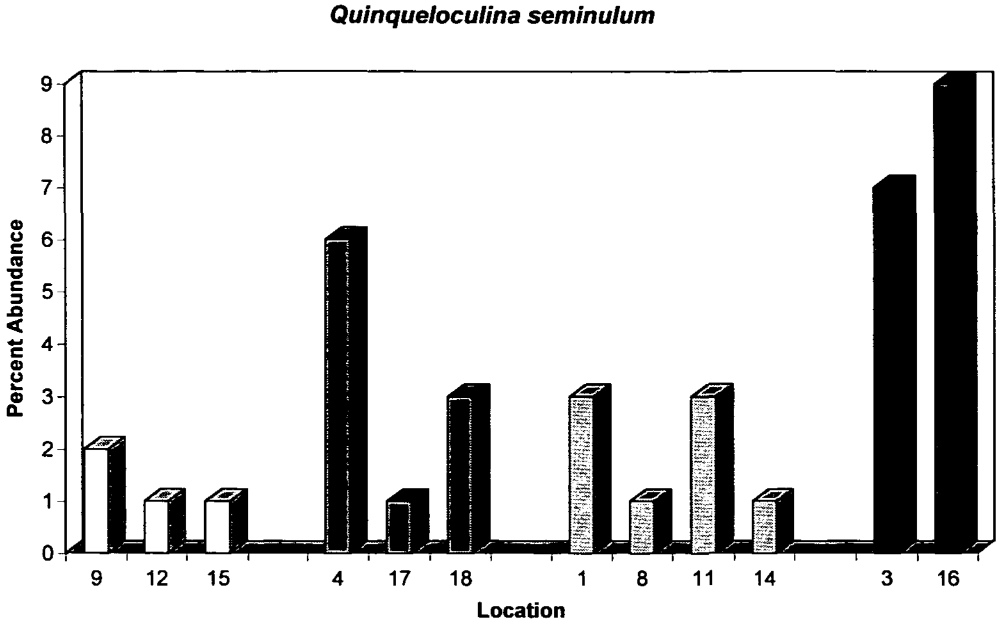


Figure. 9.56 Percentage abundance of *Q. seminulum* within the various Locations, which have been grouped into the four basic sediment facies; muds = purple, mixed = blue, sand = yellow and pink = gravels.

This species ranges in size from 63μm to >500μm but in is most common within the 125μm and 250μm fractions. It has a robust, rounded, fusiform morphology which suggests that depending on its size has a low, moderate or high traction velocity. This species can be expected to occur within all facies but smaller tests may be distributed within muds and mixed facies and the largest tests within gravels. Although the largest specimens occur within gravels this does not explain this species numerical abundance within this facies. Many smaller specimens also occur within the gravel facies. The high abundance of this species within the gravels may be a result of its live distribution combined with its strength and robustness of test, which may resist destruction while other species test are destroyed. This species may then increase in abundance relative to other species over time. Small to medium size tests are distributed throughout mud, mixed and sand facies. This species very robust, fusiform test means that it has a very good fossil potential.

9.16.10. Massilina secans

This species nearly always occurs in relatively low abundance within the Sound. It is virtually absent from the mud facies. It has a low abundance in gravel facies, moderate abundance in mixed sediment facies and is most abundant within sand facies (particularly coarse sand; Locations 8 and 11). See Figure 9.57.

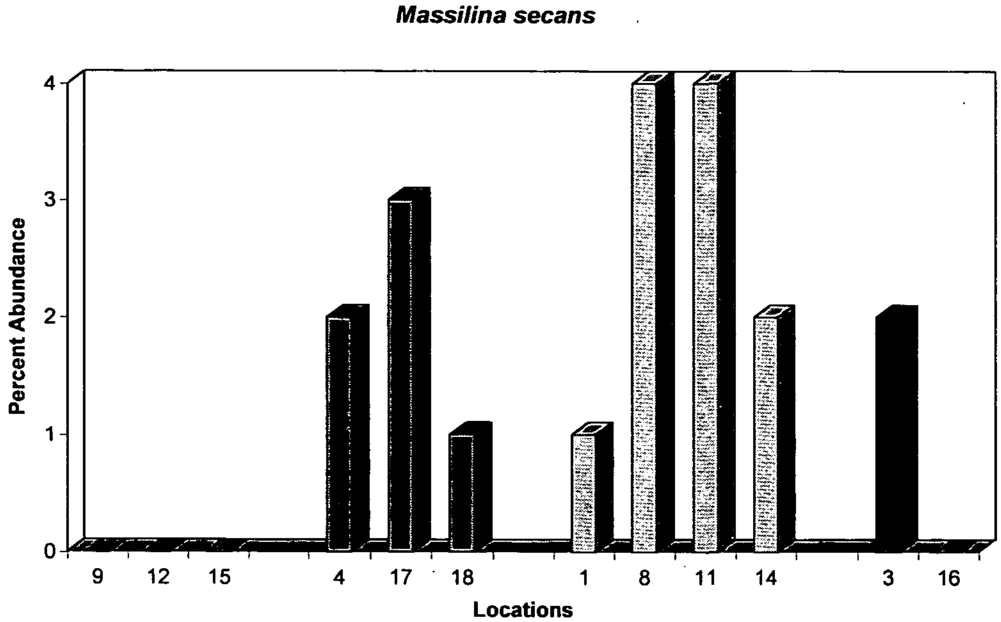


Figure. 9.57 Percentage abundance of *M. secans* within the various locations, which have been grouped into the four basic sediment facies; muds = purple, mixed = blue, sand = yellow and pink = gravels. NB It forms less than 1 % of the assemblage at Locations 9, 12, 15 and 16.

Massilina secans has a large, robust test which is a flatten oval in form when adult. This species is most abundant within the 250μm and 500μm fractions but not uncommon within the 1000μm fraction. Its size, mass, and shape suggests that it has a high to very high traction velocity. Its absence in mud facies indicate that it may not be indigenous to such facies because if it were it would not easily be removed. Its high abundance in mixed and sand sediments imply that it is indigenous to such environments. Its occurrence within gravel facies may be due to post-mortem transport (as the energy in these environments is high enough to exceed the traction velocity of this species) or biological distribution. Many specimens have extremely abraded and damaged tests and this may be due to the large size of the tests incurring greater physical erosion because of its hydrodynamic treatment and/or the empty tests may be extremely long lived (durable) even when damaged. The physical strength of the test of this species ensures that it has a high fossil potential.

9.16.11. Other Important Taxa

Several other species are significant in either all or some of the locations. They generally account for 1 or 2 percent of the entire Plymouth Sound fauna. Because none of these species are abundant, are small in size and fragile in construction they generally have a low fossil potential.

Rosalina williamsoni has a plano-convex morphology. It is small to medium in size, being most common in the 125μm fraction. This species small size suggests it has a low to medium traction velocity. It occurs mainly in mud facies but is most common in shell gravel facies. This is not surprising for an adhering species and probably reflects its live distribution within shell gravels.

Unlike another adhering species with a similar morphology; *Rosalina globularis*'s greatest abundance in mud facies and mixed facies is probably entirely the result of post-mortem transportation as it is unlikely to live in such environments.

Planorbulina mediterranensis has a flattened morphology which implies that it has a high traction velocity for its size and density. Although this species is distributed in most facies, it is most abundant in the shell gravels and some sand facies which reflects its original biological distribution.

Brizalina spathulata has a small test with a flattened, tapered morphology. It is most common within mud facies.

Elphidium williamsoni is indigenous to estuaries, its distribution within the Sound is almost entirely the result of post-mortem transportation. It is widely distributed occurring in all facies. It is, however, most abundant at Location 1 (*H. germanica* the other estuarine species, was also common at this Location).

Species such as *Elphidium gerthi, M. circularis, Q. aspera* (all forms), *C. jeffreysii* and *Q. lata* are less important generally but may be important locally.

9.12. Discussion and Conclusions

The dead assemblage is derived from the living assemblage. If the tests of foraminifera were not destroyed or transported, the dead assemblage would be a perfect reflection of the live assemblage; i.e. an ideal dead assemblage.

Foraminiferal tests are extremely varied in size, composition, shape, density, strength, etc., and the post-mortem agencies (such as transportation, destruction, mixing, winnowing, etc.) can utilise these differences to selectively alter the dead assemblage. The amount of change which occurs depends on many factors including time, original live assemblage, which post-mortem processes are occurring and to what degree they effect individual taxa.

Some dead assemblages are very similar to the live assemblage. They are almost ideal dead assemblages (that is perfect reflections of the live assemblages) in which many of the post-mortem processes are absent or weakly developed. Species production are also similar or balanced by post-mortem processes. The foraminifera within the Plym Estuary (Chapter 4) form one such assemblage. Very few exotic species are present and the proportions of living

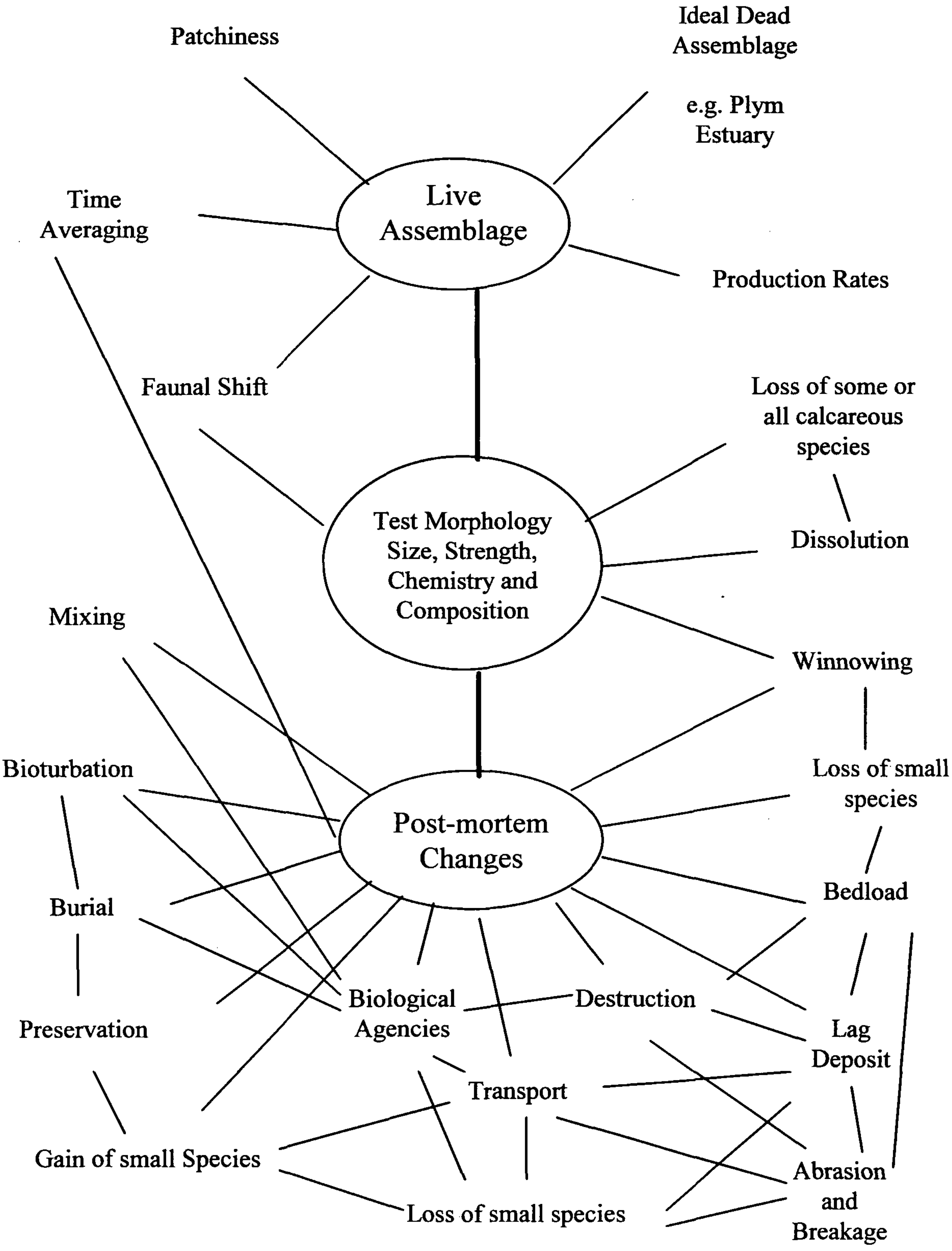


Figure 9.58. Spider diagram showing the processes which affect the creation of the dead assemblage.

and dead species are extremely similar. Analysis of the dead assemblage would result in an accurate reflection of the indigenous live fauna of the Plym Estuary.

Other assemblages are quite different from the indigenous fauna. The processes of destruction and transport can remove the indigenous tests after death and deposit exotic tests from adjacent areas and environments. The principal species at Location 16 within the live and dead assemblage are a good example of this.

The live assemblage was dominated by *T. truncata* and *R. williamsoni* (Chapter 8, Section 8.11) but the dead assemblage (Chapter 9, Section 9.10) by *E. crispum, A. beccarii batavus* and *C. lobatulus*; species which were rare or absent within the live assemblage. Analysis of the dead assemblage would result in a very different, and erroneous interpretation of the indigenous fauna at this location.

Transport is one of the major processes which affect the dead assemblage. Once foraminifera die they are no longer bound to their biotopes. They are winnowed, sorted and transported by currents, waves, tides, sediment slumps and biological agencies, eventually coming to rest on or in sediments in which they are at greater equilibrium, i.e. medium sized tests in sandy sediments. Because new tests are constantly being contributed from the live assemblage and some of the processes of transportation are inefficient, perfect equilibrium is rarely achieved hence coarse sands and gravels may, and do, contain small tests.

The live assemblage varies markedly from season to season and may change significantly over a period of years. The dead assemblage, on the other hand, is not so variable as it represents the sum of many generations of live foraminifera which may have accumulated over many years, as well as, transported exotic foraminifera. In areas of low sedimentation the dead assemblage may represent many hundreds or thousands of years of foraminiferal accumulation.

Different production rates are also important in the generation of the dead assemblage. For example, if species A accounts for 10% and species B for 90% of the live assemblage, but species A has a production rate 10 times that of species B, both species will occur in near equal numbers within the derived dead assemblage.

Test strength, particularly in areas of low sedimentation where there may be a long period of time between death and burial, is very important. A species which is rare within the live assemblage but has a durable and resistant test, may over time, come to dominate the dead assemblage.

Mixed sediment and mud facies exhibited low dominance and high species evenness. Diversity is also high to very high. The assemblages in these facies are dominated by small tests (63µm and 125µm) with only occasional large tests. The condition of the tests was good. Small foraminifera are easily transported as they are equivalent to silt size quartz grains and so deposited where silt is accumulating or present. Because of this the mud and mixed sediment facies may be enriched with many small foraminifera, both indigenous and exotic species.

The original biological distribution of species is an important factor. Where transport and alteration of the assemblage has been small the original biological distribution of species is preserved. *Elphidium crispum* is abundant in the live assemblage in mixed facies. This large species is not easily transported so the tests remain *in situ* in the subsequent dead assemblage.

Variation in species abundance throughout the year is associated with contributions from the live assemblage and to a lesser degree patchiness and post-mortem processes (this was discussed in detail in Chapter 8).

- The dead assemblage is reasonably consistent throughout the year. It represents the sum of many generations of living assemblages as well as exotic elements. It is also potentially shaped by a range of post-mortem processes.

- The variations which are observed within the dead assemblage throughout the year are the result of contributions from the live assemblage, transport of tests into and out of the area and natural variation (patchiness).

- The greatest controlling factor on the distribution of species within the dead assemblage is energy and associated sediment type. Foraminiferal assemblages form four distinct groups which correlated with mud, mixed, sand and gravel facies.

- The original biological distribution is also very important in the distribution of foraminifera; it is best preserved in mud rich sediments.

- Sand and gravel sediments are prone to winnowing and destruction of small tests. They exhibit low to moderate diversities.

- Mud and mixed facies are prone to enrichment of small tests and little removal of indigenous tests. They exhibit high diversities.

CHAPTER TEN

10.0 THE LIVE AND DEAD ASSEMBLAGES

10.1. The Exotic Component

Analysis of foraminiferal samples for both the live and dead fauna (which are retrieved over a significant period of time to allow a reasonably complete picture of the live assemblage to be formed) at the same site and time, can be used in several ways. The most obvious use of such samples and subsequent data is to highlight differences and similarities between both assemblages. The dead assemblage can be examined to identify species (or morphologies) which were present living but are not present within the dead assemblage (this highlights species which are being removed). Similarly some species may be present within the dead assemblage but were absent from the live assemblage. These species are referred to as exotic species because they are not indigenous to the sample site. It may be that the live assemblage was not observed for a sufficiently long period of time to correctly identify all the exotic and indigenous fauna. During this study foraminifera which were not observed living or occurred as one or two live individuals (but had very large dead populations) throughout one year are referred to as exotic.

Exotic foraminifera lived in adjacent areas and environments and the presence of their tests within areas (in which they do not live) can only be due to post-mortem transportation. In its most obvious case, the tests of these foraminifera may be carried in suspension or as bedload from other areas. This process is undoubtedly occurring within the Sound. Post-mortem transport can occur in several other ways, such as within and on vertebrates (fish and birds) and invertebrates (worms, gastropods, echinoids, attached to bivalve shells, etc.) and later excreted, sediment slides and slumps, bioturbation (which particularly effects the vertical movement throughout the sediment), wind, floating plants, etc.

The numbers of exotic foraminifera within an environment depends on several factors. One of the most important of which is the productivity of the area. If no foraminifera are produced then all of the tests present in a sample will be exotic. Another equally important factor is the number of exotic tests available for transport and re-deposition, for if exotic tests are not available or rare, the dead assemblage (with an indigenous fauna of its own) will usually consist of only a small percentage of exotics. Thirdly, the energy and grain size of the area is related to the post-mortem processes which act on the indigenous fauna and will determine to a certain extent if the indigenous fauna is removed or not, or exotic species are deposited.

Taking these points into consideration the percentage of the exotic fauna from the dead assemblage of each location can be calculated and are shown in Table 10.1 and Figure 10.1. The locations can then be compared and the exotic fauna used as a crude measure of post-mortem alteration of the assemblage at that location.

Location Number	Sediment Type	Percent of Exotic Component
8	Coarse sand	**60**
14	Medium sand	**60**
3	Gravel	**53**
16	Gravel	**54**
17	Medium sand (some silt)	**52**
1	Fine sand	**35**
18	Mixed	**30**
4	Mixed	**22**
9	Mud	**20**
12	Mud	**20**
15	Mud	**20**
11	Coarse sand	**5**

Table 10.1. Sample locations are shown and their sediment type denoted. The percentage of exotic fauna is shown in bold.

All of the dead assemblages of Plymouth Sound contained exotic foraminifera. The amount present varies from approximately 20% to 60% of the total dead assemblage. When the locations are divided into the four basic sediment groups, a very clear trend is observed (Figure 10.1). The sands, particularly the coarse sand facies have the highest percentage of exotics and have suffered the most severe post-mortem alteration. Nearly all of the tests of the dead assemblage exhibit signs of damage. The gravel facies have also suffered a high degree of alteration as over 50% of their dead assemblages are composed of exotic species. Again many empty tests exhibit abundant damage. Mixed sediments contain a much lower proportion of exotics and the mud facies have the lowest and most uniform amount of exotic fauna. The empty tests from the mud facies exhibit some damaged tests but most are in good condition. The very low abundance of exotic foraminifera from Location 11 is due to several possible exotic species being represented by a few live individuals (i.e. most of the tests of those species may have been transported, but because a few live individuals of those species are present they cannot be regarded as exotic).

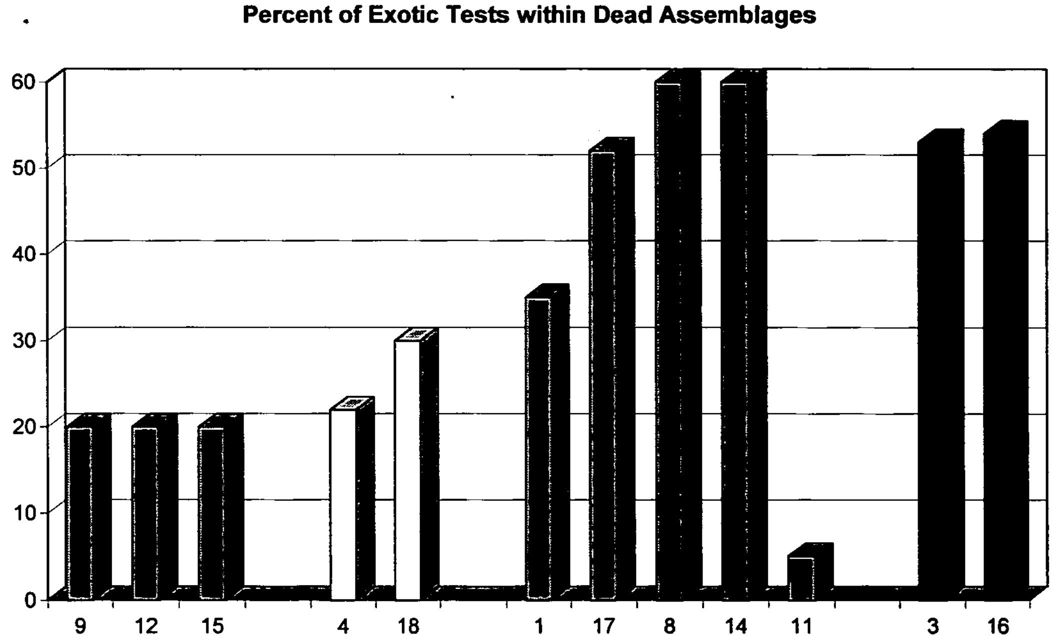


Figure 10.1. The proportion of exotic tests within the dead assemblages of Plymouth Sound. The locations are divided into the four basic sediment types. From left to right; mud, mixed, sand and gravel.

The distribution of the exotic faunas correlates very well with the energy of the locations and the diversity and productivity of the indigenous fauna. The sand facies experience some of the highest energies and have the sparsest live faunas with low production rates (see Chapter 8). The mud facies have some of the highest productivities and lowest energy levels.

For low energy mud facies, high live diversities mean that many foraminifera transported in this area are more likely to have live counterparts and are not referred to as exotic, even though some of their tests were produced elsewhere and transported to these sites. The low energy conditions also mean that foraminiferal tests can only be transported during periods of high turbulence (storms) and also show a bias towards small, light, easily transported forms (not all of the potentially exotic forms can be transported). Indigenous tests in low energy facies are not easily winnowed and removed. The high productivity of these facies means that a large quantity of indigenous tests are produced and, if not removed or destroyed a large amount of exotic tests have to be deposited to form a significant proportion of the dead assemblage with a large range of test sizes.

Generally speaking, the opposite is true for sand and gravel facies which not only have low productivities but may loose their indigenous empty tests through winnowing and destruction. The mean higher energy of these sites means that there is more time for exotic forms to be transported to these areas enriching a smaller (in terms of diversity and absolute abundance) dead assemblage.

10.2. Missing or rare species

Analysis of both the live and dead assemblages revealed that at all locations many live species were not represented proportionally within the dead assemblage and while were quite rare or absent from the dead assemblage (although abundant within the live assemblage). There are several reasons why this may occur. Differential production rates may, over time, create a very different dead assemblage from the live assemblage. Lower production rates of these species may mean that they are common or dominant within the live assemblage but much rarer within the dead assemblage, particularly if the dead assemblage has been enriched with many exotics, which further reduce the relative abundance of these species tests. Transport and destruction of the empty tests of these species may be occurring, which can also reduce their abundance within the dead assemblage. This can be of particular importance if a species has a test with a low traction velocity. The durability or fragility of a test can be of great importance in a dynamic environment where sedimentation rates are not high. A tough test can become far more abundant within the dead assemblage than it was within the live assemblage because of the selective destruction of other tests. Finally, but also importantly, the pattern of distribution and abundance of live foraminifera built up over the year, may be un-characteristic of the live assemblage observed over one or several years.

Several species seem to be far more abundant within the dead assemblage. *Elphidium crispum* is common living at three locations, but is reasonably abundant dead throughout the Sound, particularly in coarse grained sediments (sands and gravels). It would seem that the tests of this species, once produced, are redistributed after death to coarse grained sediments where these large tests are in hydrodynamic equilibrium. The tests of *A. beccarii batavus* probably undergo a similar process.

Eggerelloides scabrum is generally rare in the live assemblages of Plymouth Sound but is a common component of the dead assemblage at most locations. The tests of this species are relatively well cemented and of medium size which suggests that it may be extensively transported. Nonetheless its dead abundance at many locations throughout the Sound can only be due to this species having a high rate of productivity, the tests having more than average resistance to destruction, or individuals being transported into the Sound from other areas (net transport into the Sound).

Textularia truncata, R. williamsoni and *P. mediterranensis* are species which only occur living in reasonable abundances within the shell gravel facies. Their empty tests are rare with this facies but significant in fine sand and mud-rich facies. It seems most likely that the empty tests of these species are transported (dispersed) to adjacent areas and destroyed.

Other species which appear to be more common within the dead assemblages, but are rare and/or restricted to one or two locations are *C. jeffreysii, S. concava* var. *loeblichi*, both species of the genus *Miliolinella*, *P. bowmanni* and all species of the genus *Brizalina*. The tests of these species probably undergo considerable transport and destruction.

10.3. Exotic Species

Exotic tests at most locations are composed of the same several species. Table 10.2 shows the 11 locations sampled within the Sound where exotic species occurred within the dead assemblages. By far the most abundant exotic species was *C. lobatulus* which occurred at all locations and sometimes accounted for nearly half of the dead assemblage.

Locations	**1**	**3**	**4**	**8**	**9**	**12**	**14**	**15**	**16**	**17**	**18**	Average
C. lobatulus	14	18	8	48	2	7	40	9	10	41	21	**20**
R. globularis	3	2	2	2	6	3	0	2	2	1	2	**2**
H. germanica	6	4	3	2	6	0	1	0	0	1	2	**2**
E. crispum	0	11	0	0	0	0	0	0	10	0	0	**2**
A. b. limnetes	4	2	2	0	0	6	0	0	2	1	2	**2**
A. b. batavus	4	3	0	0	2	2	0	2	3	0	1	**2**
E. williamsoni	4	2	2	2	2	0	2	0	0	1	2	**2**
C. pseudoungerianus	0	0	0	0	0	0	0	0	10	0	0	**1**
Q. seminulum	0	7	0	0	0	0	0	0	0	0	0	**1**

Table 10.2. Nine of the most important exotic species are shown with their percentage abundance at each location. An average value is shown in the right hand column.

Within the sand facies locations *C. lobatulus* is the most important exotic species. It makes up approximately one third of the dead assemblages. Also important are the estuarine species *H. germanica* and *E. williamsoni* (Table 10.3). The high abundance of *C. lobatulus* is probably due to its medium to large size which is close to equilibrium (hydrodynamically) with sand size grains.

Sand facies locations	**1**	**8**	**14**	**Average**
C. lobatulus	14	48	40	**34**
H. germanica	6	2	1	**3**
E. williamsoni	4	2	2	**3**
R. globularis	3	2	0	**2**
A. b. limnetes	4	0	0	**1**
C. pseudoungerianus	4	0	0	**1**

Table 10.3. Six of the most important exotic species are shown with their percentage abundance at each sand facies location. An average value is shown in the right hand column.

Within the mud facies of the Sound *C. lobatulus* and *R. globularis* are the most important exotic species (Table 10.4). The presence of *C. lobatulus* is probably the result of its great abundance. *Rosalina globularis* is, however, most abundant in mud rich facies.

Mud facies locations	9	12	15	Average
C. lobatulus	2	7	9	**6**
R. globularis	6	3	2	**4**
H. germanica	6	0	0	**2**
A. b. limnetes	0	6	0	**2**
C. pseudoungerianus	2	2	2	**2**
E. williamsoni	2	0	0	**1**

Table 10.4. Six of the most important exotic species are shown with their percentage abundance at each mud facies location. An average value is shown in the right hand column.

Mixed sediment facies are again dominated by *C. lobatulus* while other exotic species are generally rare (Table 10.5). This is probably due to the mixed sediments being slightly coarser and allowing the inward transport of larger tests.

Mixed facies locations	4	17	18	Average
C. lobatulus	8	41	21	**23**
H. germanica	3	1	2	**2**
A. b. limnetes	2	1	2	**2**
E. williamsoni	2	1	2	**2**
R. globularis	2	1	2	**2**
C. pseudoungerianus	0	0	1	**0**

Table 10.5. Six of the most important exotic species are shown with their percentage abundance at each mixed facies location. An average value is shown in the right hand column.

Shell gravel facies locations	3	16	Average
C. lobatulus	18	10	**14**
E. crispum	11	10	**11**
A. b. batavus	0	10	**5**
Q. seminulum	7	0	**4**
C. pseudoungerianus	3	3	**3**
H. germanica	4	0	**2**
A. b. limnetes	2	2	**2**
R. globularis	2	2	**2**
E. williamsoni	2	0	**1**

Table 10.6. Six of the most important exotic species are shown with their percentage abundance at each shell gravel location. An average value is shown in the right hand column.

The shell gravel facies show a very different exotic fauna to the rest of the Sound (Table 10.6). *Cibicides lobatulus* is the most abundant species but *E. crispum* and *A. beccarii batavus* are also important. The dominance of large exotic species is the result of the coarse grained high energy environments of the shell gravel facies. Small exotic tests are either being transported through the shell gravels or are trapped between grains.

The greatest disparity between the live and dead fauna of Plymouth Sound is due to the presence of *C. lobatulus*. This species was extremely common within all the dead assemblages and is one of the most abundant species in Plymouth Sound. Very few individuals were found correctly stained; several took on a poor pink stain which was dismissed as invalid. It is almost entirely absent from the live assemblages, a fact which has been noticed by previous workers (Murray, 1970). During sampling, several large shell, rock and plant fragments were examined for this attached species and although some did bear several specimens, none stained red. These fragments did, however, reveal that this species has an attached mode of life and that it usually attaches itself to large surfaces and not grains within loose sediment. Atkinson (1969) stated that the morphology of *C. lobatulus* and *R. globularis* are ideally suited to an attached life on algal fronds. Hawood and Haynes (1976) examined a bivalve shell from Plymouth Sound and found a total of 22 live species attached to it. The most abundant species was *C. lobatulus* but other important species such as *C. jeffreysii*, *Spiroplectammina wrightii* and *R. globularis* were also noted. These later species are also rare live and relatively common dead within the Sound. Sturrock (Ph.D. thesis) identified a range of species (*C. lobatulus, R. globularis, C. jeffreysii, S. wrightii, M. subrotunda, M. circularis, Acervulina inhaerens* and various species of *Trochammina*) which live attached to various substrates including bivalves, hydroids, Bryozoa and pebbles. Most of these species rarely if ever occur live in the loose sediment of Plymouth Sound but are relatively abundant dead in this sediment. Because of this mode of life the empty tests are eventually contributed to the sediment with no live individuals ever having been observed. Although this and other attached species are regarded as exotic, they are more specifically exotic to the sediment not necessarily the area or location. The abundance of *C. lobatulus* indicates that it has a very large standing crop, is very productive or its tests are very resistant to destruction (or a combination of these factors).

Haynesina germanica and *E. williamsoni* are found in all sediment types throughout, and outside, the Sound. Their small rounded planispiral tests are easily transported and this is probably the reason for their extensive distribution. Although they have been recorded as living in parts of the Sound they are extremely rare live. These species are estuarine and extremely abundant within the estuaries that feed into the Sound. Together they account for over 95% of the live and dead foraminiferal fauna of the Plym Estuary (Chapter 4) and they are very common within the Tamar Estuary (Murray, 1961; Ellison, 1981). The estuaries are the major source of most of these tests encountered within and outside of the Sound. They indicate a net transport of estuarine foraminifera seawards (probably in suspension).

Rosalina globularis is a species with an extensive distribution. Similar to *C. lobatulus* in morphology, it too was rarely recorded living within the Sound. It is likely that this attached form either lives in areas of the Sound that could not be sampled such as rocks, shells or seaweeds or it does not live within the Sound at present. Sliter (1965) found an association between *R. globularis* attached to the corraline algae *Corallina officinales*, while Delaca and Lipps (1972) observed that the same species attached itself to a range of substrates including algae, wood, seaweeds, molluscs and crustaceans. This may also be the case for *C. pseudoungerianus* which is very similar in morphology. Its test is medium to small in size and is probably easily transported, thereby accounting for its abundance in the finer grained sediments of the Sound.

Ammonia beccarii limnetes is an exotic subspecies which was rarely observed living within the Sound. Taxonomically this subspecies has proved problematic (See Chapter 9, Section 9.16.7 and Chapter 3). Traditionally this is a euryhaline or estuarine subspecies of *Ammonia beccarii*. It was, however, not recorded within the Plym Estuary and is not common within the Tamar Estuary. It may be that relatively small populations of this species live within the Plymouth Sound region. Under certain temperatures Bradshaw (1961) found that several subspecies could develop from a single stock of *Ammonia beccarii*. This process may account for the tests of *A. beccarii limnetes*.

10.4. Dominance of the Live and Dead Assemblages

The dominance plots simply compare the dominance of the species within the live and dead assemblages of the various locations (Figures 10.2 and 10.3). Most locations have a live assemblage which has a higher species dominance than the dead assemblage and is less diverse than the dead assemblage (higher up the Y axis and shorter along the X axis). The exception to this is location 8 which has greater species dominance within its dead assemblage (10.2). This indicates that the live assemblage has a high degree of species evenness. Location 12 exhibits the live assemblage with the highest species dominance. The mud rich Locations 4, 9, 12, and 15 show the greatest difference between the dominance of the live and dead assemblages, while the sand facies 1, 11, 8, 14 and 17 exhibit the smallest difference between the dominance of the live and dead assemblage, showing that these assemblages are overall quite similar while the mud facies are very different in terms of species dominance.

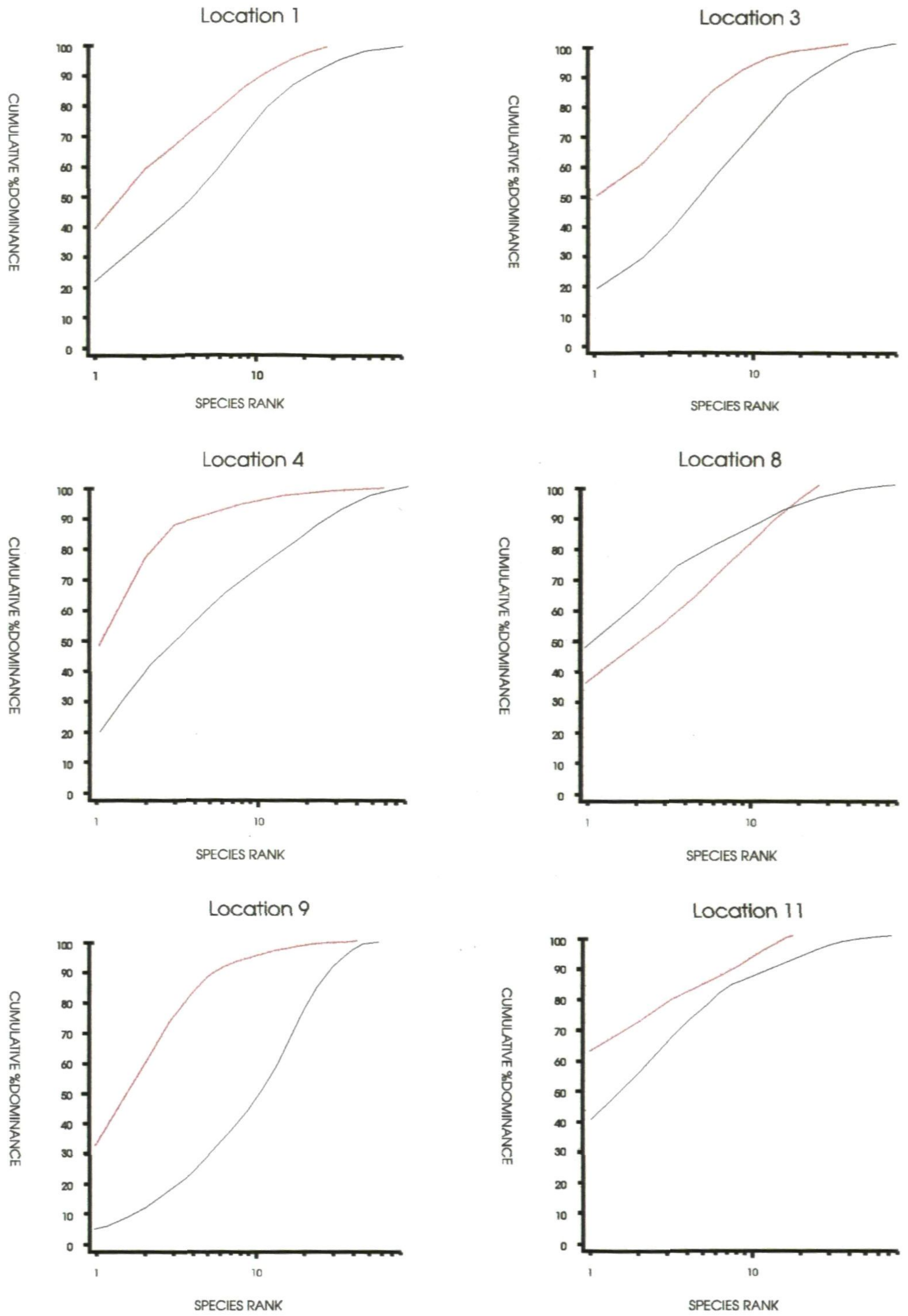


Figure 10.2. Dominance plots for live (red) and (dead) assemblage for locations 1 to 11.

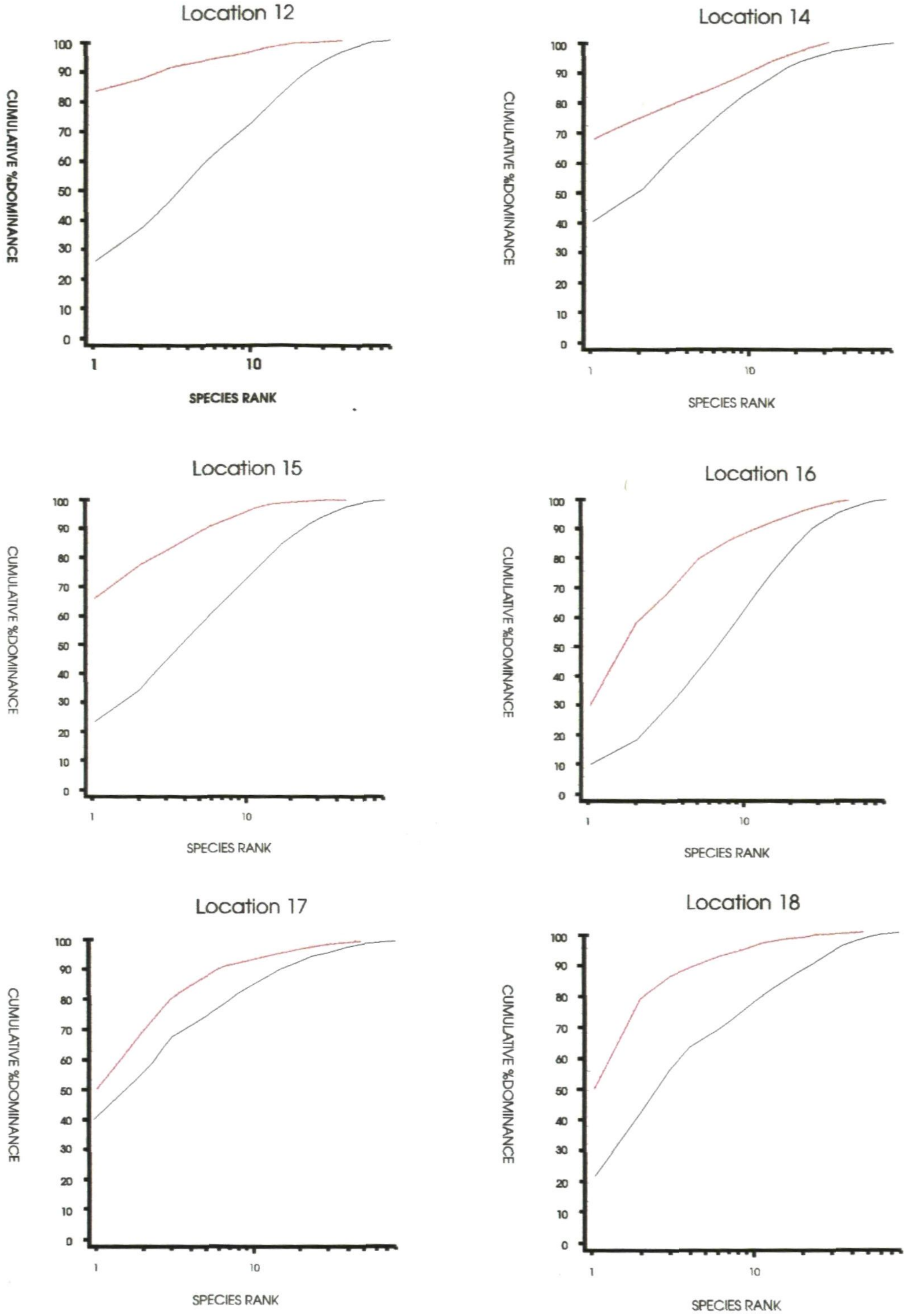


Figure 10.3. Dominance plots for live (red) and (dead) assemblage for locations 12 to 18.

10.5. Triangular Plots

The yearly dead and live assemblages have been plotted on triangular diagrams to highlight their differences and similarities (Figure 10.4 a & b). The majority of assemblages, both live and dead, plotted within the bottom left corner of the diagram indicating that these samples are dominated by hyaline tests. The live assemblages of Location 8 show a considerable number of porcellaneous tests. The same is true to a lesser extent for the Location 16 dead assemblages. Both of the live shell gravel assemblages show a higher number of agglutinated foraminifera. Figure 10.4b shows the areas occupied by all of the live and dead assemblages. The area occupied by the dead assemblages can be seen to be much smaller indicating greater similarity between the dead assemblages than the live. Post-mortem processes would appear to reduce the differences between assemblages perhaps by removing and destroying fragile and rare species, while transporting common species into these assemblages. The live assemblages occupy a far larger area and consequently are far more different from each other in terms of the proportion of tests and their composition. Many of these differences are later eroded after death by post-mortem alteration of the assemblages.

The overall live and dead assemblages for Plymouth Sound shown in Figure 10.5 indicate the close similarity of these assemblages. Both assemblages plot in the far bottom left corner of the diagram testifying to their almost complete dominance of hyaline tests. The most significant difference is the small (4%) increase of agglutinated tests from live to dead assemblages. This small shift tends to indicate that (assuming a reasonably typical live assemblage) agglutinated tests are either more durable than other tests types (this does not really seem likely) or that this group of foraminifera are more productive.

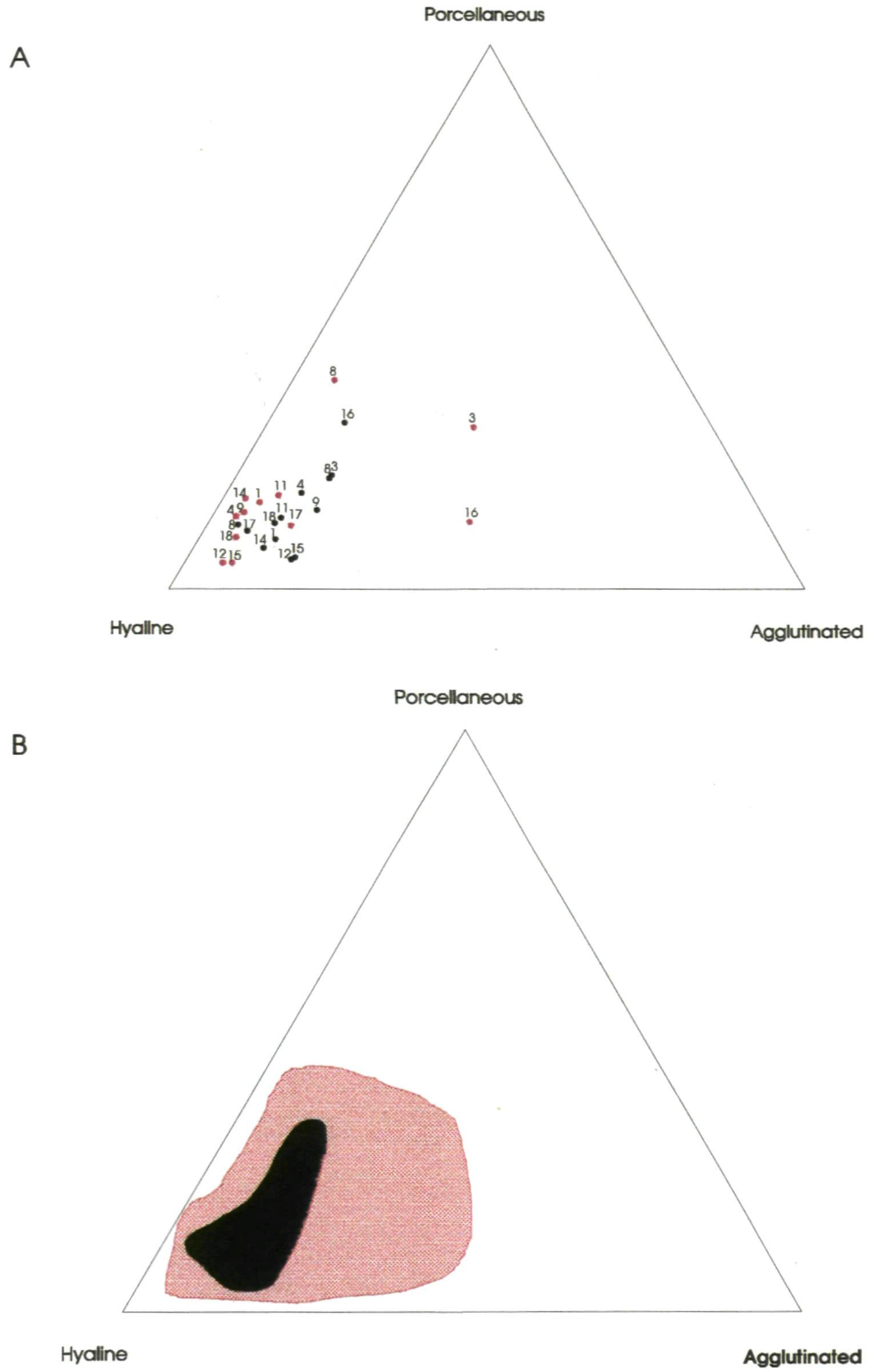


Figure 10.4. Triangular plots of the years assemblages for all of the locations of Plymouth Sound. Figure **A** shows the individual locations. Figure **B** shows the area occupied by dead (black) and the live assemblages (red).

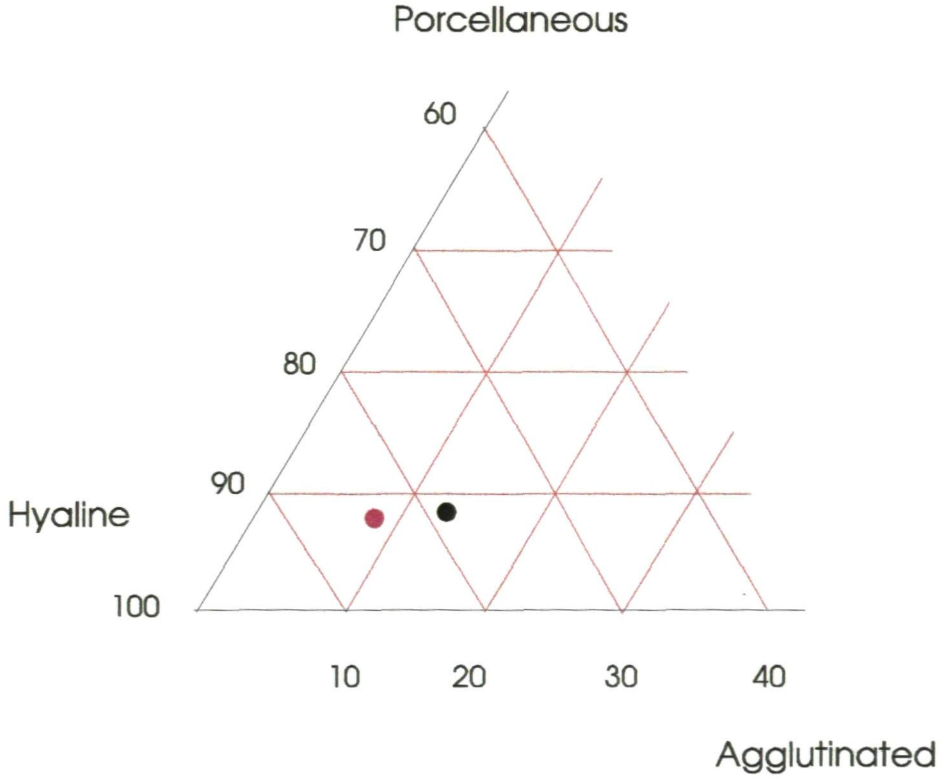


Figure 10.5. Triangular plot showing the total live (red) and dead (black) assemblages of the Plymouth Sound foraminifera.

Figure 10.6 shows all of the live and dead assemblages from sand facies plotted on a triangular diagram. The live assemblages occupy a larger area than the dead assemblages indicating that they are more varied than the dead assemblages. The dead assemblages drawn from those live assemblages show a reduction in porcellaneous tests and a gain of hyaline tests. This suggests that porcellaneous forms are either being removed or destroyed after death (or low productivity) or that the dead assemblage is enriched by other tests types after death or that the porcellaneous taxa have lower production rates.

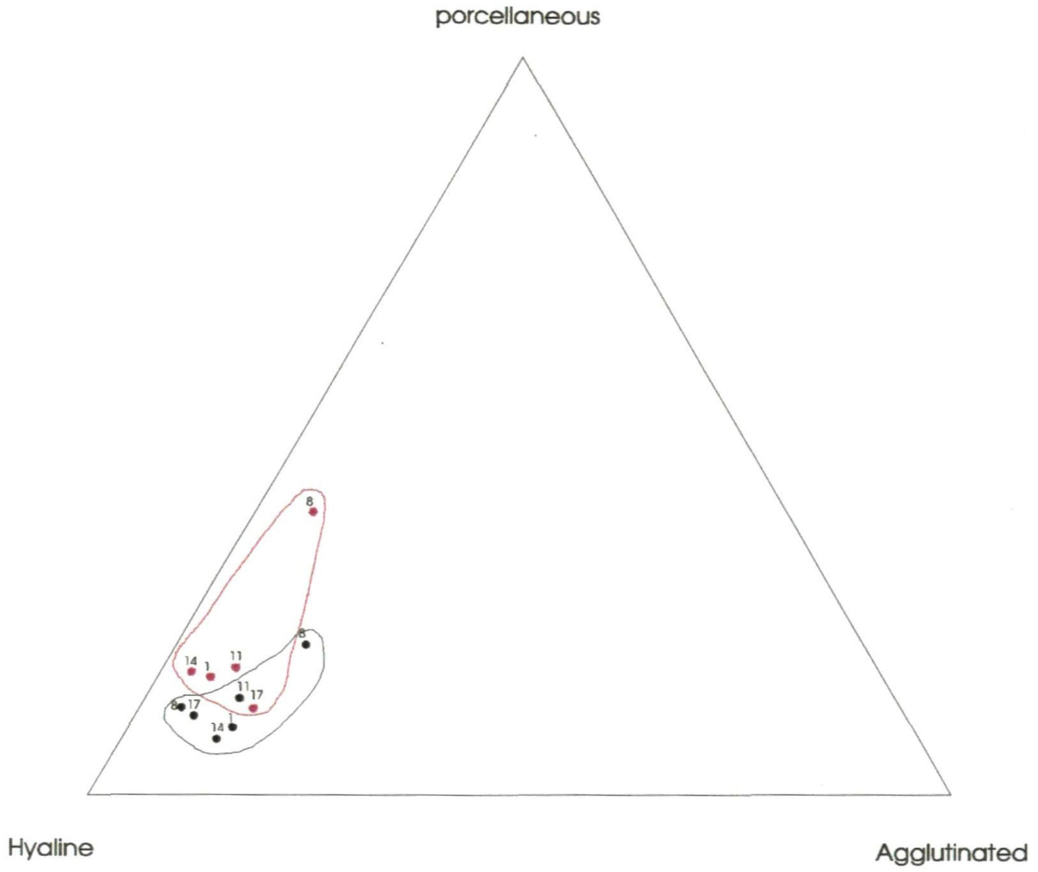


Figure 10.6. Triangular plot showing the sand facies live (red) and dead (black) assemblages of the Plymouth Sound foraminifera.

The live and dead assemblages of mud and mixed facies show a similar trend and have been plotted on the same triangular diagram (Figure 10.7). The dead assemblages occupy a larger area indicating that they are more variable than the live. The live assemblages plot in a tight cluster in the bottom left of the diagram showing that they are all very similar. The dead assemblages formed from the live assemblages show an enrichment of agglutinated forms which may be due to transportation of these forms into the assemblages or a higher production rate of foraminifera with this tests type. The fact that the dead assemblages are more variable than the live assemblages from which they are derived, is strongly suggestive of post-mortem alteration.

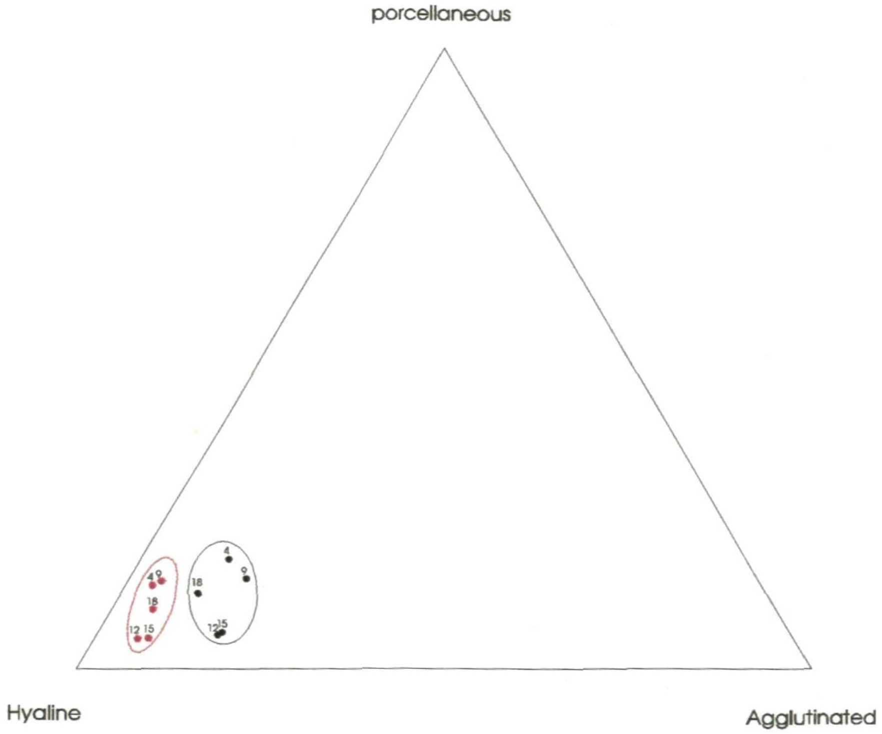


Figure 10.7. Triangular plot showing mixed sediment total live (red) and dead (black) assemblages of the Plymouth Sound foraminifera.

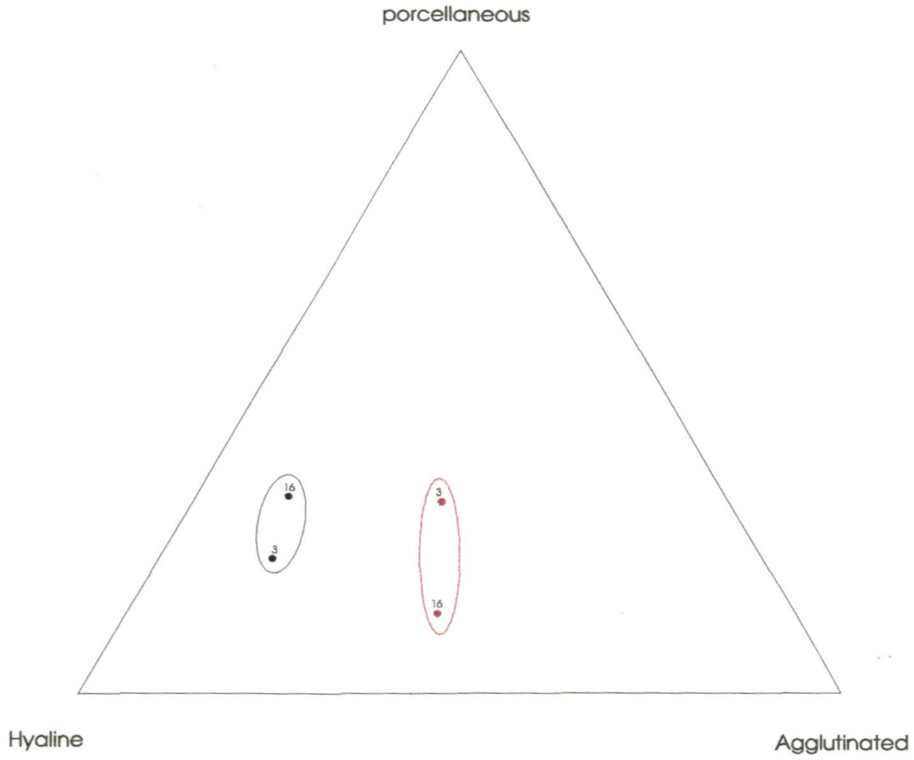


Figure 10.8. Triangular plot showing the shell gravel live (red) and dead (black) assemblages of the Plymouth Sound foraminifera.

Live and dead assemblages from the gravel facies exhibit the greatest differences (Figure 10.8). Both sites show slightly different trends; overall the live assemblages are composed of a significantly greater amount of agglutinated tests (approximately 35%). The loss of agglutinated foraminifera which accompanies the shift from live to dead assemblage is due to post-mortem winnowing and destruction which is further exacerbated by the addition of hyaline tests after death. Location 16 also suffers enrichment of porcellaneous tests while Location 3 gains in porcellaneous tests after death. These changes are probably also due to post-mortem alteration.

10.6. Conclusions

- The live and dead yearly assemblages from the same locations show several distinct and important differences:-
    1. The proportions of the same species are often quite different within the live and dead assemblage.
    2. The absolute abundance of tests within both assemblages are quite different; the dead assemblage is composed of many more tests.
    3. The dead assemblage is often far more diverse

- The dead assemblages contain varying numbers of exotic species. The most common group of exotic species belong to the plano-convex morphogroup (H4); *C. lobatulus* is by far the most abundant. The marine species may live within the Sound but were rarely encountered living within the loose sediment. The other notable group of exotic species is composed principally of *H. germanica* and *E. williamsoni*. These species are probably transported into the Sound from the Tamar and Plym Estuaries.

- Some common live species are absent form the dead assemblages; this highlights that post-mortem alteration is occurring.

- Post-mortem processes effect the assemblages at all the locations analysed.

- Mud facies show the least degree of alteration and a relatively small percentage of empty tests show damage. The proportion of exotic species is also low (approximately 20%). Mixed sediment facies are similar to mud facies but exhibit slightly higher degrees of alteration.

- Sand facies show the highest degree of alteration with nearly all tests being damaged. The proportion of exotic species is typically high, reaching as much as 70%.

- The gravel facies exhibit a high degree of alteration with many of their indigenous species being removed after death. Up to half the tests of the dead assemblage show damage and breakage. Exotic species make up approximately half these assemblages.

- The overall shift from live to dead is reflected by a gain in agglutinated tests, primarily due to *E. scabrum*.

- The implications for fossil assemblages are:-
    1. Sand and gravel facies will probably show the greatest alteration
    2. Mud and Mixed sediment facies show moderate alteration
    3. Plano-convex forms are likely to indicate the presence of hard substrates (pebble, shell, wood, seaweed, etc.. Low energy facies often show an enrichment of small foraminifera.
    4. The degree of damage cannot be used to identify exotic species except possibly in low energy environments

CHAPTER ELEVEN

11.0 Long Term Faunal Change

11.1. Introduction

Plymouth Sound has had a long history of foraminiferal study beginning in 1895 with Lister's study of *Polystomella crispa* (now *E. crispum*) and ending with the present study (for the time being). The numerous foraminiferal studies vary greatly in terms of the levels of data which they provided, those of Lister (1895), Jepps (1942), Myers (1942a), Buchanan and Hedley (1960) and many others are studies based on a particular species and they have little bearing in the overall foraminiferal assemblages of Plymouth Sound. Other studies such as Worth's (1904) faunal descriptions of the Plymouth region are published as brief papers, the original data and specimens are loss or unobtainable. More recently studies such as those of Ellison (1984) and Castignetti (1996) concentrate on a specific area adjacent to Plymouth Sound (the Tamar and Plym Estuaries respectively) and although interesting, are not directly relevant.

The Plymouth Marine Laboratory has had a long history of marine floral and faunal research and the general ecology of Plymouth Sound and surrounding areas (Maddock and Swan, 1977; Southward, 1983, 1988 and 1991; Southward *et al.,* 1995 and many others). These studies highlight gradual changes in the general ecology of Plymouth Sound and South West Britain and may have a direct bearing on the foraminiferal assemblages of the Sound.

Part of C. J. Manley's (1997) research on the effects of heavy metals on foraminiferal cultures is also concerned with the distributions of wild populations and the effects of biotic variables such as bacteria, organic content of sediments, etc., from the Plymouth Sound area for 1993 to 1994. Her findings have not yet been published.

Several foraminiferal studies provide relevant data which can be compared and contrasted with the data from the present study to identify any differences, similarities and long term faunal changes. They are as follows:-

Author	Time Period the study covers	Area of study
Heron Allen & Earland	1916-1920	Several locations within the Sound
Murray	1962	Several locations within the Sound
E. C. Manley (unpublished)	1973-1974	Jennycliff area
Castignetti (undergraduate research)	Approximately the last 12 000 years	Two boreholes from the Palaeo-Tamar within Plymouth Sound

Table 11.1 Table showing relevant foraminiferal studies, the period the study covers and the location within Plymouth Sound.

The aim of this Chapter is to compare the relevant studies shown in Table 11.1 in order to build up a picture of the foraminiferal assemblages of Plymouth Sound through time. The largest problem is that of comparable data. As most of the studies were carried out by different people at different times, there is a lack of uniformity between processes and techniques employed by various workers. For example Heron-Allen and Earland's study was undertaken before the use of rose Bengal or any other protoplasmic stains, so data regarding live foraminifera are rare or absent. Heron-Allen and Earland's is also a qualitative study with one or several individuals chosen at random to represent a species rather than abundant species being represent by many individuals and vice versa. Murray's (1965) study was based on seasonal sampling (winter, spring and summer). The exact size of samples is not known (due to problems in their retrieval). Manley dived to obtain samples (of fixed volume) in a sealed container from several sites at a weekly frequency but unfortunately much of his samples have subsequently been lost. The study was also restricted to the eastern Sound in particularly Jennycliff. Sturrock sampled to the south and south west of the Sound in May, September and October 1978 as part of a larger study and because of this his data are only of passing interest. Castignetti's study on the fossil fauna of two boreholes is obviously very different from studies based on modern fauna.

11.2. DESCRIPTIONS AND RESULTS OF THE RELEVANT STUDIES

11.2.1. The Heron-Allen and Earland Collection

Heron-Allen and Earland sampled the Plymouth region between 1914 to 1920, their collection is based on a range of stations from Plymouth Sound to the Eddystone and across into Cornwall. The following 4 stations were located within the Plymouth district and are comparable to the locations of the present study.

> Station 1: Inside Drake's Island at about 7m depth (the sample was rich in algal matter as is the case at present) it consisted of "little sand and mud", 4 cc of processed material was examined.
>
> Station 3: A shore gathering of black mud from Rum Bay (near the Mountbatten breakwater where the present location 15 is situated). 1.2 cc of processed sediment was examined.
>
> Station 6: A dredging from Cawsand Bay (to the South West of the Plymouth Breakwater) at about 6 m, 12 cc were examined yielding many fine forms.
>
> Station 8: a small amount of material from the J.J. Lister collection probably from Drake's Island or Cawsand Bay.

Sample preparation included sieving the samples over various grades. A process of elutriation (the separation of particles on the bases of density by suspension within a flow of liquid or gas) primarily to clean the sediment by the elimination of organic plant material and debris. A floatation process was used to concentrate foraminifera within the sediment.

Two of the four stations were sampled from the shore (littoral), while the other two were sampled by boat probably using a dredge. These are quite different methods to those employed by the other studies.

The author has examined the plates and descriptions of foraminifera from their paper entitled "The foraminifera of the Plymouth district" where 258 specimens are described and recorded, and has studied the specimens themselves situated in the Natural History Museum were approximately 94 species are present in total for the Plymouth district.

The Heron-Allen and Earland study poses the greatest problems for a comparison with other studies. Many of the generic names have changed and some species names proved impossible to tie down (not figured in their papers or present in their collection). Notwithstanding these differences a qualitative comparison has been made (Appendix 6).

11.2.2. Murray's Study - The Foraminiferida of the Plymouth Region

Murray sampled a transect from the Tamar Estuary to the Eddystone lighthouse but only the samples taken within Plymouth Sound are of direct relevance to the present study. A total of 5 stations were sampled during the spring and summer of 1962. All of these stations coincide with locations sampled in the current study. Due to poor weather no winter data was available for these stations. Data on live foraminifera are available for all stations for both seasons with the exception of Barn Pool, for which no summer data were available. Data for dead foraminifera were only available for Melampus Beacon, Location 4 (station number 258) and Queen's Ground during the spring (see Table 11.2).

Location	Station Number	Spring	Station Number	Summer
Drake's Island	256	Live	288	Live
Barn Pool	255	Live		
Melampus Beacon	257	Live and Dead	289	Live
Location 4	258	Live and Dead	290	Live
Near Queens Ground	259	Live and Dead	291	Live

Table 11. 2 Murray's data for the Plymouth Sound area, showing location, station numbers and type of data for each season.

As described by Murray (1965) live foraminifera were very sparse at all stations; no species occurred in abundances of more than 20 or 30 individuals and no samples contained more than 100 live individuals in total. This is in contrast to foraminiferal abundance within the present study which although on occasion low were often an order of magnitude higher.

The most abundant species at Drake's Island were *E. scabrum* and *A. beccarii batavus* all other species were very rare but included *N. depressulus, H. germanica* and *E. articulatum* = *E. cuvillieri*. All of these species are very common in the present study the notable exception is the absence of *Q. oblonga* in Murray's samples as it is the second most abundant species in the current study at Drake's Island (Location 14).

The principal species at Barn Pool were *C. jeffreysii, A. beccarii batavus* and *Protelphidium anglicum* = *H. germanica*. Only *A. beccarii batavus* was abundant in the current study at Barn Pool. *Haynesina germanica* was rare and *C. jeffreysii* was absent (although it was present at other mud rich locations).

Melampus Beacon had a sparse fauna in the current study but in Murray's study the fauna was one of the more abundant for the Sound. The most abundant species were *B. pseudopunctata, Q. auberiana* and *B. spathulata* which is very different from the current fauna dominated by *E. crispum, Q. seminulum* and *A. beccarii batavus*. The stark faunal differences are suggestive of a different sedimentary facies.

Stations 290 and 258 at the current Location 4 were dominated by *A. beccarii batavus, E. selseyensis, B. pseudopunctata* and *E. scabrum*. In the current study only *A. beccarii batavus* was abundant although *B. pseudopunctata* and *E. scabrum* were present. The area is now dominated by *E. crispum*.

The area of stations 291 and 259 is very near Queen's Ground. The fauna was sparse, the most abundant species being *B. pseudopunctata, E. scabrum* and *Q. auberiana*. Which is very different from the present fauna dominated by *R. williamsoni* and *T. truncata*. These differences are again very suggestive of different facies.

The dead assemblages were dominated by *A. beccarii batavus* with *C. lobatulus* being common, as was *H. germanica*. This is very reflective of the current situation for Plymouth Sound generally.

The location of Murray's stations and those of the present study may not coincide accurately further more, sedimentary facies may have shifted or changed, all of which can result in very different assemblages. These facts probably explain most of the differences between both assemblages.

The paucity of live species cannot be explained by such changes and may either be the result of sampling bias (as suggested by Murray, 1965) or a real increase in abundance of foraminifera, through perhaps eutrophication of Plymouth Sound.

11.2.3. Manley's Study of Jennycliff; 1973-1974 (Unpublished)

11.2.3.1. Introduction

Mr Pete Manley under took a microfaunal study of the eastern Sound at Jennycliff which included living and dead foraminifera, ostracods and diatoms. Only the foraminifera are of relevance to this study. Two major sample sites were marked with square concrete blocks and referred to simply as block 'A' and block 'B'. In the current study Locations 18 and 17 respectively have been chosen to correlate with these two sites. The blocks themselves could not be found but detailed small scale maps (drawn by Mr Manley) made their original locations possible to establish with a good degree of accuracy.

Using the 'A' and 'B' blocks as permanent markers a series of jackstay sample sites were established (approximately 20 in total) these were sampled less frequently. Unfortunately the dates of collection of the jackstay samples have been lost subsequently and as they are therefore of little use they have not been processed.

11.2.3.2. 'A' and 'B' block samples

11.2.3.3. Methodology

Foraminiferal samples were taken from Jennycliff in Plymouth Sound. Samples were retrieved once a week from two sites between the 18/10/73 to the 07/11/74 by divers (Mr E. C. Manley and others) in a circular tin of fixed volume (452 cm^3). The tin was pushed through the sediment horizontally (parallel with the sediment surface) with the sediment/water interface at the maximum diameter of the tin, until full.

Samples from the 'B' block were wet sieved over a 75µm sieve by Mr E. C. Manley and processed by the current author as mentioned in Chapter 2 (materials and methods).

The 'A' block samples were wet sieved over a 75µm sieve, processed and picked by Mr E. C. Manley, using a technique which involved picking a fixed proportion of the total sample i.e. a sub-sample. For example if the sample weighted 80 gm and a sub-sample from this weight 10 gm. The sub-sample was entirely picked of all live and dead foraminifera and their amount (abundance) multiplied by 8 to extrapolate the amount of foraminifera present in the whole sample (80 gm), had the whole sample been picked.

Although foraminiferal contents of some sub-samples varied from approximately 100 to 1000 individuals, irrespective of whether live or dead, the majority of sub-samples contained 100 to 150 individuals. Most sub-samples were picked from 125µm and 250µm size fractions and above. The original samples were lost, hence slides of mounted foraminifera from sub-samples are the only material available from the 'A' block samples.

A potential problem with this method is if the sub-sample is not representative of the entire sample large errors may occur, this method is only worthwhile for abundant species as rarer species will either be omitted or over represented. The diversity of the live and dead assemblage was measured from the live and dead individuals mounted on slides and hence is probably lower than in reality.

11.2.3.4. Temperature, Salinity and pH.

Temperature, salinity and pH were measured at one point every week during sampling (at the sea surface), one measurement sufficed because of the close proximity of the sites.

The highest sea temperature occurred during October 1973 at the beginning of the sampling program, it then dropped sharply, sea temperature were elevated again from May to October 1974 (between 10°C-16°C), reaching a peak during July, August and September. Salinity remained constant for most of the year at 34‰ - 35‰ although it fluctuated sharply several times, particularly during December and January were it commonly fell to 30‰ and 25‰, pH also dropped sharply at this time, probably due to dilution of sea water from increased river runoff, of low pH, although pH remained constant for most of the year (Figure 11.1).

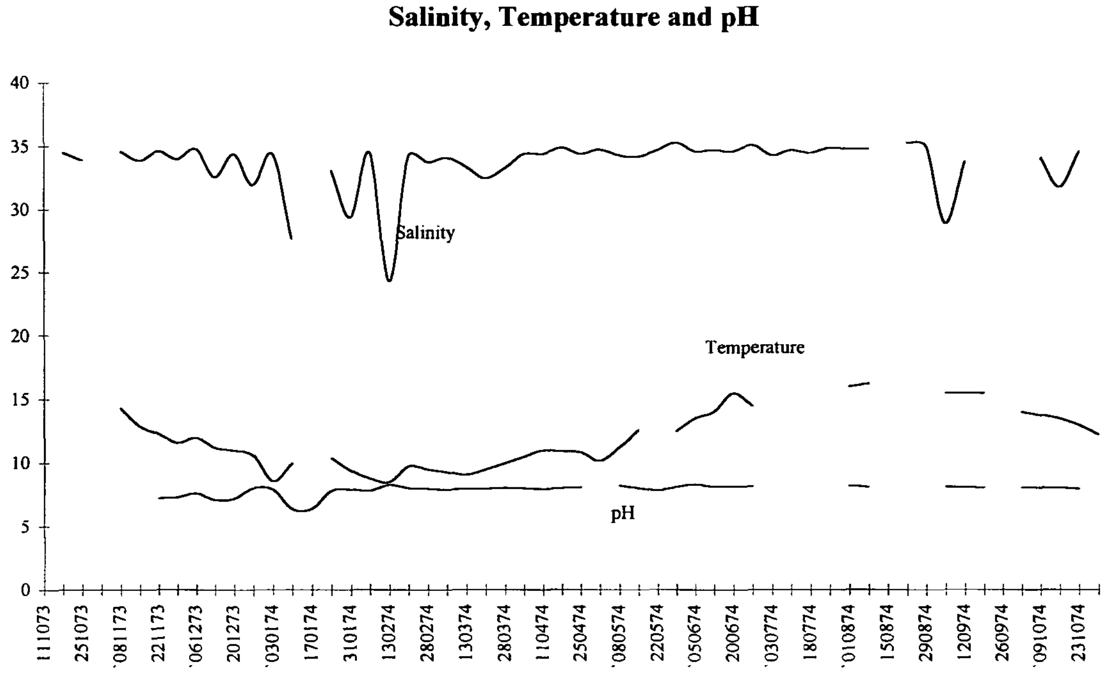


Figure 11.1 Temperature, salinity and pH measured from surface waters at Jennycliff from October 1973 to October 1974. (Temperature in degrees Celsius and salinity in parts per thousand).

11.2.3.5. 'A' Block Live Foraminifera

The maximum abundance of live foraminifera (950 individuals) was reached on the 25th October 1973 (Figure 11.2). The slides contained 17 live species of these only two were common; *A beccarii batavus* (59%) and *E crispum*, (27%), these species dictated the overall pattern of live foraminifera. *Ammonia beccarii batavus* and *E crispum* showed a peak in abundance during September, October and November, *A beccarii batavus* showed its greatest extrapolated numbers of 452 individuals on the 1st November 1973, whilst *E crispum* reached its extrapolated peak of 200 individuals on the 5th September 1974 (Figure 11.3). The occurrence of all live species is patchy and shows little correlation, which may in part be due to the extrapolation of species abundance and associated problems of this method as mentioned earlier.

The occurrence of these species generally correlates with the warmer sea temperatures in particular when high sea temperatures were declining which suggests that reproduction may be induced by temperature (Figure 11.1). The total foraminiferal peak, in particular the *A beccarii batavus* peak on the 25th October 1973 coincides with a sea temperature of 25°C. During May, June, July and August when sea temperatures were rising and reached their peak, low foraminiferal densities are observed. Reproduction may have occurred at maximum sea temperatures and foraminiferal abundance increased thereafter.

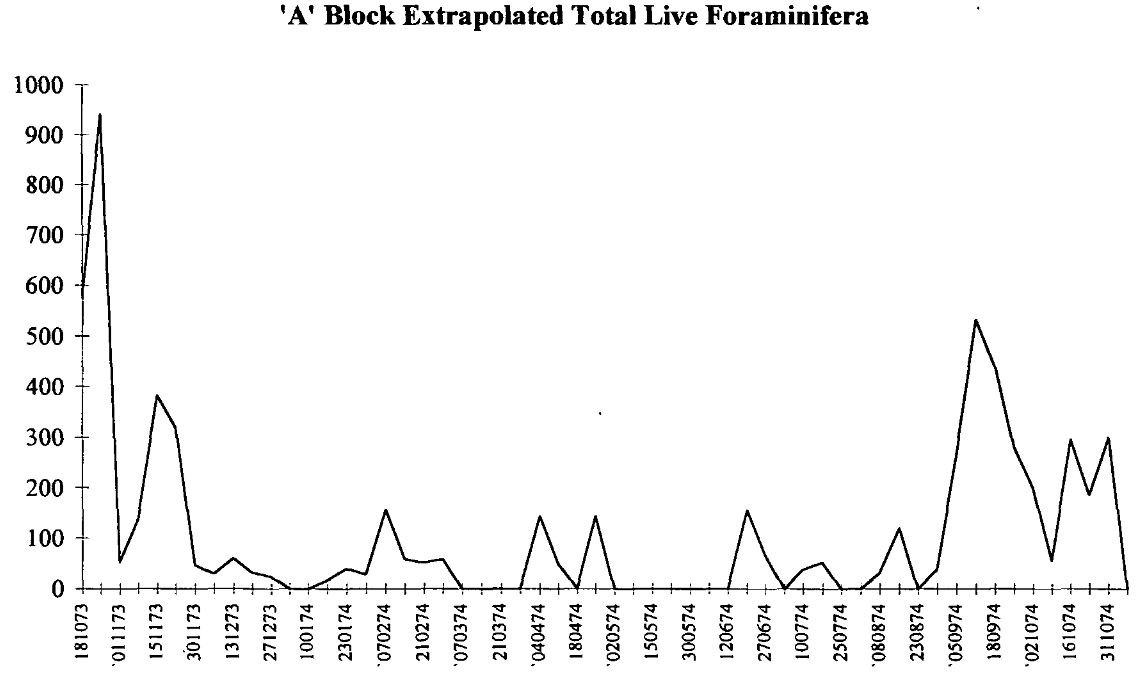


Figure 11.2 The abundance of live foraminifera extrapolated from sub-sample data from block 'A', for the period from October 1973 to October 1974. Shown as number of individuals.

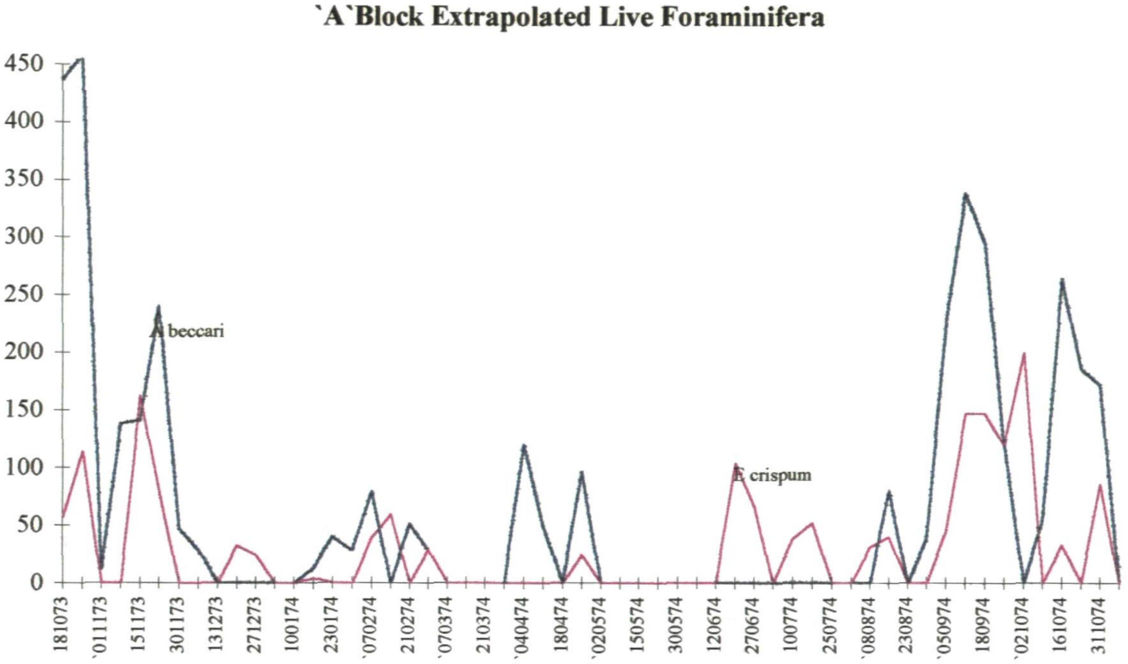


Figure 11.3 The abundance of live *A. beccarii batavus* (blue) and *E. crispum* (pink) extrapolated from sub-sample data from block 'A', for the period from October 1973 to October 1974. Shown as number of individuals.

Although it has been suggested (earlier in this Chapter) that potentially large errors may occur due to the extrapolation of the live assemblage numbers from much smaller sub-samples, this extrapolated data should usually provide a guide as to which species are common in this location and an approximation of their abundances.

11.2.3.6. 'A' Block Dead Foraminifera

The dead population consisted of 52 species dominated by large forms (>125μm), no quantitative representation was thought worthwhile because of the narrow cross section (in terms of size) of the population and the small number of individuals within each of the sub samples (averaging 30-50 individuals).

11.2.3.7. 'B' Block Live Foraminifera

Live foraminifera were not abundant, never exceeding 80 individuals per sample and were often fewer than 20 individuals per sample (Figure 11.4). Maximum abundance occurred at the end of July 1974.

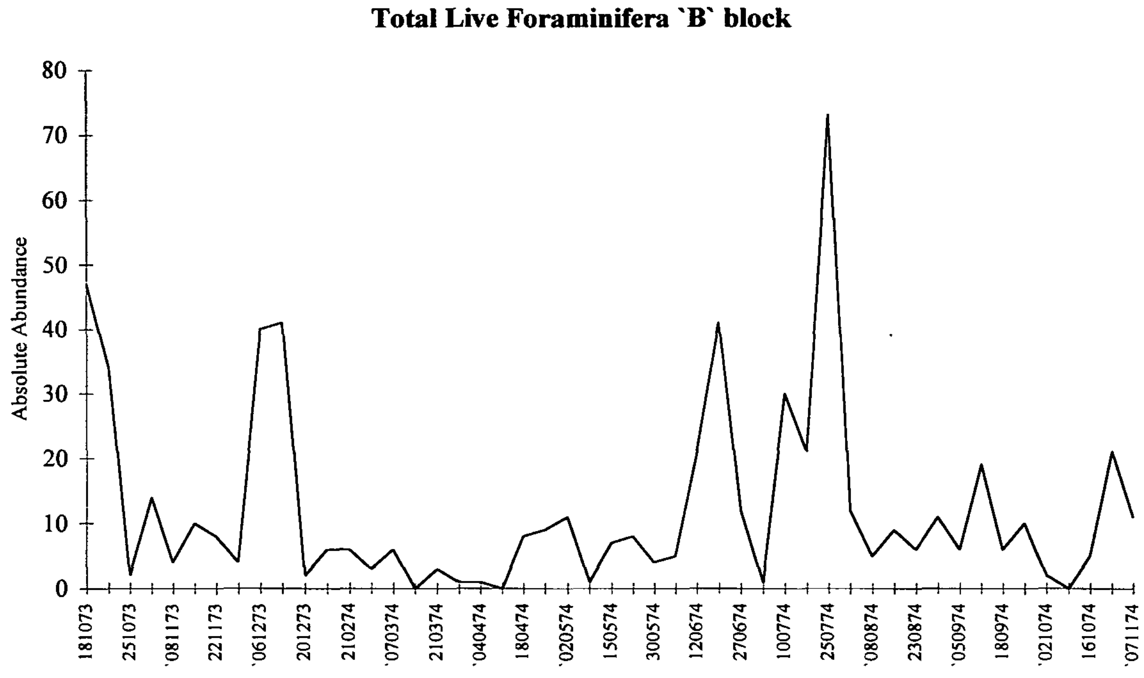


Figure 11.4 The abundance of live foraminifera extrapolated from sub-sample data from block 'B', for the period from October 1973 to October 1974. Shown as number of individuals.

The samples contained 24 live species, of these *Q lata* (33%) and *A beccarii batavus* (25%) were the most abundant. *Ammonia beccarii batavus* attained its maximum abundance on the 11th October 1973 while *Q. lata* showed elevated populations from May to September, but reached it greatest abundance during July and September (Figures 11.5 and 11.6). *Eggerelloides scabrum* (23%) exhibited a peak during the first half of December 1973. Other species which occurred consistently but in low numbers were *E crispum* (5%) and *M secans* (3%).

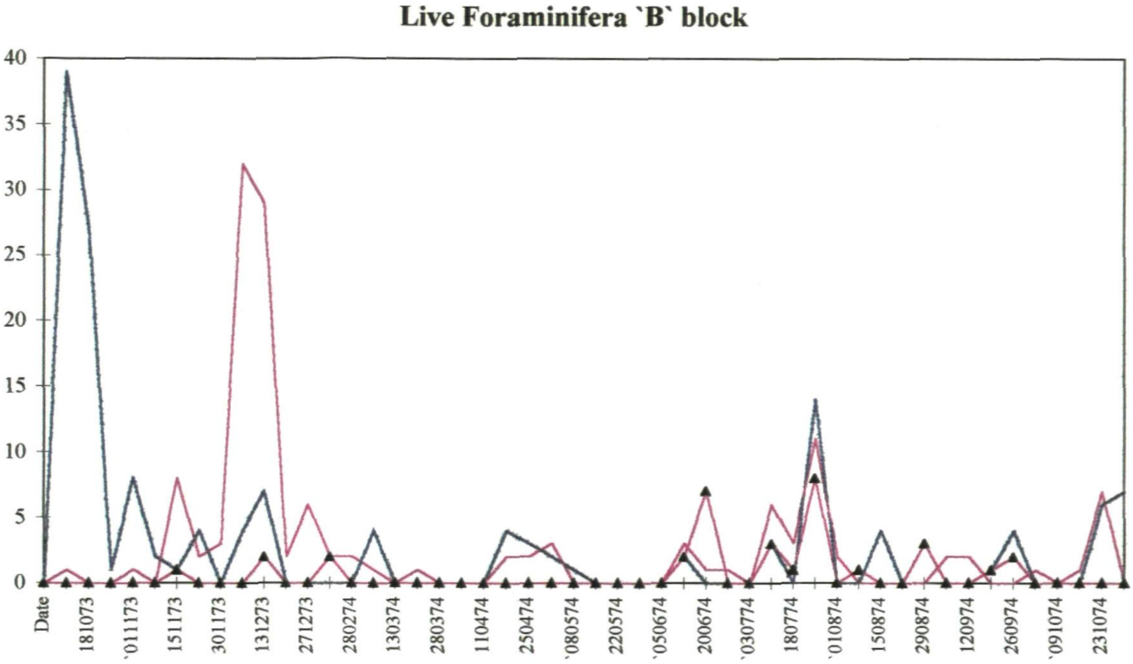


Figure 11.5 The abundance of live *A. beccarii batavus* (blue), *E. crispum* (pink) and *E. scabrum* (purple) extrapolated from sub-sample data from block 'B', for the period from October 1973 to October 1974. Shown as number of individuals.

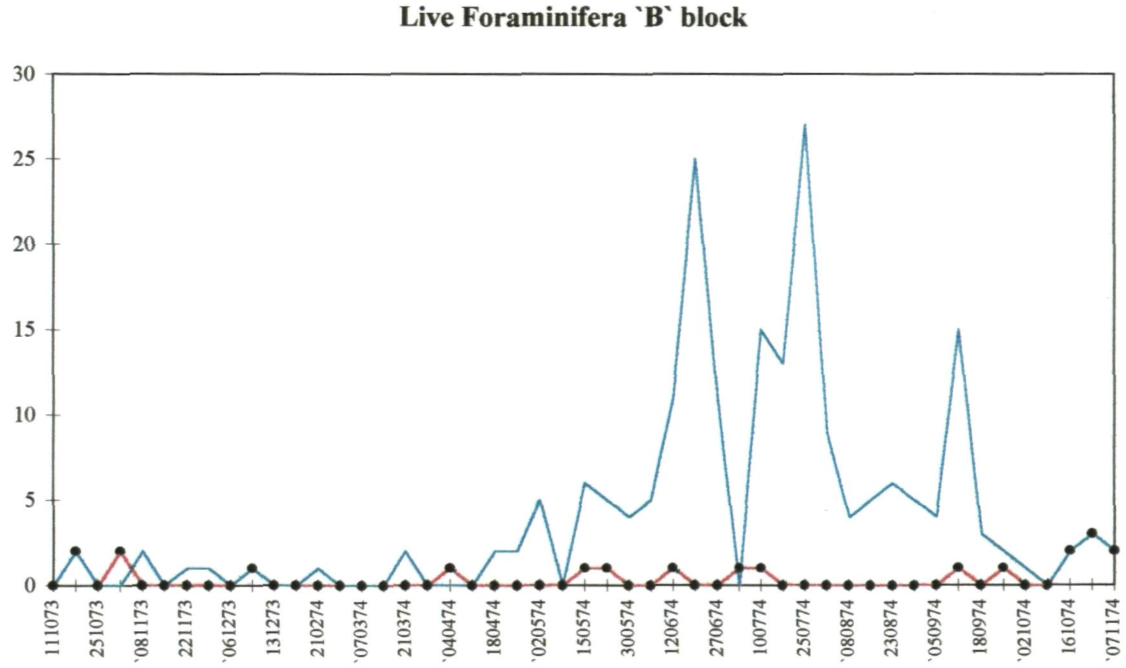


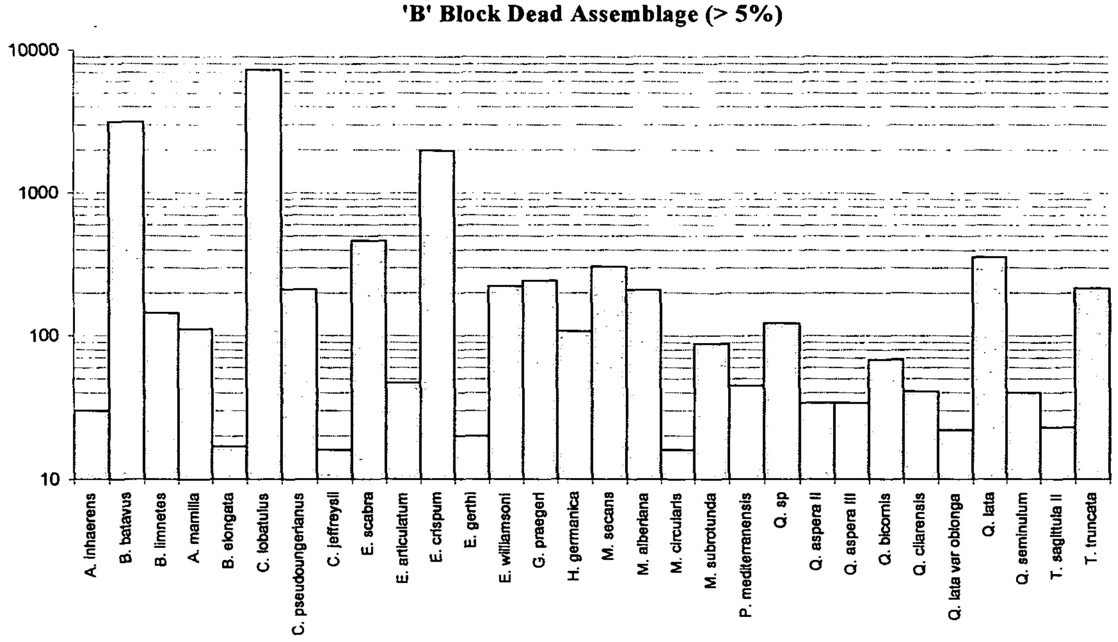
Figure 11.6 The abundance of live *Q. lata* (blue) and *M. secans* (pink) extrapolated from sub-sample data from block 'B', for the period from October 1973 to October 1974. Shown as number of individuals.

Population densities of *Q lata* coincided very well with summer sea temperatures, reaching its peak during August (16.25°C) and September (15.5°C). *Ammonia beccarii batavus* bloomed during high sea temperatures of October 1973 (25°C). *Eggerelloides scabrum* peaked sharply during a period of low sea temperatures (10°C), and variable salinity and pH.

Correlation of live foraminifera from the 'A' and 'B' block is very poor with one exception, *A beccarii batavus* peaked from both localities during the end of October 1973.

11.2.3.8. 'B' Block Dead Foraminifera

The total dead assemblage from the 'B' block is composed of 70 species, but generally individual samples have a low to moderate diversity with a Fisher Alpha diversity index of 5 or 6. The dead assemblage is dominated by *C lobatulus, A beccarii batavus* and *E crispum,* other very common species include *E scabrum, Q lata* and *M secans* (Figure 11.7). These abundant dead species reflect the live assemblage with the exception of *C lobatulus*. *Cibicides lobatulus* is extremely common in the dead assemblage throughout most of the Sound, but generally absent in the live assemblage within most sediments.



'B' Block Dead Assemblage (> 5%)

Figure 11.7 The years total dead assemblage of species >5% from the block 'B'. Shown as number of individuals

11.2.3.9. Comparison of the 'A' and 'B' Block Assemblages

Common live species from 'A' and 'B' sites show elevated densities during October and November 1973 followed by low densities throughout the rest of 1973 and most of 1974 until numbers increased once more during the end of August through to October 1974 when sampling ended. *Ammonia beccarii batavus* displayed as a percentage of the dead assemblage (Block 'B' only), over this period reflects the contribution of empty (dead) *A beccarii batavus* tests to the dead assemblage. During the summer, a period of low productivity, empty tests of *A. beccarii batavus* accounts for less than 10% of the dead assemblage but during the autumn of 1973 and 1974 periods of high productivity it accounted for greater than 30% of the dead assemblage (Figure 11.8).

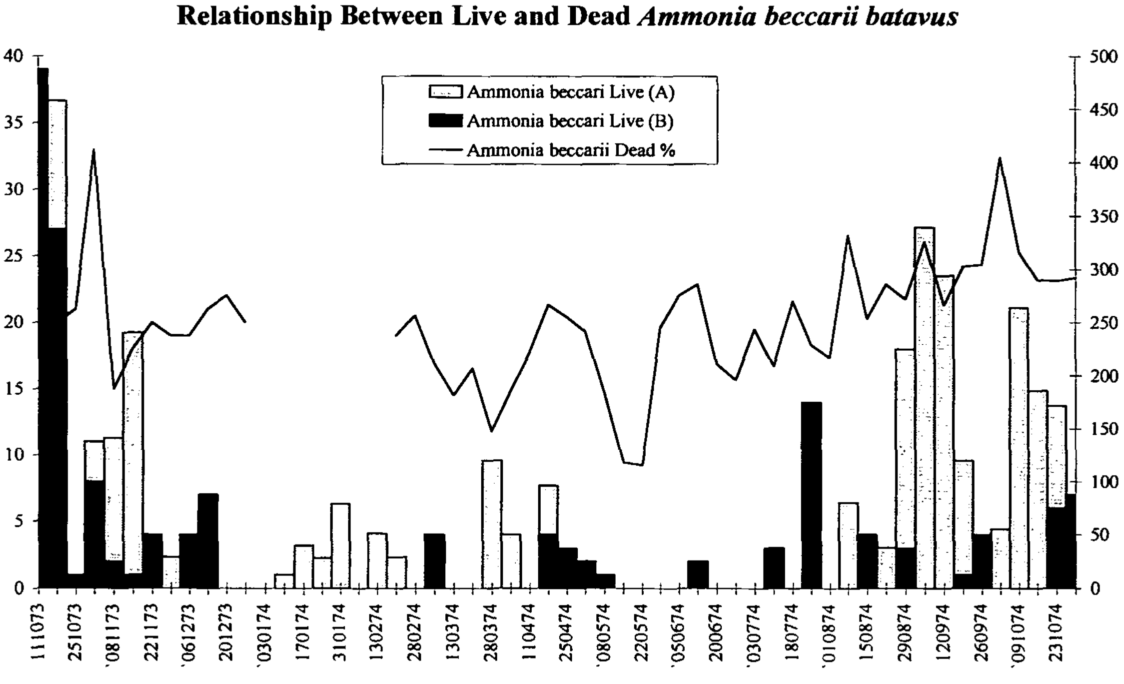


Figure 11.8 Live *A. beccarii batavus* for block 'A' (dark grey) shown on right axis and block 'B' (pale grey) shown on left axis. The percentage of *A. beccarii batavus* within the dead assemblage of block 'B' is shown as a black line on left axis.

Both the 'A' and 'B' samples have far larger dead assemblages, 'A' is composed of 52 dead species represented by 17 live species (33%), whilst 'B' is composed of 70 dead species represented by 24 live species (34%). Although the 'A' block samples would appear to be less diverse this is probably due to the extrapolation of data, had the whole samples been present a more accurate diversity would have been obtained. Approximately

1/3 of the dead assemblage is represented by live species. This is probably the result of the studies small extent within the Sound

The 'A' block which coincides with the present location 18 displayed an extrapolated maximum abundance of 210 individuals per 100cm^3 at any one time very different to the maximum of 1314 individuals at location 18. The distribution of live individuals throughout the year is quite different for both studies but this is believed to differ from year to year. The most abundant species at block 'A' were *A. beccarii batavus* which attained a maximum of 93 individuals per 100cm^3 and *E. crispum* which attained a maximum of 45 individuals per 100cm^3. These two species are also the most abundant in the current study with *A. beccarii batavus* attaining a maximum of 656 individuals and *E. crispum* 459 individuals, again similar proportions (Table 11.3) but very different abundances.

The 'B' block displayed a maximum abundance of 72 individuals per 100cm^3(a very low number). Not surprisingly live foraminifera were more abundant in the present study at Location 17 with a maximum of 1197 individuals. The distribution of live foraminifera throughout the year was again different. The most abundant species at block 'B' were *A. beccarii batavus*, *E. scabrum, Q. lata*, *E. crispum* and *M. secans* all in small populations (not exceeding 12 individuals at any one time). In the present study at Location 17 *A. beccarii batavus* is the most abundant species followed by *E. crispum, E. scabrum* with *Q. lata* and *M. secans* also being important (Figure 11.3). Their maximum abundances are however much higher.

Block 'A'	**Location 18**
A. b. batavus 59%	*A. b. batavus* 50%
E. crispum 27%	*E. crispum* 30%
E. scabrum 3%	*E. scabrum* 2%

Block 'B'	**Location 17**
Q. lata 33%	*A. b. batavus* 51%
A. b. batavus 25%	*E. crispum* 20%
E. scabrum 23%	*E. scabrum* 11%
E. crispum 5%	*Q. lata* 2%

Table 11.3 Species percent abundances from A & B blocks compared to the abundance of the same species from Locations 18 & 17.

11.2.3.10. Summary

Live foraminifera are sparse at block 'B', but appear to be more abundant (an order of magnitude) at Block 'A'. This reflects the current differences between Location 18 ('A') and 17 ('B').

Both the 'A' and 'B' sites have a similar species composition as Locations 18 and 17 but in much lower abundance.

Live *A beccarii batavus* is associated with high sea temperatures in the autumn ('A'&'B' sites). This is also suggested as a possible reason for its distribution generally within the Sound for the present study

Live *Q lata* is associated with summer sea temperatures ('B' site). Live *E crispum* is relatively common throughout the year ('A' site)

11.2.4. Sturrock's Study 1978 (PhD Thesis, Unpublished)

Sturrock sampled the sandy and rocky substrates of the Western Approaches. A large section of the study was based on the foraminifera of this area. Although Sturrock never sampled within Plymouth Sound. He sampled an area of muddy and sandy sediments south of the Sound which he referred to as the Plymouth embayment. Although not directly relevant it is worth a passing mention.

Nine samples were collected in total during May, September and October 1978, seven of which were mud rich. Most of the samples were dominated (18% to 75%) by an elongate species *Fursenkoina fusiformis*. This was not regarded as a freak occurrence but simply as a species which prefers and best utilises the soft, quiet, mud rich sediments of the area. This species is very rare living or dead within the Sound and is rarely recorded as more than isolated individuals. Other common species such as *E. scabrum, A. beccarii batavus, B. gibba/elongata* and *Q. oblonga*, are all common within Plymouth Sound. The reason why this species should not be common in the Sound is not known, it may be related to differences in salinity, food supply and type, competition or other factors.

11.2.5. Foraminiferal Cores and Radio Isotopes

Radio isotope dating of cores from three areas of the Sound (Barn Pool, The Breakwater and Withyhedge Beacons) allow the dating of dead assemblages within those cores. The foraminiferal cores described in detail in Chapter 6 range in age from present to 80 years old form the Breakwater and Withyhedge Beacons and 150 years old for Barn Pool (foraminiferal dead assemblages from the base of these cores are circa these ages). A preliminary examination of the assemblages show little change in species composition down the cores although some species show minor changes in relative abundance. These assemblages have suffered taphonomic alteration as agglutinated forms may decrease and absolute abundance may be lower than at the surface.

11.3. Boreholes 1 and 2 of the Palaeo-Tamar

11.3.1. Introduction

During the 1980s high resolution seismic surveys were undertaken within Plymouth Sound, these reveal a system of infilled rock channels or valleys (Eddies and Reynolds 1988, Reynolds 1987). Other studies have shown that many of the major rivers of the South west exhibit buried rock channels, Codrington noted the submerged rock valley of the Dart in 1898, the buried valleys of the Teign and Exe have been described by Durrance 1966 and 1971, and Macfarlane (1955) describes the buried rock valley of the Erme. The buried channel systems of the South West England are associated with sea level rise during the Flandrian (Delibrias & Guillier 1971, Hawkins 1941, Kidson 1977, Kidson and Heyworth 1976, Mottershead 1977 and Shennan 1989).

During 1988 two sites were identified from the geophysical data and subsequently drilled An almost complete sequence of core was obtained from one site, borehole 1, which reached valley bedrock of Devonian slates at -39 m O. D. A preliminary investigation of the foraminiferal fauna of Borehole 1 is described by Eddles and Hart (1988). A second borehole drilled approximately 300 m to the Northwest (Figure 11.9) encountered stormy weather conditions and as a result an incomplete core was recovered down to -25.7 m O. D. Both boreholes (cores) were sampled in detail, the fauna and sedimentology were described in detail within an undergraduate project of Castignetti 1992, the results and interpretations are published by Castignetti (1993).

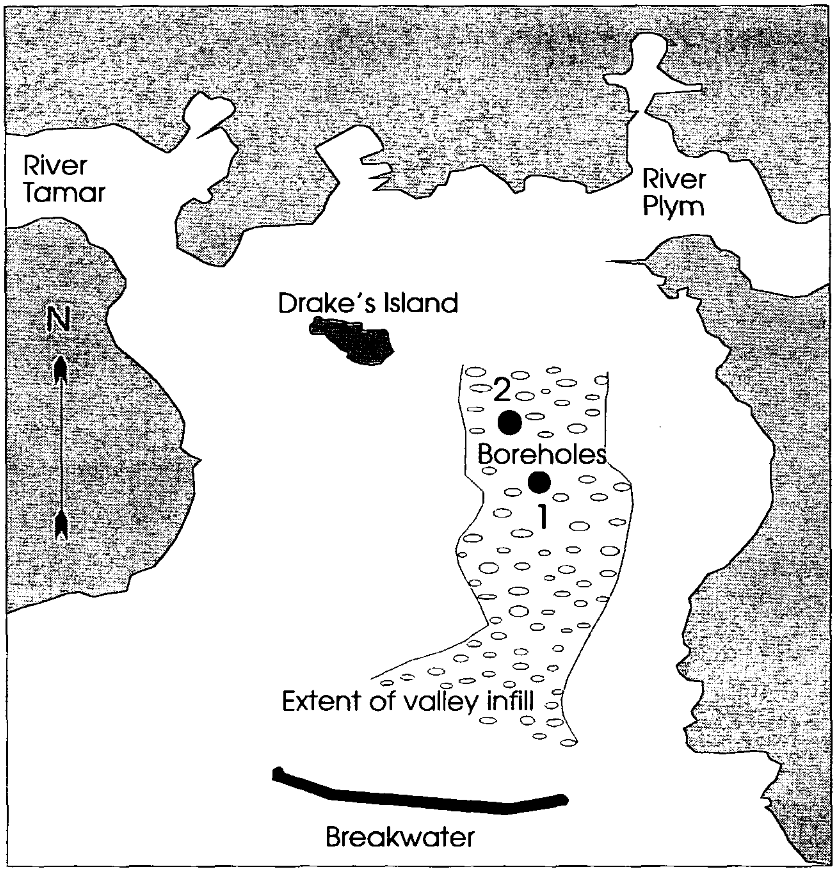


Figure 11.9 Map of Plymouth Sound showing the extent of the palaeo-Tamar rock valley as determined be geophysical interpretation and the sites of Borehole 1 and 2.

Subsequent to this initial research a detailed and comprehensive study of the foraminiferal assemblages of Plymouth Sound and of the previously unstudied Plym Estuary (which flowed into the palaeo-rock valley) have been carried out, in view of this the borehole data is briefly re-described and reinterpreted.

The sediment water interface for Borehole 1 and 2 occurs at -10 m O. D.

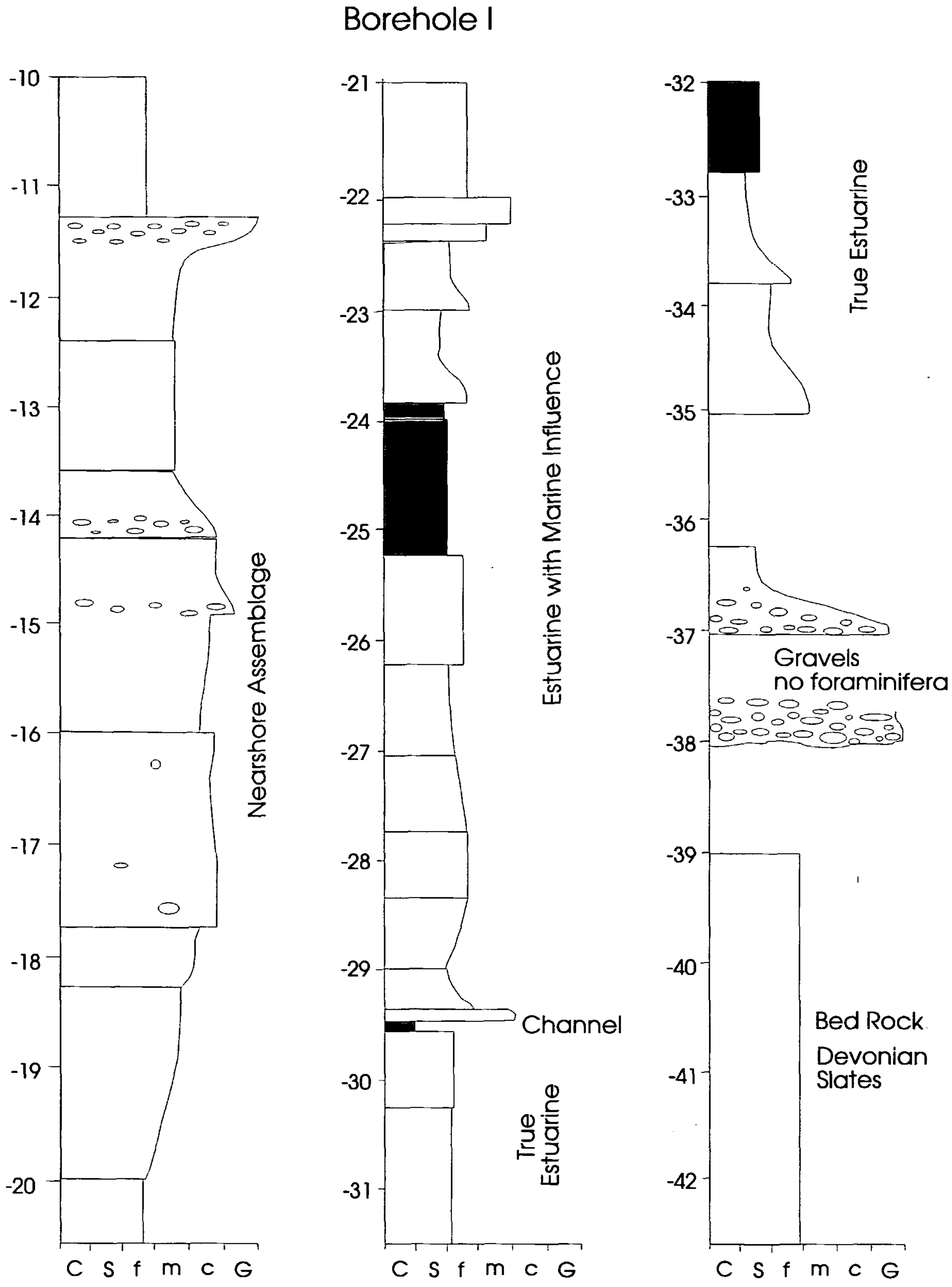


Figure 11.10 Sedimentary log of borehole 1 in meters below O. D.. Original log drawn by Dr Ian Tunbridge. Shaded areas are clay rich sediments

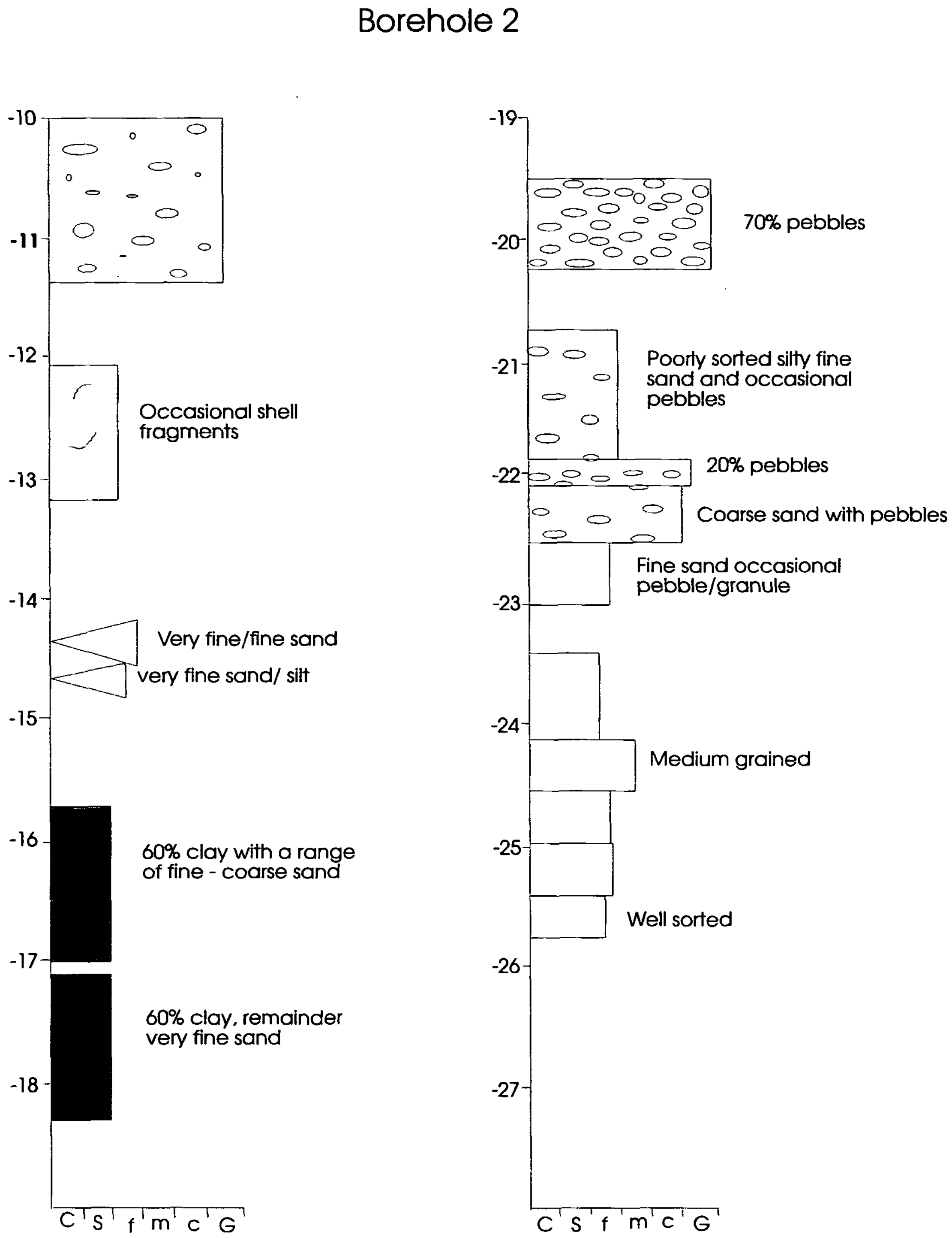


Figure 11.11 Sedimentary log of borehole 2 in meters below O. D.. Log drawn from bag samples.

11.3.2. Borehole 1

The first 10 metres (-10 m O. D. to -20 m O. D.) of borehole 1 consists of fine to medium grained sands containing some pebble rich horizons. From -20 m O. D. to -35 m O. D. the sedimentary sequence consists of silts and clays with occasional pebble beds. The final 4 metres of the sequence -35 m O. D. to -39 m O. D. consists of coarse sands and rounded pebbles becoming more angular towards the base at -39 m O. D.

11.3.3. Borehole 2

The first metre of the sequence is a coarse poorly sorted sand with abundant pebbles (this zone may be produce by the periodic dredging of the shipping channel). The next 8 metres of the sequence from -11 m O. D. to -19 m O. D. are dominated by clays and silts. From -19 m O. D. to -25 m O. D. the sequence consists of fine to medium well sorted sands with the exception of a prominent pebble bed -22 m O. D. to -22. 5 m O. D.

11.3.4. Recap of Methods Used

Foraminifera were picked from the 500μm, 250μm and 125μm fractions as they were sparse or absent from other fractions. Three hundred foraminifera were picked in total from each sample where possible. A total of 46 samples from borehole 1 and 22 from borehole 2 were analysed for foraminifera, 23 samples from borehole 1, and 17 samples from borehole 2 contained ample foraminifera. In samples containing a sparse abundance of foraminiferal fauna 10 trays (120 mm x 80 mm) of processed sediment were picked.

11.3.5. Foraminiferal Assemblages

It was found that a total of 6 taxa represented over 98% of the fauna in both boreholes, *Cibicides lobatulus* being a minor species accounting for 3% of the total assemblages and occurring irregularly throughout the borehole sequences. Species belonging to the *Quinqueloculina* genus such as *Q. bicornis*, *Q. lata/seminulum*, *Q. cliarensis* etc. are grouped together forming the *Quinqueloculina* spp. group. *Elphidium crispum* includes the *E. macellum* variety. Surprisingly no agglutinated foraminifera were recorded from the borehole samples, and it has been postulated by Eddles and Hart (1988) that they may have disintegrated or decomposed after burial and storage.

11.3.6. Foraminifera of Borehole 1

The foraminiferal fauna of borehole 1 consists of three assemblages denoting three distinct sub-environments. The boundaries of the three assemblages correlate very well with major seismic reflectors.

The first 10 metres of the sequence from -10 O. D. to -20 m O. D. contains an assemblage of *Elphidium crispum*, *Ammonia beccarii*, and *Quinqueloculina* spp. with small amounts of *Cibicides lobatulus* (within the uppermost few metres). This is essentially a nearshore shallow marine fauna, typical of many areas of Plymouth Sound at present (Figure 11.12). The high percentage of *E. crispum* and *Quinqueloculina* spp. (2/3 of the assemblage) is indicative of normal marine salinities.

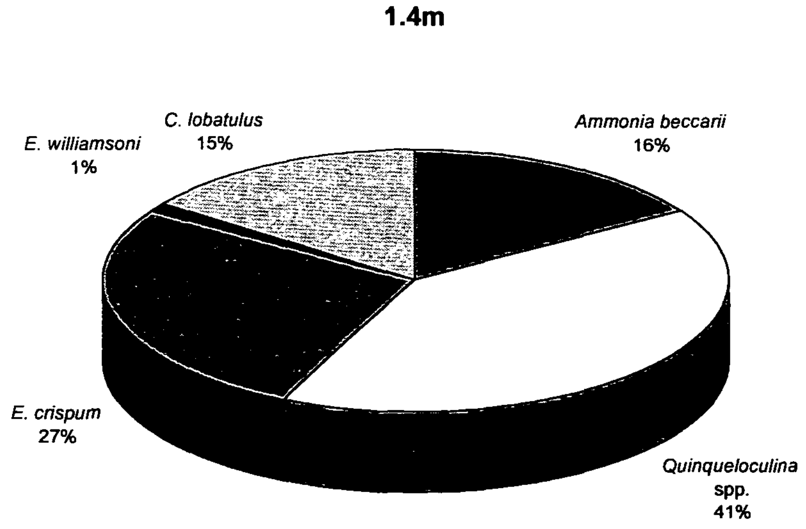


Figure 11.12 Normal marine assemblage typical of the upper 10 m of borehole 1

From -22m to -29 m O. D. a sharp change in the foraminiferal fauna occurs, *A. beccarii* becomes slightly more abundant, indicating and estuarine influence, whilst the marine forms; *E. crispum* and *Quinqueloculina* spp, decrease markedly to less than 1/3 of the assemblage. The occurrence of large numbers of the euryhaline species *Elphidium williamsoni* and *Haynesina germanica* indicate the proximity of estuarine conditions (Figure 11.13).

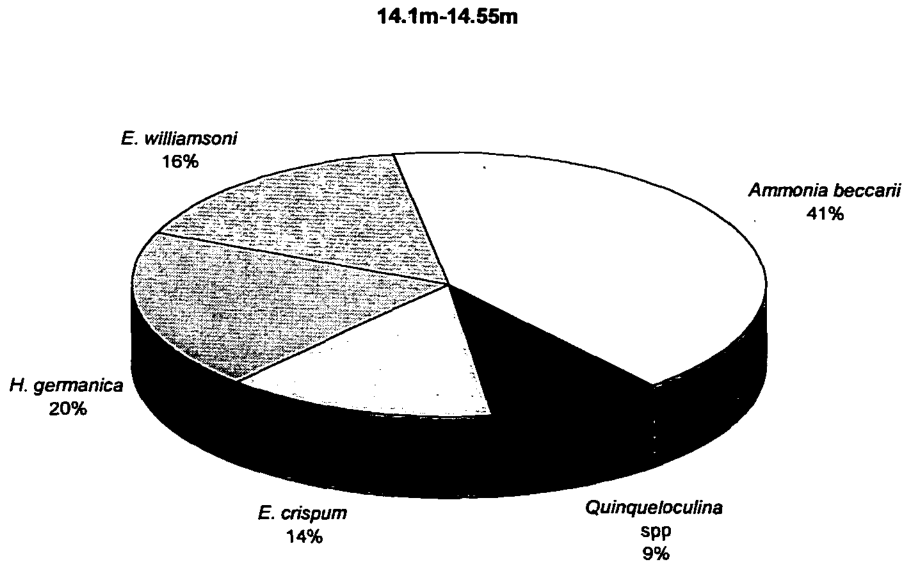


Figure 11.13. Foraminiferal assemblage from the second sub-environment (-22 m O. D. to -29 m O. D.) of borehole 1, indicating a strong estuarine influence.

Another abrupt change in faunal composition heralds the beginning of the third assemblage, from -29 m O. D. to -35 m .O. D. *A. beccarii* declines in abundance to form approximately 20% of the assemblage, the marine forms *E. crispum* and *Quinqueloculina* spp. become sparse (generally less than 10%), but *E. williamsoni* and *H. germanica* increase greatly in abundance to form over 80% of the assemblage within this part of the sequence (Figure 11.14). This fauna reflects true estuarine conditions.

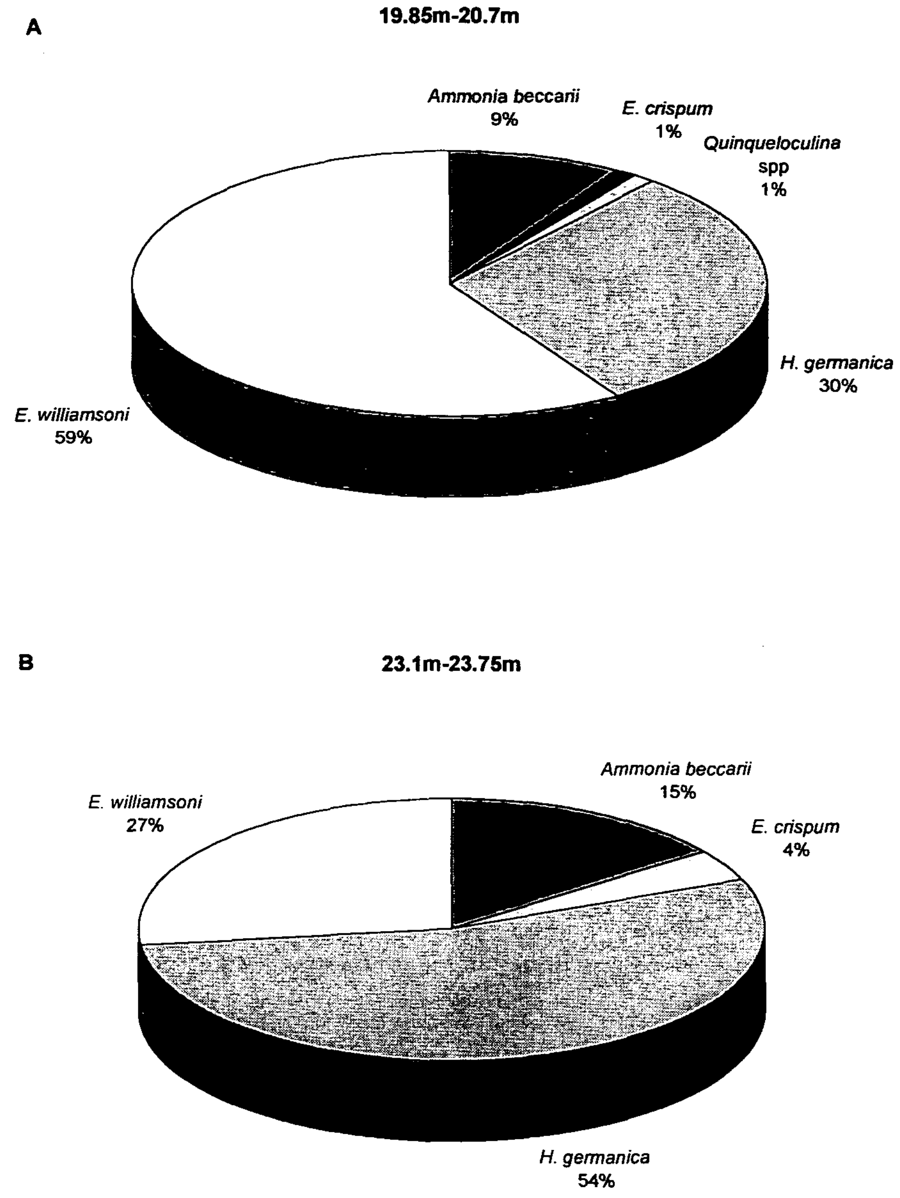


Figure 11.14 A&B. Foraminiferal assemblage from the lowermost 9 metres of foraminiferal sediment (-29 m O. D. to -35 m .O. D) of borehole 1 exhibiting a truly estuarine fauna. Chart A represents the fauna of a palaeo-channel, chart B a palaeo-mudflat.

11.3.7. Foraminifera of Borehole 2

The foraminiferal assemblages of borehole 2 show a high degree of variability. Considerable portions of the core are missing (through non recovery) and foraminifera were generally sparse throughout the sequence, nonetheless three assemblages can be seen which are similar to those of borehole 1 although less distinctive.

From -10 m O. D. to -11.35 m O. D. an assemblage of *A. beccarii, E. crispum* and *Quinqueloculina* spp represent a typical nearshore marine fauna which correlates well with the marine assemblage of borehole 1, although within borehole 2 this assemblage is poorly developed and restricted to the uppermost 1 m of the sequence (Figure 11.15).

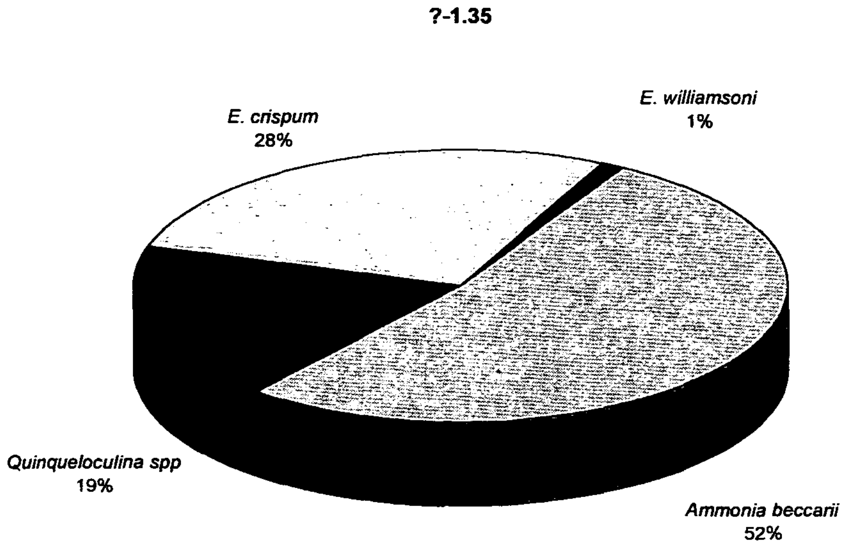


Figure 11.15 Marine assemblage from the top of borehole 2, the large numbers of *A. beccarii batavus* indicates a possible, slight estuarine influence.

Between -11.35 m O. D. to -19 m O. D. the assemblage is dominated by *A. beccarii*, with *E. crispum*, *Quinqueloculina* spp, *E. williamsoni* and *H. germanica* all present in moderate numbers. The assemblage is strongly influenced by estuarine conditions, as the presence of moderate amounts of *E. williamsoni* and *H. germanica* testify (Figure 11.16).

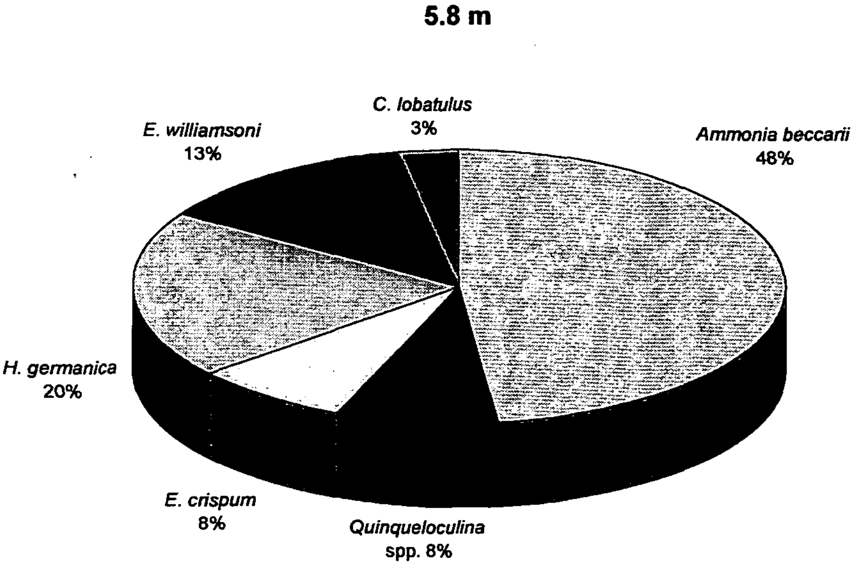


Figure 11.16 Assemblage exhibiting strong estuarine influence from borehole 2, typical of -11.35 m O. D. to -19 m O. D.

The third assemblage from the lower part of the borehole is characterised by a decrease in the abundance of *A. beccarii* and an increase in abundance of *H. germanica* This faunal shift corresponds partially to the estuarine assemblage of borehole 1 but it is not very well developed as marine species are quite common (Figure 11.17).

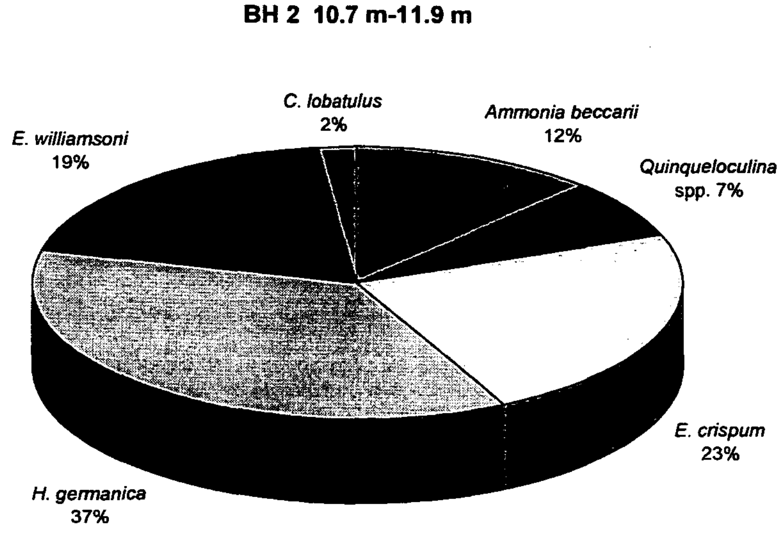


Figure 11.17 Estuarine assemblage from borehole 2 although still exhibiting a strong marine influence with relatively large numbers of *E. crispum.*

11.3.8. DISCUSSION

Borehole 1 shows a complete sequence in which the three assemblages are well developed. The final metres -35 m O. D to -39 m O. D. of sediment sequence consist of gravels which bear no foraminifera. Borehole 2 shows an incomplete sedimentary sequence in which the foraminiferal assemblages are poorly developed. Foraminifera were generally sparse after -18 m O. D. the sediment is a strong ochreous yellow with much localised calcareous cementation which may account for the foraminiferal paucity.

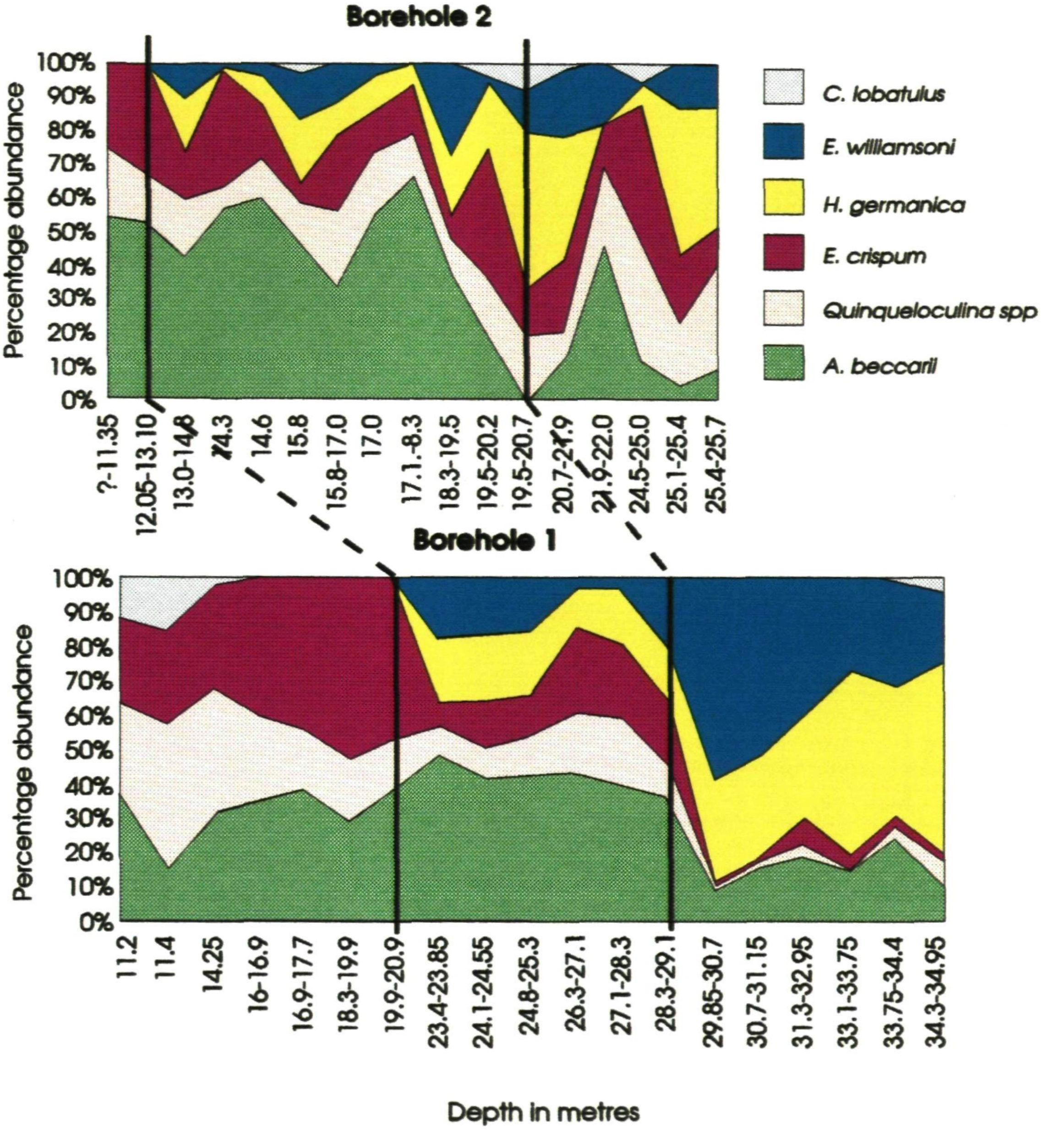


Figure 11.18 Foraminiferal assemblages of borehole 1 and 2 showing the correlation between seismic markers and assemblage boundaries in metres below O.D..

Sedimentary correlation between the boreholes is poor but this is not surprising considering a valley infill setting (poor lateral continuity). Seismic reflectors and foraminiferal assemblage boundaries correlate well suggesting that the reflectors represent time gaps through non deposition or erosion. The 12m marker of borehole 1 correlates with the 2 m marker of borehole 2 which suggest that approximately 10 m of the marine sequence is absent from borehole 2, probably due to non deposition and or erosion. The 19 m marker of borehole 1 correlates with the 9 m marker of borehole 2, these sequences are similar in length (Figure 11.18).

11.3.9. Environmental reconstruction

Three distinct foraminiferal assemblages described represent three sub-environments indirectly defined on salinity. The assemblages and sub-environments are separated by seismic reflectors and as a result probably time gaps, either through non deposition and/or erosion. The assemblages are represented within the present day environments of the Plymouth region.

During the late Quaternary Plymouth Sound was within a fluvially dominated regime in which coarse clastics were deposited, at first angular to sub-angular later sub-rounded as the fluvial system matured. No foraminifera were present within this sequence which probably represents fresh water conditions

A relatively sea level rise created fresh/ brackish conditions in which *E. williamsoni* and *H. germanica* are dominant. Studies of the Tamar show that *H. germanica* (with lesser amounts of *E. williamsoni*) dominate the testate foraminiferal live (Ellison, 1984; Murray, 1965) and dead assemblages (Murray, 1965). Salinities recorded at high tide ranged between 24‰-32‰ (Murray, 1965), Milne (1938) recorded salinities of 16‰-25‰ at low water in the upper estuary.

The Plym Estuary (salinity variations of 15‰-34‰ during the study period) has a dead foraminiferal assemblage (Figure 11.19) dominated by *H. germanica* and *E. williamsoni* with small amounts of *A beccarii* (Castignetti, 1996) which is very similar to the lowest borehole assemblage (Figure 11.14B).

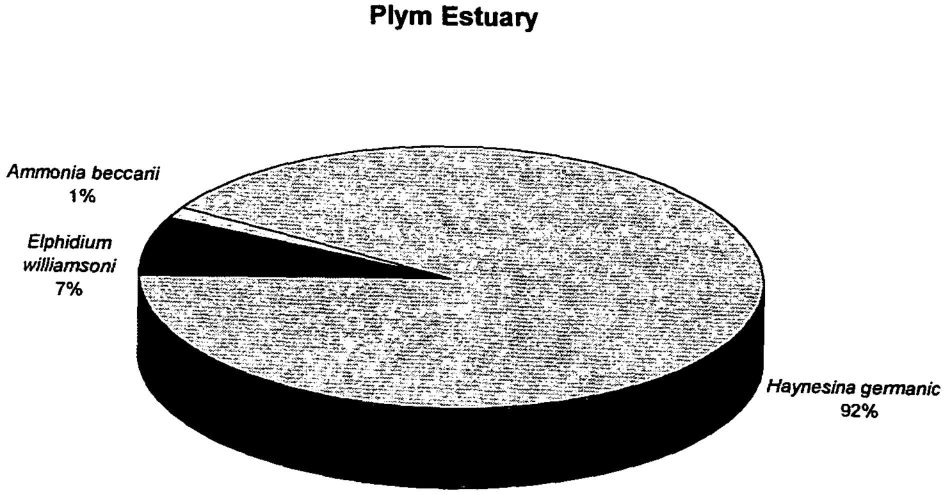


Figure 11.19 Foraminiferal dead assemblage from the Plym Estuary mudflats

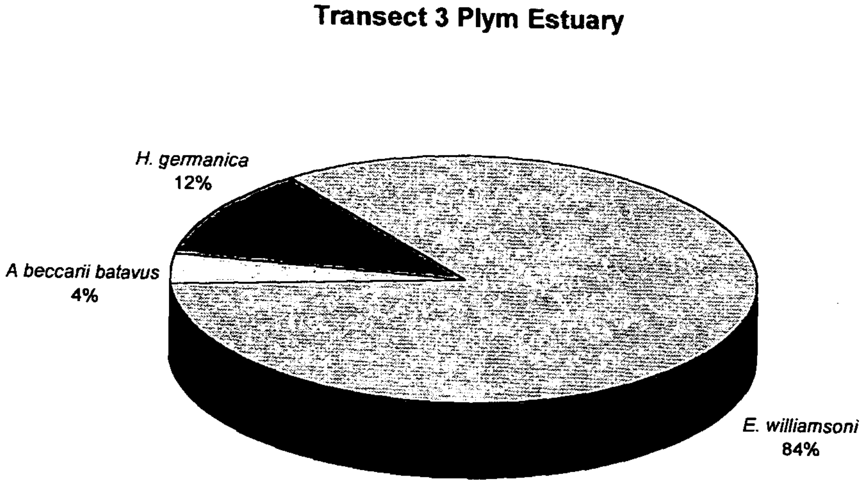


Figure. 11.20 Foraminiferal fauna of the Plym Estuary central river channel.

Within the lower borehole assemblage (-29 m O. D. to -35 m O. D.) *H. germanica* is dominant within muddy facies which probably represent mudflat type environments similar to those of the Plym Estuary Figure 11.19. At between -29 m O. D. and -30 m O. D. of borehole 1, *E. williamsoni* becomes the dominant species of the assemblage, this coincides with a channel facies within the sequence see Log 1 (Figure 11.10). Within the channel deposits of the Plym estuary the normally dominant *H. germanica* becomes subordinate and *E. williamsoni* dominates the assemblage (see Figures 11.20 and 11.14A).

With an increase of relative sea level the estuarine assemblage of the boreholes gave way to an assemblage in which the true estuarine species *H. germanica* and *E. williamsoni* are common, as are the marine species *E. crispum* and *Q.* spp.. This environment exhibits strong estuarine and marine influences and probably represents an estuary mouth setting. Within Plymouth Sound at present Barn Pool is the location sampled which is closest to an estuary mouth (Tamar) and hence estuarine influences. The dead assemblage (the sum of 1 year) is plotted in Figure 11.21.

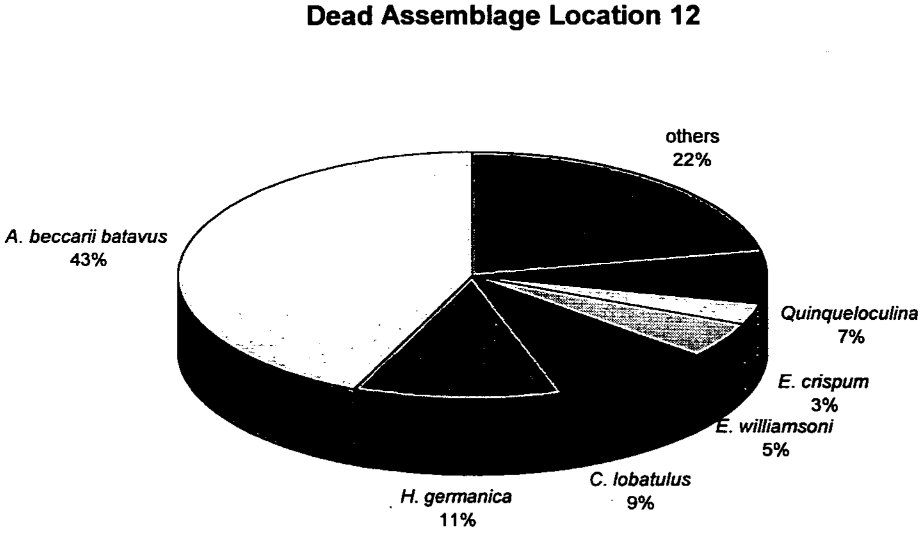


Figure 11.21 The dead assemblage from close to a present day estuary mouth, the agglutinated foraminifera have been removed as they are not preserved within the borehole samples. Only species > 1% of the assemblage are plotted. The species within the 'Others' group are mainly composed of attached foraminifera which may or may not have been present adjacent to the borehole environment.

This modern sample from close to the mouth of the Tamar is dominated by *A. beccarii batavus*, with reasonable amounts of *E. williamsoni* and *H. germanica* as well as *E. crispum* and *Quinqueloculina* spp. as in the borehole samples from the intermediate sub-facies.

The third assemblage is characterised by an absence of the estuarine species *E. williamsoni* and *H. germanica*. *Ammonia beccarii* is common as are the true marine species *E. crispum* and *Quinqueloculina* spp.. This assemblage is typical of any modern Plymouth Sound assemblage from silt/sand or sandy areas (Figure 11.22).

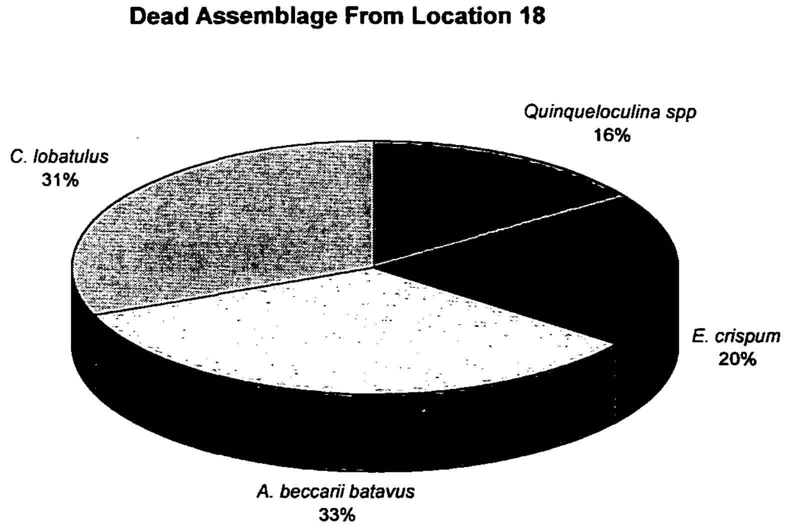


Figure 11.22 Present day assemblage excluding agglutinated foraminifera and foraminifera less than 5 % of the total assemblage (Loc 18 yearly of dead foraminifera).

11.3.10. Conclusions

The borehole sediments consist of a series of facies stacked upon each other which describe a transition from fluvial environments to estuarine mudflat and channel environments (essentially the same as the Plym and possibly the Tamar estuaries) to estuary mouth environment and finally the uppermost assemblage represents a shallow marine environment essentially the same as the modern day Plymouth Sound. The transition from fluvial to marine environments and hence the infill of the rock valley took approximately 12 thousand years to occur, based on sea level curves (Kidson, 1977).

Agglutinated species are not present in any of the core samples although they are important in the Plymouth Sound area (forming as much as 20% of some assemblages) and present within both the Plym and Tamar estuaries, it is assumed that they were present in at least some parts of the borehole environments but have not been preserved.

The assemblages of the boreholes generally have a low Alpha Fisher Diversity of 1 or 2 while environments within Plymouth Sound commonly have an Alpha Fisher Diversity Index of 6 to ≥20 for the sum of one year. The estuarine environments probably had a low diversity originally, but the marine environments may have had far higher diversities which have been lowered by the removal of rare and fragile species, resulting in the selective preservation of only the most stable and abundant species.

Cibicides lobatulus forms a very small percentage of borehole assemblages whereas in Plymouth Sound at present it forms up to 60% of the dead assemblage. This suggests that it has a poor preservation potential or more likely it has become much more abundant in the present day environment..

11.4. Faunal trends of other organisms in and around Plymouth Sound

Maddock and Swan (1977) studied temperature records for most of the 20th century which were recorded within the Sound (water) and on the Hoe (air). They established that during the period from the 1920s to the 1950s the climate was warmer and less severe and this tended to favour southern species rather than northern species within the Sound. In 1961/62 the warm period was brought to an abrupt end by exceptionally cold weather in fact the coldest weather this century and cold water species increased in abundance.

Southward *et al.,* (1983) have analysed the fluctuations in the relative abundance of herring and pilchards through scientific and historical records. They determined a direct relationship between temperature and the abundance of these fish species for over 400 years. During warm years pilchards were abundant and herring scarce and during cold years the opposite was observed. Southward *et al.*, (1983) also showed that a similar relationship which was controlled by mean temperature also occurred between competing pairs of other marine animals including invertebrates.

Southward (1983) analysed a range of fauna from Plymouth Sound and the surrounding coast and correlated changes within the fauna to temperature and ultimately sunspot activity. He found that from 1930 onwards (warm period) a high diversity community of macroplankton was replaced by a lower diversity community, this trend was reversed during the 1960s. Fish species were also effected by the fluctuations in temperature which in turn Southward suggested may influence the benthic community.

Southward (1991) showed that communities of barnacles from Plymouth Sound changed in composition according to mean annual temperature. Warm water species became increasingly more common from 1930 to 1950 but cold water species have increased in abundance from 1962 (very cold period). He concluded that temperature accounts for 40% of the variance in barnacle communities. The barnacle species showed a quick response to both the 1961/2 (very cold) and 1988/9 (warm) temperature extremes.

Southward *et al.*, (1995) have reported extensive changes in marine communities (fish, barnacles, zooplankton, macroplankton, limpets, snails, shore plants and seaweeds) during the past 70 years in SW Britain and Western Europe. There have been changes of several orders of magnitude and 200-400 mile shifts in latitude of some organisms, resulting from a mean annual temperature fluctuation of approximately 0.5 ° C.

From these studies and more it is clear that temperature fluctuations have effected marine communities in the past which undoubtedly include foraminifera and will probably do so in the future.

11.5. Conclusions on Long Term Faunal Change

Heron Allen and Earland study has many species in common with the other studies which is to be expected as the foraminiferal fauna is unlikely to have completely changed. Their study can only be used in a qualitative fashion based effectively on dead assemblage. Furthermore because of significant taxonomic problems many of their species have not been recorded in the last 40 years during the other studies. This is unlikely to be due to faunal shift or change but simply differences in the allocation an erection of species (Heron-Allen and Earland had a reputation of being splitters in the allocation of foraminiferal species and varieties). Overall considering the problems of many species which are not represented in their plates or collection their study cannot provide enough resolution to be able to identify changes in patterns of foraminiferal fauna.

Murray's study shows some similarities but also many differences from the present study, and as discussed earlier many of these differences can be attributed to sampling different sedimentary facies. Because the exact location of sample sites cannot be pinpointed changes in the proportion and dominance of species cannot be taken as anything other than sampling in slightly different areas. The very low number of live foraminifera at all the sample stations is quite different from the present situation, although some sites at present have sparse faunas (typically Locations 8, 11 and 14) and most sites exhibit at some period of the year low abundances, most localities produced on average a few hundred live foraminifera per sample (100 cm^3). As discussed earlier in the chapter the size of the samples is not known as is the efficiency of the grab sampler used. Considering the overall problems and the small number of samples relevant to this study, changes in the composition and abundance of foraminiferal assemblages within the Sound cannot be determined although there is the possibility that foraminiferal abundance has significantly increased perhaps due to increased nutrient and food levels or temperature.

Manley's samples were retrieved in a relatively warm (warmer than 1962 but not as warm as 1994) and stable period of climate. Manley's data are however very limited in terms of stations sampled and area covered within the Sound, nonetheless one years data is present for the 'B' block (53 samples) and extrapolated data for the 'A' block (in total over 100 samples for 'A' and 'B' blocks combined). The samples taken by Manley were over 4 times the volume of those retrieved by the author (452 cm^3 and 100 cm^3 respectively). The 'A' block shows an extrapolated abundance which is very much lower to that of the present study. There is a good similarity between species compositions, unfortunately this data is based on extrapolations from small sub-samples reducing the degree of certainty. The 'B' block is based on entire samples but foraminiferal abundance is extremely low and comparable with that of Murray and far lower than present (2 orders of magnitude). The species composition is fairly similar but there are some differences in species relative abundances. The site of Manley's stations have been located and re-sampled with a reasonable degree of accuracy. The fauna is very similar to the present but both locations exhibit a far lower total abundance this further adds to the idea that foraminiferal abundances were lower in the past and have only recently increased. However this must remain a very tentative assumption because of the quality, reliability and amount of

Murray's and Manley's data. (Manley's other samples could be examined purely to determine the total live abundance but they probably total 40 or 50 samples and are unlikely to result in significant differences).

A preliminary examination of the dead assemblages from radio isotope dated areas of Barn Pool, Withyhedge Beacons and the Breakwater show little change in species composition vertically through the sediment although some species show minor changes in relative abundance. This suggests that overall significant faunal change has not occurred during the last 80 to 150 years in these areas

The borehole data shows that very large faunal changes have occurred within the assemblages of Plymouth Sound during the past. These changes reflect changes in environment based mainly on salinity and may have taken thousands of years to occur.

A number of studies show clear correlations between fauna and temperature and with temperatures higher now than at the time of the other studies. Temperature may have a role to play in explaining any differences in the abundance of foraminifera.

Based on the sunspot cycle Southward *et al.*, (1975) had suggested that cooling which began at the start of the 1960s would continue into the next century but the temperature has been rising since the 1980s and many greenhouse models (Hansen *et. al.*, 1981; Crane and Liss, 1985; Dickinson and Cicerone, 1986; Gribbin, 1986; Jones, Wigley and Wright, 1986) predict further warming

Faunal change of foraminiferal species within the Sound is unlikely to have occurred to any significant degree. Very minor species may have changed but there is insufficient data to prove or disprove this. Murray's data based on 9 samples and Manley's data based on over 100 samples (but restricted to two stations), both indicate far lower abundances of live foraminifera (Figure 11.23). A significant increase in foraminiferal abundance may be unreal i.e. a result of uncharacteristic samples and biases collection and retrieval, or it may be real. If real then it is unlikely to be due solely to increases in annual mean temperature (as temperatures were only slightly lower during collection of Manley's samples).

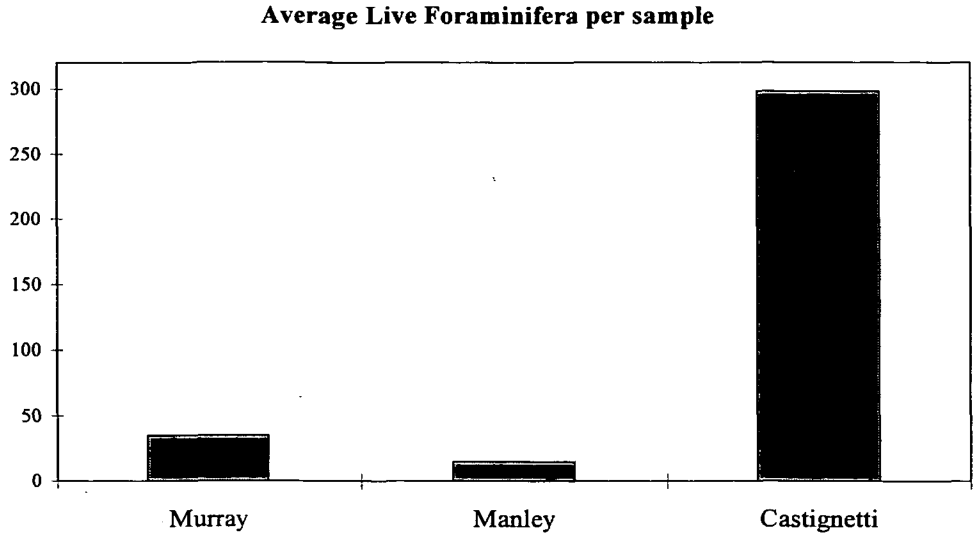


Figure 11.23 Mean average abundance of live foraminifera per sample recorded during 1962 (Murray, 1965), 1973/4 (Manley) and 1994 (Castignetti).

The most obvious reason for increased abundance of foraminifera is the increased abundance in food which the foraminifera can access. This suggests that eutrophication of Plymouth Sound may be a possibility, and if so, probably through increased discharge of sewage and increased used of fertilisers over at least the past 20-30 years. The present study represents a very good data base which will act as a gauge for future studies. South West Water plans a clean up operation aimed at reducing levels of sewage discharged into nearshore areas (Plymouth Sound included). If the clean up operation significantly reduces sewage and other effluent which enters the Sound than examine of foraminiferal abundance at a number of sites should determine whether enrichment has occurred, particularly if abundance falls to the levels recorded by Murray and Manley. Other studies may be undertaken in 10, 20 or 30 years time to observe the effects of increased warming, anthropogenic influences and natural variation upon the Plymouth Sound assemblages.

The Marine Biological Association (MBA) have a good data base on other benthonic organisms which live in the Plymouth Sound area. Any future studies which are undertaken of these various faunas may be compared to previous studies to identify any changes in biomass and assemblage structure.

CHAPTER TWELVE

12. SUMMARY OF FINDINGS

This study was carried out to provide a detailed examination of the foraminiferal assemblages of Plymouth Sound. It encompasses a wide range of topics and its findings can best be summarised under a series of headings.

12.1. Live Assemblages

The greatest part of the study was the examination of the foraminiferal live assemblage. Twelve locations were sampled on a monthly basis for one year. The locations were from a wide range of sedimentary facies within the Sound. The sediment facies is believed to be the single most important factor influencing the foraminiferal assemblages, in terms of diversity, absolute abundance and distribution throughout the year. Salinity has a much smaller, subtle effect and is of much less importance in shaping the foraminiferal assemblages within the Sound. Four very distinctive assemblages are associated with the four main sediment types found within the Sound.

The most diverse and productive assemblages are associated with mud facies. They are typified by a wide range of test morphologies, particular infaunal morphologies (elongate, conical, cylindrical, tapered, flattened tapered, etc.). The mud facies are dominated, in slightly hyposaline areas, by the species *A. beccarii batavus* and, in stenohaline areas, by the brizalinids.

The mixed sediment facies are very similar to the mud facies both in terms of sedimentology and foraminiferal assemblages. This mixed sediment facies contain a greater amount of sand and gravel, and are generally poorly sorted. The foraminiferal assemblages are diverse and productivity is high. These assemblages are characterised by the abundance of *E. crispum,* although *A. beccarii batavus* is also important.

The sand facies contain foraminiferal assemblages which exhibit low diversities and low to very low productivities. They are usually dominated by the most abundant species in Plymouth Sound such as *A. beccarii batavus* and *E. crispum,* but are characterised by a relatively high abundance of miliolids, particularly *Q. lata,* which are best suited to this environment. The sand facies represent unstable substrates and foraminifera obviously have difficulty colonising them. Some of the most unstable sand facies are almost barren of live foraminifera and the few individuals observed are either transported into the area or colonise it during the most favourable conditions.

The gravel facies are very unusual in that they occupy a relatively small area of the Sound and are composed of assemblages which are completely different to those of other facies (The sand, mixed and mud facies assemblages have many species in common and it is the species proportions which are different). The gravel assemblages are dominated by attached or clinging species such as *R. williamsoni* and *T. truncata* (which are absent from other facies). They exhibit moderate diversities and productivities.

Foraminiferal distribution throughout the year is observed to fluctuate greatly from low to high abundance (see Figure 8.108 Chapter 8), although mud and mixed sediment facies generally exhibit moderate to high abundances. Many species exhibit a correlation with temperature, being most common between July to October, the period of highest sea temperatures. Species from the mud and mixed sediments exhibit less correlation with temperature. Reproduction is influenced either directly or indirectly by temperature. Fluctuations in salinity throughout the year show little correlation with foraminiferal assemblages but the mean salinity of an area influenced both its species composition and diversity (which were slightly lower).

In total over 40800 live foraminifera were examined and 126 individual species or varieties recorded. The Plymouth Sound foraminiferal assemblages are dominated by the rotaliid species *A. beccarii batavus* and *E. crispum. Brizalina pseudopunctata, Q. oblonga* and *E. scabrum* are characteristic of muddy areas.

12.2. Dead Assemblages

The dead assemblages of the Sound exhibit a less distinct sub-division based on sedimentary facies although a distinction is still evident. The examination of monthly dead assemblages at each location reveals that they were far more stable than the live assemblages (fluctuate less throughout the year). They show little influence of temperature and salinity. The dead assemblages are far more diverse than the live assemblages but are most diverse in mud facies and least diverse in sand facies. Many species show a fluctuation in their relative abundances throughout the year which is suggested as being the result of post-mortem alteration, patchiness and influences from the live populations. The tests of many species and individuals exhibit damage (abrasion and breakage) this was most significant in the individuals retrieved from sand and shell gravel facies but is observed in every facies.

Over 44000 dead individuals were examined and 130 species or varieties recorded. The dead assemblages of Plymouth Sound are dominated by *C. lobatulus* with lesser numbers of *A. beccarii batavus* and *E. crispum.*

12.3. Live and Dead Assemblages

The examination of both the live and dead assemblages from the same location at the same time provides a great deal of information and is the only way the palaeontologist can gain a significant understanding of the processes which occur during the first stage of the transition from living organism to fossil. The extent of post-mortem processes (winnowing out and into an area, introduction of exotic species and destruction of certain taxa can be determined.

Post-mortem alteration is highest in sand and gravel facies which gain a large percentage of exotic forms from other areas and lose small forms, so much so, that the original live assemblage is unrecognisable from the dead assemblage. In gravel facies the live and dead assemblages are completely different. This is due to the large scale removal of indigenous species either by transport or destruction and their almost complete replacement by exotic species. The unusual shell gravel live assemblage has little or no fossil potential and examination of the dead assemblage to identify indigenous species would be of little use.

The mud rich facies exhibit the least alteration after death. Differences are due mainly to the addition and enrichment of small rare forms transported into these low energy areas.

Several species are identified as being common living, but rare or absent dead, which testifies to their post-mortem destruction or removal. Other species are common within the dead assemblages but rare or absent within the live assemblages (exotics). This indicates post-mortem transport and enrichment of these species from areas, or niches, which were not sampled.

12.4. Plym Estuary

In addition to the main study within Plymouth Sound, the Plym Estuary was also sampled at a monthly frequency throughout the year. There are two primary reasons for sampling the Plym Estuary. The first is because it would provide information on how foraminiferal populations and assemblages developed throughout the year and could be compared to the Sound (this was less useful as assemblages in the Sound exhibit great degree of variation in their distribution throughout the year). The second was because no information was available on the foraminifera of the Plym Estuary which outflows into the Sound.

The live assemblage of the estuary is very similar to that of the Tamar and other British estuaries. The fauna of three hyaline species exhibit their maximum abundance during May and a smaller maxima during September. The Plym Estuary is microtidal and few exotic forms were present. Taphonomic processes act uniformly on the dead assemblage which consequently mirrors the live assemblage. Production calculations show little sign of post-mortem alteration, and production rates were similar for all species. The Plym Estuary is a closed system with little addition and mixing of adjacent faunas/areas. In this respect it is very different to the Sound which is a very much more open system with a large degree of transport and mixing. Selective destruction and removal of foraminifera also creates large differences between live and dead assemblages.

12.5. Cores and Vertical Distribution

The sample suite obtained from the Sound and the Plym Estuary is based on sediment samples from the uppermost 1 cm of the sediment from the sediment/water interface. To evaluate and validate that this uppermost 1 cm contained the highest abundance of foraminifera which were also characteristic of the assemblage as a whole, a series of 9 sediment cores were collected.

The cores show that, in all but one, the highest abundance of live foraminifera occurs in the uppermost 1 cm. This is particularly true of mud rich cores which exhibit a strong concentration of live foraminifera in the layer of oxidised sediment at the top of the cores. The sand and gravel cores exhibit a more diffuse distribution of live foraminifera within the cores. No foraminiferal species occur exclusively below the uppermost 1 cm section. Sampling the uppermost 1 cm of sediment is therefore considered reasonable.

12.6. Radio-Isotope Cores

Three cores were collected from different areas of the Sound and dated using a combination of Lead 210 and Caesium 137 isotopes. These cores show that sediment accumulation rates for the Sound range between 0.19 cm to 0.52 cm per year. This indicates that Plymouth Sound is an area of net sediment accumulation, but that sediment accumulation is relatively slow.

In addition to sediment accumulation, the distribution of radio isotopes within the cores are very indicative of a dynamic and turbulent sedimentary history for Plymouth Sound generally.

12.7. Long Term Faunal Change

From two boreholes drilled into the palaeo-Tamar rock valley in Plymouth Sound three foraminiferal assemblages can be seen to mark an overall transition from estuarine conditions to mixed (estuary mouth conditions) to normal near shore marine conditions over a period of approximately 12000 years. In modern times the composition of foraminiferal assemblages does not seem to have changed significantly based on Murray's and Manley's studies in 1962 and 1973/4 respectively.

Assemblages from the base of foraminiferal cores dated using ^{210}Pb and ^{137}Cs at circa 80 years old for the Breakwater and Withyhedge and 150 years old for Barn Pool, show no significant differences from the present assemblages, in terms of species composition.

The studies of Murray and Manley both indicate a paucity of live foraminifera. If this is real (i.e. characteristic of the Sound and not a result of poor sampling or other biases) then this study (showing foraminiferal abundances which are 10 to 20 times greater than those of Murray and Manley) would indicate that a significant increase may have occurred in foraminiferal abundance during the last 20 to 30 years.

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Appendix 1

Plym Estuary foraminiferal data.

Assemblage from station 3

Live	*Haynesina germanica*	*Elphidium williamsoni*	*Ammonia beccarii batavus*	Total
Dec	22	20	4	46
Jan	90	192	6	288
Mar	304	68	2	374
Apr	305	93	1	399
May	4106	17	2	4125
June	1048	6	1	1055
July	982	82	2	1066
Aug	1022	38	3	1063
Sep	53	25	4	82
Oct	584	378	24	986
Nov	56	21	2	79
	8572	940	51	9563
Live	**89%**	**10%**	**0.53%**	

Dead	*Haynesina germanica*	*Elphidium williamsoni*	*Ammonia beccarii batavus*	
Dec	172	38	1	211
Jan	299	20	5	324
Mar	277	27	7	311
Apr	290	13	4	307
May	229	10	3	242
June	148	28	1	177
July	285	14	6	305
Aug	248	12	4	264
Sep	207	14	3	224
Oct	220	17	6	243
Nov	274	14	2	290
	2649	207	42	2898
Dead	92%	7%	1.40%	

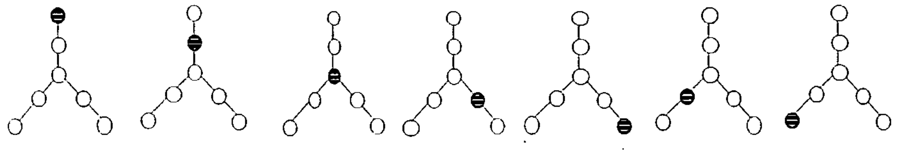
	Total Live Foraminifera	**Gains**	**Losses**
Dec	46	0	0
Jan	288	242	0
Mar	374	86	0
Apr	399	25	0
May	4125	3726	0
June	1055	0	3070
July	1066	11	0
Aug	1063	0	3
Sep	82	0	981
Oct	986	904	0
Nov	79	0	907
Total	**9563**	**4994**	**4961**

	Haynesina germanica	*Elphidium williamsoni*	*Ammonia beccarii batavus*
Live	89%	10%	0.53%
Dead	92%	7%	1.40%

Dead Assemblage from 40 cm core from station 3

Dead	*H. germanica*	*E. williamsoni*	*A. beccarii batavus*	Others	Total
A = 0-5	180	22	6	0	208
B = 5-10	250	9	2	0	261
C = 11-15	225	24	2	1	252
D = 16-20	178	22	0	2	202
E = 21-25	238	2	1	0	241
F = 26-30	292	0	1	1	294
G = 31-38	300	15	1	4	320
Total	**1663**	**94**	**13**	**8**	

Microlateral distributions Plym estuary (Live Foraminifera)



Absolute	**N2**	**N1**	**C**	**E1**	**E2**	**W1**	**W2**	**1 metre**	**10 metre**
H. germanica	91	37	71	96	138	131	55	110	60
E. williamsoni	50	20	45	39	63	42	32	55	36
A beccarii batavus	1	0	0	0	1	0	1	0	0
Total	**142**	**57**	**116**	**135**	**202**	**173**	**88**	**165**	**96**

%	**N2**	**N1**	**C**	**E1**	**E2**	**W1**	**W2**	**1 metre**	**10 metre**
H. germanica	64	65	61	71	68	76	63	67	63
E. williamsoni	35	35	39	29	31	24	36	33	38
A beccarii batavus	1	0	0	0	0	0	1	0	0

Live foraminifera from transect

Transect from 100cm3 samples	Trans 1	Trans 2	Trans 3	Trans 5	Trans 6
H. germanica	280	410	6	290	562
E. williamsoni	76	522	42	130	142
A beccarii batavus	0	16	2	0	0
Total	**356**	**948**	**50**	**420**	**704**
%	Trans 1	Trans 2	Trans 3	Trans 5	Trans 6
H. germanica	79	43	12	69	80
E. williamsoni	21	55	84	31	20
A beccarii batavus	0	2	4	0	0

Appendix 2

Sediment data

Plymouth Sound Monthly samples

Loc 1	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov
Original weight	56.24	no sample	137.57	81.03	118.68	119.8	149.5	91.72	121.3	212.93	85.3	164.02
<63	0.5		2.35	1.73	2.38	1.72	2.5	1.08	1.3	2.95	0.7	1.92
63	4.55		15.7	11.8	16.94	12.46	16.1	9.34	13.75	23.9	12.34	20.98
90	14.12		34.38	25.83	38.2	32.04	38.85	20.17	31.54	53.6	26.26	49.48
125	23.76		42	23.96	33.03	42.14	55.74	34.03	37.52	77.89	20.76	51.97
180	7.41		17.2	7.26	11.92	10.94	13.91	9	12.93	23.08	8.3	17.17
250	2.66		12.3	5.48	7.94	8.76	8.28	6.22	10.38	12.48	5.54	11.58
355	0.96		6.7	2.68	3.96	6.56	5.22	3.98	6.61	0.07	3.63	6.17
500	0.69		2.75	1.07	1.68	2.7	3.32	2.63	5.5	2.55	1.58	2.22
710	0.54		1.7	0.5	0.98	1.34	3.2	2.47	2.18	1.95	1.86	1.11
1000	0.84		1.11	0.27	0.57	0.56	2.14	1.48	1.01	0.87	0	0.71
2000	0.21		0.15	0.01	0	0.15	0.24	0.34	0	0.1	0	0.09
4000	0		0	0	0	0	0	0	0	0	0	0
8000	0		0.17	0	0	0	0	0	0	0	0	0
Final weight	56.24		136.51	80.59	117.6	119.37	149.5	90.74	122.72	199.44	80.97	163.4

Loc 3	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov
Original weight	6.8	28.78	193.49	102.52	175.82	466.99	375	71.64	138.5	172.42	96.34	159.34
<63	0	0	0.01	0.01	0.02	0.02	0.03	0	0.01	0.05	0	0
63	0	0.01	0.06	0.1	0.14	0.06	0.11	0.01	0.07	0.32	0.08	0.07
90	0.01	0.01	0.14	0.08	0.25	0.2	0.3	0.01	0.1	0.5	0.1	0.16
125	0.01	0.01	0.35	0.42	0.9	1.46	1.2	0.01	0.27	0.9	0.22	0.76
180	0.02	0.1	0.25	0.56	0.41	2.12	1.86	0.01	0.33	0.71	0.2	0.97
250	0.06	0.36	0.48	1.45	1.1	4.04	4.7	0.2	0.8	0.92	0.3	2.28
355	0.15	1.62	2.97	6.47	3.75	24.62	20.64	1.65	3.99	5.04	1.12	8.4
500	0.35	4.42	12.4	18.68	11.78	77.94	52.75	6.14	12.85	15.66	4.33	19.19
710	0.9	6.2	29.8	31.82	33.6	141.98	91.6	12.75	34.34	38.3	12.6	36.54
1000	1.9	11.55	85.15	36.7	91.15	172.86	135	31.52	65.2	69.32	32.96	70.3
2000	2.7	1.62	46.75	4.62	20.22	33.87	49.28	11.67	15.5	23.4	13.62	18.07
4000	0.9	0.5	14.4	0.85	5.46	6.26	12.42	4.15	3.19	10.13	7.33	2.34
8000	0.59	2.3	0.16	0	0.35	0.38	3.96	3.55	1.64	6.21	22.21	0
Final weight	7.59	28.7	192.92	101.76	169.13	465.81	373.85	71.67	138.29	171.46	95.07	159.08

Loc 4	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov
Original weight	90.03	58.42	91.88	149.07	213.06	225.37	179.95	173.9	115.2	120.08	112.63	187.85
<63	0.25	1.9	0.07	1.8	3.08	1.63	8.15	2.04	0.3	1.31	0	0.4
63	2.1	7.3	0.77	9.06	11.94	6.76	18.18	7.7	1.88	7.51	3.3	5.9
90	4.21	10.86	2.47	13.58	16.84	11.06	34.54	11.73	5.55	14.07	16.47	13.95
125	11.36	15.26	9.35	26.98	36.45	24.48	51.71	24.87	18.74	25.2	45.27	32.89
180	10.8	8.88	12.45	23.98	40.51	35.75	33.13	28.87	30	18.58	28.59	35.8
250	7.25	4.2	9.06	11.96	28.04	26.09	13.84	19.09	20.96	9.73	11.71	19
355	7.72	2.18	9.6	9.42	18.74	20.45	7.12	15.32	12.8	6.9	2.7	13.62
500	10.69	1.68	11.28	11.58	14.26	19.77	4.58	16.28	8.63	7.15	1	15.68
710	13.06	1.68	12.08	14.14	17.24	18.42	3.1	16.73	7.77	7.92	0.38	17.75
1000	16.46	1.91	11.83	18	16.5	15.93	2.44	17.41	6.18	11.05	0.42	19.08
2000	4.06	1.15	2.85	5	3.78	6.01	1.44	4.72	1.71	4.51	0.2	4.95
4000	2.04	0.7	3.28	2.14	2.34	5.48	1.22	4.58	1.55	3.42	0.18	2.15
8000	0	0.75	6.63	1	2.68	32.9	0	3.62	0	2.18	0	6.02
Final	90	58.45	91.72	148.64	212.4	224.73	179.45	172.96	116.07	119.53	110.22	187.19

weight												
Loc 8	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov
Original weight	97.82	28.62	117.91	223.86	103.16	98.11	100.9	75.12	143.55	94.06	121.32	143
<63	0	0	0.08	0	0.02	0.01	0.17	0.09	0.12	0.24	0	0.04
63	0.11	0.01	0.77	0.1	0.22	0.12	0.34	0.3	0.71	0.5	0.24	0.83
90	0.21	0.08	2.62	0.3	0.35	0.34	0.84	0.94	1.3	1.41	0.54	1.34
125	1.2	0.91	10.54	2.51	0.62	2.11	7.04	10.83	6.38	12.09	4.32	3.15
180	3.56	3.1	16.02	11.91	1.26	6.34	20.34	24.28	15.43	22.45	14.8	6.01
250	7.87	6.62	19.22	30.68	5.37	14.18	30.89	21.74	24.64	22.95	24.25	11.24
355	12.94	5.42	20.83	49.4	15.12	19.66	22.78	10.27	26.64	15.72	25.58	13.3
500	17.17	5.14	15.51	42.82	22.69	17.99	11.56	3.42	19.33	11.06	18.22	12.16
710	20.11	3.17	12.73	35.4	26.6	15.66	4.64	1.78	15.52	4.55	11.07	12.41
1000	26.7	3.3	12.32	34.77	25.34	13.08	2.03	0.95	20.48	2.1	11.73	21.82
2000	6.53	0.6	4.64	11.28	4.7	3.58	0.42	0.3	10.09	0.51	6.31	11.81
4000	1.07	0.13	1.14	4.03	0.75	1.84	0	0	2.81	0	1.85	9.73
8000	0	0	0.17	0	0	3.02	0	0	0	0	1.5	38.39
Final weight	97.47	28.48	116.59	223.2	103.04	97.93	101.05	74.9	143.45	93.58	120.41	142.23

Loc 11	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov
Original weight	51.17	76.74	68.12	93.05	45.74	65.27	95.29	98.97	92.9	92.6	206	117.83
<63	0.02	0.01	0.01	0.08	0.01	0.06	0.1	0	0.08	0.05	0	0.08
63	0.17	0.51	0.25	0.4	0.16	0.2	0.4	0.4	0.6	0.24	0.5	0.81
90	1.44	2.02	1.15	1.96	1.03	0.84	1.62	0.02	2.43	1.6	3.62	2.07
125	7.06	15.94	9.63	14.1	7.9	8.71	14.67	18.37	16.15	15.43	39.54	18.92
180	12.96	22.1	17.6	26.32	12.26	17.14	27.66	31.89	24.02	23.36	67.62	27.11
250	14.27	16.77	18.06	19.08	10.1	16.1	19.54	22.5	17.94	18.81	43	20.58
355	6.8	9.33	12.13	14.64	6.12	12.74	15.77	12.6	14.64	13.65	22.72	17.79
500	3.71	4.2	5.57	8.08	3.96	4.97	7.6	4.53	7.86	9.17	13.52	14
710	1.06	2.88	2.48	4.8	2.26	2.14	5.08	2.29	4.97	5.86	5.56	9.04
1000	1.11	2.1	1.28	2.94	1.63	1.65	2.46	2.22	2.97	3.45	4.25	5.31
2000	1.28	0.4	0.21	0.5	0.27	0.14	0.44	1.12	0.55	0.5	0.48	0.85
4000	0.8	0.12	0.03	0	0.08	0	0	0.32	0.19	0.2	0	0.22
8000	0	0	0	0	0	0	0	0	0	0	0	0
Final weight	50.68	76.38	68.4	92.9	45.78	64.69	95.34	96.26	92.4	92.32	200.81	116.78

Loc 14	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov
Original weight	32.27	48.07	88.99	43.43	150.04	88.66	162.48	80.23	115.18	111.64	110.65	160.76
<63	0.07	0.02	0.05	0.08	0.27	0.3	0.6	0.38	0.28	0.75	0.33	0.01
63	0.62	0.54	0.96	1.01	2.12	1.85	3.32	2.22	2.94	5.31	3.3	0.66
90	3	4.5	8.94	7.42	13.59	9.6	15.9	11.96	12.3	21.7	20.24	3.8
125	9.82	20.98	38.64	20.05	58.05	38.23	58.9	41.27	51.54	49.58	52.6	25.85
180	8.53	12.06	24.53	8.18	36.8	19.31	44	16.58	27.33	21.36	20.36	37.37
250	7	6.7	10.5	4.04	14.95	10.31	18.54	5.65	12.04	8.11	7.8	36.92
355	1.27	2.15	4.4	1.96	13.68	5.7	0.92	1.23	3.68	2.8	2.29	30.21
500	0.7	0.45	0.43	0.38	2.37	1.18	1.64	0.25	0.71	0.4	0.7	16.45
710	0.2	0.15	0.12	0.14	0.64	0.62	0.68	0.15	0.34	0.41	0.3	5.99
1000	0.24	0.11	0.06	0.08	0.5	0.41	0.8	0.17	0.38	0.44	0.5	2.34
2000	0.2	0.01	0.01	0.01	0.31	0.22	0.9	0.29	0.54	0.73	0.25	0.49
4000	0.69	0	0	0	0.5	0.01	0.1	0	0	0	0	0.24
8000	0	0	0	0	5.1	0	9.48	0	0	0	0	0
Final weight	32.34	47.67	88.64	43.35	148.88	87.74	155.78	80.15	112.08	111.59	108.67	160.33

Loc 16	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov
Original weight	109.25	181.27	245.18	160.22	72.68	missing	195.59	207.41	88.5	367.09		177.19
<63	0	0	0.01	0	0		0.01	0	0	0.13	0	0
63	0.02	0.03	0.05	0.01	0.01		0.12	0.1	0	0.82	0.22	0.06
90	0.17	0.06	0.12	0.06	0.01		0.22	0.14	0.08	0.85	0.24	0.14
125	0.25	0.1	0.16	0.1	0.04		0.37	0.23	0.12	0.93	0.32	0.36
180	0.45	0.27	0.57	0.52	0.1		0.96	0.56	0.12	1.62	0.73	0.01
250	2.24	2.04	2.86	1.76	0.77		5.23	4.94	0.3	7.47	5.31	5.55
355	3.74	7.24	8.17	6.62	2.54		15.31	19.73	1.78	20.89	13.81	14.27
500	8.61	19.02	20.84	19.5	6.47		32.35	45.73	5.21	45.44	32.84	26.55
710	15.38	35.3	46.9	40.64	13.23		49.16	58.48	11.31	82.15	39.97	34.45
1000	33.18	69.99	102.23	66.12	25.18		61.73	44.35	15.45	119.9	75.84	40
2000	20.58	28.5	46.52	18.69	10.9		17.94	11.23	10.12	49.95	14.84	18.45
4000	19.25	9.99	15.68	5.69	10.76		7.45	7.49	12.58	26.8	7.95	20.86
8000	5.6	8.12	0.12	0	2.34		2.81	13.69	9.03	7.56	9.03	14.98
Final weight	109.47	180.66	244.23	159.71	72.35		193.66	206.67	66.1	364.51	201.1	175.68

Loc 17	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov
Original weight	66.33	84.7	46.55	91.16	118.67	154.31	195.21	95.14	74.33	126.45	41.52	55.43
<63	0.06	0.02	0.02	0.13	0.01	0.16	1.55	0.66	0.14	1.86	0	0
63	0.4	0.21	0.17	1.52	0.32	0.64	5.75	3.1	0.78	8.64	0.42	0.1
90	0.69	0.6	0.85	3.14	1.71	1.85	10.02	11.02	2.02	14.86	0.92	0.15
125	1.28	3.95	4	11.32	10.99	10.77	32.33	16.11	12.52	19.31	2.16	2.5
180	2.75	17.6	11.24	22.61	28.42	30.47	53.66	14.68	22.29	11.73	3.42	12.66
250	5.64	27.74	14.59	25.8	35.59	41.9	34.74	10.02	16.2	5.75	11.77	18.97
355	7.42	18.55	6.64	15.75	18.56	32.19	14.29	7.16	7.06	6.53	12.02	10.59
500	7.85	7.34	2.57	5.22	8.54	13.84	8.11	5.4	3.5	9.1	7.89	3.85
710	8.25	4.38	4.22	3.06	4.72	9.52	6.66	4.3	2.28	10.1	0.89	2.34
1000	17.97	3.45	2.52	2.02	4.71	8.32	13.12	8.77	4	11.13	1.09	3.05
2000	10.98	0.55	1.66	0.1	2.58	3.6	9.78	7.96	2.54	8.54	0.38	1.14
4000	1.85	0	0.58	0	1.15	0.3	2.56	2.17	0.5	6.72	0.01	0
8000	0.85	0	0	0	1.04	0	2.29	3.42	0.22	12.17	0.01	0
Final weight	65.99	84.39	49.06	90.67	118.34	153.56	194.86	94.77	74.05	126.44	40.98	55.35

Loc 18	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov
Original weight	75.33	82.4	51.05	114.32	156	186.6	169.15	49.56	228.4	100.18	111.32	76.87
<63	0.7	0.75	0.66	0.64	0.8	1.44	2	0.53	3.77	1.36	0	0
63	4.46	2.87	2.7	3.54	4.06	6.58	7.59	2.62	14.17	4.59	4.5	4.16
90	6.92	5.85	5.08	6.7	8.66	12.49	11.65	4.68	20.5	6.05	8.32	6.44
125	13.3	17.85	13.25	21.9	29.05	31.99	29.22	10.32	44.52	17.12	16.21	16.06
180	16.7	19.5	12.43	29.55	46.26	44.73	38.15	11.5	52.78	24.87	22.25	18.77
250	15.06	4.6	8.7	23.88	33.8	36.56	29.76	9.23	41.16	21.01	26.4	13.22
355	7.7	7.37	4.3	12.92	16.24	17.58	17.86	5.07	20.37	13.24	11.18	7.62
500	2.87	2.65	1.24	4.06	5.59	5.26	5.52	1.95	10.05	4.7	4.54	2.82
710	1.25	1.18	0.64	1.75	2.67	2.5	2.33	0.95	3.76	1.78	1.99	1.3
1000	0.96	1.42	0.5	1.6	2.5	2.02	2.65	0.65	2.84	1.22	2.47	1.09
2000	0.92	2.04	0.36	1.93	1.92	2.19	5.1	0.9	2.02	0.99	2.24	1.49
4000	3.44	1.8	1.15	1.3	1.34	3.92	7.51	1.03	3.88	0.93	7.79	2.52
8000	0.77	3.3	0	4	1.77	18.52	9.42	0	7.66	1.97	0	0.74
Final weight	75.05	71.18	51.01	113.77	154.66	185.78	168.76	49.43	227.48	99.83	107.89	76.23

Plymouth Sound monthly samples (duplicate samples including clay and silt fraction)

Loc 9 Original weight	157	190	105	204
<63	115	121.83	55.21	159.01
63	16.5	20.4	13.56	21.53
90	10.94	15.24	9.74	14.21
125	6.71	11.01	5.32	9.85
180	2.58	2.09	1.95	2.2
250	1.7	1.02	1.21	3.5
355	1.37	0.09	0.56	0.83
500	0.96	0.07	0.08	0.21
710	0.44	0.06	0.05	0.01
1000	0	0.1	0.01	0.02
2000	0	0.1	0	0.05
4000	0	0.25	10.3	0
8000	0	0	0	0
Final weight	156.2	172.26	97.99	211.42

Loc 12 Original weight	186..5	91.06	151.3	99.55
<63	147.45	21.93	85.74	48
63	10.4	5.85	8.98	23.8
90	9.82	7.82	8.21	6.32
125	8.14	10.37	7.84	7.2
180	4.36	7.26	5.61	4.2
250	2	6.8	4.11	3.52
355	0.01	4.05	1.32	3.02
500	0.01	3.18	0.11	2.59
710	0.01	2	0.32	0.2
1000	0.01	2.48	0	0.4
2000	0	5.01	0	0
4000	0	4.4	7.6	0
8000	0	9.15	11.02	0
Final weight	182.21	90.3	140.86	99.25

Loc 15 Original weight	300.7	148.02	103.89	205.11
<63	157.3	88.58	48.65	124.8
63	23.48	11.35	9.12	18.47
90	25.96	15.55	13.21	16.08
125	56.8	1.06	7.99	3.58
180	18.28	0.27	9.54	0.85
250	5.57	0.56	4.27	0.15
355	4.84	0.3	3.25	0.01
500	1.92	0.36	1.79	0.01
710	2.47	0.49	0.25	5.62
1000	2.1	0.1	2.01	0.01
2000	1.8	0	0.88	0
4000	0.36	0	0.22	0
8000	0	0	0.4	0
Final weight	300.88	118.62	101.58	169.58

Loc 17 Original weight	151.94	125.23	146.87	102.2
<63	12	24.05	3.21	3
63	2.38	3.15	0.64	1.05
90	4.98	5.63	1.85	0.96
125	17.66	15.79	10.77	8.94
180	28.16	31.2	30.47	38.64
250	27.55	22.44	36.9	24.53
355	18.77	12.98	32.19	10.5
500	14.55	9.58	13.84	4.4
710	11.08	5.71	9.52	0.43
1000	9.01	4.01	5.32	0.12
2000	2.07	2.44	3.6	0.06
4000	2.13	1.01	0.3	0.01
8000	1.44	0.32	0	0
Final weight	151.78	138.31	148.61	92.64

Loc 18 Original weight	101.83	151.41	98.72	198.4
<63	21.25	18.5	29.98	42.12
63	3.02	4.06	0.2	4.15
90	5.3	8.66	6.3	18.18
125	12.76	29.05	9.22	34.54
180	14.22	36.26	12.84	41.71
250	11.65	28.8	7.65	23.13
355	7.26	16.24	3.26	13.84
500	2.94	5.59	2.94	7.12
710	1.92	2.67	1.92	4.58
1000	2.22	2.5	2.22	3.1
2000	7.84	1.92	7.42	2.44
4000	9	1.34	1.59	1.44
8000	6.85	1.77	4	1.22
Final weight	106.23	157.36	89.54	197.57

Plym Original weight	191.16	66.55	101.65	147.8
<63	168.67	50.9	80.05	126.2
63	3.43	0.2	2.51	5.21
90	6.2	1.95	1.57	1.2
125	3.71	3.02	5.68	0.25
180	1.88	2.015	4.78	4.55
250	1	1.02	0.15	3.17
355	0.57	0.61	0	0.47
500	0.05	0.5	0	0.11
710	0.1	0.01	0	0.24
1000	0.28	0.01	1.02	0.01
2000	0.35	0.01	0.54	0.21
4000	0.3	0.01	0.01	0.1
8000	0.88	0	0	0
Final weight	187.42	60.255	96.31	141.72

Loc 4 Original weight	90.22	98.14	124.98	151.01
<63	13.64	29.5	7.54	19.03
63	6.5	1.9	4.3	4.5
90	4.73	7.3	1.88	8.32
125	6.95	10.86	5.55	16.21
180	13.2	15.26	18.74	35.25
250	10.5	8.88	30	26.4
355	5.05	4.2	20.96	11.18
500	4.1	2.18	12.8	4.54
710	6.99	1.68	8.63	1.99
1000	11.03	1.68	6.21	2.47
2000	3.16	1.91	1.14	2.24
4000	4.33	1.15	1.84	7.79
8000	0	0.7	0.2	2.1
Final weight	90.18	87.2	119.79	142.02

Average percentage of silt and clay from muddy sites (base on seasonal duplicate samples)

Loc					
	Feb	***May***	***July***	***Oct***	**Average**
Plym	88.20	75.33	79.12	84.44	**82**
Loc 9	72.00	61.69	57.13	79.21	**67**
Loc 12	78.50	23.13	55.81	48.28	**51**
Loc 18	20.54	12.30	31.23	21.50	**21**
Loc 15	50.70	58.30	47.21	61.80	**55**
Loc 17	6.55	18.63	1.92	2.56	**7**
Loc 4	14.54	28.30	4.60	12.30	**15**

Sediment distribution for silt and clay (using Malvern Master Sizer)

µm	0-1	0-2	0-4	0-8	0-16	0-32	<63
Loc 4	3.62	8.45	17.84	31.23	48.04	67.45	87.96
	3.62	4.83	9.39	13.39	16.81	19.41	20.51
Cum Tot	**4.12**	**9.61**	**20.28**	**35.51**	**54.62**	**76.69**	**100.01**
Loc 9	2.6	7.56	16.48	29.58	46.6	68.67	88.56
	2.6	4.96	8.92	13.1	17.02	22.07	19.89
Cum Tot	**2.94**	**8.54**	**18.61**	**33.40**	**52.61**	**77.53**	**99.98**
loc 12	3.66	9.7	20.69	35.91	53.55	72.23	88.93
	3.66	6.04	10.99	15.22	17.64	18.68	16.7
Cum Tot	**4.11**	**10.90**	**23.26**	**40.36**	**60.19**	**81.19**	**99.96**
Loc 15	3.46	8.65	17.2	28.65	42.43	61.26	86.48
	3.46	5.19	8.55	11.45	13.78	18.83	25.22
Cum Tot	**4.00**	**10.00**	**19.88**	**33.12**	**49.05**	**70.82**	**99.97**
loc 17	2.88	7.67	16.69	28.89	43.49	63.6	86.53
	2.88	4.79	9.02	12.2	14.6	20.11	22.93
Cum Tot	**3.33**	**8.87**	**19.29**	**33.40**	**50.27**	**73.52**	**100.03**
Loc 17	1.35	3.33	6.72	12.45	27.33	57.11	84.58
	1.35	1.98	3.39	5.73	14.88	29.78	27.47
Cum Tot	**1.60**	**3.94**	**7.94**	**14.72**	**32.30**	**67.50**	**99.97**
loc 18	4.06	9.06	19.65	34.86	53.11	74.84	93.37
	4.06	5	10.59	15.21	18.25	21.73	18.53
Cum Tot	**4.35**	**9.70**	**21.05**	**37.34**	**56.88**	**80.15**	**100.00**
Loc 18	*4.27*	*9.5*	*21.29*	*37.54*	*53.22*	*70.62*	*90.52*
	4.27	5.23	11.79	16.25	15.68	17.4	19.9
Cum Tot	**4.72**	**10.50**	**23.53**	**41.48**	**58.81**	**78.04**	**100.02**

Sample descriptions taken on board Sepia

1st DECEMBER 1993

LOC 1 South of Breakwater

Fine well sorted, well washed sands, very slightly muddy.
Normal scoop taken.
10.85°C / 34.00‰ / depth 14m

LOC 3

Very well washed medium to coarse shell sand (mainly thin bivalves), some coal fragments. Very small sample obtained.
9.2°C / 32.10‰ / depth 8m

LOC 4

Poorly sorted sediment, A muddy fine to coarse shell sand. Normal scoop obtained
10°C / 33.55‰ / depth 10m.

1. LOC 8 Off Ramscliff

Coarse shell and pebble sand, well washed. Normal scoop taken.
9.8°C / 33.26‰ / depth 9m

LOC 9 North of Breakwater

Silty muds, thin oxic brown top, black anoxic muds below. Very large sample taken, mainly anoxic muds.
10.1°C / 33.70‰ / depth 14m

LOC 17 Anchorage Beacons

Muddy medium to coarse shelly, poorly sorted sediment with a wide range in grain size. Normal scoop obtained.
9.68°C / 32.52‰ / depth 9m

LOC 18 Withyledge beacons

Very muddy silt to medium sand, moderately sorted, abundant tube worms. Large scoop.
9.68°C / 32.52‰ / depth 9m

LOC 11

Well sorted, well washed medium sands with shell and coal fragments. Normal scoop.
9.8°C / 33.15‰ / depth 9m

LOC 12 Barn Pool

Silty muds, Very thin brown oxic layer, 4 to 5 mm thick, then very dense black mud below, and some thin large shell fragments.

8.8°C / 30.25‰ / depth 7m

LOC 14 Drakes Island

Well sorted well washed medium sands, no mud, coal fragments, some large shell fragments. Normal scoop.

9.15°C / 32.00‰ / depth 2m

LOC 15 Mount Batten Breakwater

Silt and muds, small shell fragments, worm tubes. Large scoop

9.8°C / 32.34‰ / depth 6m

LOC 16 Queens ground

Very coarse pebbly shell gravel, well washed

10.1° / 33.70‰ / depth 11m

4th JANUARY 94

LOC 1 South of breakwater

No sample taken due to bad weather

LOC 16

Coarse shelly sand and gravel. Two scoops taken, sample poor.

9°C / 35.10‰ / 13m

LOC 9 North of the breakwater

Very over-full black mud.

9.6°C / 34.92‰ / 16m

LOC 3

Very small sample obtained, medium to coarse shell sand.

9.6°C / 35.00‰ / 12m

LOC 11

9.5°C / 34.89‰ / 12m

LOC 4
Very over-full, muddy
9.6°C / 34.86‰ / 14m

LOC 8 Off Ramscliff
Medium well washed sands, two scoops taken , small sample.
9.6°C / 34.87‰ / 12m

LOC 17 Anchorage Beacons
Over-full with medium well washed sands.
9.6°C / 34.90‰ / 12m

LOC 18 Withyledge Beacons
Very muddy medium sand, over-full.
9.6°C / 34.54‰ / 9.5m

LOC 15 Mount Batten Breakwater
Over-full with mud, worm tubes present
9.4°C / 34.09‰ / 10m

LOC 14 Drakes Island
Medium well washed sands
9.8°C / 32.74‰ / 5m

LOC 12 Barn Pool
Dense black mud, half full wedge.
9.2°C / 32.00‰ / 15m

2nd FEBRUARY 94

LOC1 South of Breakwater
Fine sand, normal scoop.
9.0°C / 34.15‰ / 18m

LOC 16
Coarse shell, normal scoop
8.8°C / 35.05‰ / 13m

LOC 9 North of Breakwater

Because of the nature of the sediment, more than 100cm^3 (in fact as much as 5 or 6 times this amount) may be collected, this is because the grab sinks deeply into the mud. To over come this problem which only consistently occurs at this locality, two wooden blocks about 3cm thick were lashed to the underside of the grab for this locality. The result was a normally full grab, of light brown oxic muds, with worm tubes. A grain size analysis sample was retrieved.

8.8°C / 34.95‰ / 16m

LOC 3

Over-full scoop of very coarse shell fragments

8.8°C / 34.96‰ / 11m

LOC 11

Medium well sorted sand, normal scoop.

8.8°C / 34.86‰ / 11.5m

LOC 4

Very muddy medium sand with abundant gastropods, coarser shell fragments, light brown mud. Poor grab. Duplicate taken.

8.8°C / 34.90‰ / 12.5m

LOC 8 Off Ramscliff

Medium sand, coarser shell fragments, slightly muddy

8.8°C / 34.75‰ / 12.5m

LOC 17 Anchorage Beacons

Medium sands, coarser shell fragments clean well washed. Normal scoop. Grainsize sample taken

8.8°C / 34.75‰ / 13m

LOC 18 Withyledge Beacons

Good scoop about half sand half mud. Duplicate was more muddy

8.8°C / 34.75‰ / 9m

LOC 15 Mount batten

Good scoop mainly silty muds, some worm tubes. Grainsize duplicate taken

8.8°C / 34.75‰ / 11m

LOC 14 Drakes Island

Medium well sorted sands, poor scoop.

8.7°C / 33.71 / 5.5m

LOC 12 Barn Pool

Dense black mud with thin sharp brown oxic layer on top, normal scoop. Duplicate retrieved.

8.6°C / 32.91‰ / 11m

2nd MARCH 94

LOC 1

Fine silty sand well sorted. ¾ of normal scoop

9.0° / 35.20‰ / 18m

LOC 16

Reasonable scoop well washed coarse shell gravel.

9.0° / 35.11‰ / 13m

LOC 9

Good scoop with wood blocks, silty mud, yellow brown colour.

8.9°C / 34.92‰ / 13m

LOC 3

Shell gravel, normal scoop.

8.9°C / 34.64‰ / 11m

LOC 4

Poorly sorted sediment, ranging from brown mud to coarse shell. Rock found with live sea squirts. Also present were bryozoa, and *Cibicides lobatulus*, these did not stain red.

8.9°C / 35.02‰ / 12m

LOC 8

well washed coarse shell gravel, large tube worm.

8.8°C / 34.70‰ / 12m

LOC 17

Two scoops taken. The first was very muddy, with worm tubes. The second was clean medium sands, with *Ensis* and sea spiders present (this shows how variable sediment type is, even in a small area).
8.8°C / 34.70‰ / 11m

LOC 18

Muddy medium sands, worm tubes, rag worms and shell fragments.
8.8°C / 34.70‰ / 8m

LOC 15

Mud with worm tubes, good scoop.
8.8°C / 34.50‰ / 10m

LOC 14

Medium sand slightly muddy, small sample
8.8°C / 33.78‰ / 4m

LOC 12

Very full scoop of soft brown muds, with worm tubes
8.8°C / 31.50‰ / 11.5m

LOC Plym

Brown mud, interstitial water salinity 20.00‰

Special note; on this months sampling a line of fresh water was noted approaching the breakwater (it was about over LOC 3), salinity measurements were taken as usual on the bottom, in addition to this surface salinity was also measured and although not recorded officially it was noticed that surface salinities were consistently 2 or 3‰ less this was the case at each locality, except at LOC 12 Barn Pool. This showed identical salinities at the bottom and top. It is suspected (from the skipper) that at this locality there is a strong tidal scour and good mixing of the water column, this locality being at the mouth of the Tamar. It is most likely to experience hyposaline conditions at the bottom. If so, should be reflected in its foraminiferal populations.

APRIL SAMPLE 30/3/94/

Loc 1

Good scoop, fine to medium grained sand, well washed.
9.4° / 35.12‰ / 19m.

Loc 16

Good sample, coarse shell gravel.

9.4° / 35.10‰ / 17.5m.

Loc 9

Over-full sample approximately twice as much as normal, soft light brown muds, worm tubes present as well as juvenile *Turritella* gastropod.

9.3° / 35.05‰/ 16m.

Loc 8

Medium, coarse to very coarse shell gravel, slightly muddy. Normal scoop size.

9.4 °/ 34.68 ‰/ 12m.

Loc 17

Medium sands, well washed.

9.4 °/ 34.68‰ / 12m

Loc 18

Muddy fine to medium brown sands, coarser shell fragments, worm tubes.

9.4 °/ 34.68 ‰/ 7.5m.

Loc 4.

Medium to coarse muddy sands.

9.4 °/ 34.96‰ / 12m.

Loc 3

Coarse to very coarse shell gravel, well washed.

9.4 °/ 34.04‰ / 11m.

Loc 11

Poor scoop, two were taken in all , which totalled half a normal scoop. Medium yellow well washed sands.

8.0° / 34.56‰ / 11m

Loc 12.

Black hard mud wedge with thin anoxic layer.

9.4 °/ 33.64‰ / 9m.

Loc 14.

Medium sands well sorted, lots of eel grass.
9.3 °/ 34.10‰ / 3.0m.

Loc 15

Silty black mud with a brown oxic top, half scoop, worm tubes abundant.
9.4 °/ 34.50‰ / 8.5m.

Plym 30/03/94

Orangy brown oxic mud black a few mm below, salinity from small pools 30‰

10th May 1994

Loc 1

Normal size sample, clean fine sands.

Loc 16

Grab dropped six times, very poor sample obtained, clean shell gravel and one large bivalve shell.

Loc 9

Good sample obtained, yellow brown mud, second sample taken for grain size analysis.

Loc 3

Very large sample of shell gravel, clean (double normal size).

Loc 4

Three grabs taken each with very small amount of sediment altogether a small sample. Very poorly sorted sand with light brown mud and pebbles. Grain size analysis sample taken.

Loc 11

Two small grabs taken, medium grained sands with coarser coal fragments, well washed.

Loc 8

Three grabs taken, medium mod well sorted sands, clean.

Loc 17

Two grabs taken, medium sands, well sorted, slightly cloudy. A second grain size sample was taken

Loc 18

Medium sands, some pebbles and mud, live pelican shell. A second grain size sample was taken, less sandy than usual.

Loc 12

Thin oxic mud, black silty mud below, grain size sample also taken.

Loc 14

Good sample obtained, well washed, lots of coal fragments.

Loc 15

Good sample worm tubes muddy, second taken for grain size analysis.

Plym

Orangey mud, two samples taken one for grain size analysis. Salinity 35‰.

(salinometer and MC5 broken, loose connection)

9th June 94

Loc 18

One good sample, fairly muddy, poorly sorted sand with some pebbles.
11.8°C/35.05‰ / 11.8m.

Loc 17

Three samples taken, normal.
11.8 °C/35.05‰ / 11m

Loc 8

Medium, well sorted, clean sands, normal sample
11.8°C /35.05‰ / 11m.

Loc 1

Two attempts made, fine sand.

11.3 °C/35.30‰ / 16.5m.

Loc 16

Normal sample, coarse shell gravel.

11.6°C/35.15‰ / 11.5m.

Loc 9

One good sample, mud.

11.7°C /35.15‰ / 15m.

Loc 3

One good sample.

12.4°C /34.10‰ / 9m.

Loc 11

Fair sample, clean well sorted medium sand.

11.8°C /35.16‰ / 9m.

Loc 4

ALBATROSS on spot, sampled 20m on Plymouth side, good muddy sample.

11.9°C /35.06‰ / 12m.

Loc 12

Good sample.

12.5°C / 33.89‰ / 13m.

Loc 14

Two attempts made, weedy, medium sand, slightly muddy.

12.8°C /33.50‰ / 3.5m.

Loc 15

One good sample.

12.0°C / 34.96‰ /6.5m.

Plym

Orangy brown mud. Salinity from pools over water 25.00‰
Salinity from pools in tyres 15.00‰

22nd July 94

Loc 18
9.0°C / 35.30‰ / 8m

Loc 17
Brown muddy medium sand. Duplicate retrieved.
9.1°C / 35.30‰ / 11m

Loc 8
9.1°C / 35.30‰ / 11m

Loc 14
Medium sand, lots of micro algae.
10.1°C / 35.05‰ / 3.5m

Loc 12
!0.3°C / 35.04‰ / 18m

Loc 11
Fine to medium clean sands.
16.2°C / 35.1‰/ 9m

Loc 4
Light brown muddy sand, duplicate taken.
8.7°C / 35.19‰ / 11m

Loc 9
9.8°C / 35.19‰ / 13m

Loc 3
Med to coarse shell gravel, clean.
10.2°C / 34.85‰ / 8m

Loc 16
Medium shell gravel, slightly muddy
7.8°C / 35.20‰ / 9m

Loc 1
Clean fine medium sand
7.8°C / 35.30‰ / 14m

Loc 15
Silty mud, duplicate.
? /35.16‰ / 6m (error in thermometer)

Plym ?

Spurious temp results from MC5 for this months samples !!!

10th August 94

P. C. not present C. J. M. retrieved samples and recorded variables

Loc 1
16.5°C / 35.28‰ / 18m

Loc 16
16.6°C / 35.29‰ / 13m

Loc 9
16.4°C / 35.25‰ / 16m

Loc 8
16.6°C / 35.10‰ / 12m

Loc 17
16.6°C / 35.10‰ / 11.5m

Loc 18
16.6°C / 35.10‰ / 12m

Loc 4
16.6°C / 35.22‰ / 12m

Loc 11
16.6°C / 35.05‰ / 11m

Loc 3
16.6°C / 35.01‰ / 11m

Loc 12
16.7°C / 34.94‰ / 10m

Loc 14
16.7°C / 34.91‰ / 9m

Loc 15
16.6°C / 35.1‰ / 9m

Plym 35.00‰

20th September 94

Loc 18
Medium muddy sand
14.8°C / 35.20‰ / 9.5m

Loc 17
Muddy, poorly sorted
14.8°C / 35.20‰ / 11m

Loc 8
14.8°C / 35.20‰ / 12m

Loc 1
Fine sand silty, good sample
14.8°C / 35.35‰ / 16m

Loc 16
Good sample coarse shell gravel, slightly muddy
14.8°C / 35.25‰ / 11m

Loc 9
Mud, normal size sample
14.78°C / 34.09‰ / 14m

Loc 3
14.6°C / 33.69‰ / 10m

Loc 11

Good sample, clean medium washed shell sand

14.75°C / 34.55‰ / 9m

Loc 4

Sandy light brown clay, smallish sample

14.8°C / 35.16‰ / 12m

Loc 12

Hard black mud, tube worms abundant

14.62°C / 33.40‰ / 17m

Loc 14

Medium sand, sticky and dark (reducing)

14.62°C / 33.15‰ / 3.5m

Loc 15

Dark, silty sediment, worm tubes

14.4°C / 34.85‰ / 7m

Plym 32.00‰

6th OCTOBER 1994

Loc 18

Large sample, medium grained sand, quite a lot of mud. Duplicate taken

14.6°C /35.25‰ / 9m

Loc 17

Smallish sample, medium well sorted sand, some mud. Duplicate taken after two attempts.

14.6°C / 35.25‰ / 12m

Loc 8

Normal scoop, medium to coarse sand, mud in suspension.

14.6°C / 35.25‰ / 13.5m

Loc 1

Smallish sample, clean fine sand.
14.6°C / 35.35‰ / 17m

Loc 16
Normal grab, fine shell gravel, mud in suspension.
14.2°C / 35.10‰ / 16.5m

Loc 9
Just off the mark as the A388 frigate was getting touchy. Large mud sample and duplicate.
14.4°C / 35.46‰ / 15.5m

Loc 3
Normal sample, coarse shell gravel, four attempts taken
14.3°C / 34.89‰ / 10.0m

Loc 11
Large grab, clean well sorted medium sands
14.4°C / 34.86‰ / 10.0m

Loc 4
Normal sample poorly sorted, muddy sand to gravel. Duplicate retrieved.
13.19°C / 35.23‰ / 11m

Loc 12
Large grab thin oxic layer, some stones. Duplicate sediment sample taken.
14.4°C / 34.71‰ / 9m

Loc 14
Normal grab, medium well sorted sand, mud in suspension
14.4°C / 34.81‰ / 4m

Loc 15
Very large sample, black muds worm tubes, thin oxic layer. Duplicate sample taken.
14.4°C / 35.18‰ / 7m

Plym 32.00‰, duplicate taken

17 November 94

Loc 12

Large sample same as usual

12.8°C / 29.4‰ / ?

Loc 4

Good sample, medium to coarse sand, slightly cloudy

13.2°C / 32.15‰ / ?

Continued on Sepia in the afternoon due to break down of Catfish !

Loc 1

Two small grabs = average sample of fine clean well sorted sand

13.58°C / 35.29‰ / 15m

Loc 16

3 attempts, normal size sample, shell gravel, clean some pebbles

13.5°C / 35.11‰ / 10.5m

Loc 3

2 attempts, average shell gravel

13.56°C / 35.02‰ / 9.5m

Loc 11

Two attempts, average sample, medium sand clean, well sorted

13.4°C / 35.01‰ / 9m

Loc 4

Average grab, sandy pebbly, brown mud

13.48°C / 34.92‰ / 11m

Loc 9

Large sample, soft oxic top darker below, *Turritella* present

13.48°C / 35.12‰ / 15m

Loc 8

Smallish sample, muddy shell sand and gravel

13.42°C / 34.81‰ / 10m

Loc 17

Three attempts very small sample obtained, well sorted clean sand
13.42°C / 34.81‰ / 8.5m

Loc 18

Small sample, sandy clay, medium brown colour
13.42°C / 34.81‰ / 8.5m

Loc 15

Large sample, muddy
13.40°C / 34.46‰ / 8.5m

Appendix 3

Plymouth Sound Foraminiferal Core data

Queens Ground	**30/06/94**		**QG 1cm**		**QG 2cm**		**QG 5a**		**QG 5b**		**QG 5c**
		Live	**DEAD**	**Live**	**DEAD**	**Live**	**DEAD**	**Live**	**DEAD**	**Live**	**DEAD**
Cribrostomoi	*jeffreysii*	3	4	2	10	4	7		3		2
Eggerelloide	*scabrum*		4		3		9		5		3
	truncata	12	11	9	18	1	17	1	15		
Miliolina	*auberiana*		2	1	5		6		5		
Miliolinella	*circularis*			8	4	3	6		2		1
	subrotunda	5	4	6	5		6		2		
Quinquelocul	spp.	1	5	5	12	3	11	1	9	1	5
	lata		4		2		6		9		4
	oblonga		1	1	2		5		1		
	seminulum		7	1	6		18	1	27	1	8
	cf. *lata*	3	1	2	2		6				
Ammonia	*batavus*	1	9		22		11		32		17
	limnetes				6		25		7		5
Bolivina	*pseudoplicata*		7	1	5				9		1
Brizalina	*pseudopunctata*		2		4		3	1	4		3
	spathulata		2		11		3		6		2
	striatula		1		1		1		1		
Buliminella	*elegantissima*								1		
Bullimina	*elongata*				4		2		3		1
	gibba				4	1	3		4		3
	marginata						2				
Elphidium	*cuvillieri*		2		2	1	6		6		5
	crispum		2		12		13		23		10
Fissurina	*lucida*						2	1	3		3
Nonion	*depressulus*		1		2		1		2		
Nonionella	*turgida*	1			1			1			
Planorbulina	*mediterranensis*	4	5	11	7	12	7		1		4

Barn Pool	**30/06/94**		**BP 1cm**		**BP 2cm**		**BP 5a**		**BP 5b**		**BP 5c**		**BP 10a**
		Live	**DEAD**	**Live**	**DEAD**	**Live**	**DEAD**	**Live**	**DEAD**	**Live**	**DEAD**	**Live**	**DEAD**
Cribrostomoi	*jeffreysii*		11		6		6		4		8		4
Eggerelloide	*scabrum*	2	20	4	33	2	17		8		16		13
	truncata		2		5		1				2		2
Miliolina	*auberiana*		2		1		3		2				1
Miliolinella	*circularis*		4								2		
	subrotunda						1				1		
Quinquelocul	spp.		5		7		4		3		2		6
	lata												
	oblonga		1		2		5		1		5		2
	seminulum		5		1		5	1	4		2		7
	cf. *lata*												
Ammonia	*batavus*	11	85	3	75		60		96		79	1	76
	limnetes		5	1	12		7		12		7		10
Bolivina	*pseudoplicata*	1	5		2		9		3		3		1
Brizalina	*pseudopunctata*	4	8		7		5		3		3		2
	spathulata		5		4		11		5		5		3
	striatula		1		1		2						
Buliminella	*elegantissima*												
Bulimina	*elongata*	1			2		2				2		2
	gibba		8		2		3		2		3		2
	marginata		2		1								1
Elphidium	*cuvillieri*		5		6		1		3		2		3
	crispum		5		8		14		12		13		4
	lucida				1		3		3	1	5		2
Nonion	*depressulus*		1		2		1		3		1		
Nonionella	*turgida*												
Planorbulina	*mediterranensis*		7		4		1		6		1		5

Withyhedge Beacons			WL1 cm		WL2 cm		WL 5a		WL 5b		WL 5c		WL1 0a		WL 10b
30/06/94		Live	DEAD	Live	DEAD	Live	DEAD	Live	DEAD	Live	DEAD	Live	DEAD	Live	DEAD
Cribrostomoi	jeffreysii				2		2		11		4		1		
des Eggerelloide	scabrum	1	23		19		19		13	1	12		11		9
s	truncata		7	1	6		3		1		8		4		4
Miliolina	auberiana	3	2		4		4		2		3		5		9
Miliolinella	circularis				3		2	2			2		5		1
	subrotunda						1		5		1		8		10
Quinquelocul	spp.		3		1		3		3		6		11		4
ina	lata	1	4		1				1		3				1
	oblonga	2					3				1	1	3		1
	seminulum		4		10		8		7		4		9		18
Ammonia	batavus	8	53		59		19		49	5	64		110		27
beccari	limnetes	1	8		3		9	1	14				23		1
Bolivina	pseudoplicata				2		1		2		2		6		7
Brizalina	pseudopunctata	1	4		5				3	1	3		4		7
	spathulata	2	2		7		5		2	3	3				2
	striatula														1
Buliminella	elegantissima									3					
Bulimina	elongata		3		9		7		5		3				1
	gibba	1	4		2		3		2	4			10		1
	marginata	2	1						3		1		2		
Elphidium	cuvillieri	1	5	1	6		3		12	2	11		6		14
	crispum	96	22	7	19	2	13	3	26	23	25	26	54	1	24
Fissurina	lucida		3		4		5	1	1		2		6		2
Nonion	depressulus	11	5		6	1	4	1	6	7	2	1	3		1
Planorbulina	mediterranensis				2		3		5		3		3		2

Drakes Island			**DI 1**		**DI 2**		**DI 5a**		**DI 5b**		**DI 5c**		**DI 10a**		**DI 10b**
30/06/94		Live	DEAD	Live	DEAD	Live	DEAD	Live	DEAD	Live	DEAD	Live	DEAD	Live	DEAD
Cribrostomoides	*jeffreysii*				1		1		1		1		2		
Eggerelloides	*scabrum*		29		45		27		8		22		10		1
Textularia	*sagittula*				1										
	truncata	2	14		25		16		11		8		11		9
Massilina	*secans*	2	43		72		44		20		31		23		10
	juvenile		5		15		7		1		3		3		4
Miliolina	*auberiana*		5				1		4		7		6		5
Miliolinella	*circularis*				1				1		2				
	subrotunda		2		2		9		6		4				1
Pyrgo	*depressa*						1		1						
Quinqueloculina	sp 5				2										
	spp.		4		5		6		9		4		10		7
	aspera I										1				
	aspera II		1		2		4				2				1
	aspera III		2		2				1		1		5		1
	bicornis				1		3				1				1
	cf. cliarensis		3				2		1		1				
	cf. cliarensis (tube neck)				1		1								
	lata var. oblonga								1				1		1
	lata		1		1		3		1		9		2		
	oblonga		1		4								2		
	seminulum		6		8		16		9		7		6		4
	williamsoni		1				2						5		1
Spiroloculina	*excavata*										1				1
Acervulina	*inhaerens*		2												
Ammonia beccarii	*batavus*	1	30		30		65		50		44		60		34
	limnetes		14		7		28		12		13		17		9
Asterigerinata	*mamilla*		5		6		11		6		5		2		4
	spathulata										1		1		
	elongata		2		3				2		2		4		1
	gibba				1		2		1		2				
Cibicides	*lobatulus*		121		186		162		106		99		111		157
	pseudoungerianus		10		30		16		7		10		3		7
Elphidium	*cuvillieri*		4		15		13		11		9		7		2
	crispum		30		46		48		25		24		23		31
	margaritaceum						1								
	gerthi				4		4				3				
	williamsoni		14		21		21		13		15				7
Fissurina	*lucida*				1		1				1		1		
	marginata						1				1		1		
Fursenkoina	*fusiformis*						1								
Rosalina	*williamsoni*				4				1				1		
Gavelinopsis	*praegeri*		6		3		7		3		4		11		5
Globulina	*gibba*			1					1		2				
Haynesina	*germanica*		15		31		39		11		17				10
	squamosa						1								
Planorbulina	*mediterranensis*		10		12		16		9		5				7
Rosalina	*globularis*										2				
Trifarina	*angulosa*		2		1						2				

Melampus Beacon			M 1cm		M 2cm		M 5a		M 5b		M 5c
	***Beacon* 4/6/95**	Live	DEAD	Live	DEAD	Live	DEAD	Live	DEAD	Live	DEAD
Clavulina	*obscura*		1								
Cribrostomo	*jeffreysii*		2				3				1
Eggerelloide	*scabrum*	1	17		15	1	9		3		13
Psammosp	*bowmani*		1								
Textularia	*sagittula*						1				
Spiroplecta.	*wrightii*		1								
Textularia	*truncata*		10		10		7				8
Dueterammin	*ochracea*		1								1
Adelosina	normal				1						
Massilina	*secans*		4		4		4		7		3
Miliolina	*auberiana*		1		2		4		5		3
Miliolinella	*circularis*		3				3		1		
	subrotunda		8		4		3		1		1
Quinquelocu	sp. 5		1		1				1		1
lina	sp.		11		1		4		3	1	7
	aspera I		1		1						1
	aspera II				3						1
	aspera III				3		4		2		2
	bicornis		1		1		1		1		3
	cf. *cliarensis*		3				2		2		2
	cf. *cliarensis tube*								1		2
	lata var *oblonga*				1		1				
	lata		1		3		5		3		1
	oblonga		1		5		4		3		4
	seminulum		2		2		9		8		4
	williamsoni										1
	cf. *lata*		5		2						1
Spiroloculina	*excavata*						1				1
	rotunda								1		
Acervulina	*inhaerens*						3				2
Ammonia	*batavus*	2	34		41		36		46		52
	limnetes		5		10		9		6		12
Asterigerinat	*mamilla*		5		13		5		3		7
Bolivina	*pseudoplicata*				1				2		2
Brizalina	*pseudopunctata*		1				2				2
	spathulata		1		1				2		1
	striatula		1		1						1
	elongata		1		3		1		1		3
	gibba		1		1		5		2		2
	marginata								1		
Cibicides	*lobatulus*		76		45		59		93		57
	pseudoungerianus		10		10		3		7		14
Cyclogyra	*involvens*				1						
Elphidium	*cuvillieri*		10		7		6		9		3
	crispum		38		31		48		54		34
	earlandi								1		1
	margaritaceum		3								1
	gerthi		3		3		3		3		3
	williamsoni		10		4		2		11		2
Fissurina	*lucida*						2			1	5
	orbignyana										1
Rosalina	*williamsoni*		3				4		1		4
Gavelinopsis	*praegeri*		6		1		6		2		9
Globulina	*gibba*						1				
Haynesina	*germanica*		19		18		16		17		12
Nonion	*depressulus*				2		2				1
Oolina	*melo*										1
	squamosa										1
	williamsoni		1								
Patellina	*corrugata*				2sp						1
Planorbulina	*mediterranensis*		5		11		11				8
Rosalina	*globularis*		1		1						1
Trifarina	*angulosa*									1	3

Barn Pool			BP 1cm		BP 2cm		BP 5a		BP 5b		BP 5c		BP 10a
		Liv	DEAD	Live	DEAD	Live	DEAD	Live	DEAD	Live	DEAD	Live	DEAD
Ammoscalari	*pseudospiralis*	e					1						
Clavulina	*obscura*		1		3		3		1				3
Cribrostomoi	*jeffreysii*		9		12		12		5		8		2
Eggerelloide	*scabrum*		24		18		27		44		20		24
Psammasph	*bowmani*	1			1		1						
Reophax	*scottii*										2		
Textularia	*truncata*		3				1				2		2
	earlandi		1		2		3		4		3		
Deuterammin	*ochracea*		2		1								
	rotaliformis				1		1						1
Portatrocham	*murrayi*								1				
Massilina	*secans*		1				3		1		2		2
Miliolina	*auberiana*				1		1						
Miliolinella	*circularis*		3										1
	subrotunda		5										
Pyrgo	*depressa*		1										
Quinqueloculi	sp. 5											1	1
	spp.		4		2		3				3		3
	aspera I		1										
	aspera II								1		1		1
	aspera III		2				1						
	bicornis								1				
	cf. *cliarensis*						1						1
	lata		4		1						1		
	oblonga	4	3				2	1	3		2		3
	seminulum				1				3		3		2
	williamsoni						1				2		
	cf. *lata*				2				4				
Spiroloculina	cf. *grata*		1										
Ammonia	*batavus*	9	79		72	4	107	1	128		86		131
	limnetes		4		1		5		2		9		4
Amphicoryna	cf. *A. scalaris*								1				
Asterigerinat	*mamilla*		2		2		1				2		
Bolivina	*pseudoplicata*	1	6		1		3				1		1
Brizalina	*pseudopunctata*	2	4		17		7		3		2		3
	spathulata		4		9		4		1		2		2
	striatula		2		2		3		1		1		1
Bulimina	*elongata*		3		1		1		4		1		2
	gibba		2		2		3				2		2
	marginata		1		2				1				
Cibicides	*lobatulus*		11		7		10		6		9		10
	pseudoungerianus		12		9		14		4		10		5
Cyclogyra	*involvens*		1		1	1			2				1
Elphidium	*cuvillieri*		2		3		4		1				
	crispum		8		5		10		6		16		4
	earlandi		1		3		2		1				
	margaritaceum		3		2		6		3		7		4
	gerthi		7		6		14		6		12		9
	williamsoni		6		7		8		6		9		3
Fissurina	*lucida*		2		1	2	4		3	1	3		1
	marginata				2		3		1		2		1
	orbignyana								3		1		
Fursenkoina	*fusiformis*		3				2		2				1
Rosalina	*williamsoni*		10		8		1		1		2		2
Gravelinopsi	*praegeri*		4		11		6		2		7		5
Globulina	*gibba*		1				2						
	gibba var *myristifor*		1										
Haynesina	*germanica*	1	31		36		40		39		62		18
Lagena	*clavata*		1		1		1						1
	gracilis		1										
	laevis		1		1		1				1		
	lyellii		1										
	perlucida						1				1		
	substriata						1		1				
	sulcata		1				2		1		1		
Nonion	*depressulus*	2	2				2				5		2
Oolina	*melo*												1
	williamsoni				1				1		1		2
Patellina	*corrugata*		1		1		1sp						

Planorbulina	*mediterranensis*		1		1		3		3		1		4
Rosalina	*globularis*										1		
Trifarina	*angulosa*		1		1		1		2				
Uvigerina	sp.	2	3		1								

Drakes Island			DI 1cm		DI 2cm		DI 5a		DI 5b		DI 5c		DI 10a
06/04/95		Live	Dead	Live	Dead	Live	Dead	Live	Dead	Live	Dead	Live	Dead
Cribrostomoi	*jeffreysii*										1		
Eggerelloide	*scabra*		35		24		23		9		20		4
Psammasph	*bowmani*	2		2	1	4		2	1			2	
Spiroplectam	*wrightii*						1						
Textularia	*truncata*		17		11		8		8		22		15
Massilina	*secans*		4		4		4		8		6		10
Miliolina	*auberiana*		2		3		2		4		7		5
Miliolinella	*circularis*		1	2									
	subrotunda		2		1		3		1		2		4
Pyrgo	*depressa*				1								
Quinqueloculi	sp. 5				1		1						
	spp.		2		5		1		2				1
	aspera I		1		2								2
	aspera II						1		4				
	aspera III				1		2				4		2
	bicornis								2		1		
	cf. *cliarensis*		2		1		5		2		3		
	cf. *cliarensis tube*				1								
	lata				1		2				2		
	oblonga			2			1		1	1	2		2
	seminulum	1	3		2		6		3		14		1
	williamsoni		1										1
	cf. *lata*		1		1		1						
Spiroloculina	*excavata*		1										
	rotunda				1								
Acervulina	*inhaerens*		1				1		1				
Ammonia	*batavus*	4	32		22		33	1	24		42		10
	limnetes		8		8		6		6		20		5
Asterigerinat	*mamilla*		4		3		3		6		8		
Bolivina	*pseudoplicata*								2				
Brizalina	*pseudopunctata*						1						
	spathulata				1								
	elongata		1		3		3		2		4		1
	gibba			1	1		1		1		2		1
	marginata			1							1		
Cibicides	*lobatulus*	1	87		101		84		84		136		232
	pseudoungerianus		15		5		12		9		18		3
Elphidium	*cuvillieri*		5		5		9		8		9		5
	crispum		20		20		15		26		23		16
	margaritaceum		1	1			1						
	gerthi						1		1		2		1
	williamsoni		7		11		16		23		7		3
Fissurina	*lucida*						2						
	marginata				1		1				1		
	orbignyana						1						
Rosalina	*williamsoni*		1		1								
Gavelinopsis	*praegeri*		10		4		3		4		7		
Globulina	*gibba*		2				1		1		1		
Haynesina	*germanica*		11		8		13		15		27		16
Lagena	*substriata*							1					
Nonion	*depressulus*			1			1		1		1		
Oolina	*squamosa*										1		
Planorbulina	*mediterranensis*		4		1		2		4		8		18
Polymorphin	*concava*								1				
	cf. *novangliae*		1										
Rosalina	*globularis*			1									
Stainforfia	*concava*	1											
Trifarina	*angulosa*		1		2								1

Withyhedge Beacons			WL1cm		WL 2cm		WL 5a		WL 5b		WL 5c		WL 10a		WL 10b
06/04/95		Liv	**Dead**	**Live**	**Dead**	**Live**	**Dead**	**Live**	**Dead**	**Live**	**Dead**	**Live**	**Dead**	**Live**	**Dead**
Ammoscalari	*pseudospiralis*	e	1												
Clavulina	*obscura*		4												1
Cribrostomoi	*jeffreysii*		4										1		
Eggerelloide	*scabrum*	1	12		19	1	7		12		8	2	14		12
Psammasph	*bowmani*	1	1												
Spiroplectam	*wrightii*		1				1								
Textularia	*truncata*		14						3		2		2		5
	earlandi		2												
Massilina	*secans*				2		2		4		2		2		3
Miliolina	*auberiana*		1		2		3		2		1				3
Miliolinella	*circularis*		5		2				1	3			3		3
	subrotunda		1		2		1				8		6		8
Pyrgo	*depressa*												1		
Quinquelocul	sp.5		1										1		
	spp.		3		1				2		7		4		
	aspera I					1					4		1		
	aspera II				3		2		6		1		2		3
	aspera III		2				1								1
	bicornis		1		2		1		1		1		1		
	cf. *cliarensis*						1		1		1		4		
	lata		2		1		2		2						2
	oblonga		1				2		1		1	1	1		2
	seminulum		1		3		4		1		2		6		4
Spiroloculina	*excavata*														1
Acervulina	*inhaerens*		1		1						1				1
Ammonia	*batavus*	1	42		50	13	54	1	63	8	46	44	46	3	36
	limnetes		14		20		20		15		12		10		6
Asterigerinat	*mamilla*		2		2		4	1	3		2		1		2
Bolivina	*pseudoplicata*	1	1						5		8		1		6
Brizalina	*pseudopunctata*		5				1		1		9		4		5
	spathulata		4				1		2		1		3		1
	striatula						1						1		
Buliminella	*elegantissima*											1			
Bulimina	*elongata*		3				2		3		3		1		2
	gibba		2										1		2
	marginata								1				1		
Cibicides	*lobatulus*		80		106		102		95		72		74		74
	pseudoungerianus		23		9		13		17		21		16		10
Lenticulina	*orbiculatis*				1										
Elphidium	*cuvillieri*		7		5		1		7		7		4		14
	crispum		26	1	42	3	32	3	25	4	22	23	24	1	29
	earlandi														2
	margaritaceum		2		1				1		4		2		2
	gerthi		6		1		7		26		17		8		12
	williamsoni		9		2		9		8		5		15		3
Fissurina	*lucida*		6		1	2	1	3	4		2	2	2		6
	marginata	2	1	1			1		1				1		2
	orbignyana		1						1		1				
Fursenkoina	*fusiformis*		1												1
Rosalina	*williamsoni*						1		2		1				
Gavelinopsis	*praegeri*		18		6		12		11		17		10		20
Globulina	*gibba*		1		2	2			2				1		
Haynesina	*germanica*		14		3		3		5		8		13		10
Lagena	*clavata*								1		1	1			
	gracilis						1								
	semistriata												1		
	sulcata														2
Nonion	*depressulus*	2	5		2		3		5	6	1	25	3		4
Oolina	*squamosa*								1						
	williamsoni								1						
Planorbulina	*mediterranensis*		1				2		4		1		3		2
Polymorphin	*cf. novangliae*		1		1								1		
Stainforfia	*concava*	1													
Trifarina	*angulosa*						1		1		2				1
Uvigerina	sp.		1		1										

Breakwater			BW 1cm		BW 2cm		BW 5a		BW 5b		BW 5c		BW 10a	BW 10b	BW10 c
4/6/95		LIVE	DEAD	LIVE	DEAD	LIVE	DEAD	LIVE	DEAD	LIVE	DEAD	LIVE	DEAD	DEAD	DEAD
Clavulina	*obscura*		1				6		7		9		5	8	7
Cribrostomoi	*jeffreysii*		8		5		8		6		15		13	15	14
Eggerelloide	*scabrum*		12		10		0		9		5		4	3	2
Psammosph	*bowmani*		0						1						
Reophax	*scottii*		1				1		1						
Technitella	*teivyense*		0		1										
	sp. ear bud form		0												1
Textularia	*sagittula*		0						1		1				
	truncata		3		4		4		4		2		3	4	5
	earlandi		0				3		3		2		3	1	
Deuterammin	*ochracea*		2				2		2		6		3	4	2
a	*rotaliformis*		2		2		2		1		2		1	1	3
Remaneica	*helgolandica*		0						1		1				
Adelosina	*normal*		0		1										
Massilina	*secans*		0										1		1
Miliolina	*auberiana*		1		3								1		1
Miliolinella	*circularis*		0		2		4		1		3		6	4	5
	subrotunda		0		3		1		3		2		1	1	1
	williamsoni		0		1						2		1		
Quinqueloculina	sp. 5		1				1								
	spp		6		5		8		7		7		4	6	6
	aspera I		0				1				1				
	aspera II		0											1	
	aspera III		0		1										1
	bicornis		1		2				1						
	cf. *cliarensis*		0		2										1
	lata var. *oblonga*						1								
	lata		3		5		4		3		2		1		
	oblonga		2		7		6		11		4		5	6	5
	cliarensis								1					1	
	seminulum				2				2		1		1	3	1
	cf. *lata seminulum*		14			1	2		1		3		10	5	7
Spiroloculina	*excavata*					1									
Acervulina	*inhaerens*														1
Ammonia	*batavus*		18		23		12		20		9		9	5	4
beccari	*limnetes*		7		6		5		6		6		4	9	3
Amphicoryna	cf. *A. scalaris*														1
Asterigerina	*mamilla*		2				1				2		6	3	7
Bolivina	*pseudoplicata*		3		17		11		8		16		9	18	14
Brizalina	*pseudopunctata*		6		15		20		32		24		30	24	19
	spathulata		6		16		13		9		20		25	29	17
	striatula		7		1				4		3		5	4	6
Buliminella	*elegantissima*													2	
Bulimina	*elongata*		2		2		1		4		2		2	5	3
	gibba		2		8		7		6		4		6	3	6
	marginata		1		3		2		2		1		4	1	3
Cibicides	*lobatulus*		1		5		5		10		6		2	5	2
	pseudoungerianus		19		15		17		19		11		13	11	9
Lenticulina	*crepidula*				1						1				
	orbiculatis		1		0		3						1		
Cyclogyra	*involvens*		2		4		2		2		2		4	3	3
Dentalina	sp.						1						1		
Elphidium	*cuvillieri*		5		6		4		7		9		2	5	3
	crispum		4		3		5		2		4		2		2
	earlandi		4		2		1		3		3		1	1	1
	margaritaceum		2		2				4		1		1	2	1
	gerthi		7		11		12		9		3		9	8	10
	williamsoni		2		3		5		6		6		9	2	6

Fissurina	*lucida*		8		6		4		11		7	1	9	7	11
	marginata		2		2		4		5		10		3	5	8
	orbignyana		2		4		3		2		4			5	5
	quadrata form				1								1	2	1
Fursenkoina	*fusiformis*		9		3		9		20		10		17	15	17
Rosalina	*williamsoni*		7		10		9		14		11		6	6	12
Gavelinopsis	*praegeri*		21		18		17		27		17		20	16	20
Globulina	*gibba* var. *myristiformis*													1	
Nodosaria	*pyrula*											1			
Haynesina	*germanica*		28		34		33		18		21		24	23	25
Lagena	*clavata*		1		2						1			2	
	laevis						2				1			3	4
	lyellii		1				3		1						
	perlucida		1		1				1				2	1	
	semistriata		2		1		3		1		3		1		1sp
	substriata		2		1				1		2		1	1	2
	sulcata		1		1				1						2
Nonion	*depressulus*		4		3		7		7		1		1	3	7
Nonionella	sp.												1		1
Nonionella	*turgida*		2		1		1		1		1		2		1
Oolina	*hexagona*										1			1	
	squamosa		1								1		1	2	1
	williamsoni				1				1						
Patellina	*corrugata*				4		3		2				3	3	
Planorbulina	*mediterranensis*		2				4		3		3			1	5
Polymorphin	*cf. novangliae*		1				1								
Rosalina	*globularis*				3				1		1		1		
Stainforfia	*concava*								1						
Trifarina	*angulosa*				7		9		6		9		7	6	4
Uvigerina	sp.								3		2			1	

Appendix 4

Radio Isotope Data

Anchorage Beacons

Sample AB	**Pb210**	**Pb214**	**Pb210-Pb214**	**K40**	**Cs137**	**Be7**	**Co60**
1	41.8	23.2	18.5	831.4	1.8	10.0	0
3	49.7	24.0	25.7	877.4	2.9	0	0
5	47.4	25.0	22.4	903.7	2.7	0	0
7	34.6	23.6	10.9	838.4	2.9	0	0
9	40.4	23.0	17.5	835.6	2.5	0	0
11	30.3	21.9	8.4	867.1	1.6	0	0
13	29.4	21.8	7.6	899.9	1.5	0	0
15	35.5	24.4	11.1	928.8	2.4	0	0
17	37.9	22.5	15.4	935.8	1.4	0	0
19	34.4	23.3	11.1	988.4	0	0	0
21	28.5	22.8	5.7	956.0	0	0	0
23	24.9	22.8	2.2	994.8	0	0	0
25	31.0	25.6	5.4	998.2	0	0	0
27	29.9	24.2	5.7	981.6	0	0	0

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.811714
R Square	**0.65888**
Adjusted R Square	0.630453
Standard Error	4.246503
Observations	14

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	417.9681	417.9680869	23.1782341	0.000423
Residual	12	216.3934	18.03278388		
Total	13	634.3615			

RESIDUAL OUTPUT

Observation	*Predicted Y*	*Residuals*
1	20.7888	-2.2488
2	19.43336	6.264642
3	18.07792	4.345084
4	16.72247	-5.78447
5	15.36703	2.121967
6	14.01159	-5.57059
7	12.65615	-5.01515
8	11.30071	-0.22871
9	9.945266	5.434734
10	8.589824	2.485176
11	7.234382	-1.50638
12	5.878941	-3.72194
13	4.523499	0.901501
14	3.168057	2.522943

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.000%*	*Upper 95.000%*
Intercept	21.46652	2.274212	9.439102819	6.6576E-07	16.51144	26.4216	16.51144	26.421603
X Variable 1	-0.67772	0.14077	-4.814377856	0.00042306	-0.98443	-0.37101	-0.98443	-0.371009

Barn Pool Core

Sample BP	Pb210	PB214	PB210-PB214	K40	Co60	Be7	Cs137
1	47.432	21.824	25.608	783.677	0	11.725	4.906
3	68.583	26.158	42.425	1029.003	0	0	8.504
5	63.339	24.865	38.474	966.657	0	0	8.724
7	65.503	28.991	36.512	983.447	0	0	7.416
9	63.141	24.118	39.023	931.111	0	0	8.595
11	73.4	28	45.4	1019	1.34	0	8.99
13	65.011	26.706	38.305	974.502	0	0	8.626
15	62.545	26.925	35.62	1000.421	0	0	8.93
17	62.138	27.14	34.998	958.057	0	0	9.367
19	42.043	27.68	14.363	898.9	1.716	0	7.371
21	32.2	19.78	12.42	805	0	0	3.45
24	17.3	16.81	0.49	635	0	0	1.28
27	22.2	19.26	2.94	732	0	0	1.17
29	22.8	18.15	4.65	677	0	0	1.01
31	23.5	17.77	5.73	734	12.06	0	0
33	24.1	20.3	3.8	754	0	0	0

Regression Statistics	
Multiple R	0.841827
R Square	**0.708673**
Adjusted R Square	0.687864
Standard Error	9.338886
Observations	16

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	2970.18	2970.18	34.05593	4.32E-05
Residual	14	1221.007	87.21479		
Total	15	4191.187			

RESIDUAL OUTPUT

Observation	*Predicted Y*	*Residuals*
1	45.14875	-19.5408
2	42.4048	0.020201
3	39.66085	-1.18685
4	36.9169	-0.4049
5	34.17294	4.850057
6	31.42899	13.97101
7	28.68504	9.619961
8	25.94109	9.678913
9	23.19714	11.80086
10	20.45318	-6.09018
11	17.70923	-5.28923
12	13.5933	-13.1033
13	9.477376	-6.53738
14	6.733424	-2.08342
15	3.989472	1.740528
16	1.24552	2.55448

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.000%*	*Upper 95.000%*
Intercept	46.52073	4.540129	10.24657	6.9E-08	36.78311	56.25834	36.78311	56.25834
X Variable 1	-1.37198	0.235099	-5.83575	4.32E-05	-1.87621	-0.86774	-1.87621	-0.86774

Sample	**Pb210**	**Pb214**	**Pb210-Pb214**	**Cs137**	**Co60**	**Be7**	K40
1	4.7687	24.04		3.732		6.196	839.4
3	59.518	24.012	35.506	3.509			835.6
5	54.1	22.451	31.649	3.431			811
7	50.956	22.311	28.645	2.914	1.415		762.3
9	53.328	23.512	29.816	3.982			809
11	51.986	23.205	28.781	3.843			794
13	48.9	23.46	25.44	3.22			891
15	58.4	24	34.4	4.55			902
17	46.8	23.3	23.5	3.51			894
19	35.9	20.7	15.2	3.8			827
20	37.2	24.5	12.7	3.62			847
21	43.5	23.4	20.1	3.19			873
23	41.6	22.3	19.3	2.97			842
25	37.1	23.26	13.84	2.83			847
27	32.3	22.72	9.58	2.07			831
29	39.5	21.69	17.81	2.72			802
31	36.8	22.22	14.58	1.22			829
33	38.1	23.78	14.32	1.88			854
35	32.6	23.53	9.07	1.34			843
37	35.6	24.4	11.2	1.21			862
39	32	22	10	1.25			847
41	30.7	19.89	10.81	1.91			612

Regression Statistics	
Multiple R	0.888447
R Square	**0.789339**
Adjusted R Square	0.778251
Standard Error	4.137527
Observations	21

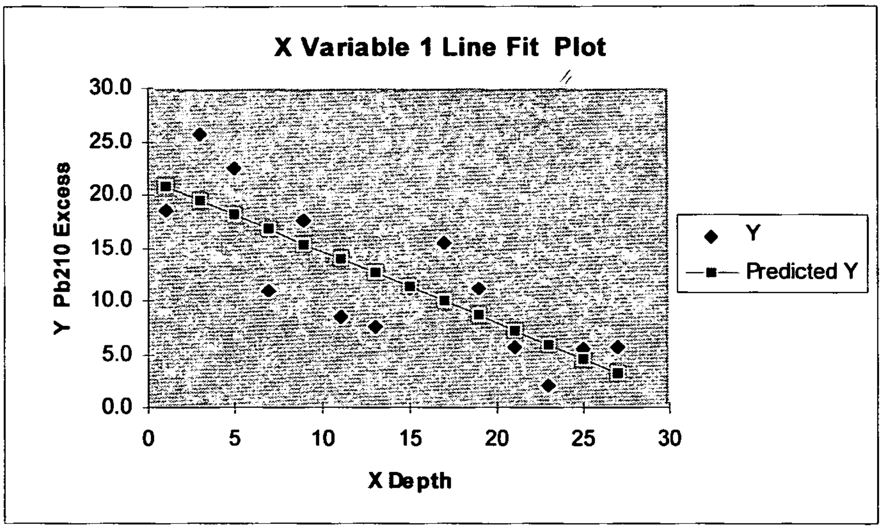
ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	1218.748	1218.748	71.1922	7.53E-08
Residual	19	325.2635	17.11913		
Total	20	1544.012			

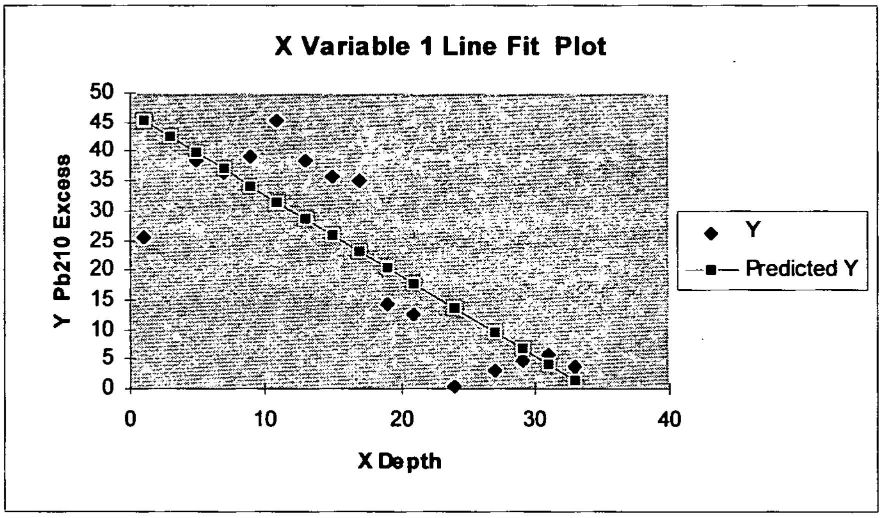
Observa t	*Predicted Y*	*Residuals*
1	32.60852	2.897479
2	31.25572	0.393285
3	29.90291	-1.25791
4	28.5501	1.265896
5	27.1973	1.583702
6	25.84449	-0.40449
7	24.49169	9.908313
8	23.13888	0.361119
9	21.78608	-6.58608
10	21.10967	-8.40967
11	20.43327	-0.33327
12	19.08046	0.219536
13	17.72766	-3.88766
14	16.37485	-6.79485
15	15.02205	2.787954
16	13.66924	0.91076
17	12.31643	2.003565
18	10.96363	-1.89363
19	9.610823	1.589177
20	8.258017	1.741983
21	6.905212	3.904788

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.000%*	*Upper 95.000%*
Intercept	34.63773	1.974533	17.54224	3.4E-13	30.50498	38.7704	30.50498	38.77048
X Variable 1	-0.6764	0.080166	-8.43755	7.53E-08	-0.84419	-0.50861	-0.84419	-0.50861

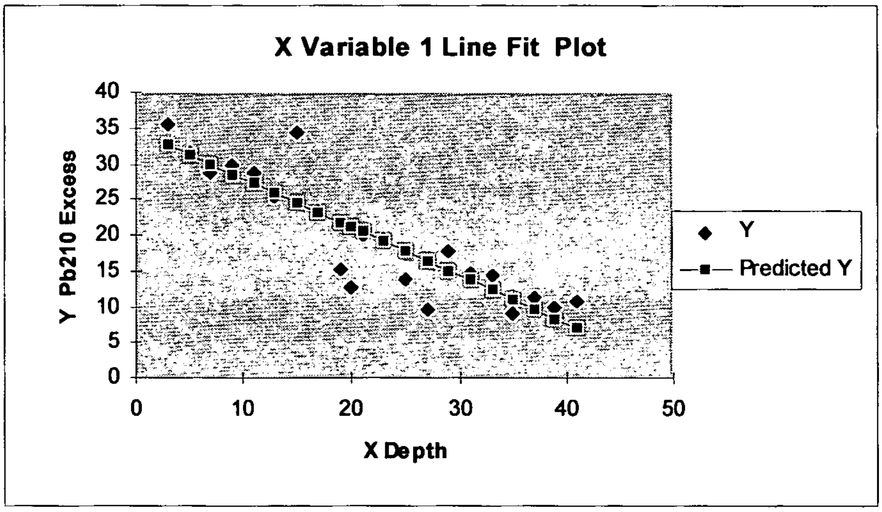
Best fit line plots for supported lead 210 data at the 3 sites



Anchorage Beacons



Barn Pool



Breakwater

Appendix 5a

Plymouth Sound Live Foraminifera
from December 1993 to November 1994

Location 1		**Dec**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**July**	**Aug**	**Sep**	**Oct**	**Nov**
Ammonia beccarii	*batavus*	5	1	2	9	4	4	8	6	5	0	22
Brizalina	*pseudopunctata*	0	0	0	0	3	1	0	0	0	0	0
	striatula	0	0	0	0	1	0	0	0	0	0	0
	elongata	3	0	0	0	0	0	2	1	0	0	1
	gibba	0	0	0	0	1	0	0	1	0	0	0
Clavulina	*obscura*	0	0	0	0	0	0	2	0	0	0	0
Eggerelloides	*scabrum*	0	0	0	0	10	1	0	0	0	0	0
Elphidium	*cuvillieri*	0	0	0	0	0	0	2	1	0	0	0
	crispum	5	2	0	2	0	0	122	0	1	3	2
	gerthi	0	0	0	0	0	0	3	0	0	0	0
Rosalina	*williamsoni*	0	0	0	0	2	0	0	0	0	0	0
Nonion	*depressulus*	0	0	0	7	6	5	6	0	1	0	0
Planorbulina	*mediterranensis*	0	0	0	0	0	0	15	0	0	0	0
Psammosphaera	*bowmani*	0	0	0	0	0	0	8	1	1	0	0
Quinqueloculina	*aspera I*	0	0	0	0	0	0	2	0	0	0	0
	aspera II	0	0	0	0	1	0	0	0	0	0	1
	lata	0	1	2	0	2	0	0	2	1	2	1
	mediterranensis	0	0	0	0	0	0	0	0	0	0	0
	oblonga	0	3	0	3	2	0	0	3	1	6	0
	oblonga var.. *lata*	0	0	0	0	0	0	0	0	0	0	0
	seminulum	0	2	0	1	0	0	0	0	0	2	0
	scottii	0	0	0	0	0	0	0	0	0	2	0
Stainforthia	*concava*	0	0	0	0	0	1	0	0	0	0	0
Textularia	*sagittula*	0	0	0	0	1	0	2	0	0	0	0
Spiroplectammina	*wrightii*	0	0	0	0	0	0	0	0	0	2	0

No data is available for January 1994 for Location 1

Location 3		**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**July**	**Aug**	**Sep**	**Oct**	**Nov**
Ammonia beccarii	*batavus*	0	1	0	0	0	1	0	2	1	2	1
Asterigerinata	*mamilla*	0	1	0	0	0	0	0	0	1	0	0
Bolivina	*pseudoplicata*	0	0	0	0	0	0	0	2	0	0	0
Brizalina	*pseudopunctata*	0	0	0	0	0	2	4	0	0	2	0
	spathulata	0	0	0	0	0	0	0	0	1	0	0
Bulimina	*gibba*	0	0	0	0	0	0	0	0	1	0	0
Cibicides	*pseudoungerianus*	0	0	0	0	0	0	0	2	0	0	0
Clavulina	*obscura*	0	0	0	0	0	0	0	2	1	1	0
Cribrostomoides	*jeffreysii*	0	0	0	0	0	0	4	5	6	7	1
Lenticulina	*crepidula*	0	0	0	0	0	0	0	1	0	0	0
Cyclogyra	*involvens*	0	0	0	0	0	0	0	0	1	1	0
Eggerelloides	*scabrum*	0	0	0	0	0	0	1	0	0	0	1
Elphidium	*cuvillieri*	0	0	0	0	0	0	0	0	1	1	0
Fissurina	*marginata*	0	1	0	0	0	0	0	0	1	0	0
Rosalina	*williamsoni*	4	1	0	4	6	8	18	26	22	8	2
Haynesina	*germanica*	0	0	0	0	0	1	0	2	0	0	0
Miliolinella	*circularis*	0	2	0	1	0	1	0	12	0	0	2
	subrotunda	0	0	0	0	0	0	8	10	18	4	0
Nonion	*depressulus*	0	0	0	0	0	0	1	0	0	0	0
Patellina	*corrugata*	0	2	1	0	0	0	0	1	0	0	0
Planorbulina	*mediterranensis*	0	0	0	0	0	6	0	38	1	0	0
Quinqueloculina	*aspera* II	0	0	0	0	0	0	0	0	1	0	0
	bicornis	0	0	0	0	0	0	0	0	0	1	0
	cliarensis	0	0	3	0	0	0	1	2	1	2	1
	cf. *cliarensis*	0	0	0	1	0	0	0	0	0	0	0
	lata	0	0	0	1	0	1	0	0	1	0	0
	williamsoni	0	2	0	0	0	0	0	0	0	0	0
	cf. *lata/seminulum*	0	0	0	0	0	0	0	1	0	1	1
	spp.	0	3	1	3	4	3	22	6	10	3	2
Reophax	*monoliformis*	0	0	0	0	0	0	0	0	0	1	0
Spirophthalmidium	*acutimargo* var. *emaciatum*	0	0	0	0	0	0	3	0	3	0	0
Technitella	*teivyense*	0	0	0	0	0	0	1	0	0	0	0
	legumen	0	0	0	0	0	0	0	0	1	0	0
	sp. (ear bud form)	0	6	1	1	5	2	42	30	9	4	4
Textularia	*truncata*	0	0	0	0	0	0	0	1	1	0	0
	earlandi	0	19	0	0	0	0	0	0	1	1	0
Trifarina	*angulosa*	4	38	7	9	16	25	102	141	80	37	15

No data is available for December 1993 for Location 3

Location 4		**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**July**	**Aug**	**Sep**	**Oct**	**Nov**
Ammonia beccarii	*batavus*	51	72	45	112	19	96	77	170	44	508	133	170
	limnetes	0	2	0	0	0	0	0	0	0	0	0	0
Ammoscalaria	*pseudospiralis*	3	0	0	0	0	1	5	1	0	9	4	12
	runiana	0	0	0	0	0	0	1	0	0	0	0	0
Astacolus	*crepidulus*	0	0	0	0	1	0	0	0	0	0	0	0
Asterigerinata	*mamilla*	0	0	0	0	0	0	0	0	0	1	0	0
Bolivina	*pseudoplicata*	2	0	0	1	0	0	0	5	0	0	0	0
Brizalina	*pseudopunctata*	2	0	0	9	3	4	7	16	1	8	3	4
	spathulata	0	0	0	2	1	2	14	11	0	14	1	2
	variabilis	0	0	0		0	0	1	2	0	2	1	1
Buliminella	*elegantissima*	0	0	2	2	0	1	4	2	2	6	2	1
Bulimina	*gibba*	0	0	0	1	1	0	5	2	0	6	1	0
	marginata	0	0	0		1	0	0	0	1	1	0	0
Clavulina	*obscura*	0	0	0	0	0	0	0	0	0	0	0	1
Cribrostomoides	*jeffreysii*	0	0	0	0	0	1	0	0	0	0	0	0
Lenticulina	*crepidula*	0	2	0	0	0	0	1	0	0	0	0	0
	orbiculatis	2	0	0	0	0	0	0	0	0	0	1	1
Cyclogyra	*involvens*	0	0	0	0	1	0	0	0	0	0	0	0
Dentalina	*sp.*	2	0	0	0	0	0	0	0	1	0	0	0
Eggerelloides	*scabrum*	0	0	0	0	0	11	4	0	1	33	4	0
Elphidium	*cuvillieri*	0	0	0	1	0	0	0	1	17	1	1	6
	crispum	202	83	206	210	35	398	34	350	89	277	337	326
	earlandi	0	0	2	0	0	0	0	0	0	0	0	0
Fissurina	*lucida*	0	0	0	1	0	0	0	0	0	2	0	0
	marginata	0	0	0	0	0	0	0	0	1	0	0	0
Rosalina	*williamsoni*	0	0	2	1	0	2	0	10	1	2	1	2
Rosalina	*globularis*	0	0	0	0	0	0	0	0	1	1	0	0
Globulina *gibba*	var. *myristiformis*	0	0	0		0	0	0	0	0	0	1	0
Jadammina	*macresens*	0	0	0	1	0	0	0	0	0	0	0	0
Lagena	*gracilis*	0	0	0	1	0	1	0	1	2	0	2	1
	semistriata	0	0	2	0	0	0	0	0	0	0	2	0
Miliammina	*fusca*	0	0	0	2	1	1	0	0	0	2	0	0
Miliolinella	*circularis*	0	0	0	0	0	1	0	0	0	0	0	0
	subrotunda	0	0	0	0	0	1	0	0	0	0	0	0
Nonion	*depressulus*	0	0	0	0	0	1	2	1	1	0	0	1
Nonionella	sp.	0	0	0	0	0	0	0	0	0	0	1	0
Nonionella	*turgida*	0	0	0	0	0	0	0	1	0	6	1	1
Planorbulina	*mediterranensis*	0	0	0	0	0	1	0	1	1	1	0	0
Polymorphina	cf. *novangliae*	0	0	0	0	0	2	0	1	0	0	0	0
Psammosphaera	*bowmani*	2	2	0	0	0	1	0	1	0	0	0	0
Pyrgo	*depressa*	0	0	3	0	0	2	5	2	0	1	1	1
Quinqueloculina	sp. 5	0	0	0	0	0	0	0	1	0	0	0	0
	aspera I	0	0	0	1	2	0	0	0	1	0	1	0
	aspera II	0	0	3	1	0	0	0	1	1	0	0	0
	aspera III	0	0	2	0	0	0	0	0	0	0	0	0
	bicomis	0	0	0	1	0	0	0	0	0	0	2	2
	cf. *cliarensis*	2	0	0	0	0	0	0	3	0	0	0	1

	lata	0	0	0	0	0	1	0	1	0	0	0	0
	mediterranensis	2	0	0	0	1	0	0	3	1	0	1	1
	oblonga	14	24	6	39	27	32	18	45	10	79	138	86
	oblonga var. *lata*	0	0	0		1	0	0	0	0	0	0	0
	seminulum	5	3	14	12	2	8	8	6	10	13	17	12
	spp.	3	5	0		1	0	1	1	0	2	0	0
Reophax	*fusiformis*	0	0	0	1	0	0	0	0	0	0	0	0
	scottii	0	0	0	2	0	1	0	0	0	0	0	0
Stainforthia	*concava*	0	11	0	5	4	2	14	3	2	15	5	8
Spiroloculina	*excavata*	0	0	0	0	0	0	1	0	0	0	0	0
	sp.	0	0	0	1	0	0	0	0	0	0	0	0
Technitella	*teivyense*	0	0	0	2	0	0	0	0	0	0	0	0
	legumen	0	0	0	0	0	1	0	1	0	0	0	0
Textularia	*sagittula*	0	0	0	3	0	1	0	3	2	0	6	4
	truncata	0	0	2	0	0	0	0	0	1	0	1	0
	earlandi	0	0	0	0	0	1	0	1	0	1	1	1
Portatrochammina	*murrayi*	0	0	0	0	0	0	0	0	0	1	0	0
Uvigerina	sp.	0	0	0	0	0	0	0	0	0	2	0	1
Genus 3		0	0	0	1	0	0	0	0	0	0	0	0

Location 8		**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**July**	**Aug**	**Sep**	**Oct**	**Nov**
Adelosina	normal	0	0	0	0	0	0	0	0	0	0	2	0
Ammonia beccarii	*batavus*	0	0	0	0	1	0	2	3	0	47	0	3
Brizalina	*pseudopunctata*	0	0	0	0	0	1	0	0	1	1	0	5
Bulimina	*elongata*	0	0	0	0	0	0	0	0	0	0	0	3
Cibicides	*lobatulus*	0	0	0	0	0	0	0	0	0	1	1	0
Eggerelloides	*scabrum*	0	0	0	0	0	5	0	0	0	0	0	0
Elphidium	*crispum*	0	0	0	0	0	0	0	6	0	2	0	0
Rosalina	*williamsoni*	0	0	0	0	0	0	0	0	3	0	0	0
Massilina	*secans*	0	0	0	0	0	0	2	0	0	0	0	0
Miliolinella	*circularis*	0	0	0	0	0	0	0	8	0	0	0	0
Nonion	*depressulus*	0	0	0	0	0	0	0	0	0	1	0	0
Pateoris	*hauerinoides*	0	0	0	0	1	0	0	0	0	0	0	0
Planorbulina	*mediterranensis*	0	0	0	0	0	0	0	0	0	0	0	1
Polymorphina	cf. *novangliae*	0	0	0	0	0	0	0	0	0	0	0	0
Psammosphaera	*bowmani*	0	0	0	0	0	0	0	0	0	1	0	0
Quinqueloculina	*aspera* I	0	0	0	0	0	0	0	2	0	0	0	1
	aspera II	0	0	0	0	0	0	0	2	0	0	0	0
	bicornis	0	0	0	0	0	0	0	0	1	0	0	0
	cf. *cliarensis*	0	0	0	0	1	0	0	0	0	0	0	0
	lata	0	0	0	0	0	1	1	17	0	2	0	0
	oblonga	0	0	0	0	0	0	1	3	0	0	0	0
	seminulum	0	0	0	0	0	0	0	2	0	6	0	0
	williamsoni	0	0	0	0	0	0	1	0	1	1	0	0
Textularia	*truncata*	0	0	0	0	0	0	0	2	0	1	1	0
Uvigerina	sp.	0	0	0	0	0	0	0	0	0	0	0	1

Location 9		Dec	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov
Ammonia beccarii	*batavus*	0	0	398	357	145	166	41	1174	292	76	35	401
	limnetes	0	0	4	4	0	0	0	0	0	0	0	0
Ammoscalaria	*pseudospiralis*	0	0	4	2	0	7	3	17	18	8	1	7
Amphicoryna	*cf. A. scalaris*	0	0	4	0	0	7	1	0	1	0	0	0
Astacolus	*crepidulus*	0	0	4	0	1	1	0	1	0	1	0	1
Bolivina	*pseudoplicata*	0	0	3	6	1	5	1	0	1	1	0	1
Brizalina	*pseudopunctata*	3	2	810	48	131	153	484	748	76	21	6	32
	spathulata	1	0	111	50	83	138	67	130	45	3	2	27
	striatula	0	0	8	0	1	28	0	1	1	0	0	0
	variabilis	0	0	91	11	60	80	36	84	12	1	0	1
Buliminella	*elegantissima*	0	0	4	0	2	0	0	0	0	0	1	5.4
Bulimina	*elongata*	1	0	13	13	24	0	0	5	0	3	1	19
	gibba	0	0	13	2	4	54	5	18	5	0	0	4
	marginata	0	0	0	2	2	26	2	11	4	0	0	1
Buccella	*frigida*	0	0	0	0	0	1	1	0	1	0	0	0
Cibicides	*lobatulus*	0	0	0	2	0	0	0	0	0	0	0	0
Clavulina	*obscura*	0	0	3	0	2	0	0	0	0	1	1	0
Cornuspirella	*diffusa*	0	0	0	0	0	21	1	0	1	1	0	0
Cribrostomoides	*jeffreysii*	0	0	1	0	0	0	0	18	1	0	0	0
Lenticulina	*crepidula*	0	0	1	0	1	0	0	0	0	0	0	0
Lenticulina	*orbiculatis*	0	0	23	15	2	2	0	0	0	0	0	1
Cyclogyra	*involvens*	0	0	0	0	1	2	0	4	1	0	0	1
Dentalina	sp.	0	0	0	0	1	1	1	12	0	0	0	0
Eggerelloides	*scabrum*	0	0	34	189	19	61	1	1	3	6	2	5
Elphidium	*cuvillieri*	0	0	8	0	1	4	3	14	7	2	1	16
	crispum	0	0	3	0	0	1	0	34	4	1	0	1
Fissurina	*lucida*	0	0	1	0	0	14	0	0	0	0	0	1
	marginata	0	0	0	0	0	0	0	0	0	0	0	1
	orbignyana	0	0	3	0	1	0	0	0	0	0	0	0
	quadrata	0	0	1	0	0	0	0	0	0	0	0	0
Fursenkoina	*fusiformis*	1	1	1	0	0	0	0	0	0	0	0	0
Rosalina	*williamsoni*	0	0	1	0	0	0	0	1	0	0	0	0
Globulina	*gibba*	0	0	0	0	1	0	0	1	0	0	0	1
Haynesina	*germanica*	0	0	1	0	0	0	0	0	0	0	0	0
Lagena	*clavata*	0	0	0	2	1	1	0	0	1	0	0	0
	gracilis	0	0	5	0	1	0	0	0	0	0	0	0
	laevis	0	0	0	0	0	1	0	0	0	0	0	0
	lyellii	0	0	0	0	0	1	0	0	0	0	0	0
	perlucida	0	0	0	0	0	0	0	0	0	0	0	1
	substriata	0	0	4	0	0	0	0	0	1	0	0	1
Massilina	*secans*	0	0	1	0	0	0	0	0	0	0	0	0
Miliolinella	*circularis*	0	0	0	0	0	0	0	1	0	0	0	0
Nodosaria	*pyrula*	0	0	1	0	0	1	0	0	0	0	0	0
Nonion	*depressulus*	0	0	4	0	1	3	1	1	0	0	0	0
Nonionella	sp.	0	0	0	0	1	0	0	0	0	0	0	0
Nonionella	*turgida*	0	0	1	0	1	10	0	24	1	3	0	2
Oolina	*hexagona*	0	0	0	0	0	0	5	0	0	0	0	0
Psammosphaera	*bowmani*	1	0	0	0	0	1	1	1	1	0	0	0
Pyrgo	*depressa*	1	0	1	0	0	2	0	62	7	0	0	0
Quinqueloculina	sp. 5	0	0	0	0	0	0	0	2	0	0	0	0

	aspera I	0	0	0	0	0	0	0	0	1	0	0	0
	aspera II	0	0	0	0	0	0	0	0	0	0	0	1
	aspera III	0	0	3	0	0	0	1	2	0	0	0	0
	auberiana	0	0	0	0	0	0	0	0	0	1	0	0
	bicornis	1	0	0	0	0	0	0	0	0	0	0	0
	cliarensis	0	0	1	0	0	0	0	0	0	0	0	0
	cf. *cliarensis*	1	0	9	4	5	5	0	8	5	0	0	0
	lata	0	0	1	0	0	0	0	0	0	0	0	0
	mediterranensis	0	0	3	0	1	0	0	6	0	0	0	1
	oblonga	17	0	169	86	193	362	78	294	80	83	76	310
	lata var. *oblonga*	0	0	0	0	0	2	0	0	0	0	0	0
	seminulum	1	0	5	6	5	5	2	65	28	12	4	5
	spp.	1	0	3	0	0	1	0	0	0	0	0	0
Reophax	*fusiformis*	1	0	1	2	0	3	0	0	0	0	0	4
	monoliformis	0	0	0	0	0	1	0	0	0	0	0	0
	scottii	0	0	1	4	6	19	5	48	0	3	0	0
Siphogeneroides	sp.	0	1	1	0	0	2	0	0	0	0	0	0
Stainforthia	*concava*	7	0	182	86	85	252	47	166	34	27	11	95
Spirillina	*vivipara*	0	0	1	0	0	0	0	0	0	0	0	0
Spiroloculina	*excavata*	0	0	0	0	1	0	0	1	0	0	0	0
Textularia	*sagittula*	0	0	0	0	0	0	0	0	1	0	0	0
	earlandi	0	0	0	11	4	22	1	5	2	3	0	5
Trifarina	*angulosa*	0	0	1	0	0	0	0	2	0	1	0	1
Uvigerina	sp.	0	0	0	0	1	2	0	1	0	0	0	0
Genus 1		0	0	4	0	1	3	1	0	1	0	0	5
Genus 3		0	0	0	0	0	1	0	0	0	0	1	0

Location 11		**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**July**	**Aug**	**Sep**	**Oct**	**Nov**
Ammonia beccarii	*batavus*	2	0	0	0	0	0	0	0	0	6	0	2
Asterigerinata	*mamilla*	0	0	0	0	0	0	0	1	0	0	0	0
Bulimina	*elongata*	0	0	0	0	2	0	0	0	0	0	0	0
Cibicides	*lobatulus*	0	0	0	0	0	0	0	0	0	4	0	0
Elphidium	*crispum*	0	0	0	0	0	0	0	6	26	54	1	10
Globulina	*gibba*	0	0	0	0	0	0	0	0	0	1	0	0
Massilina	*secans*	0	0	0	0	0	0	0	0	1	1	0	0
Planorbulina	*mediterranensis*	0	0	0	0	0	0	0	1	0	0	0	0
Psammosphaera	*bowmani*	0	0	0	0	0	0	0	0	0	0	0	3
Quinqueloculina	*auberiana*	0	0	0	0	0	0	1	0	0	0	0	1
	oblonga	2	0	0	0	0	0	0	0	0	0	0	0
	seminulum	0	0	0	1	0	0	1	0	2	5	1	4
	williamsoni	0	0	0	0	0	2	0	0	0	0	0	1
	spp.	0	0	0	0	0	0	0	2	0	1	0	0
Reophax	*monoliformis*	0	0	0	0	0	0	0	0	0	0	0	1
Textularia	*truncata*	0	0	0	1	0	0	0	2	1	0	0	0
Genus 3		4	0	0	0	0	0	0	0	0	0	0	0

Location 12		**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**July**	**Aug**	**Sep**	**Oct**	**Nov**
Ammonia beccarii	*batavus*	224	372	167	6	281	15	140	494	468	602	476	323
Ammoscalaria	*pseudospiralis*	0	0	0	0	0	0	0	0	0	0	1	0
Asterigerinata	*mamilla*	0	0	0	0	0	0	0	0	0	2	0	0
Brizalina	*pseudopunctata*	7	0	3	0	4	1	5	13	3	12	7	0
	spathulata	0	0	0	0	0	1	11	13	7	2	15	0
	striatula	0	0	0	0	0	0	0	0	1	0	0	0
	variabilis	0	0	0	0	0	0	2	2	3	3	4	0
Buliminella	*elegantissima*	0	0	0	0	2	0	0	2	0	0	0	0
Bulimina	*elongata*	7	2	0	0	4	1	5	4	5	3	1	1
	gibba	0	0	3	0	4	0	5	0	7	9	0	1
	marginata	0	0	0	0	2	0	0	2	0	0	1	0
Clavulina	*obscura*	0	0	0	0	0	0	2	0	0	0	0	0
Lenticulina	*orbiculatis*	0	0	0	0	2	0	0	0	0	0	0	0
Cyclogyra	*involvens*	0	0	0	0	4	0	0	6	0	0	0	0
Eggerelloides	*scabrum*	4	2	0	0	124	0	0	0	0	6	0	0
Elphidium	*cuvillieri*	0	3	0	0	0	0	4	8	0	0	3	2
	crispum	0	0	5	0	0	0	2	0	0	0	1	3
	gerthi	0	0	0	0	2	0	0	0	0	0	0	0
	williamsoni	0	0	0	0	2	0	0	0	0	0	0	0
Fissurina	*lucida*	0	0	0	0	2	0	0	0	0	2	1	0
Rosalina	*williamsoni*	0	0	0	0	0	0	0	0	0	2	0	0
Haynesina	*germanica*	4	0	3	0	0	0	0	0	0	0	0	0
Lagena	*clavata*	0	0	0	0	0	0	0	0	0	2	1	0
Nonion	*depressulus*	0	0	0	0	0	0	2	0	0	0	0	0
Patellina	*corrugata*	0	0	0	0	0	0	2	0	0	0	0	0
Planorbulina	*mediterranensis*	0	0	0	0	0	0	0	2	0	0	0	0
Psammosphaera	*bowmani*	0	0	0	0	0	0	0	0	1	3	4	2
Quinqueloculina	sp. 5	0	0	0	0	0	0	0	0	0	0	1	0
	aspera I	0	0	0	1	0	0	0	0	0	0	1	0
	aspera II	0	0	0	0	0	0	0	0	0	2	0	0
	auberiana	0	2	2	1	0	0	0	0	0	0	0	0
	cf. *cliarensis*	0	0	3	0	8	0	0	0	0	0	0	0
	mediterranensis	0	0	2	0	0	0	0	0	0	2	0	0
	oblonga	4	9	9	0	29	4	11	30	13	12	48	10
	seminulum	7	6	3	0	2	1	4	4	5	2	7	0
	spp.	4	0	0	0	6	0	0	0	1	0	0	0
Reophax	*scottii*	0	0	0	0	10	0	5	4	3	0	0	0
Stainforthia	cf. *concava*	4	0	0	0	4	0	5	2	4	3	1	2
Spiroloculina	sp.	0	0	0	0	2	0	0	0	1	0	0	0
Textularia	*truncata*	0	0	0	0	0	0	0	2	0	0	0	0
	earlandi	0	0	0	0	4	0	0	0	1	2	0	0
Uvigerina	sp.	0	0	0	0	0	0	0	0	0	0	1	0

Location 14		**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**July**	**Aug**	**Sep**	**Oct**	**Nov**
Ammonia beccarii	*batavus*	6	0	3	0	3	5	3	50	12	63	25	10
	limnetes	0	0	1	0	0	0	0	0	0	0	0	0
Brizalina	*spathulata*	0	0	0	0	0	0	0	3	0	0	0	0
Bulimina	*elongata*	0	0	0	0	1	0	0	0	0	0	1	1
Cibicides	*lobatulus*	0	0	0	0	0	0	0	1	0	0	0	0
Cyclogyra	*involvens*	0	0	0	0	0	0	0	0	1	0	0	0
Eggerelloides	*scabrum*	0	0	0	0	0	0	0	1	1	0	3	0
Elphidium	*cuvillieri*	0	0	0	0	0	0	0	0	0	3	0	0
	crispum	0	0	0	0	1	1	0	0	0	1	0	0
Globulina	*gibba*	0	0	0	0	1	0	0	0	0	0	0	1
Haynesina	*germanica*	0	0	0	0	0	0	0	4	0	0	1	0
Massilina	*secans*	0	0	0	0	0	0	1	0	0	1	0	0
Nonion	*depressulus*	0	0	0	0	0	5	1	1	0	2	0	0
Nonionella	*turgida*	0	0	0	0	0	0	0	0	0	0	0	1
Psammosphaera	*bowmani*	0	0	0	0	0	1	0	0	0	0	0	1
Pyrgo	*depressa*	0	0	0	0	1	0	0	0	0	0	0	0
Quinqueloculina	sp. 5	0	0	0	0	0	0	0	0	0	1	0	0
	aspera I	0	0	0	0	0	1	1	3	1	1	0	0
	auberiana	1	0	0	0	0	1	0	0		0	0	0
	cf. *cliarensis*	0	0	0	0	0	0	0	0	1	0	0	0
	lata	0	0	0	0	0	0	0	3	0	1	0	0
	oblonga	0	0	1	0	0	0	1	4	2	11	2	0
	seminulum	0	0	0	0	0	0	1	0	0	2	0	0
	williamsoni	0	0	0	0	0	0	1	0	0	0	0	0
Stainforthia	*concava*	0	0	0	0	1	0	0	0	0	0	0	0
Textularia	*truncata*	0	0	0	0	0	0	0	0	1	0	0	0

Location 15		**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**July**	**Aug**	**Sep**	**Oct**	**Nov**
Ammonia beccarii	*batavus*	316	389	350	429	517	29	13	374	432	128	99	167
	limnetes	1	0	38	0	0	0	0	0	0	0	0	0
Ammoscalaria	*pseudospiralis*	0	0	0	1	0	1	0	0	2	1	1	1
Amphicoryna	cf. *A. scalaris*	0	0	0	0	0	0	0	0	0	1	0	0
Bolivina	*pseudoplicata*	0	0	0	0	0	1	0	1	1	0	0	0
Brizalina	*pseudopunctata*	2	1	0	0	12	27	3	73	1	2	6	0
	spathulata	8	0	1	2	13	9	7	19	2	3	0	0
	striatula	0	0	0	0	2	1	0	1	0	0	0	0
	variabilis	0	0	0	0	2	5	1	12	0	0	1	0
Buliminella	*elegantissima*	2	0	14	0	1	4	0	31	0	0	2	0
Bulimina	*elongata*	4	0	5	3	13	5	1	14	3	5	4	1
	gibba	2	1	0	1	6	3	0	8	2	3	2	1
	marginata	1	0	2	2	0	0	0	0	0	0	0	0
Clavulina .	*obscura*	0	0	0	0	0	1	0	2	0	0	0	0
Cornuspirella	*diffusa*	0	0	1	0	0	0	0	0	0	0	0	0
Lenticulina	*orbiculatis*	0	0	0	0	0	0	0	1	0	1	0	0
Cyclogyra	*involvens*	0	0	1	0	1	0	0	1	0	1	0	1
Eggerelloides	*scabrum*	2	2	3	16	187	3	0	2	0	6	4	1
Elphidium	*cuvillieri*	6	1	1	3	2	0	4	21	6	3	2	7
	crispum	2	1	31	18	12	10	0	370	60	18	18	30
	gerthi	0	0	0	0	0	1	0	1	0	0	0	0
	margaritaceum	1	0	0	0	0	0	0	0	0	0	0	0
	williamsoni	1	0	0	0	0	0	0	0	0	0	1	0
Fissurina	*lucida*	0	0	0	0	1	1	1	0	2	2	0	1
	marginata	0	0	0	0	0	1	0	0	0	0	1	0
Fursenkoina	*fusiformis*	1	0	0	0	1	0	0	0	0	0	0	0
Rosalina	*williamsoni*	0	0	0	0	0	0	0	0	0	1	0	0
Globulina	*gibba*	0	0	0	0	1	0	0	0	0	0	0	0
Haynesina	*germanica*	2	0	0	0	0	1	0	0	0	0	0	0
Lagena	*clavata*	1	0	0	0	0	0	0	0	1	1	0	0
Nonion	*depressulus*	1	0	0	1	0	0	1	12	1	2	0	0
Nonionella	sp.	0	0	0	0	0	0	0	0	0	1	0	0
Nonionella	*turgida*	0	0	0	0	0	0	0	1	0	1	0	0
Pateoris	*haurinoides*	0	0	0	0	0	0	0	0	0	1	0	0
Psammosphaera	*bowmani*	1	0	1	0	0	0	0	1	1	2	1	0
Quinqueloculina	sp. 5	0	0	0	0	0	0	0	0	0	0	1	1
	aspera I	0	1	0	4	0	0	0	1	1	2	1	1
	aspera II	0	0	0	0	0	1	0	1	0	0	1	0
	aspera III	2	1	2	1	0	2	0	0	0	0	1	0
	cf. *cliarensis*	0	0	0	0	1	0	0	0	0	0	0	0
	oblonga	19	14	5	25	38	12	2	30	2	22	28	10
	seminulum	0	3	1	4	3	0	0	2	0	4	3	1
	williamsoni	0	0	1	0	0	0	0	0	0	0	0	0
	spp.	2	0	0	0		0	0	0	0	1	1	0
	scottii	3	1	2	8	10	30	13	11	3	2	1	0
Stainforthia	*concava*	7	2	1	2	1	4	3	20	2	4	3	3
Textularia	*sagittula*	0	0	0	0	1	0	0	0	1	1	0	0
	earlandi	0	0	0	0	0	0	0	0	1	1	0	0
Trifarina	*angulosa*	2	0	1	0	0	0	0	0	0	0	1	0
Uvigerina	sp.	0	0	0	0	0	0	0	3	0	0	0	0

Location 16		**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**July**	**Aug**	**Sep**	**Oct**	**Nov**
Ammonia beccarii	*batavus*	0	1	0	1	0	0	0	0	2	1	0	0
Asterigerinata	*mamilla*	0	0	0	0	0	0	0	0	3	0	0	0
Bolivina	*pseudoplicata*	0	0	0	0	0	0	0	6	5	0	0	0
Brizalina	*pseudopunctata*	0	0	0	1	0	4	0	1	5	0	0	0
	spathulata	0	0	0	1	0	2	0	0	2	3	0	0
	variabilis	0	0	0	0	0	0	0	0	2	0	0	0
Buliminella	*elegantissima*	0	0	0	0	0	2	0	0	0	0	0	0
Bulimina	*elongata*	0	0	0	0	0	0	0	1	0	0	0	0
	marginata	0	0	0	0	0	0	0	0	3	0	0	0
Cibicides	*pseudoungerianus*	0	0	0	0	0	0	0	0	0	3	0	0
Clavulina	*obscura*	0	0	0	0	0	0	0	0	3	3	0	0
Cribrostomoides	*jeffreysii*	0	0	0	0	0	2	0	3	70	7	1	2
Lenticulina	*crepidula*	0	0	0	0	0	0	0	0	2	0	0	0
Eggerelloides	*scabrum*	0	0	0	0	0	0	0	0	0	1	0	0
Elphidium	*cuvillieri*	0	1	0	0	0	0	0	0	2	2	0	0
	crispum	0	0	0	1	0	0	0	1	0	0	0	0
	gerthi	0	0	0	0	0	4	0	1	2	0	0	0
Fissurina	*lucida*	0	0	0	0	0	0	0	0	2	0	0	0
	marginata	0	0	0	0	0	0	0	0	3	0	0	0
Rosalina	*williamsoni*	2	4	1	3	0	13	10	25	206	22	1	2
Globulina	*gibba*	0	0	0	0	0	0	0	0	2	1	0	0
Haynesina	*germanica*	0	0	0	0	2	0	1	1	3	1	0	1
Lagena	*laevis*	0	0	0	0	0	0	0	0	2	0	0	0
Massilina	*secans*	0	0	0	6	0	0	0	0	0	0	0	0
Miliolinella	*circularis*	2	0	1	1	0	14	1	5	2	0	0	0
	subrotunda	0	0	0	0	0	0	0	7	11	4	1	1
Nonion	*depressulus*	0	0	0	0	0	4	0	0	2	0	0	0
Patellina	*corrugata*	4	1	0	1	2	0	0	1	3	0	0	0
Planorbulina	*mediterranensis*	1	0	0	0	2	0	1	6	56	1	0	0
Psammosphaera	*bowmani*	1	0	0	0	2	2	0	0	0	0	0	0
Quinqueloculina	*aspera*	0	0	0	0	0	0	0	0	2	0	0	0
	auberiana	0	0	0	0	0	0	0	0	2	0	0	0
	lata	0	0	0	1	0	0	0	0	0	0	0	0
	mediterranensis	1	0	0	0	0	0	0	0	0	0	0	0
	oblonga	0	0	0	0	0	0	0	0	0	2	0	0
	seminulum	0	2	1	2	0	0	0	1	0	5	1	2
	williamsoni	0	0	0	0	0	2	0	3	0	1	0	0
	spp.	1	1	1	2	4	9	1	8	16	7	0	2
Reophax	*scottii*	0	0	0	0	0	2	0	0	0	0	0	0
Technitella	*teivyense*	0	0	0	0	0	0	0	1	2	0	0	0
Textularia	*truncata*	2	8	0	3	9	36	13	35	168	4	1	0
	earlandi	1	0	0	0	0	0	1	0	3	1	0	0
Trifarina	*angulosa*	0	0	0	0	0	0	0	0	2	0	0	0

Location 17		**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**July**	**Aug**	**Sep**	**Oct**	**Nov**
Ammonia beccarii	*batavus*	9	1	17	17	45	27	102	132	109	747	81	68
Ammoscalaria	*pseudospiralis*	0	0	0	0	0	0	0	0	0	3	0	0
Bolivina	*pseudoplicata*	0	0	0	0	0	0	0	0	5	0	0	0
Brizalina	*pseudopunctata*	0	0	2	0	0	0	1	10	8	1	3	0
	spathulata	0	0	8	0	0	0	1	3	2	2	0	0
	striatula	0	0	0	1	0	0	0	0	0	0	0	0
	variabilis	0	0	0	0	0	0	0	2	0	0	0	0
Bulimina	*elongata*	0	0	0	1	1	0	3	1	2	1	0	0
	gibba	0	0	0	0	0	0	1	0	3	2	0	0
	marginata	0	0	0	0	1	0	0	0	0	2	0	0
Cibicides	*pseudoungerianus*	0	0	0	0	0	0	0	0	2	0	0	0
Clavulina	*obscura*	0	0	0	0	0	0	0	0	0	2	5	0
Cornuspirella	*diffusa*	0	0	0	0	0	0	0	0	0	2	0	0
Eggerelloides	*scabrum*	0	0	0	1	22	16	1	0	3	254	0	0
Elphidium	*cuvillieri*	0	0	0	0		0	1	3	0	0	5	0
	crispum	2	6	0	8	23	20	133	130	138	0	15	64
	williamsoni	0	0	0	0	0	0	1	0	0	0	0	0
Fissurina	*lucida*	0	0	0	0	0	0	0	0	2	3	0	0
Rosalina	*williamsoni*	0	0	0	0	0	0	0	0	0	8	0	0
Globulina	*gibba*	0	0	0	0	1	0	0	0	2	0	0	0
Haynesina	*germanica*	0	0	1	0	0	0	1	0	0	0	0	0
Jadammina	*macresens*	0	0	0	0	0	0	0	0	0	0	0	0
Lagena	*semistriata*	0	0	0	0	0	0	1	0	0	0	0	0
Massilina	*secans*	0	0	1	5	0	3	4	1	0	0	0	0
Miliolinella	*circularis*	0	0	0	0	0	0	1	0	0	0	0	0
	subrotunda	0	0	0	0	0	0	0	0	2	1	0	0
Nonion	*depressulus*	0	0	0	0	0	0	1	4	5	3	0	0
Psammosphaera	*bowmani*	0	0	0	1	0	0	0	1	2	2	0	0
Quinqueloculina	sp. 5	0	0	0	0	0	0	1	0	0	0	0	0
	aspera I	0	0	0	0	4	0	4	2	2	3	2	0
	aspera II	0	0	0	0	1	1	1	1	0	0	0	2
	aspera III	0	0	0	0	0	1	0	0	0	1	0	0
	auberiana	0	0	1	0	1	1	0	0	2	2	0	2
	cf. cliarensis	0	0	0	0	0	0	1	0	2	1	0	0
	lata	0	2	2	3	7	12	5	1	6	1	3	22
	mediterranensis	0	0	0	0	0	0	2	0	3	0	0	0
	oblonga	0	0	0	0	1	1	8	11	0	64	6	0
	seminulum	0	1	2	1	5	1	2	5	5	70	0	0
	williamsoni	0	0	0	0	0	0	2	1	0	0	0	0
	spp.	0	0	0	3	0	0	1	0	2	6	5	0
Reophax	*scottii*	0	0	0	0	0	0	1	3	0	1	2	0
Stainforthia	*concava*	0	0	0	0	0	0	0	0	0	4	0	0
Spiroloculina	*excavata*	0	0	0	0	0	0	1	0	0	0	0	0
Textularia	*sagittula*	0	0	0	0	0	0	2	2	8	6	0	0
	truncata	0	0	0	0	0	0	1	2	2	1	0	0
	earlandi	0	0	0	0	0	0	0	0	2	0	2	0
Trifarina	*angulosa*	0	0	0	0	0	0	0	0	0	1	0	0

Location 18		**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**July**	**Aug**	**Sep**	**Oct**	**Nov**
Ammonia beccarii	*batavus*	240	43	398	211	656	34	88	490	298	470	280	480
Ammoscalaria	*pseudospiralis*	3	0	0	0	0	1	1	5	7	11	21	6
Brizalina	*pseudopunctata*	1	0	8	1	2	3	16	46	5	4	4	2
	spathulata	3	1	11	0	0	1	14	7	2	1	10	0
	variabilis	0	0	0	0	0	0	2	13	2	0	1	0
Bulimina	*elongata*	8	1	10	0	0	5	9	10	6	1	10	5
	gibba	0	0	4	0	1	0	2	12	6	0	2	2
	marginata	1	0	0	0	0	0	0	0	0	0	0	2
Cornuspirella	*diffusa*	0	0	0	0	0	0	0	1	0	7	3	0
Lenticulina	*crepidula*	0	0	1	0	0	0	0	0	0	0	0	0
	orbiculatis	0	0	1	0	0	0	1	0	0	0	0	0
Cyclogyra	*involvens*	0	0	0	0	0	0	0	0	0	0	1	0
Eggerelloides	*scabrum*	5	1	2	1	112	9	0	0	1	1	6	0
Elphidium	*cuvillieri*	1	0	0	0	0	0	3	0	7	1	7	21
	crispum	312	83	138	304	321	79	99	459	257	4	93	85
	gerthi	0	0	1	0	0	0	2	0	1	0	0	2
Fissurina	*lucida*	1	0	0	0	0	0	0	0	2	4	2	0
Rosalina	*williamsoni*	0	0	0	0	0	0	0	3	1	1	1	0
Globulina	*gibba*	1	1	1	1	1	0	2	1	4	2	1	0
Haynesina	*germanica*	0	0	0	0	0	1	0	1	0	0	0	0
Lagena	*clavata*	0	0	1	0	0	0	0	0	0	0	0	0
	laevis	0	0	0	0	0	1	1	0	1	0	0	0
	semistriata	0	0	0	0	0	0	2	0	0	0	0	0
Massilina	*secans*	0	0	0	0	2	0	0	0	0	0	0	0
Miliolinella	*circularis*	1	0	0	0	0	0	0	0	0	0	0	0
Nonion	*depressulus*	0	0	0	0	0	0	4	62	7	1	17	3
Nonionella	*sp.*	1	0	0	0	0	0	0	0	2	1	1	0
Planorbulina	*mediterranensis*	1	0	0	0	0	0	0	0	1	0	0	2
Psammosphaera	*bowmani*	0	0	0	0	2	1	0	0	0	0	1	0
Pyrgo	*williamsoni*	0	0	0	0	0	0	0	0	1	0	0	0
Quinqueloculina	sp. 5	1	1	0	0	0	0	2	0	0	0	0	0
	aspera I	1	0	5	4	0	5	2	0	2	1	2	0
	aspera II	0	1	0	0	0	0	0	0	0	1	0	0
	aspera III	1	1	0	0	6	1	0	0	0	0	1	0
	auberiana	0	0	1	0	0	0	0	3	0	0	0	0
	cf. cliarensis	1	0	4	0	2	0	2	7	1	2	1	0
	lata	0	0	0	0	2	1	1	0	1	0	1	0
	mediterranensis	0	0	0	0	1	0	0	0	1	1	0	0
	oblonga	35	1	66	13	11	23	39	104	33	50	42	58
	lata var. *oblonga*	0	0	1	0	0	0	0	0	0	0	0	0
	seminulum	6	2	16	9	12	8	7	59	16	23	26	16
	williamsoni	0	0	1	0	0	0	1	0	0	0	0	0
	spp.	0	1	2	0	0	0	0	5	1	0	0	0
Reophax	*scottii*	0	0	1	0	1	1	2	1	2	0	2	0
Siphogeneroides	sp.	1	0	0	0	0	0	0	0	0	0	0	0
Stainforthia	*concava*	3	1	2	0	0	0	3	17	3	6	5	5
Spiroloculina	*excavata*	0	0	0	0	0	0	0	0	1	0	0	0
Textularia	*sagittula*	0	0	2	0	1	0	0	3	2	0	0	0
	truncata	0	0	0	0	0	0	0	3	2	1	1	0
	earlandi	0	0	0	0	0	0	0	4	1	0	0	0
Uvigerina	sp.	0	0	0	0	0	0	0	0	2	0	1	0

Appendix 5b

Plymouth Sound Dead Foraminiferal data
from December 1993 to November 1994

Location 1	**Dec**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**July**	**Aug**	**Sep**	**Oct**	**Nov**
Acervulina inhaerens	0	0	0	0	0	0	1	0	0	0	0
Adelosina sp (normal)	1	0	1	1	0	0	0	1	0	0	0
Ammonia beccarii batavus	115	86	58	77	68	62	93	100	54	51	86
A. beccarii limnetes	8	21	17	8	7	11	10	11	19	17	21
Amphicoryna cf. *A. scalaris*	0	0	0	0	0	0	0	0	0	0	1
Asterigerinata mamilla	10	5	4	5	13	13	3	1	6	11	8
Bolovina pseudoplicata	1	0	2	1	1	2	3	2	0	0	0
Brizalina pseudopunctata	1	1	2	0	0	2	1	1	1	0	1
B. spathulata	3	0	7	1	4	4	1	3	2	4	1
B. striatula	0	0	0	2	0	1	0	0	0	0	0
B. variabilis	0	0	0	0	0	0	0	1	0	0	0
Bulimina elongata	6	1	5	3	2	4	3	2	3	2	5
B. gibba	4	2	1	1	6	1	1	1	0	4	5
B. marginata	0	0	0	1	0	0	0	1	0	0	0
Cibicides lobatulus	84	35	60	58	30	33	111	32	35	34	28
C. pseudoungerianus	9	5	11	19	17	13	20	12	18	7	15
Clavulina obscura	0	0	1	1	0	2	1	0	1	1	1
Cribrostomoides jeffreysii	0	0	0	0	1	0	3	1	0	0	2
Lenticulina crepidula	0	0	0	0	0	0	1	0	0	0	0
L. orbiculatis	1	0	0	0	0	1	0	0	0	1	0
Eggerelloides scabrum	35	29	5	18	17	14	22	22	18	20	14
Elphidium cuvillieri	11	9	3	11	13	7	12	6	10	8	8
E. crispum	38	29	18	35	16	15	38		19	26	25
E. earlandi	0	0	0	0	1	0	0	21	1	0	0
E. margaritaceum	0	0	2	1	2	0	0	0	0	0	0
E. gerthi	1	1	3	2	2	4	1	0	3	4	2
E. williamsoni	26	10	19	9	10	13	9	16	10	13	9
Fissurina lucida	3	2	1	2	1	6	1		1	1	1
F. marginata	0	0	2	0	1	0	0	0	0	0	0
F. orbignyana	1	0	1	1	1	2	1	0	1	0	0
Fursenkoina fusiformis	0	0	1	0	0	0	0	0	1	0	0
Rosalina williamsoni	1	2	2	5	7	7	3	3	10	6	7
R. praegeri	11	6	7	4	9	10	11	18	5	12	10
Globulina gibba	0	1	0	1	0	1	1	2	0	0	0
G. gibba var. *myristiformis*	0	1	0	1	0	0	4	0	0	1	0
Haynesina germanica	0	16	18	27	22	21	28	21	29	29	20
Lagena clavata	0	0	0	1	0	0	0	0	0	0	0
L. laevis	0	0	0	1	0	0	1	0	0	0	0
L. perlucida	0	0	0	0	0	0	1	0	0	1	0
L. sulcata	0	0	0	1	0	0	0	0	1	0	0
Massilina secans	3	2	3	3	2	4	12	0	3	2	1
Quinqueloculina auberiana	3	1	2	3	3	3	7	0	3	2	0

Miliolina subrotunda	0	0	1	2	1	3	4	0	0	2	1
Nonion depressulus	0	0	1	1	0	1	0	3	3	2	0
Oolina melo	0	0	0	0	0	0	0	1	0	1	0
O. squamosa	1	0	0	0	1	0	0	0	0	1	0
O. williamsoni	1	0	0	0	0	0	0	0	0	1	1
Patellina corrugata	0	0	0	0	0	1	0	0	0	1	0
Planorbulina mediterranensis	3	2	2	4	2	1	0	1	4	2	4
Polymorphina concava	0	0	0	0	0	1	0	0	0	0	0
P. cf. *novangliae*	0	1	0	0	0	0	1	0	0	0	0
Psammosphaera bowmani	0	0	0	1	1	1	1	0	0	1	1
Pyrgo depressa	0	1	0	0	0	0	0	0	0	0	0
Quinqueloculina sp. 5	0	1	0	0	0	1	0	0	0	0	0
Quinqueloculina. spp	5	1	3	2	2	0	0	3	2	5	2
Q. aspera II	3	4	0	4	1	1	8	3	1	3	2
Q. aspera III	1	0	2	1	2	2	0	1	0	1	1
Q. bicornis	1	1	1	3	2	1	1	1	2	1	2
Q. cf. *cliarensis*	0	1	2	3	1	4	2	2	0	5	1
Q. mediterranensis	1	2	0	0	0	0	1	0	0	0	0
Q. lata var. *oblonga*	2	3	2	3	5	2	3	1	1	0	0
Q. lata	12	6	8	6	2	5	2	4	2	5	3
Q. oblonga	0	1	0	0	0	3	1	1	0	1	0
Q. cliarensis	0	0	1	0	0	0	0	0	0	0	0
Q. seminulum	4	15	5	11	4	5	24	8	12	6	3
Q. striated form	0	0	0	0	0	0	0	0	0	0	0
Q. williamsoni	0	0	2	1	0	0	0	0	0	0	0
Q. cf. *lata seminulum*	3	0	0	0	0	0	0	0	0	0	0
Reophax fusiformis	0	0	0	1	0	0	0	0	0	0	0
Rosalina globularis	0	1	1	0	2	0	0	0	0	0	0
Polymorphina cf. *concava*	0	0	0	0	0	1	0	0	0	0	0
Spirallina runiana	0	0	1	0	0	0	0	0	0	0	0
Spiroloculina excavata	0	1	0	1	1	0	0	1	1	1	0
S. rotunda	1	2	1	1	0	1	1	0	0	0	1
Textularia sagittula	0	3	0	1	1	0	1	0	1	3	0
Spiroplectammina wrightii	1	3	1	0	0	2	4	1	1	15	1
Textularia truncata	9	15	23	20	15	13	41	13	18	0	15
Deuterammina (Lepidodeuterammina) ochracea var. *sinuosa*	0	0	0	0	0	1	0	0	0	0	0
Deuterammina (Deuterammina) rotaliformis	0	0	0	0	0	0	0	1	0	0	0
Trifarina angulosa	0	0	2	2	1	2	1	0	3	3	1
Vaginulina linearis	0	0	0	0	1	0	0	0	0	0	0

No data is available for January 1994 for Location 1

Location 3	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**July**	**Aug**	**Sep**	**Oct**	**Nov**
Acervulina inhaerens	0	0	2	0	1	0	0	0	0	0	1
Adelosina (normal)	0	0	0	0	0	1	0	1	0	0	0
Ammonia beccarii batavus	7	9	23	30	14	33	17	23	8	10	39
A. beccarii limnetes	0	3	3	7	11	2	0	3	11	11	8
Asterigerinata mamilla	0	1	3	4	3	0	0	7	6	0	7
Bolivina pseudoplicata	0	0	1	0	1	0	0	1	1	0	0
Brizalina pseudopunctata	0	0	1	0		0	9	1	1	1	2
B. spathulata	1	0	5	1	4	0	1	1	1	2	0
B. striatula	0	0	0	0	0	0	0	0	1	0	0
B. variabilis	0	0	0	0	0	0	0	0	0	1	0
Bulimina elongata	0	3	0	0	2	1	1	0	0	3	1
B. gibba	0	0	0	1	0	2	0	0	1	1	0
B. marginata	0	0	0	0	0	0	0	2	0	1	0
Cibicides lobatulus	3	20	45	66	83	74	44	47	37	36	64
C. pseudoungerianus	2	3	17	11	5	4	6	5	8	7	10
Clavulina obscura	0	0	1	0	0	0	0	1	0	1	0
Cribrostomoides jeffreysii	0	0	0	3	1	2	5	3	6	7	
Lenticulina crepidula	0	0	0	0	0	0	1	0	0	0	0
L. orbiculatis	0	0	0	0	0	0	0	0	1	0	0
Cyclogyra involvens	0	0	0	0	0	0	0	0	2	3	0
Eggerelloides scabrum	3	3	13	19	13	9	5	9	7	11	14
Elphidium cuvillieri	0	6		4	3	3	2	2	1	3	7
E. crispum	5	9	32	47	46	58	22	19	12	7	40
E. earlandi	0	0	0	1	0	0	1	3	0	0	0
E. margaritaceum	0	0	1	0	0	0	0	1	2	1	0
E. gerthi	0	1	0	1	0	1	2	4	3	2	0
E. williamsoni	1	5	3	5	4	4	3	8	5	4	9
Fissurina lucida	0	0	1	0	0	0	1	0	0	1	1
F. marginata	0	0	0	0	1	1	1	4	0	1	0
F. orbignyana	0	0	0	0	1	0	0	0	0	1	2
Fursenkoina fusiformis	0	0	1	0	0	0	0	0	0	0	0
Rosalina williamsoni	0	0	1	1	2	4	7	11	11	25	4
R. praegeri	0	5	8	3	0	4	4	7	7	12	7
Globulina gibba	0	0	0	1	4	0	0	1	0	1	0
Haynesina germanica	2	6	13	13	5	5	6	18	16	14	6
Lagena laevis	0	0	0	0	0	0	1	0	0	0	0
L. semistriata	0	0	0	0	0	0	0	1	11	0	0
L. sulcata	0	0	0	0	0	0	0	0	1	0	0
Massilina secans	0	4	3	11	12	5	1	4	4	3	9
Miliammina fusca	0	1	0	0	0	0	0	0	0	0	0
Quinqueloculina auberiana	0	2	0	0	5	7	2	1	2	1	4
Miliolinella circularis	0	0	0	0	0	1	0	11	3	3	3
M. subrotunda	2	2	0	0	1	5	2	17	18	14	8
Nonion depressulus	0	1	2	0	0	0	1	2	2	1	0

williamsoni	0	0	0	0	0	0	0	0	1	0	0
Patellina corrugata	0	1	0	0	2	1	2	0	0	3	1
Polymorphina mediterranensis	1	6	4	4	3	3	25	16	28	21	4
Psammosphaera bowmani	0	0	0	0	0	1	0	0	1	1	3
Pyrgo depressa	0	1	0	0	0	0	0	0	0	0	0
Quinqueloculina .spp	0	5	0	7	0	5	1	13	16	11	4
Q. aspera II	0	1	0	1	3	1	4	1	3	0	1
Q. aspera III	0	0	0	0	0	1	1	1	1	1	1
Q. bicomis	1	4	5	5	7	3	1	4	2	1	2
Q. cf. *cliarensis*	0	1	0	0	3	2	0	0	1	3	0
Q. mediterranensis	0	0	1	0	0	0	0	0	0	0	0
Q. lata var. *oblonga*	0	0	1	1	0	1	0	1	0	3	3
Q. lata	1	2	2	2	0	0	2	0	6	0	1
Q. oblonga	0	2	0	2	1	0	0	0	3	3	0
Q. seminulum	5	11	22	16	40	37	17	20	18	10	14
Q. williamsoni	0	0	0	1	1	1	6	5	0	1	0
Q. cf. *lata seminulum*	0	2	0	1	0	0	0	4	0	0	5
Reophax monoliformis	0	0	4	0	2	0	0	4	2	0	2
R. scottii	0	0	0	0	0	0	0	0	1	0	0
Rosalina globularis	0	0	1	2	1	0	0	0	0	0	1
Stainforthia cf. *concava*	0	0	0	0	0	0	1	0	0	0	0
Spiroloculina excavata	0	0	0	0	0	0	0	0	0	0	1
Spiroloculina cf. *S. grata*	0	0	0	0	0	0	0	0	0	0	1
Spiroloculina sp	0	0	0	0	0	0	0	0	0	1	0
Technitella sp (earbud form)	0	0	0	0	0	0	0	1	0	0	0
Textularia sagittula	0	0	1	0	0	0	0	0	0	0	0
Spiroplectammina wrightii	0	0	0	1	0	0	0	0	0	0	2
Textularia truncata	1	13	15	21	36	25	43	17	40	29	18
T. earlandi	0	0	0	0	0	0	0	0	0	1	0
Deuterammina (Lepidodeuterammina) ochracea var. *sinuosa*	0	0	0	0	1	1	4	3	0	1	0
Deuterammina (Deuterammina) rotaliformis	0	0	0	0	1	0	1	1	1	1	0
Remaneica helgolandica	0	0	0	1	0	0	1	0	0	1	0
Trifarina angulosa	0	0	0	0	1	0	0	4	3	1	0
Vaginulina linearis	1	0	0	0	3	1	0	1	0	0	1

No data is available for December 1993 for Location 3

Location 4	Dec	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov
Acervulina inhaerens	1	1	1	0	1	0	0	0	4	1	0	2
Adelosina (normal)	1	0	0	0	0	0	1	0	0	1	1	0
Ammonia beccarii batavus	121	58	75	57	76	56	72	53	66	34	47	60
A. beccarii limnetes	0	5	4	10	0	5	9	0	4	22	8	4
Ammoscalaria pseudospiralis	5	2	3	0	1	1	2	1	2	1	0	0
Amphicoryna cf. *A. scalaris*	0	0	0	0	0	0	0	1	0	0	0	0
Asterigerinata mamilla	5	0	6	1	1	10	4	5	5	2	2	2
Bolivina pseudoplicata	0	0	0	0	3	1	0	1	0	0	3	1
Brizalina pseudopunctata	1	3	1	2	5	1	1	0	2	0	6	1
B. spathulata	1	0	1	1	5	1	1	3	2	5	4	2
B. striatula	0	0	0	0	0	1	0	0	0	0	1	1
B. variabilis	0	0	0	0	2	0	0	0	0	0	1	1
Buliminella elegantissima	0	0	0	0	0	0	0	0	0	0	1	0
Bulimina elongata	1	1	0	5	1	4	4	0	1	3	3	0
B. gibba	0	2	0	0	0	1	8	0	0	3	4	0
B. marginata	1	2	0	0	1	0	1	0	1	2	0	0
Buccella frigida	0	0	0	0	0	0	0	0	0	0	0	0
Cibicides lobatulus	34	20	15	12	24	38	22	26	33	25	23	30
C. pseudoungerianus	0	7	2	5	2	4	2	0	2	3	8	1
Clavulina obscura	0	2	0	0	1	3	0	1	0	1	3	0
Cribrostomoides jeffreysii	0	1	0	2	0	0	1	5	1	0	9	0
Lenticulina crepidula	0	0	0	1	0	0	1	0	0	0	0	0
L. orbiculatis	1	0	0	1	0	1	0	0	0	0	0	1
Cyclogyra involvens	0	0	0	0	0	0	0	2	0	0	0	0
Dentalina spp.	0	0	0	0	0	0	1	0	0	0	0	0
Eggerelloides scabrum	9	29	9	19	17	6	30	14	5	29	20	18
Elphidium cuvillieri	5	5	0	5	2	5	9	4	3	7	10	6
E. crispum	133	48	90	65	92	68	47	48	69	32	25	61
E. earlandi	0	0	0	0	0	0	0	2	0	0	0	1
E. margaritaceum	0	1	0	0	0	0	0	0	1	0	1	0
E. gerthi	1	3	0	3	2	1	1	2	0	4	1	3
E. williamsoni	3	9	1	6	4	8	10	3	4	6	4	5
Fissurina lucida	1	0	0	1	1	2	0	0	1	2	2	1
F. marginata	0	0	0	0	0	1	0	1	0	0	0	0
F. orbignyana	1	0	0	0	1	1	1	1	1	0	0	0
Fursenkoina fusiformis	0	0	0	1	0	1	0	1	0	1	1	1
Rosalina williamsoni	0	2	1	0	4	2	0	2	0	8	11	6
R. praegeri	0	7	3	3	3	4	6	8	2	6	13	5
Globulina gibba	1	1	0	0	0	1	1	1	1	1	2	2
G. gibba var. *myristiformis*	2	1	2	1	1	1	0	0	0	0	1	0
Nodosaria pyrula	0	0	0	0	0	0	0	0	0	0	0	0
Haynesina germanica	0	20	3	8	6	9	18	12	8	22	18	10
Jadammina macresens	0	0	0	0	0	0	0	0	0	0	0	0
Lagena clavata	1	0	0	0	1	1	1	1	0	0	1	2
L. laevis	1	0	0	0	1	0	0	0	0	0	0	0
L. perlucida	0	0	0	0	0	0	1	1	0	0	0	0
L. semistriata	0	0	0	0	0	0	0	2	0	0	0	0
L. substriata	0	0	0	0	0	0	0	1	0	0	0	1
L. sulcata	0	2	0	1	1	0	0	1	0	0	0	1
L. sulcata var. *torquiformis*	0	0	1	0	0	0	0	0	0	0	0	0
Massilina secans	3	2	4	7	9	4	3	6	11	0	5	5
Miliammina fusca	0	0	0	0	0	0	0	0	0	0	0	0
Quinqueloculina auberiana	3	4	1	2	5	1	3	2	4	3	1	
Miliolinella circularis	1	1	0	1	1	1	3	1	1	0	2	1
M. subrotunda	2	5	0	1	1	3	1	1	0	0	3	1

Nonion depressulus	0	0	0	3	2	2	1	2	0	0	1	0
Nonionella sp.	0	1	0	0	0	0	0	0	1	0	0	0
Nonionella turgida	0	0	0	0	0	0	0	0	1	0	1	0
Oolina melo	0	0	0	0	0	0	1	0	0	0	0	0
O. williamsoni	1	1	0	0	0	0	1	0	0	1	0	0
Patellina corrugata	0	0	2	0	0	0	0	1	0	0	0	0
Planorbulina mediterranensis	3	3	1	10	8	7	8	0	4	1	6	6
Polymorphina concava	0	0	0	0	0	0	0	1	0	1	0	0
P. cf. *novangliae*	1	1	0	0	0	1	1	0	1	0	0	2
Psammosphaera bowmani	0	0	0	0	0	1	1	0	0	0	0	0
Pyrgo depressa	1	1	1	0	1	1	3	2	1	1	1	0
P. williamsoni	0	1	1	0	0	0	0	0	0	0	0	0
Quinqueloculina sp. 5	1	0	1	1	1	0	3	0	1	1	2	3
Q. spp.	2	4	3	2	2	0	3	3	0	6	0	3
Q. aspera I	0	1	2	1	1	0	1	1	0	1	0	1
Q. aspera II	2	6	5	5	2	4	0	4	3	2	2	5
Q. aspera III	0	1	0	0	4	4	1	1	4	0	0	2
Q. bicornis	5	2	1	2	1	1	2	1	1	1	1	1
Q. cf. *cliarensis*	3	3	7	6	2	4	6	1	4	4	2	4
Q. mediterranensis	0	3	3	3	2	1	1	0	0	0	1	0
Q. lata var. *oblonga*	2	4	1	0	1	1	0	0	2	3	3	0
Q. lata	3	1	7	3	3	5	1	0	1	6	3	2
Q. oblonga	2	7	0	1	6	2	8	7	1	5	7	4
Q. cliarensis	0	1	0	1	0	0	0	0	0	0	0	0
Q. seminulum	38	24	19	17	17	11	15	23	27	25	10	20
Q. striated forms	0	0	0	0	0	0	1	0	0	0	0	0
Q. williamsoni	1	1	1	1	0	1	0	1	1	2	0	1
Q. cf. *lata / seminulum*	0	1	0	0	0	0	0	0	0	0	0	0
Fursenkoina fusiformis	1	0	0	2	1	1	1	0	0	0	0	0
Reophax monoliformis	0	0	0	0	0	2	0	0	0	0	0	0
R. scottii	0	0	0	1	1	1	0	0	0	0	0	1
Rosalina globularis	0	1	0	0	1	1	0	0	1	0	0	1
Polymorphina cf. *concava*	1	1	0	0	1	0	1	0	0	0	2	0
Spiroloculina excavata	1	0	1	1	1	1	1	1	0	0	0	0
S. rotunda	1	1	1	0	0	0	0	0	1	0	0	0
Spiroloculina sp	0	0	0	1	1	0	0	0	0	0	0	0
Textularia sagittula	0	2	4	4	5	2	0	3	5	4	0	2
Spiroplectammina wrightii	0	0	2	0	1	1	0	0	0	0	0	0
Textularia truncata	7	10	2	13	9	11	5	11	5	12	13	7
T. earlandi	0	1	0	0	1	1	8	2	0	3	4	0
Deuterammina (Lepidodeuterammina) ochracea var. *sinuosa*	0	0	0	2	0	0	0	0	0	0	0	0
Deuterammina (Deuterammina) rotaliformis	0	0	0	0	0	0	0	1	0	0	0	0
Remaneica Helgolandica	0	1	0	0	0	0	0	0	0	0	0	0
Portatrochammina murrayi	0	0	0	1	1	0	0	0	0	0	0	0
Trifarina angulosa	0	1	0	0	1	1	0	1	0	1	2	1
Uvigerina sp.	0	0	0	0	0	0	0	0	0	0	1	1
Vaginulina linearis	0	0	0	1	0	0	0	0	0	0	0	0
Siphogeneroides sp.	0	0	0	0	0	0	0	1	1	0	0	0

Location 8	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**July**	**Aug**	**Sep**	**Oct**	**Nov**
Acervulina inhaerens	4	1	1	0	0	1	1	1	1	2	1	2
Ammonia beccarii batavus	32	37	25	66	49	40	60	30	47	15	48	31
A. beccarii limnetes	0	3	1	0	0	0	0	0	2	0	2	10
Asterigerinata mamilla	3	1	2	1	1	5	0	0	1	3	2	2
Bolivina pseudoplicata	0	0	0	0	0	1	0	1	0	0	0	2
Brizalina pseudopunctata	0	0	0	0	0	1	0	0	1	1	0	5
B. spathulata	1	0	0	0	0	1	0	1	5	0	0	5
B. striatula	0	0	0	0	0	0	0	0	0	0	0	1
B. variabilis	0	0	0	0	0	0	0	0	0	0	0	2
Buliminella elegantissima	0	0	0	0	0	0	0	0	0	0	0	0
Bulimina elongata	0	0	0	0	0	3	0	0	0	1	1	2
B. gibba	0	0	0	0	1	0	1	0	0	0	0	0
Cibicides lobatulus	138	156	183	157	117	147	153	180	121	158	154	77
C. pseudoungerianus	6	0	3	0	2	3	0	0	3	1	3	14
Clavulina obscura	0	0	0	0	0	0	0	0	1	0	0	1
Cornuspira diffusa	0	0	0	0	0	0	0	0	0	0	0	0
Cribrostomoides jeffreysii	2	0	0	0	0	2	1	0	0	0	0	2
Lenticulina crepidula	0	0	1	0	0	0	0	0	0	0	0	0
Cyclogyra involvens	0	1	0	0	0	0	0	0	0	0	0	2
Eggerelloides scabrum	2	5	2	7	8	2	4	5	9	6	5	7
Elphidium cuvillieri	5	0	0	1	0	0	0	2	0	1	1	3
E. crispum	43	44	28	37	32	31	33	35	32	32	43	14
E. earlandi	0	0	0	0	0	0	0	0	0	0	0	2
E. margaritaceum	1	0	0	0	0	0	0	0	0	0	0	0
E. gerthi	0	0	0	1	0	0	0	0	3	0	0	1
E. williamsoni	2	2	2	1	5	1	3	2	8	2	4	8
Fissurina lucida	1	0	0	0	1	0	0	0	3	0	0	2
F. marginata	0	0	0	0	0	0	0	0	0	0	1	0
F. orbignyana	0	1	0	0	0	0	0	0	1	0	0	0
Rosalina williamsoni	3	0	0	1	0	0	0	0	2	0	1	13
R. praegeri	10	1	2	2	3	3	1	2	5	2	1	26
Globulina gibba	0	0	1	1	0	1	0	0	0	0	0	0
G. gibba var. *myristiformis*	1	0	1	2	1	3	4	0	0	1	2	0
Haynesina germanica	4	3	2	0	10	5	3	2	14	3	2	10
Lagena clavata	0	0	1	0	0	0	0	0	0	0	0	0
L. lyellii	0	0	0	0	0	1	0	0	0	0	0	0
L. sulcata	0	0	0	0	1	0	0	0	1	0	0	0
Massilina secans	9	33	7	12	22	14	8	5	6	11	3	4
Quinqueloculina auberiana	1	1	2	5	4	1	4	3	2	3	2	3
Miliolinella circularis	0	0	0	0	0	0	0	1	1	0	0	0
M. subrotunda	0	0	1	4	0	2	1	1	0	0	1	6

Nonion depressulus	1	0	0	0	0	0	0	0	1	0	0	0
Oolina williamsoni	0	0	0	0	0	0	0	0	0	0	0	1
Planorbulina mediterranensis	3	1	2	0	0	1	0	0	2	2	1	10
Polymorphina concava	0	0	0	1	0	0	0	0	0	0	0	0
P. cf. *novangliae*	1	0	0	0	0	0	0	0	0	1	0	0
Psammosphaera bowmani	0	0	0	1	0	1	0	1	1	0	0	0
Pyrgo depressa	0	0	0	0	0	0	0	0	0	0	0	1
P. williamsoni	0	0	0	0	0	1	0	0	0	0	0	0
Quinqueloculina sp. 5	0	0	1	0	0	1	0	1	0	0	0	0
Q. spp.	3	2	3	0	0	2	3	2	4	5	0	10
Q. aspera I	0	0	0	0	0	1	0	0	0	0	0	0
Q. aspera II	0	0	0	1	0	2	1	0	1	0	2	0
Q. aspera III	0	0	0	1	0	0	0	0	0	0	0	0
Q. bicornis	10	9	8	9	10	13	4	1	4	5	4	2
Q. cf. *cliarensis*	1	3	1	1	0	0	2	2	1	1	0	0
Q. lata var. *oblonga*	0	1	0	0	0	1	0	0	0	0	0	1
Q. lata	4	2	1	7	2	3	10	5	3	4	3	1
Q. oblonga	0	0	1	0	1	0	0	1	1	0	0	1
Q. seminulum	4	0	1	6	2	3	5	2	1	4	3	6
Q. williamsoni	0	0	0	1	0	0	0	1	1	0	1	1
Rosalina globularis	0	2	0	2	1	1	0	0	1	1	0	0
Stainforthia concava	0	0	1	0	0	0	0	0	0	0	0	0
Spiroloculina excavata	0	0	1	0	0	0	0	0	0	0	0	2
S. rotunda	1	0	1	0	0	0	0	1	0	1	0	0
Textularia sagittula	0	0	0	1	0	1	5	0	0	0	0	0
Spiroplectammina wrightii	0	0	2	2	1	1	0	1	0	0	1	0
Textularia truncata	7	8	10	7	9	12	5	8	16	14	9	6
Remaneica helgolandica	0	0	0	0	0	0	0	0	0	0	0	1
Trifarina angulosa	0	0	0	0	0	0	0	0	0	0	0	3
Vaginulina linearis	0	0	0	1	0	0	0	0	0	0	0	0

Location 9	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**July**	**Aug**	**Sep**	**Oct**	**Nov**
Adelosina (normal)	0	1	1	1	0	0	0	0	0	1	1	1
Ammonia beccarii batavus	26	33	16	14	8	0	0	0	0	14	10	8
A. beccarii limnetes	3	2	2	5	10	12	12	25	15	11	15	7
Ammoscalaria pseudospiralis	1	1	8	2	2	8	11	6	8	0	0	1
A. runiana	0	0	0	1	0	0	2	2	1	0	0	0
Amphicoryna cf. *A. scalaris*	1	1	2	0	1	0	0	0	0	0	2	2
Astacolus crepidulus	0	0	0	0	0	3	0	2	1	0	0	0
Asterigerinata mamilla	4	1	1	2	1	0	1	1	0	12	2	1
Bolivina pseudoplicata	7	8	3	7	9	6	1	1	4	4	14	6
Brizalina pseudopunctata	11	20	10	12	6	7	6	3	6	27	25	24
B. spathulata	6	26	12	7	9	11	17	12	16	4	19	11
B. striatula	6	0	1	2	3	10	21	14	10	2	0	1
B. variabilis	0	0	1	1	1	8	0	1	1	2	6	8
Buliminella elegantissima	4	2	4	4	2	4	3	2	5	0	0	0
Bulimina elongata	5	1	5	3	3	0	1	0	0	1	2	5
B. gibba	1	4	2	1	3	2	6	4	4	1	2	3
B. marginata	1	0	1	1	1	2	1	5	3	0	1	1
Buccella frigida	0	0	0	0	0	3	0	0	1	0	0	0
Cibicides lobatulus	9	15	5	2	9	0	0	0	0	6	8	12
C. pseudoungerianus	3	6	5	6	11	4	4	2	8	10	8	10
Clavulina obscura	3	3	1	7	8	11	6	11	10	3	6	6
Cornuspira diffusa	0	0	0	1	0	5	10	8	3	0	0	0
Cribrostomoides jeffreysii	7	6	5	16	17	0	0	1	1	16	5	18
Lenticulina crepidula	1	0	0	1	1	21	16	9	11	0	0	0
Lenticulina orbiculatis	0	0	0	0	0	0	0	0	0	0	1	0
Cyclogyra involvens	5	6	4	2	3	0	1	0	0	3	6	6
Dentalina spp.	1	0	1	0	0	5	4	3	2	0	0	0
Eggerelloides scabrum	11	20	58	18	9	4	9	17	16	16	3	11
Elphidium cuvillieri	7	1	4	12	5	1	6	3	5	4	11	2
E. crispum	5	7	4	3	1	4	8	3	4	3	5	6
E. earlandi	1	1	1	0	1	3	1	4	3	5	2	2
E. margaritaceum	2	0	0	2	1	1	3	2	1	1	2	1
E. gerthi	5	2	8	7	4	5	5	2	6	5	6	3
E. williamsoni	6	4	5	8	9	2	5	3	8	2	5	9
Fissurina lucida	10	6	1	2	5	3	4	6	2	2	8	6
F. marginata	4	2	2	3	6	2	7	3	1	4	7	8
F. orbignyana	5	2	2	1	6	2	2	6	3	2	0	1
F. quadrata	0	0	0	0	1	0	1	0	0	1	0	0
Fursenkoina fusiformis	7	4	2	4	9	2	5	4	1	1	4	6
Rosalina williamsoni	7	8	2	5	4	9	5	2	4	12	13	8
R. praegeri	20	24	9	16	17	21	15	19	24	25	22	12
Globulina gibba	2	2	0	0	0	0	0	0	0	0	1	0
Haynesina germanica	22	15	12	17	10	20	28	16	18	29	15	15
Lagena clavata	2	0	0	1	2	1	1	1	1	1	0	1
L. gracilis	0	0	1	0	1	0	0	0	0	0	0	1
L. laevis	2	1	0	1	2	0	2	2	1	0	0	1
L. lyellii	4	1	0	0	1	1	1	1	0	3	0	0
L. perlucida	1	1	2	1	1	2	2	0	0	1	2	0
L. semistriata	0	0	0	1	0	0	1	1	0	0	0	0
L. substriata	0	1	1	2	0	0	0	1	1	0	1	0
L. sulcata	1	0	2	0	1	1	0	3	0	1	1	0
Massilina secans	0	3	3	3	0	0	0	0	0	2	1	1
Quinqueloculina auberiana	2	3	0	1	3	0	3	0	1	0	0	1
Miliolina circularis	2	0	1	0	1	2	4	1	3	4	1	2
M. subrotunda	8	4	8	4	9	10	1	5	4	12	10	7

Nonion depressulus	5	3	3	6	3	11	5	5	6	2	7	3
Nonionella sp.	0	0	1	0	0	0	0	0	0	0	0	0
Nonionella turgida	0	0	0	0	0	0	1	1	0	0	0	2
Oolina hexagona	0	0	0	0	0	0	1	0	1	0	0	1
O. melo	0	0	0	0	1	0	0	0	0	2	0	0
O. squamosa	0	0	1	1	0	1	1	0	1	0	0	0
O. williamsoni	2	1	0	0	0	1	0	1	0	0	1	1
Patellina corrugata	1	0	1	1	1	0	4	0	2	0	1	2
Planorbulina mediterranensis	10	12	5	6	4	9	6	4	10	2	7	10
Polymorphina concava	0	0	1	0	0	0	0	0	0	0	0	0
P. cf. *novangliae*	0	0	0	0	1	0	1	0	0	1	1	0
Psammosphaera bowmani	0	0	1	0	0	1	0	1	0	0	0	0
Pyrgo depressa	0	1	0	0	1	2	1	3	1	1	1	0
P. williamsoni	1	0	0	0	0	0	0	0	0	0	0	0
Quinqueloculina sp. 5	0	1	1	2	0	1	1	0	1	0	0	0
Q. spp.	8	4	1	9	4	4	2	2	9	1	6	9
Q. aspera I	0	0	0	0	1	1	0	0	0	0	0	0
Q. aspera II	1	1	4	1	1	1	1	3	1	0	0	0
Q. aspera III	1	1		0	0	1	1	0	0	1	0	1
Q. bicornis	2	0	1	0	0	0	0	0	1	0	1	1
Q. cf. *cliarensis*	2	1	10	2	1	5	1	1	5	1	1*	1
Q. mediterranensis	0	0	1	0	0	1	0	0	0	0	0	0
Q. lata var. *oblonga*	0	0	0	0	0	0	0	0	1	0	1	0
Q. lata	0	2	0	0	0	0	0	0	0	0	0	0
Q. oblonga	7	6	4	3	7	5	10	6	7	4	9	8
Q. cliarensis	1	3	2	1	1	0	1	1	1	0	0	0
Q. seminulum	11	6	10	4	4	4	4	8	9	1	4	9
Q. williamsoni	1	0	1	0	0	0	1	1	0	0	0	1
Q. cf. *lata seminulum*	0	0	0	0	0	1	0	2	0	7	0	0
Reophax fusiformis	2	1	2	1	1	0	0	1	1	1	0	0
R. monoliformis	0	0	0	1	1	1	0	0	0	0	0	0
R. scottii	0	2	1	1	4	1	1	1	1	0	1	1
Rosalina globularis	2	0	0	2	0	2	0	0	0	1	0	0
cf. *concava*	3	1	5	1	2	13	5	7	7	12	4	6
Spirillina runiana	0	0	0	0	0	0	0	0	0	0	1	0
S. vivipara	0	0	2	1	1	0	1	2	0	1	1	1
Spiroloculina excavata	0	1	0	1	0	0	0	1	1	0	0	0
S. grata	0	0	0	0	0	0	0	2	0	0	0	0
S. rotunda	0	1	0	0	0	0	0	0	1	0	0	0
S. sp	0	0	0	0	0	0	0	1	0	0	0	0
Spirophthalmidium acutimargo var. *emaciatum*	0	0	0	1	1	0	0	0	0	0	0	0
Technitella teivyense	0	0	0	1	0	0	0	0	0	0	0	0
Textularia sagittula	2	0	0	0	0	0	0	0	0	0	0	0
T. truncata	3	7	5	4	2	0	5	2	1	4	4	5
T. earlandi	2	5	2	7	6	1	2	11	12	5	3	6
Deuterammina (Lepidodeuterammina) ochracea var. *sinuosa*	5	2	0	4	5	3	2	1	1	4	2	2
Deuterammina (Deuterammina) rotaliformis	2	0	0	1	2	1	2	0	1	1	2	2
Remaneica helgolandica	0	1	1	0	1	3	0	0	0	3	1	1
Portatrochammina murrayi	0	0	0	0	0	0	1	0	0	0	0	0
Trifarina angulosa	4	3	2	3	2	3	1	6	1	2	4	2
Uvigerina sp.	0	0	1	2	3	1	1	3	0	0	0	2
Genus 1	0	0	1	1	1	0	0	0	0	0	0	0
Siphogeneroides sp.	0	0	1	0	0	1	0	0	0	0	0	0

Location 11	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**July**	**Aug**	**Sep**	**Oct**	**Nov**
Acervulina inhaerens	0	1	0	1	2	1	0	1	2	5	0	0
Adelosina (normal)	1	0	0	0	0	0	0	0	0	0	0	0
Ammonia beccarii batavus	34	18	50	35	31	30	30	38	24	24	45	44
A. beccarii limnetes	0	0	3	1	6	0	0	4	0	0	4	4
Ammoscalaria pseudospiralis	1	0	0	0	0	0	0	0	0	0	0	0
Asterigerinata mamilla	2	1	1	2	6	2	8	1	1	1	5	1
Brizalina pseudopunctata	0	0	0	0	0	0	0	1	0	0	0	0
B. spathulata	0	0	0	0	0	0	0	1	0	0	1	0
Bulimina elongata	2	0	1	0	2	1	1	0	0	1	0	1
B. gibba	1	0	1	0	1	1	0	0	0	1	0	0
Cibicides lobatulus	198	141	119	169	113	132	106	113	128	120	110	130
C. pseudoungerianus	3	0	0	1	4	1	3	0	1	11	4	6
Cribrostomoides jeffreysii	0	0	0	0	1	0	0	1	0	0	0	0
Lenticulina orbiculatis	1	0	0	1	0	0	1	0	0	0	0	0
Dentalina spp.	0	0	0	0	0	0	0	0	0	0	0	1
Eggerelloides scabrum	8	10	14	15	15	7	20	22	8	8	17	8
Elphidium cuvillieri	3	1	2	1	7	1	1	3	0	2	2	1
E. crispum	80	80	49	72	25	51	40	46	47	59	37	44
E. gerthi	1	0	0	0	1	0	0	0	0	0	0	0
E. williamsoni	2	1	3	3	7	0	2	5	3	3	9	4
Fissurina lucida	1	0	0	0	0	0	0	0	0	1	0	0
Rosalina williamsoni	1	0	0	1	1	0	0	0	0	0	0	0
R. praegeri	1	4	2	0	2	1	3	0	1	1	0	1
Globulina gibba	1	1	1	1	0	1	0	0	2	1	1	0
G. gibba var. *myristiformis*	2	2	2	1	1	1	4	1	1	1	3	2
Haynesina germanica	2	0	2	2	8	2	4	3	3	1	2	2
Lagena sulcata	1	0	0	0	0	0	0	0	0	0	0	0
Massilina secans	16	15	10	23	9	23	10	10	24	16	9	11
Quinqueloculina auberiana	2	5	6	7	3	5	2	5	7	1	0	4
Miliolina subrotunda	2	2	3	1	1	1	4	0	0	0	0	1
Nonion depressulus	0	0	0	0	0	0	0	0	0	0	0	1
Patellina corrugata	0	0	0	0	0	0	0	0	0	0	0	1
Pateoris haurinoides	0	0	0	0	0	0	0	0	2	0	0	0
Planorbulina mediterranensis	0	1	1	3	6	0	0	3	2	2	0	1
Polymorphina cf. *novangliae*	1	1	1	0	1	0	0	1	0	0	1	1
Psammosphaera bowmani	0	0	0	0	1	0	0	0	0	0	1	0
Pyrgo depressa	0	1	0	0	0	1	1	1	0	0	0	0
P. williamsoni	0	0	0	0	0	0	0	1	0	0	0	0
Quinqueloculina sp. 5	0	0	0	0	0	0	0	0	0	0	1	1
Q. spp.	2	1	3	0	2	0	0	0	0	0	0	3
Q. aspera	1	0	0	1	0	0	0	0	1	0	0	0

Q. aspera II	2	5	0	3	2	1	1	1	1	1	4	5
Q. aspera III	0	1	0	2	0	1	2	1	0	2	2	2
Q. bicornis	3	2	2	4	1	4	3	2	2	2	3	3
Q. cf. *cliarensis*	4	2	2	2	1	2	1	3	3	1	1	3
Q. mediterranensis	0	0	0	0	0	0	0	0	0	0	2	0
Q. lata var. *oblonga*	2	1	1	1	3	1	2	2	0	1	2	1
Q. lata	3	2	11	10	3	1	0	1	0	1	0	10
Q. oblonga	2	0	2	0	1	0	0	0	0	0	0	0
Q. seminulum	13	8	9	5	16	2	6	6	5	12	20	7
Q. williamsoni	0	0	0	0	2	1	1	1	0	0	2	0
Q. cf. *lata seminulum*	0	0	0	1	0	0	0	0	0	0	0	0
Reophax monoliformis	1	0	0	0	0	0	0	1	0	0	0	0
Rosalina globularis	0	1	2	1	1	1	1	0	2	0	0	0
Spiroloculina excavata	2	1	1	1	1	1	0	0	2	0	0	0
S. rotunda	1	0	1	1	1	1	0	0	1	0	0	1
Technitella teivyense	0	0	0	0	0	0	0	1	0	0	0	0
Textularia sagittula	10	1	0	1	0	1	0	1	0	0	0	0
Spiroplectammina wrightii	0	1	0	0	0	1	1	0	1	0	0	2
Textularia truncata	29	16	24	24	16	17	20	18	32	27	22	7
Trifarina angulosa	0	0	0	0	2	0	0	0	0	0	0	0
Vaginulina linearis	0	0	1	0	0	0	1	0	0	0	0	0
Siphogeneroides sp.	0	1	0	0	0	0	0	1	0	0	0	0

Location 12	Dec	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov
Adelosina (normal)	0	0	0	0	0	0	0	0	0	1	1	0
Ammonia beccarii batavus	97	168	65	16	88	94	100	75	60	30	42	114
A. beccarii limnetes	10	9	23	7	6	33	40	10	25	20	29	12
Ammoscalaria pseudospiralis	0	1	0	0	0	1	1	0	0	0	0	0
Amphicoryna cf. *A. scalaris*	0	0	1	0	0	0	1	0	0	0	0	0
Asterigerinata mamilla	4	1	4	0	1	3	0	3	1	1	0	0
Bolivina pseudoplicata	1	0	4	9	2	1	3	3	2	5	2	0
Brizalina pseudopunctata	2	2	6	22	1	2	3	4	4	7	14	0
B. spathulata	1	3	5	10	5	4	5	4	8	11	2	0
B. striatula	0	0	2	1	1	1	0	1	1	0	1	0
B. variabilis	0	0	1	4	0	0	1	1	2	2	4	0
Buliminella elegantissima	1	0	0	0	0	0	0	0	0	0	0	0
Bulimina elongata	1	0	1	3	3	1	2	2	3	4	7	4
B. gibba	0	2	2	9	3	1	1	5	1	7	2	0
B. marginata	0	0	1	0	1	2	0	2	0	2	0	1
Cibicides lobatulus	35	20	15	4	38	45	13	9	13	11	20	24
C. pseudoungerianus	3	2	4	12	4	2	9	9	8	12	12	10
Clavulina obscura	1	1	2	1	1	1	2	5	5	10	4	2
Cribrostomoides jeffreysii	0	2	10	18	4	2	3	14	4	11	14	7
Lenticulina crepidula	0	0	1	0	1	0	0	0	0	0	0	0
L. orbiculatis	0	0	0	0	0	0	0	1	0	0	0	0
Cyclogyra involvens	0	0	1	5	0	2	1	1	1	1	0	0
Dentalina spp.	0	0	0	0	0	0	0	0	1	0	0	0
Eggerelloides scabrum	66	52	46	14	36	35	38	25	23	20	33	23
Elphidium cuvillieri	8	1	9	2	0	5	3	4	6	4	3	11
E. crispum	7	12	7	2	4	7	6	4	5	0	6	11
E. earlandi	0	0	1	2	1	0	1	2	4	0	1	0
E. margaritaceum	0	0	3	5	4	1	1	2	1	1	2	4
E. gerthi	2	3	10	8	8	6	3	9	7	6	5	4
E. williamsoni	11	4	10	6	8	10	13	18	9	15	6	17
Fissurina lucida	3	2	5	4	5	4	3	4	3	4	2	1
F. marginata	0	0	2	9	1	1	1	2	2	4	1	0
F. orbignyana	1	0	1	2	1	1	1	0	2	0	0	0
F. quadrata	0	0	0	0	0	0	0	0	1	0	0	0
Fursenkoinia fusiformis	0	0	0	3	0	0	1	2	2	0	0	0
Rosalina williamsoni	4	2	4	1	2		2	4	9	12	3	1
R. praegeri	1	3	1	23	7	3	9	7	9	19	13	6
Globulina gibba	0	0	1	0	2	1	0	0	0	0	0	1
Nodosaria pyrula	0	0	0	0	0	0	1	0	0	0	0	0
Haynesina germanica	18	19	31	22	29	12	22	40	31	30	30	27
Lagena clavata	0	0	0	1	0	0	1	1	1	0	1	0
L. laevis	0	0	1	5	0	1	1	0	0	0	0	0
L. lyellii	0	0	0	0	1	0	1	0	0	0	0	0
L. perlucida	0	0	1	3	1	1	1	1	0	0	0	0
L. semistriata	0	0	0	2	0	0	0	0	0	0	1	0
L. substriata	0	0	0	0	0	0	1	0	0	0	0	0
L. sulcata	0	0	1	0	1	1	1	0	0	0	2	1

Massilina secans	1	0	0	0	0	2	1	0	1	1	0	2
Miliammina fusca	0	0	0	0	1	0	0	0	0	0	0	0
Quinqueloculina auberiana	4	3	3	1	0	0	3	1	1	0	0	0
Miliolinella circularis	0	0	1	4	1	0	0	1		1	3	0
M. subrotunda	1	2	2	4	1	1	0	1	1	4	3	1
Nonion depressulus	0	0	2	15	4	2	6	2	2	7	4	1
Oolina hexagona	1	1	0	0	0	0	0	0	0	0	0	0
O. melo	0	0	1	0	0	0	0	0	1	2	2	0
O. squamosa	0	0	0	0	0	1	0	0	0	1	0	0
O. williamsoni	1	0	0	1	0	0	1	0	1	1	0	0
Patellina corrugata	0	0	0	1	2	0	0	0	1	0	0	0
Planorbulina mediterranensis	4	0	5	7	2	1	4	3	2	5	13	1
Polymorphina cf. *novangliae*	0	0	0	1	0	1	0	0	0	0	0	0
Psammosphaera bowmani	2	5	1	0	0	1	0	1	1	0	1	0
Quinqueloculina sp 5	0	0	1	0	0	1	0	0	1	0	1	0
Q. spp.	4	1	3	7	2	4	2	0	0	7	4	2
Q. aspera II	0	2	0	1	0	0	0	0	0	0	1	1
Q. aspera III	0	2	0	0	1	0	1	2	0	0	0	0
Q. bicornis	0	0	0	0	0	0	0	0	0	0	0	0
Q. cf. cliarensis	1	1	0	1	0	2	1	0	1	1	0	1
Q. mediterranensis	0	0	0	0	0	0	1	1	1	0	0	0
Q. lata var. *oblonga*	0	0	0	0	0	0	1	0	0	0	0	0
Q. lata	3	0	0	0	0	0	0	0	1	1	0	0
Q. oblonga	0	0	1	4	4	0	1	2	4	0	1	2
Q. cliarensis	0	0	0	0	0	0	0	1	0	0	0	0
Q. seminulum	2	5	2	8	4	3	4	3	7	5	4	2
Q. williamsoni	0	0	1	0	0	0	0	0	0	0	0	0
Q. cf. *lata seminulum*	0	0	1	1	0	0	0	0	0	0	0	0
Reophax fusiformis	0	0	1	0	0	0	0	0	0	0	0	0
R. scottii	1	0	1	1	0	1	0	0	0	1	0	1
Stainforthia concava	0	0	0	0	2	0	0	1	0	0	2	1
Textularia sagittula	0	3	0	0	1	0	0	0	0	0	0	0
T. truncata	1	0	2	0	1	1	1	4	2	0	4	0
T. earlandi	0	0	0	2	0	0	1	1	0	1	2	1
Deuterammina (Lepidodeuterammina) ochracea var. *sinuosa*	1	0	0	1	1	0	1	3	1	0	3	1
Deuterammina (Deuterammina) rotaliformis	0	0	0	2	0	0	0	1	0	0	0	0
Portatrochammina murrayi	0	0	0	0	1	0	0	0	0	0	0	0
Trifarina angulosa	1	0	1	0	1	0	0	0	1	5	3	0
Uvigerina sp.	0	0	0	1	1	0	0	1	0	0	1	0
Siphogeneroides sp.	0	0	1	1	1	0	0	0	0	0	0	0

Location 14	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**July**	**Aug**	**Sep**	**Oct**	**Nov**
Acervulina inhaerens	0	1	1	0	0	0	1	0	1	0	0	2
Adelosina (normal)	0	1	0	0	0	0	2	0	0	0	0	0
A. (ribbed)	0	0	0	1	0	0	0	0	0	0	0	0
Ammonia beccarii batavus	35	10	6	29	62	20	25	29	49	46	56	33
A. beccarii limnetes	1	7	3	4	0	6	0	4	3	17	0	3
Asterigerinata mamilla	1	4	1	2	2	0	1	6	4	0	0	2
Brizalina pseudopunctata	0	0	0	0	0	0	1	0	0	2	0	0
B. spathulata	3	0	0	0	0	0	1	1	0	0	0	0
B. striatula	0	0	0	0	0	0	1	0	0	0	0	0
Bulimina elongata	1	3	1	1	0	0	4	1	0	1	3	1
B. gibba	3	1	0	1	0	0	0	0	0	0	0	0
B. marginata	1	0	0	1	1	0	0	0	0	0	0	0
Cibicides lobatulus	143	157	120	111	127	136	120	126	118	87	105	139
C. pseudoungerianus	0	0	0	5	5	0	5	0	2	5	9	14
Cribrostomoides jeffreysii	1	0	0	0	0	0	0	1	0	0	0	0
Lenticulina crepidula	0	0	0	0	0	0	0	1	0	0	0	0
L. orbiculatis	0	0	0	0	0	0	1	0	0	0	0	0
Eggerelloides scabrum	10	14	16	26	42	9	22	13	22	14	22	20
Elphidium cuvillieri	4	5	0	12	5	4	4	3	2	7	9	2
E. crispum	32	40	0	39	43	30	20	34	35	31	29	50
E. margaritaceum	0	0	0	0	0	0	0	0	1	0	0	1
E. gerthi	1	0	0	0	0	0	2	0	0	5	1	0
E. williamsoni	18	4	5	8	12	5	10	6	2	11	7	2
Fissurina lucida	2	0	0	0	1	0	0	1	0	1	0	0
F. orbignyana	0	0	0	0	1	0	0	1	0	0	0	0
Rosalina williamsoni	1	1	0	1	2	0	0	0	0	1	2	0
R. praegeri	1	3	4	6	4	1	1	2	6	8	8	2
Globulina gibba	0	1	0	0	1	1	1	1	1	0	0	0
G. gibba var. *myristiformis*	0	1	0	0	0	0	0	0	0	0	0	1
Haynesina germanica	9	4	5	11	12	2	15	15	4	28	14	6
Lagena sulcata	0	0	0	0	0	0	0	1	0	0	0	0
Massilina secans	8	9	3	4	1	6	4	3	5	1	3	18
Quinqueloculina auberiana	2	2	3	6	3	5	2	5	4	1	1	3
Miliolinella circularis	0	0	1	0	0	0	0	0	0	0	0	0
M. subrotunda	3	3	3	3	2	4	6	5	5	6	3	1
Nonion depressulus	0	0	0	0	1	0	1	0	1	0	1	0
Oolina hexagona	0	0	0	0	0	0	0	1	0	0	0	0
Patellina corrugata	1	0	0	0	0	0	1	1	1	0	0	0
Planorbulina mediterranensis	26	18	22	16	8	13	17	24	12	10	11	1
Polymorphina concava	0	0	0	0	0	0	1	0	0	0	0	0
P. cf. *novangliae*	0	0	0	1	1	0	0	0	0	0	0	0
Psammosphaera bowmani	0	1	0	0	0	0	1	1	0	0	0	0

Pyrgo depressa	0	1	0	0	1	0	0	0	0	0	1	0
Quinqueloculina sp 5	3	0	1	0	0	0	0	1	0	1	1	0
Q. spp.	7	0	1	0	0	1	2	0	0	6	3	2
Q. aspera I	1	0	0	1	0	0	1	0	0	0	0	1
Q. aspera II	1	2	0	1	1	1	0	1	0	0	3	2
Q. aspera III	0	1	0	2	0	1	4	0	3	2	1	1
Q. bicornis	1	0	0	0	2	0	0	1	0	1	1	1
Q. cf. *cliarensis*	5	2	3	0	3	0	3	1	2	2	1	0
Q. mediterranensis	1	0	0	0	0	0	0	0	0	0	0	0
Q. lata var. *oblonga*	0	1	0	0	0	0	0	0	0	0	0	0
Q. lata	1	0	0	0	0	0	0	1	2	0	0	0
Q. oblonga	1	0	2	1	0	0	1	1	1	2	0	0
Q. seminulum	2	0	1	4	15	0	4	6	3	1	2	4
Q. striated forms	0	1	0	0	0	0	0	0	0	0	0	0
Q. williamsoni	3	1	1	2	1	0	3	0	1	1	0	2
Q. cf. *lata seminulum*	2	0	0	0	3	1	0	0	0	0	0	0
Rosalina globularis	1	2	0	0	0	0	1	2	1	1	0	3
Stainforthia cf. *concava*	1	0	0	1	0	0	0	0	0	0	0	0
Spiroloculina excavata	0	1	1	0	1	1	0	0	0	2	0	0
S. rotunda	0	0	0	0	1	0	0	0	1	0	0	1
Textularia sagittula	1	0	0	0	2	0	0	0	0	0	0	0
T. truncata	8	8	8	13	22	6	12	12	12	3	11	11
T. earlandi	0	0	0	0	0	0	0	0	0	1	0	0
Trifarina angulosa	0	0	0	0	0	0	0	1	1	0	1	0
Siphogeneroides sp.	0	0	0	0	1	0	0	1	0	0	1	0

Location 15	Dec	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov
Acervulina inhaerens	0	0	0	0	0	1	0	0	1	0	0	1
Adelosina (normal)	0	1	0	0	0	0	0	0	0	0	0	1
Ammonia beccarii batavus	41	87	73	90	75	46	106	48	84	75	75	48
A. beccarii limnetes	17	2	7	6	8	17	30	5	12	11	11	3
Ammoscalaria pseudospiralis	0	5	0	1	0	0	2	1	1	0	0	0
A. runiana	0	0	0	1	0	0	0	0	0	0	0	0
Amphicoryna cf. A. scalaris	0	1	0	1	0	0	0	0	0	0	0	0
Astacolus crepidulus	0	0	1	0	0	0	0	0	0	0	0	0
Asterigerinata mamilla	0	1	0	0	0	1	0	1	1	0	0	0
Bolivina pseudoplicata	4	0	2	2	1	2	1	5	0	0	6	1
Brizalina pseudopunctata	15	1	5	1	1	8	3	8	0	6	7	4
B. spathulata	12	8	2	6	1	10	6	12	1	11	11	0
B. striatula	3	1	1	1	0	1	0	0	0	1	0	0
B. variabilis	11	0	1	1	0	2	1	5	1	0	3	0
Buliminella elegantissima	0	0	0	0	0	0	0	1	0	0	0	0
Bulimina elongata	3	8	6	5	8	7	5	15	1	9	8	4
B. gibba	9	14	0	7	2	4	5	14	1	6	5	2
B. marginata	1	0	5	2	1	4	1	1	1	0	0	0
Cibicides lobatulus	12	7	35	20	37	28	22	20	58	32	19	51
C. pseudoungerianus	7	2	2	12	3	10	1	8	1	5	12	25
Clavulina obscura	10	2	1	2	1	11	3	13	1	6	10	5
Cornuspira diffusa	0	0	0	0	0	0	1	0	0	0	0	0
Cribrostomoides jeffreysii	8	2	5	6	0	4	3	8	0	5	8	6
Lenticulina crepidula	0	0	0	0	0	0	1	0	0	0	0	0
L. orbiculatis	0	0	0	0	1	0	0	0	0	0	0	0
Cyclogyra involvens	1	1	0	1	1	0	1	1	0	0	0	2
Eggerelloides scabrum	31	34	39	46	38	24	40	14	39	46	30	33
Elphidium cuvillieri	25	22	12	18	15	8	10	14	12	7	7	6
E. crispum	19	16	39	14	22	13	26	8	49	14	16	21
E. earlandi	1	1	0	0	0	1	0	0	0	0	2	0
E. margaritaceum	2	2	4	2	1	2	0	2	1	2	3	5
E. gerthi	17	15	6	27	4	15	14	25	7	16	15	11
E. williamsoni	3	1	3	2	4	5	4	2	1	8	0	7
Fissurina. lucida	3	5	2	4	1	5	1	6	1	3	6	5
F. marginata	0	0	2	2	1	2	1	2	0	1	0	1
F. orbignyana	1	1	0	1	1	4	0	1	0	0	1	0
Fursenkoina fusiformis	3	1	0	0	1	2	1	2	0	1	0	1
Rosalina williamsoni	5	0	1	2	2	2	1	4	0	5	5	4
R. praegeri	3	0	2	7	4	8	4	12	3	8	5	5
Globulina gibba	0	1	0	0	0	1	0	2	0	1	0	1
Haynesina germanica	9	5	6	12	10	12	17	10	7	5	11	8
Jadammina macresens	0	0	0	0	0	0	0	0	0	0	0	0
Lagena clavata	0	1	0	1	1	1	1	0	0	1	1	0
L. laevis	1	1	0	0	0	0	1	0	0	0	0	0
L. lyellii	0	0	0	0	1	1	0	0	0	0	0	0
L. perlucida	0	1	0	0	0	0	0	1	0	0	0	0
L. semistriata	0	0	0	1	0	0	1	0	0	0	0	0
L. substriata	0	0	0	0	0	0	0	0	0	0	1	0
L. sulcata	4	0	0	1	1	1	1	0	0	0	0	1
L. var. *torquiformis*	1	0	0	0	0	0	0	0	0	0	0	0
L. secans	0	0	0	0	2	2	0	0	1	0	0	0

Miliammina fusca	0	2	0	0	0	0	0	1	1	1	0	4
Quinqueloculina auberiana	1	0	3	2	0	0	1	0	0	1	0	1
Miliolinella circularis	0	1	0	2	0	0	0	0	0	2	0	2
M. subrotunda	1	1	4	2	3	3	3	2	2	3	0	3
Nonion depressulus	1	1	1	0	0	5	1	4	0	3	2	5
Nonionella sp	1	1	0	0	0	0	0	0	0	0	0	0
Oolina hexagona	1	1	0	0	0	0	0	0	0	0	0	0
Oolina melo	0	0	0	0	0	0	0	0	0	0	0	0
O. squamosa	1	0	0	0	0	1	0	0	0	0	0	0
O. williamsoni	0	0	0	0	0	1	0	1	1	0	0	1
Patellina corrugata	0	1	0	0	0	1	0	0	0	0	0	0
Planorbulina mediterranensis	2	2	1	0	1	0	0	1	3	1	2	2
P. cf. *novangliae*	0	0	1	0	0	0	0	0	0	0	0	0
Psammosphaera bowmani	0	1	1	0	1	1	0	0	0	2	0	1
Pyrgo depressa	0	1	0	0	0	1	0	0	0	0	0	0
P. williamsoni	0	0	0	0	0	1	0	0	0	0	0	0
Quinqueloculina sp. 5	0	0	1	0	2	0	0	0	0	0	0	1
Q. spp.	3	2	0	3	3	3	0	0	0	3	6	3
Q. aspera I	0	1	0	3	1	0	0	0	0	2	1	0
Q. aspera II	0	0	0	0	1	1	0	1	3	0	2	5
Q. aspera III	6	3	0	0	4	2	5	3	2	3	0	2
Q. bicornis	1	0	0	0	0	0	0	0	0	0	0	0
Q. cf. *cliarensis*	0	1	3	2	0	0	0	0	0	0	0	2
Q. mediterranensis	0	0	0	0	0	0	0	0	0	0	0	2
Q. lata var. *oblonga*	0	0	0	1	0	0	0	0	0	0	0	0
Q. lata	0	1	0	1	0	1	0	0	0	0	0	0
Q. oblonga	3	0	2	2	1	3	2	5	2	1	3	0
Q. seminulum	2	5	0	3	5	4	5	5	3	3	3	2
Q. striated forms	0	1	0	0	0	0	0	0	0	0	1	0
Q. williamsoni	1	0	1	0	0	0	0	0	0	0	0	1
Reophax fusiformis	0	0	0	0	1	0	0	0	0	0	0	0
R. scottii	1	1	1	1	1	1	1	2	1	3	3	1
R. globularis	0	1	0	0	0	0	0	0	0	0	0	0
Stainforthia cf. *concava*	1	2	2	0	1	2	1	3	1	1	0	0
Spirillina vivipara	0	0	0	0	0	0	0	1	0	0	0	0
Spiroloculina excavata	0	1	0	1	0	0	0	0	0	0	0	0
S. rotunda	0	1	0	0	0	0	0	0	0	0	0	0
Textularia sagittula	1	0	0	2	2	1	1	0	1	0	0	0
T. truncata	2	2	0	0	0	0	1	2	1	0	2	1
T. earlandi	1	0	0	2	1	1	0	0	1	0	0	0
Deuterammina (Lepidodeuterammina) ochracea var. *sinuosa*	0	0	1	0	0	0	0	1	0	1	0	0
Deuterammina (Deuterammina) rotaliformis	0	0	0	1	0	0	0	0	0	0	0	0
Remaneica helgolandica	0	0	0	0	0	0	0	1	0	1	0	1
Trifarina angulosa	6	0	1	1	1	3	0	1	0	0	2	1
Uvigerina sp.	2	0	0	0	0	0	0	0	0	1	3	0
Siphogeneroides sp.	0	0	0	1	1	0	0	0	0	0	0	0

Location 16	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**July**	**Aug**	**Sep**	**Oct**	**Nov**
Acervulina inhaerens	0	3	0	0	0	1	0	0	0	1	1	0
Adelosina (normal)	0	0	0	1	0	0	0	1	1	0	0	0
Ammonia beccarii batavus	16	11	26	49	13	29	19	24	12	15	18	48
A. beccarii limnetes	6	2	4	10	0	4	7	4	6	10	7	4
Asterigerinata mamilla	2	6	0	7	3	2	1	0	2	0	4	1
Bolivina pseudoplicata	1	2	1	1	0	2	2	3	3	4	0	0
Brizalina pseudopunctata	1	0	4	1	0	1	1	2	2	2	1	0
B. spathulata	1	2	2	6	0	2	1	5	5	9	3	6
B. striatula	2	1	0	1	0	0	1	0	0	1	0	0
B. variabilis	0	0	0	0	0	0	0	0	2	2	0	0
Buliminella elegantissima	0	0	0	0	0	0	0	0	0	2	0	0
Bulimina elongata	1	1	0	5	1	3	1	1	1	2	0	1
B. gibba	1	1	0	2	0	1	0	1	1	1	1	0
B. marginata	0	0	1	1	0	0	2	0	0	1	0	0
Cibicides lobatulus	60	24	32	17	10	27	14	26	9	11	16	34
C. pseudoungerianus	11	0	11	19	7	5	2	5	5	6	13	5
Clavulina obscura	0	0	0	0	0	1	0	1	2	9	1	0
Cribrostomoides jeffreysii	4	8	2	1	0	3	2	3	8	18	6	2
Lenticulina crepidula	0	0	0	0	0	0	0	1	0	0	0	0
L. orbiculatis	0	0	0	0	0	1	0	0	0	0	0	0
Cyclogyra involvens	0	0	0	0	0	0	0	1	0	3	0	0
Eggerelloides scabrum	7	3	6	8	0	6	1	1	1	3	2	11
Elphidium cuvillieri	0	3	3	2	0	3	3	1	2	5	2	2
E. crispum	32	24	36	32	15	14	25	42	16	9	24	36
E. earlandi	0	2	1	0	0	0	0	2	0	1	2	0
E. margaritaceum	0	0	0	2	0	0	0	0	1	1	0	1
E. gerthi	2	1	5	2	1	3	0	2	4	4	2	5
E. williamsoni	5	5	1	7	1	4	7	4	2	3	2	2
Fissurina lucida	0	1	0	1	0	0	1	2	2	2	3	1
F. marginata	0	0	0	2	0	1	1	1	3	2	0	0
F. orbignyana	0	0	1	0	0	0	0	0	3	1	0	0
Fursenkoina fusiformis	0	0	0	0	0	1	0	1	1	1	0	0
Rosalina williamsoni	1	3	5	10	1	4	4	20	24	35	34	3
R. praegeri	3	12	10	5	1	6	4	0	0	8	7	3
Globulina gibba	0	0	0	0	0	0	0	1	1	0	1	0
G. gibba var. *myristiformis*	1	1	0	1	0	0	0	0	0	0	1	1
Haynesina germanica	7	9	8	20	7	7	8	7	16	20	10	7
Lagena clavata	0	0	0	0	0	0	0	0	0	1	0	0
L. laevis	0	0	0	0	0	0	0	0	0	1	0	0
L. lyellii	0	1	0	0	0	0	0	0	0	0	0	0
L. perlucida	0	0	0	0	0	1	0	1	0	1	0	0
L. sulcata	2	0	0	0	0	0	0	0	1	0	0	0
L. secans	34	4	22	17	10	8	17	11	6	3	14	10
Quinqueloculina auberiana	4	4	3	0	5	4	6	4	4	0	3	6
Miliolinella circularis	0	3	2	1	0	0	1	14	4	3	1	0
M. subrotunda	2	0	0	0	0	3	1	26	15	24	8	4
Nonion depressulus	0	1	2	1	1	2	1	1	4	0	2	1

Oolina hexagona	0	0	0	1	0	0	0	0	0	0	0	0
O. melo	0	0	0	1	1	0	0	0	0	0	0	0
O. squamosa	0	0	0	0	0	0	0	2	0	0	0	0
Patellina corrugata	2	0	0	0	0	0	0	1	5	1	0	1
Planorbulina mediterranensis	6	2	1	4	2	2	1	6	28	32	25	5
Polymorphina concava	0	0	0	0	0	0	0	0	1	0	0	0
Psammosphaera bowmani	0	0	0	0	0	0	0	0	1	1	2	0
Pyrgo depressa	0	0	0	0	0	0	0	0	0	0	1	0
Quinqueloculina sp. 5	1	0	1	0	0	0	0	0	3	0	2	0
Q. spp.	8	9	5	6	0	2	5	3	8	10	2	6
Q. aspera I	1	0	0	1	0	0	0	1	0	0	1	0
Q. aspera II	13	2	7	6	4	10	5	11	0	2	3	10
Q. aspera III	1	3	0	0	1	0	2	1	1	0	2	0
Q. bicornis	3	5	9	10	1	2	8	8	2	1	5	6
Q. cf. *cliarensis*	5	2	3	3	4	0	3	1	0	2	0	0
Q. mediterranensis	1	0	0	1	1	0	0	0	1	0	0	0
Q. lata var. *oblonga*	4	0	3	3	1	6	4	1	3	1	3	8
Q. lata	7	6	14	33	2	3	20	5	4	5	11	10
Q. oblonga	0	2	0	0	0	2	1	5	0	0	4	2
Q. seminulum	26	19	30	13	12	26	25	26	19	10	21	31
Q. williamsoni	0	1	0	0	0	4	0	1	2	1	1	2
Q. cf. *lata seminulum*	0	2	2	0	0	0	0	0	0	0	0	0
Reophax fusiformis	0	1	0	0	0	0	0	0	0	0	0	0
R. monoliformis	1	0	0	1	1	0	2	0	1	1	1	1
Rosalina globularis	0	0	0	0	0	1	1	1		1	1	0
Stainforthia concava	0	0	0	0	0	0	0	0	1	0	0	0
Spirillina vivipara	0	0	0	0	0	0	0	0	0	1	0	0
Spiroloculina excavata	0	0	0	1	0	0	0	0	0	1	0	0
Spiroloculina rotunda	0	0	0	0	0	0	0	0	0	0	0	1
Textularia sagittula	9	0	0	0	1	1	0	0	0	0	3	0
Spiroplectammina wrightii	2	2	0	0	0	0	0	0	0	0	0	1
T. truncata	10	21	17	7	1	16	4	16	45	12	24	24
T. earlandi	0	0	0	0	0	0	0	0	1	1	2	1
Deuterammina (Lepidodeuterammina) ochracea var. *sinuosa*	0	0	1	1	0	0	0	1	1	1	0	1
Deuterammina (Deuterammina) rotaliformis	0	0	0	1	0	0	1	0	0	0	0	0
Remaneica helgolandica	0	0	0	0	0	0	0	1	0	0	0	0
Trifarina angulosa	0	2	1	0	1	1	2	1	5	0	2	1
Uvigerina sp.	0	0	1	0	1	1	0	0	0	0	0	0
Vaginulina linearis	0	0	0	1	1	1	0	3	0	0	0	1

Location 17	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**July**	**Aug**	**Sep**	**Oct**	**Nov**
Acervulina inhaerens	2	2	0	0	1	2	1	1	1	0	2	0
Ammonia beccarii batavus	45	42	45	18	39	33	31	49	65	50	62	57
A. beccarii limnetes	4	0	5	0	4	0	6	4	7	15	4	0
Amphicoryna cf. A. scalaris	0	0	0	0	0	0	0	1	0	0	0	0
Asterigerinata mamilla	0	2	1	2	1	0	2	5	1	0	4	1
Brizalina pseudopunctata	0	0	0	0	0	0	2	1	0	2	0	0
B. spathulata	0	1	1	0	0	0	0	3	1	2	1	0
B. striatula	0	0	0	2	0	0	0	0	0	0	0	0
B. variabilis	0	0	0	0	0	0	0	0	0	1	0	0
Bulimina elongata	0	1	0	1	2	0	1	2	0	2	1	0
B. gibba	0	0	0	1	0	0	2	2	0	3	1	0
B. marginata	0	0	0	0	0	0	1	0	0	0	0	0
Cibicides lobatulus	113	133	149	184	150	165	75	102	119	96	107	131
C. pseudoungerianus	2	0	0	5	5	0	0	6	7	12	4	5
Clavulina obscura	2	0	0	0	0	0	1	0	2	1	0	0
Cribrostomoides jeffreysii	0	0	0	1	0	0	2	4	0	4	0	1
Lenticulina crepidula	0	0	0	0	0	1	0	0	0	0	0	0
L. orbiculatis	0	0	0	1	0	0	0	0	0	0	0	0
Cyclogyra involvens	0	1	0	0	0	0	0	1	0	0	0	0
Dentalina spp	0	0	0	0	0	0	1	0	0	0	0	0
Eggerelloides scabrum	5	6	16	5	6	7	19	17	19	20	9	14
Elphidium cuvillieri	1	92	1	2	1	0	4	6	2	0	6	0
E. crispum	82	0	36	42	84	30	34	27	31	0	29	47
E. earlandi	0	0	0	0	0	0	0	0	1	0	1	0
E. margaritaceum	0	0	0	1	0	0	0	1	1	0	0	0
E. gerthi	1	0	0	0	0	0	2	0	4	5	1	0
E. williamsoni	0	1	1	5	0	2	5	5	5	14	7	0
Fissurina lucida	0	0	0	0	0	0	0	2	0	1	0	0
F. marginata	0	1	0	0	0	0	0	1	0	1	0	0
F. orbignyana	1	1	0	1	1	0	0	1	0	0	0	0
Fursenkoina fusiformis	0	0	0	0	0	0	2	0	0	0	0	0
Rosalina williamsoni	0	1	0	4	0	0	0	0	2	4	1	1
R. praegeri	6	2	2	3	2	1	7	12	2	6	5	0
Globulina gibba	0	1	0	0	1	1	1	0	0	0	1	0
G. gibba var. *myristiformis*	0	1	0	0	0	0	0	0	0	0	0	0
Haynesina germanica	2	1	0	3	0	0	5	4	6	8	7	1
Lagena clavata	0	0	0	0	0	0	1	0	0	0	0	0
L. sulcata	1	0	0	0	0	0	0	0	0	0	0	0
Massilina secans	21	17	10	15	14	5	13	2	4	3	4	9
Miliammina fusca	0	0	0	0	0	0	0	0	0	0	0	0
Quinqueloculina auberiana	5	2	5	2	3	1	0	3	0	5	4	3
Miliolinella circularis	1	2	1	0	0	0	1	2	5	5	6	0

M. subrotunda	3	0	0	2	1	1	1	7	1	2	0	0
Nonion depressulus	0	1	0	0	0	0	0	1	1	1	1	0
Oolina squamosa	0	0	0	0	0	0	0	0	0	1	0	0
Patellina corrugata	0	0	0	0	0	0	0	2	0	0	0	0
Pateoris hauerinoides	0	0	0	0	0	0	0	0	0	0	0	0
Planorbulina mediterranensis	3	1	0	0	0	0	3	2	0	7	1	0
Polymorphina cf. novangliae	0	0	0	0	1	0	0	0	0	0	0	0
Psammosphaera bowmani	0	0	0	1	1	0	1	0	0	0	1	0
Pyrgo depressa	0	0	0	0	0	0	1	1	0	0	0	0
Quinqueloculina sp. 5	0	0	0	1	0	0	2	0	0	1	2	0
Q. spp.	3	2	0	0	0	0	0	0	2	2	2	0
Q. aspera I	1	0	0	0	0	1	0	0	0	0	0	0
Q. aspera II	0	1	0	1	1	1	0	1	1	0	2	1
Q. aspera III	2	1	0	0	1	1	2	1	1	3	0	0
Q. bicornis	3	4	1	3	2	1	0	3	1	0	0	3
Q. cf. cliarensis	2	0	0	1	0	0	2	1	0	2	0	0
Q. mediterranensis	0	0	0	0	0	0	1	1	0	0	1	0
Q. lata var. *oblonga*	0	0	0	0	0	0	0	0	1	0	0	0
Q. lata	17	14	14	8	7	6	6	2	4	1*	6	10
Q. oblonga	0	0	2	1	0	0	0	1	0	1	2	0
Q. cliarensis	0	4	0	0	0	0	0	0	0	0	0	0
Q. seminulum	1	0	2	2	1	1	5	4	1	7	9	1
Q. williamsoni	2	0	1	0	0	2	0	1	0	0	1	0
Reophax scottii	0	0	0	0	0	0	0	0	1	0	0	0
Rosalina globularis	1	0	0	0	0	0	2	0	0	0	0	0
Spiroloculina excavata	0	1	0	1	1	0	1	0	0	0	0	0
S. rotunda	0	0	0	0	1	0	0	0	1	0	1	0
Textularia sagittula	1	0	0	1	3	1	1	2	0	1	1	0
Spiroplectammina wrightii	0	1	0	1	1	1	0	0	0	0	1	1
Textularia truncata	4	3	5	5	1	6	7	8	11	5	10	10
Deuterammina (Lepidodeuterammina) ochracea var. *sinuosa*	0	0	0	0	0	0	0	0	1	0	0	0
Trifarina angulosa	0	0	0	0	0	0	0	2	0	1	1	
Uvigerina sp.	1	0	0	0	0	0	0	0	0	0	0	0
Siphogeneroides sp.	0	0	0	0	0	0	0	0	0	1	0	0

Location 18	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**July**	**Aug**	**Sep**	**Oct**	**Nov**
Acervulina inhaerens	0	0	0	1	0	1	1	1	0	0	4	1
Adelosina (normal)	0	1	0	1	0	0	0	0	0	0	1	0
A. (ribbed)	0	3	0	0	0	0	0	0	0	0	0	0
Ammonia beccarii batavus	80	67	43	80	50	48	63	65	95	54	62	63
A. beccarii limnetes	0	2	18	3	6	0	7	7	9	16	3	1
Ammoscalaria pseudospiralis	0	0	0	1	0	2	1	1	0	1	1	0
A. runiana	0	0	0	0	1	0	0	0	0	0	0	0
Amphicoryna cf. *A. scalaris*	0	0	0	0	1	0	0	0	0	0	0	0
Asterigerinata mamilla	1	1	3	1	0	2	1	1	0	2	0	1
Bolivina pseudoplicata	0	0	0	0	0	0	1	1	0	4	0	0
Brizalina pseudopunctata		0	3	1	0	2	0	5	1	4	1	0
B. spathulata	1	0	4	2	0	2	2	6	0	3	0	1
B. striatula	0	0	1	0	0	0	1	1	0	0	0	0
B. variabilis	0	0	0	0	0	0	0	0	0	2	0	1
Bulimina elongata	2	2	9	4	1	3	3	4	1	7	4	5
B. gibba	0	4	2	1	0	2	2	3	1	0	1	3
B. marginata	0	0	0	1	0	1	1	2	0	0	0	1
Cibicides lobatulus	79	50	59	65	114	71	52	50	53	46	86	59
C. pseudoungerianus	0	0	0	4	3	6	5	6	1	5	5	11
Clavulina obscura	1	0	0	1	1	1	3	1	1	0	0	0
Cornuspira diffusa	0	0	0	0	0	1	0	0	0	0	1	0
Cribrostomoides jeffreysii	1	0	1	0	3	0	1	3	3	3	0	0
Lenticulina crepidula	0	0	1	0	0	1	0	0	0	0	0	0
Cyclogyra involvens	0	0	0	0	0	1	1	0	0	2	0	0
Eggerelloides scabrum	30	12	28	34	12	10	21	16	23	24	26	24
Elphidium cuvillieri	7	2	16	3	2	7	9	4	9	14	5	14
E. crispum	45	70	36	38	48	43	24	41	39	25	38	51
E. margaritaceum	0	0	0	0	0	0	0	1	0	0	0	1
E. gerthi	3	5	11	3	4	7	10	9	9	19	6	8
E. williamsoni	0	3	2	7	9	3	10	7	6	3	6	10
Fissurina lucida	1	1	1	2	0	1	2	8	3	5	1	2
F. marginata	0	0	0	0	1	1	0	2	0	0	0	0
F. orbignyana	1	0	0	0	1	1	1	3	0	0	0	0
Fursenkoina fusiformis	0	0	0	0	0	0	2	1	0	0	0	0
Rosalina williamsoni	0	0	0	1	0	2	1	0	0	1	1	1
R. praegeri	5	4	7	1	6	4	7	4	3	9	3	5
Globulina gibba	1	1	1	1	2		1	1	0	1	2	1
G. gibba var. *myristiformis*	0	0	0	0	0	1	0	0	0	0	0	0
Haynesina germanica	2	8	10	6	6	8	6	4	3	4	6	7
Lagena clavata	0	0	0	0	0	0	0	1	0	0	0	0
L. laevis	0	0	0	0	0	0	1	0	0	0	0	0
L. lyellii	0	0	0	0	0	0	0	0	1	0	0	0
L. substriata	0	0	0	0	0	0	1	0	0	0	0	0
L. sulcata	1	0	0	1	0	1	0	0	0	0	0	1
Massilina secans	6	5	3	4	5	1	0	1	2	1	8	3
Miliammina fusca	1	0	0	0	0	0	0	0	0	0	0	0
Quinqueloculina auberiana	1	2	1	5	4	1	1	3		1		2

Miliolinella circularis	5	1	3	1	1	1	1	1	1	1		1
M. subrotunda	3	5	2	4	1	2	4		3	3	5	2
Nonion depressulus	1	0	4	3	3	1	4	3	1	1	2	1
Nonionella sp	2	0	0	0	0	0	0	0	0	0	0	0
Oolina williamsoni	1	0	1	0	0	1	1	1	0	1	1	0
Patellina corrugata	0	0	0	0	0	0	0	2	0	0	0	0
Planorbulina mediterranensis	2	2	0	0	6	1	2	1	0	2	1	4
P. cf. *novangliae*	0	0	0	0	1	0	1	0	0	0	0	0
Psammosphaera bowmani	1	1	0	0	0	0	0	1	0	0	0	1
Pyrgo depressa	1	0	0	0	0	1	1	0	0	0	0	0
P. williamsoni	1	0	0	0	0	0	0	0	0	0	0	0
Quinqueloculina sp. 5	1	0	1	1	1	1	2	1	0	3	1	1
Q. spp.	2	1	0	2	1	0	0	5	1	6	3	1
Q. aspera I	0	0	4	2	1	1	1	0	0	1	4	1
Q. aspera II	1	2	0	4	1	2	2	3	9	5	7	0
Q. aspera III	6	2	3	0	0	2	4	0	1	0	0	4
Q. bicornis	0	1	7	1	1	2	0	1	0	2	1	1
Q. cf. cliarensis	1	2	6	1	1	3	0	1	4	3	7	0
Q. mediterranensis	1	0	2	0	0	1	1	0	1	0	0	0
Q. lata var. *oblonga*	2	0	0	1	1	0	0	0	1	0	0	0
Q. lata	3	2	1	3	1	2	0	0	0	2	1	1
Q. oblonga	2	1	2	1	0	0	1	1	3	2	1	3
Q. seminulum	7	10	6	7	9	7	8	9	12	12	13	6
Q. striated forms	0	1	0	0	0	0	0	0	0	0	0	0
Q. williamsoni	0	0	1	1	1	1	1	0	0	0	1	1
Q. cf. *lata seminulum*	0	0	0	0	0	0	2	0	0	1	0	0
Reophax scottii	0	0	0	1	0	1	1	0	0	0	0	0
Rosalina globularis	0	1	0	0	1	0	0	0	0	0	1	0
Stainforthia concava	0	0	0	0	0	0	1	0	0	0	1	0
Spiroloculina excavata	0	0	0	1	1	1	0	0	0	0	0	0
S. rotunda	0	0	0	0	1	0	0	0	0	1	0	0
S. sp	0	0	0	0	0	1	0	0	0	0	0	0
Textularia sagittula	2	3	0	4	0	1	1	1	0	1	5	4
Spiroplectammina wrightii	1	2	0	0	0	1	0	0	0	0	0	0
T. truncata	0	1	4	3	9	1	4	5	1	5	1	0
T. earlandi	1	1	0	0	0	0	2	2	0	0	1	1
Deuterammina (Lepidodeuterammina) ochracea var. *sinuosa*	0	0	1	0	0	0	0	0	0	0	0	0
Trifarina angulosa	0	0	0	0	0	0	1	1	1	0	0	0

Appendix 6

Comparison between species recorded by Heron-Allen and Earland and those recorded by later workers

Only species that occurred at Heron-Allen and Earland's stations 1,3,6,8 are listed.

Genus	**Species**	Recorded at H-A & E Station No	Present in the H-A & E Collection	Murray 1962/63	E. C. Manley 1973/74	Castignetti 1993/94
Gromia	oviformis	**3,5**				
Biloculina	elongata	**2,4,6**	p	p		p
Biloculina	globulus	**8***				
Spiroloculina	excavata	**2,4,5,7,8**				p
Miliolina	circularis	**1,4,6 & 8**				p
	valvularis	**2,4,5,6,7**				
	dilatata	**2,5,6**				
	labiosa	**2,8**				
	subrotunda	**1,2,3,4,5,6,7,8,**				p
	seminuda	**2,4,5,6,7,8**				
	trigonula	**1,3,5**				
	tricarinata	**2,5,6,7,8**				
	nutida	**8**				
	bosciana	**all**				
	oblonga	**all**				p
	var lata	**1,2,4,5,6,7,8**				p
	vulgaris	**1,3,5**				
	seminulum	**all**				p
	dunkerquiana	**2,3,4**				p
	lamarkiana	**1,3,5,6,7,8**				
	anguina	**6,8**				
	pymaea	**1,2,6,7,**				
	scelrotica	**1,4,5,6,7,8**				
	contorta	**1,2,3,4,5,6,7**				
	angulata	**2,4,5,6,7**				
	bicomis	**1,2,4,5,7,8**			p	p
	brongniartii	**2,4,5,6,7**				
	boueana	**1,2,4,5**				
	disparilis	**1***				taken as Q. *Aspera* sp. 4
	pulchella	**1*,2*,3*,4***				
Massilina	secans	**1,3,5,6,7,8**			p	p
	var denticulata	**1*,5***				
	var tenuistriata	**2*,3***				
comispirella	involvens	**1,2,4,5,6,7**				p
	selseyensis	**2,4,5,6,7**				
Comispira	diffusa	**6***				
Psammaspera	fusca	**1,2**				taken as *P* *bowmanni*
Reophax	scottii	**1,6**			p	p
	monoliniformis	**1,2,4,5**				p
Haplofragmium	canariensis	**1,2,4,5,6,7,8**				
	var variabilis	**1*,2***				

	runianum	6*				
crithionina	mamilla	1*				p
Trochammina	squamata	2,4,6,7				
	ochracea	1,2,4,5,6,7				p
Textularia	sagittula	1,2,4			p	p
	gramen	1,2,3,4,5				
	coniica	all				
Verneulina	polystropha	all				
Gaudryina	filiformis	1,2,4,6,7				
Clavulina	obscura	1,2,4,6,7				
Bulimina	pupoides	2,4,5,6,7				
	fusiformis	1,2,3,4,5,6				
	elegans	1,2,4,5,6,7,8				
	elongata	1,2,4,5,6,8			p	p
	marginata	1,2,4,5,6,7,8				
	squammigera	1,2,6,7				
	elegantissima	1,4,6				p
Virgulina	schreibersiana	1,2,4,5				
	subsquamosa	4,8				
Bolivina	laevigata	1,2,4,6,7				
	textilaroides	1,2,5				
	nobilis	2,4,6,7,				
	punctata	1,2,4,5,6,7,8				
	dilata	1,2,3,4,5,6,7				
	robusta	1,2,4,5				
	beyrichi	4,6				
	variabilis	1,2,4,5,6,7				p
	inflata	2,3,4,6,7				
	pseudoplicata				p	p
Cassidulina	pulchella	6*				
	subglobosa	1,2,6,7				
	nitidula	2,6				
Lagena	globosa	1,2,4,5,6,7,8				
	lineata	1,2,4,7,8				
	reticulata	2*,7*,8*				
	hexagona	2,3,4,6,7,8			p	p
	squamosa	1,2,4,5,6,7,8				p
	catenulata	6*				
	melo	6	p			p
	laevis	2,4,5,6,8				p
	clavata	2,4,8			p	p
	gracimilla	2,4,6				p
	striata	2,4,5,6,8				
	perlucida	2,6,8	p			p
	sulcata	2,4,6,7,8	p	p	p	p
	var interrupta	2,4,6,7,8				
	williamsoni	1,2,4,5,6,7,8p				p
	lyelli	1,4	p			p
	striato-punctata	6*				
	costata	2,6				
	laevigata	1,2,4,5,6,7,8				
	acuta	4,6				p
	lucida	1,2,4,5,6,7,8				
	marginata	2,4,5,6,7,8			p	p
	var inaequilateralis	1,2,4				
	bicarinata	2,5,6				
	orbignayana	1,2,4,5,6,7,8			p	p

Nodosauria	communis	1,2,4,6,8				
	pyrula	2,4,6	p			p
	scalaris	2,4,6,8			p	p
Cristellaria	hauerina	1,2				
	gibba	2*,6*				p
	rotulata	1,2,4,8				
	cultrata	2,4,6				
Polymorphina	lactea	1,2,4,5,6,8				
	williamsoni	1,2,4,6,8				
	concava	1,2				p
	gibba	2,4,6,8				
	communis	2,4,5,7,8				
	compressa	2,4,6,7,8				
	myristiformis	1,2,4				
Uvigerina	angulosa	1,3,4,5,6,7				p
Globigerina	bulloides	2,4,6				
Spirillina	vivipara	1,2,4,6,7				p
Patellina	corrugata	1,2,4,5,6,7				p
Discorbina	nitida	1,2,4,5,6,7				p
	praegeri	1,2,3,4,5,6,7				p
	velardeboana	2,6				
	rosacea	all				
	mamilla	1,2,3,4,5			p	p
	planorbis	2,6				
	turbo	2,4,6				
	orbicularis	1,5,7				p
	globularis	1,2,4,5,6,7,8				p
	mediterranensis	1,2,3,4,5,6,7				p
	irregularis	1,2				
	tuberculata	2,4,6				
	chasteri	4*,6*				
	lauriei	1*				
Planorbulina	mediterranensis	all				p
Truncatulina	refulgens	2,3,5,6,7				
	lobatula	all	p	p	p	p
	variabilis	4,5,8				
	akneriana	1,2,3				
	ungeriana	1,2,3,5,7				
Pulvinulina	haliotidea	1,2,3,4,5,6,7				p
	karsteni	2,6				
Rotalia	beccarii	all	p	p	p	p
Nonionina	depressula	all		p		p
	asterizans	1,2,4,6,7				
	boueana	1,6				
	pauperata	2,4,5,7				
Polystomella	strato-punctata	all				
	var selseyensis	1,2,5,6,7		p		
	macella	1,2,3,5,6,7				p
	crispa	all	p	p	p	p

Red* = One present	Green = very rare	p = present

Appendix 7

Meteorological data for Plymouth

Data recorded from the University of Plymouth Fitzroy building (01/10/93 to 30/11/94). Which is situated approximately 1 mile north-north-east of Plymouth Sound

	AM Rainfall	**PM Rainfall**	**Max Temp**	**Min Temp**	**Mean Temp**	**Sunshine (hrs)**	**Total Rainfall**
1/10/93	11.8	11	12.5	9.6	11	1.6	22.8
2/10/93	1.6	0	15	10.9	12.9	6	1.6
3/10/93	1.8	0.4	15.1	10.6	12.9	0.8	2.2
4/10/93	4.8	2.2	14.4	7.6	11	5.3	7
5/10/93	0.3	0.1	14.7	10.9	12.8	3.8	0.4
6/10/93	11.8	1.6	14.4	8.2	11.3	2.9	13.4
7/10/93	0.9	0	13.3	9	11.1	8.7	0.9
8/10/93	3.8	0.1	14.3	10.5	12.4	4.4	3.9
9/10/93	1.8	4	14.5	11.9	13.2	6.6	5.8
10/10/93	0.8	0	16.4	12.5	14.5	6.3	0.8
11/10/93	9.8	18.3	14.6	10.6	12.6	0	28.1
12/10/93	7.4	0.4	14.7	10.2	12.5	0.8	7.8
13/10/93	2	0	12.6	7.4	10	1.7	2
14/10/93	0	0	10.8	2.8	6.8	7.3	0
15/10/93	0	0	10.2	3.2	6.7	4.1	0
16/10/93	0	0	9.2	2.9	6.1	9.4	0
17/10/93	0	0	9.7	5.6	7.7	9.5	0
18/10/93	0	0	12.6	1.8	7.2	9.7	0
19/10/93	0	0	10.9	3.1	7	10.6	0
20/10/93	0	0	12	4.2	8.1	6	0
21/10/93	0	0	10.3	2.6	6.4	9.7	0
22/10/93	0	0	11.6	3.8	7.7	9.4	0
23/10/93	0	0	11.2	5.3	8.2	6.4	0
24/10/93	0	0	9.7	6	7.9	1.8	0
25/10/93	0	0	13.4	7.2	10.3	9.1	0
26/10/93	0	0	11.1	8.2	9.6	0	0
27/10/93	0	0	13.2	8.2	10.7	0	0
28/10/93	0	0	11.1	7.9	9.5	0.1	0
29/10/93	0	0	13.3	2.7	8	8.2	0
30/10/93	0	0	8.8	5.1	6.9	4.6	0
31/10/93	0	0	8.3	7.5	7.9	0	0
1/11/93	0	0	9.1	6	7.6	0	0
2/11/93	0	1	12.6	7	9.8	0	1
3/11/93	9	0.2	14.4	8	11.2	0.4	9.2
4/11/93	0.1	0	13.7	8.2	11	2.7	0.1
5/11/93	0	0.1	13.6	6.9	10.3	0.2	0.1
6/11/93	0	0	11.4	4.5	7.9	3.2	0
7/11/93	0	0	9.6	6.3	7.9	0	0
8/11/93	5.5	0	11.5	6.2	8.8	0	5.5
9/11/93	0	4.6	11.7	8.4	10	0	4.6
10/11/93	5.8	0	11.3	5.4	8.3	7.5	5.8

11/11/93	0.5	0.1	12.1	4.8	8.4	6.7	0.6
12/11/93	1.2	0	11.7	5	8.4	6.1	1.2
13/11/93	14	13.4	12.7	7	9.9	0	27.4
14/11/93	2.6	0.2	9.5	0.2	4.8	7.7	2.8
15/11/93	0	0	10.2	3	6.6	3.5	0
16/11/93	0	0	9.9	5.5	7.7	3.8	0
17/11/93	0	0	8.1	4.9	6.5	2	0
18/11/93	0	0	8.8	4.6	6.7	2.9	0
19/11/93	0	0	9	1.6	5.3	7.3	0
20/11/93	0	0	6.9	-0.4	3.2	7.7	0
21/11/93	0	0	4.8	-3.3	0.8	7.2	0
22/11/93	0	0	4	-2	1	5.2	0
23/11/93	0	0	5.4	1.6	3.5	1.5	0
24/11/93	5.8	3.2	10.6	3.8	7.2	2	9
25/11/93	0.1	1	12.1	8.4	10.3	3	1.1
26/11/93	1	0	11.2	5.7	8.4	3.7	1
27/11/93	0	0	9.9	4.3	7.1	3.2	0
28/11/93	0	0	4.3	3.8	4.1	0.1	0
29/11/93	2.6	10.8	10.9	6.7	8.8	0	13.4
30/11/93	10.8	1.1	10	3.2	6.6	1.8	11.9
1/12/93	0.1	1	11.7	4.8	8.2	0.4	1.1
2/12/93	0.1	0.1	11.6	9.9	10.7	0	0.2
3/12/93	0	0	11.6	10.1	10.9	0	0
4/12/93	6.2	0	10.2	5.5	7.9	4.2	6.2
5/12/93	0	0.2	10.1	8.2	9.1	1.7	0.2
6/12/93	0.4	0.1	10.9	5.2	8	0.7	0.5
7/12/93	9.1	0.9	11.4	6.4	8.9	3	10
8/12/93	6.5	3.2	12.9	7.1	10	0	9.7
9/12/93	0.4	0	10.8	6.9	8.8	2.5	0.4
10/12/93	4	0	9.6	3.8	6.7	2.8	4
11/12/93	0.6	0	7.9	6.4	7.1	4.2	0.6
12/12/93	10	12.6	11.1	7.7	9.4	0	22.6
13/12/93	6.4	0.6	8.9	0.8	4.8	0.3	7
14/12/93	0.5	0	9.1	-0.4	4.3	3	0.5
15/12/93	11	0.8	7.8	4	5.9	3.6	11.8
16/12/93	0.8	0.7	10.3	5.4	7.8	3.9	1.5
17/12/93	3	0.2	10.6	9.9	10.3	0	3.2
18/12/93	1.4	1	11.3	10.9	11.1	0	2.4
19/12/93	19	1.2	12.9	5.9	9.4	0	20.2
20/12/93	19	1.7	12.2	3.4	7.8	0	20.7
21/12/93	11.7	0.5	9.6	4.2	6.9	4.1	12.2
22/12/93	4.2	1.5	9.8	5.4	7.6	2.6	5.7
23/12/93	0.1	1.3	8.4	2	5.2	0	1.4
24/12/93	2.7	0	6.7	3.3	5	4.8	2.7
25/12/93	6	0	6.6	0.9	3.7	0.4	6
26/12/93	0	0	4	0	2	0.5	0
27/12/93	0	0	9.6	1.5	5.6	0.3	0
28/12/93	17.8	0	10.1	8.4	9.2	5.9	17.8
29/12/93	1.6	5.2	10.3	7.2	8.7	1.2	6.8
30/12/93	7	22.4	10.7	5.3	8	0	29.4

31/12/93	2.2	1.4	7.6	2.5	5.1	5.1	3.6
1/1/94	0.2	1.2	10.2	2.8	6.5	0	1.4
2/1/94	21.4	0	10.5	7.4	8.9	3.6	21.4
3/1/94	2.6	4.6	9.4	5.1	7.2	1.6	7.2
4/1/94	6	3.4	9.6	4.4	7	0.5	9.4
5/1/94	14.8	0	8.4	2	5.2	2.8	14.8
6/1/94	12.8	0	4.4	1.3	2.8	1	12.8
7/1/94	0.5	0	7.4	1.7	4.5	4.4	0.5
8/1/94	0	5.8	9.3	6.8	8	0	5.8
9/1/94	8.8	5.4	10.2	7.9	9	0	14.2
10/1/94	6.4	4	9.4	6.4	7.9	0.7	10.4
11/1/94	0.2	4.2	10.1	7.4	8.7	1.2	4.4
12/1/94	9.2	2.6	10.9	6.1	8.5	0	11.8
13/1/94	4.2	0	10.6	6.9	8.7	2.9	4.2
14/1/94	1	0	9.4	6.3	7.8	5.7	1
15/1/94	3.4	0.2	10	4	7	3.6	3.6
16/1/94	0	0	6.5	0.6	3.5	6.4	0
17/1/94	0	0	7.2	0.4	3.8	7.1	0
18/1/94	0	0	8.7	3.8	6.2	0	0
19/1/94	4.1	0.4	8	2	5	5.5	4.5
20/1/94	0.5	0	10.1	7	8.5	1.5	0.5
21/1/94	0	0	10	8.4	9.2	0	0
22/1/94	0	0	10	8.7	9.4	0	0
23/1/94	3.4	0.2	11.1	5.8	8.4	1.3	3.6
24/1/94	5.2	0.5	11.4	9.7	10.5	0	5.7
25/1/94	1.7	0	11.4	6.2	8.8	2.2	1.7
26/1/94	3.2	0.2	10.4	7.2	8.8	3.5	3.4
27/1/94	0.1	1.1	11	5.2	8.1	0	1.2
28/1/94	0.4	0	9.4	6	7.7	6.6	0.4
29/1/94	0.4	0.2	9.2	7.9	8.5	0	0.6
30/1/94	2.8	0	9.7	1.5	5.6	6.5	2.8
31/1/94	0	0	9.9	4.7	7.3	3.7	0
1/2/94	1.2	5.9	10.6	2.1	6.3	1.7	7.1
2/2/94	0.2	0	10.6	3.1	6.8	0.3	0.2
3/2/94	17.5	0	10.4	5.7	8	1.8	17.5
4/2/94	4	0	9.6	6.5	8	7	4
5/2/94	2.4	0	9.7	6.4	8	6.1	2.4
6/2/94	0.8	4.8	9.3	4.3	6.8	0	5.6
7/2/94	2.4	0	8.6	2.4	5.5	7.2	2.4
8/2/94	0.1	1.7	9.3	2.6	5.9	0	1.8
9/2/94	0.7	0	8.7	0.2	4.4	4.7	0.7
10/2/94	0	0	9.8	1.3	5.5	4.9	0
11/2/94	11.7	0.1	10.5	5.8	8.1	0.8	11.8
12/2/94	0.4	0	7.7	3.5	5.6	3.7	0.4
13/2/94	0	0	5.8	2.1	3.9	2.4	0
14/2/94	0	0.3	4.7	-3.6	0.5	3.7	0.3
15/2/94	0	0	5.1	1.1	3.1	5.4	0
16/2/94	0	0	8.2	3.9	6.1	4.2	0
17/2/94	0	0	8.8	5.5	7.1	0.4	0
18/2/94	13.1	8.4	8.1	5.2	6.6	0	21.5

19/2/94	0.2	0	10.1	5.8	7.9	4.1	0.2
20/2/94	19.2	1.2	5.9	0.2	3	0	20.4
21/2/94	0.2	0	4.4	0.8	2.6	1.7	0.2
22/2/94	1.5	1.5	10.2	3.2	6.7	0	3
23/2/94	16.1	0	10.4	6.7	8.5	5.7	16.1
24/2/94	8	0	8.4	4.3	6.3	0.1	8
25/2/94	3	6	11.1	8.4	9.7	0	9
26/2/94	8.4	0.2	11.6	9.1	10.4	0	8.6
27/2/94	0	0	11.4	6.1	8.7	7	0
28/2/94	0.2	0.1	9.9	5	7.4	0.6	0.3
1/3/94	0.4	0	9.7	5	7.4	1.3	0.4
2/3/94	3.4	0	12.6	7.4	10	9.2	3.4
3/3/94	0.9	0	11.6	4.8	8.2	6.4	0.9
4/3/94	0	0.1	10	8.8	9.4	0	0.1
5/3/94	5.2	0.2	10.5	5.9	8.2	7	5.4
6/3/94	0	0	10.3	8.4	9.3	1.4	0
7/3/94	0.2	0.2	10.4	8.9	9.6	0	0.4
8/3/94	2.2	0.1	9.6	8.4	9	0	2.3
9/3/94	0.2	0.1	11	3.9	7.4	0	0.3
10/3/94	0	0	11.4	4.6	8	9	0
11/3/94	0	0	8.8	4.3	6.5	1.7	0
12/3/94	0.6	1.2	9.6	5.9	7.7	1.4	1.8
13/3/94	2.4	0	11.7	8.3	10	5.3	2.4
14/3/94	0	0	13	9.3	11.1	1.6	0
15/3/94	0	1	11.5	5.6	8.5	4.3	1
16/3/94	0.6	0	10.2	5.1	7.7	6.1	0.6
17/3/94	0	0	10.8	6.6	8.7	4.1	0
18/3/94	0.1	0	11.2	5.7	8.4	0.8	0.1
19/3/94	5.4	0	9.2	0.6	4.9	0.5	5.4
20/3/94	0	0	10.7	4.4	7.6	4.9	0
21/3/94	7.2	0	11.3	6	8.6	2.5	7.2
22/3/94	0.5	2.8	10.3	8.7	9.5	0	3.3
23/3/94	0.5	0.6	11.1	8.3	9.7	0	1.1
24/3/94	1.4	0.1	11.1	8.5	9.8	0.1	1.5
25/3/94	0.7	0	12.5	3.9	8.2	1.5	0.7
26/3/94	0	0	10.9	3.2	7	10.9	0
27/3/94	0	12	9.8	7.9	8.8	0	12
28/3/94	2.8	0.2	11.4	7.3	9.3	0.1	3
29/3/94	0	0.1	10.7	8.8	9.7	0	0.1
30/3/94	0	0	9.8	6.2	8	0	0
31/3/94	6.6	0.6	10.1	4.9	7.5	1.7	7.2
1/4/94	17.6	0.6	9.3	2.6	5.9	6.7	18.2
2/4/94	2.8	1.8	8.3	3.1	5.7	5.7	4.6
3/4/94	0.8	7.2	10	2.4	6.2	0	8
4/4/94	11.6	0.8	7.8	2.4	5.1	8.2	12.4
5/4/94	4.8	0.4	9.3	4.5	6.9	6.3	5.2
6/4/94	1.2	0	10.3	5.8	8	3.7	1.2
7/4/94	0.6	0.2	10.1	4.8	7.4	10.3	0.8
8/4/94	0	13	8.9	2.9	5.9	0	13
9/4/94	3	0.8	9.1	4.5	6.8	7.3	3.8

10/4/94	1.6	0	10.8	2	6.4	12	1.6
11/4/94	0	0	14.6	4.3	9.4	9.9	0
12/4/94	0.1	0.2	10.3	4.5	7.4	5.3	0.3
13/4/94	0	0	12.2	2.2	7.2	10.2	0
14/4/94	0	0	10.7	2.6	6.6	11.8	0
15/4/94	0	0	9.6	5.5	7.6	3.9	0
16/4/94	0	0	11.7	4.1	7.9	5	0
17/4/94	0	0	13	2.6	7.8	8.3	0
18/4/94	0	0	12.6	5	8.8	9.8	0
19/4/94	0	0	11.1	6.3	8.7	0.1	0
20/4/94	0	0	9.8	6.1	7.9	0	0
21/4/94	0	0	13.1	8.2	10.6	3.6	0
22/4/94	0	0	13.8	9.5	11.6	5.3	0
23/4/94	1.2	0	14.5	7.7	11.1	6.1	1.2
24/4/94	2.6	0.2	12	6.1	9	7.9	2.8
25/4/94	0	2.6	10.6	8.3	9.4	0.2	2.6
26/4/94	2.6	1	12.7	9.6	11.1	5.9	3.6
27/4/94	6.5	0.2	11.4	9.7	10.5	0	6.7
28/4/94	0.8	0	11.9	7.7	9.8	2.9	0.8
29/4/94	0	0	19.5	9.3	14.4	10.7	0
30/4/94	0	0	18.2	6.7	12.4	11.3	0
1/5/94	0	0	15.8	8.5	12.1	10.2	0
2/5/94	0	0	15.8	8.5	12.1	12.6	0
3/5/94	0	0	12.4	8.6	10.5	6.2	0
4/5/94	0	1.5	12.9	8.3	10.6	10.4	1.5
5/5/94	0	0.5	11.3	9.5	10.4	0	0.5
6/5/94	1.5	0	12.5	7.7	10.1	0.3	1.5
7/5/94	3.2	0	13.2	4.1	8.6	9.3	3.2
8/5/94	0	0.6	12.8	6.8	9.8	9.4	0.6
9/5/94	3.4	0	13.5	7.5	10.5	12.9	3.4
10/5/94	0	0	13.2	10.4	11.8	0	0
11/5/94	0	0	17.4	9.2	13.3	5.5	0
12/5/94	8.5	0	15.2	10.5	12.9	11.2	8.5
13/5/94	0	0	18.2	14	16.1	13.7	0
14/5/94	0	16.6	15	9.8	12.4	0.1	16.6
15/5/94	0	0	16.9	10.9	13.9	4.4	0
16/5/94	4.4	0	17.2	7.9	12.5	5.9	4.4
17/5/94	14.5	6	9.9	6.2	8	0	20.5
18/5/94	2.3	0	13.8	7.8	10.8	8.9	2.3
19/5/94	0	0	12.3	8.7	10.5	3.3	0
20/5/94	2	0.5	11	8.9	9.9	0.1	2.5
21/5/94	5.6	3.2	12.4	10.5	11.4	0	8.8
22/5/94	1	0	14	9.9	11.9	5.5	1
23/5/94	0.4	0	14.2	10.2	12.2	6	0.4
24/5/94	4	2.9	13.8	10	11.9	0	6.9
25/5/94	0	0.8	13.4	9.9	11.6	0.1	0.8
26/5/94	10.3	1	13.8	10	11.9	0	11.3
27/5/94	0	0	12.2	7.7	9.9	0.6	0
28/5/94	0	0	12.5	6.2	9.3	3.3	0
29/5/94	0	0	15.5	6	10.7	5.6	0

30/5/94	0	0	16.5	5.2	10.8	14.2	0
31/5/94	0	0	17.5	9.9	13.7	14.7	0
1/6/94	0	0	17.6	11.5	14.5	7.9	0
2/6/94	0.1	0.1	14.7	10.8	12.8	0.9	0.2
3/6/94	1	1.2	13.6	8.9	11.2	4.7	2.2
4/6/94	8	3	14.8	7.6	11.2	5.9	11
5/6/94	0	0	14.3	10.6	12.4	8.2	0
6/6/94	1.6	0	14	11.5	12.8	0.2	1.6
7/6/94	0	0	14.7	10.7	12.7	0.8	0
8/6/94	0.3	0	14.2	9.5	11.9	13.1	0.3
9/6/94	0	0	16.6	10	13.3	11.3	0
10/6/94	0	0	15	7.7	11.3	6.6	0
11/6/94	0	0	17.6	8.2	12.9	13.4	0
12/6/94	0	0	18.4	9.2	13.8	9.3	0
13/6/94	0	0	17.8	10.2	14	13.3	0
14/6/94	0	0	21.2	9.6	15.4	13.6	0
15/6/94	0	0	19.6	9.8	14.7	13.2	0
16/6/94	0	0	22.9	11.5	17.2	14.9	0
17/6/94	0	0	17.1	11.4	14.2	13.4	0
18/6/94	0	0	16.4	12.7	14.6	9.2	0
19/6/94	0	0	14.8	12.9	13.8	1	0
20/6/94	0	0	16.9	13.3	15.1	2.5	0
21/6/94	1.5	0.2	15.2	13.2	14.2	0	1.7
22/6/94	0.2	0	18	10.1	14	11.6	0.2
23/6/94	0	0	20	15.1	17.5	15.3	0
24/6/94	0	1.8	18.9	11.7	15.3	3.4	1.8
25/6/94	1.4	0	18	10.7	14.4	10.1	1.4
26/6/94	0	0	17	13.5	15.3	2.2	0
27/6/94	0	0	17.7	11.5	14.6	9.5	0
28/6/94	0	0	22	10.7	16.3	13.4	0
29/6/94	0	0	18.6	8	13.3	12	0
30/6/94	0	0	20.9	13	17	14.6	0
1/7/94	0	0	22.1	13.6	17.8	6.8	0
2/7/94	0	0	19	12.9	15.9	9.3	0
3/7/94	0	0	18.8	14.7	16.7	0.7	0
4/7/94	3.4	0.2	18.3	12.9	15.6	3.9	3.6
5/7/94	0	0	17.4	12.6	15	5.8	0
6/7/94	9.5	0.2	17.2	12.2	14.7	10.7	9.7
7/7/94	0	1.3	15.7	12.1	13.9	4.1	1.3
8/7/94	1.9	0	15	10.2	12.6	1.5	1.9
9/7/94	0	0	18.6	13.8	16.2	9.6	0
10/7/94	0	0	18.8	12.8	15.8	4.6	0
11/7/94	0	0	20.1	12.3	16.2	12.1	0
12/7/94	0	0	27.1	13.8	20.4	10.4	0
13/7/94	0	0	21.5	12	16.7	14.5	0
14/7/94	0	0	21.4	15	18.2	13.3	0
15/7/94	0	0.1	19.6	12.6	16.1	3.5	0.1
16/7/94	0	0	24.2	16.5	20.3	11.3	0
17/7/94	0	0	24.2	17.3	20.7	5.9	0
18/7/94	0	0	20.8	15.4	18.1	0.2	0

19/7/94	0	0	21.9	14.2	18	6.4	0
20/7/94	0	0	22.9	14	18.5	10.7	0
21/7/94	0	0	20.9	14.7	17.8	6.5	0
22/7/94	0	0	23	15.5	19.2	13.2	0
23/7/94	0	0	25.8	17.4	21.6	11.4	0
24/7/94	0	0	24.5	13	18.7	9.7	0
25/7/94	0	0	19.3	15.3	17.3	2.8	0
26/7/94	6.4	1.1	18	15.7	16.8	0	7.5
27/7/94	6	0	18.4	10.9	14.6	0.8	6
28/7/94	0.3	0	20.1	9.9	15	11.6	0.3
29/7/94	0	0	19.5	10.9	15.2	14	0
30/7/94	0	0	21.1	12.9	17	0.7	0
31/7/94	0	0.6	21.6	14.9	18.2	4.9	0.6
1/8/94	6.2	0	19.1	14.5	16.8	3.7	6.2
2/8/94	10.2	5	18.7	16	17.3	0	15.2
3/8/94	1.7	1.7	20.7	16.4	18.5	1.7	3.4
4/8/94	0.2	0	20	16.1	18	3.5	0.2
5/8/94	0	0	21.3	13.3	17.3	6.9	0
6/8/94	0	0	21.1	15.7	18.4	9.9	0
7/8/94	0	0	20.8	16.1	18.4	3.8	0
8/8/94	0	0	22.2	15.4	18.8	8.1	0
9/8/94	0	0.6	19.3	14.5	16.9	1.4	0.6
10/8/94	18.7	0	19.8	15	17.4	4.4	18.7
11/8/94	8.4	0	19.6	13	16.3	1.8	8.4
12/8/94	0	0	19.8	11.2	15.5	10.1	0
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14/8/94	0	0	18	13.3	15.6	12	0
15/8/94	0	0	19.4	12.6	16	11.5	0
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18/8/94	0.2	5.2	17.7	15.1	16.4	3.2	5.4
19/8/94	10.6	0	19.1	13.3	16.2	7.9	10.6
20/8/94	0	0	18.7	13.4	16	4.9	0
21/8/94	0	0	19.5	15.4	17.4	1.6	0
22/8/94	0	0	20	14.8	17.4	5.8	0
23/8/94	3.3	0	18.4	14.1	16.2	8.7	3.3
24/8/94	0.2	0.2	17	13.7	15.4	5.2	0.4
25/8/94	2	0	18	14.2	16.1	3.9	2
26/8/94	0.3	0	18.5	13.4	15.9	5.5	0.3
27/8/94	3.6	0	18.7	10.7	14.7	10.5	3.6
28/8/94	0	0.8	18.6	12.4	15.5	9.4	0.8
29/8/94	0	0	17.7	12.1	14.9	4.8	0
30/8/94	3	0.1	16	12.6	14.3	0	3.1
31/8/94	1.9	0.7	17.3	13.6	15.4	0	2.6
1/9/94	2.7	0	18.4	10	14.2	4.7	2.7
2/9/94	0	0	17.9	13.5	15.7	11.4	0
3/9/94	5	0	17.8	12.9	15.3	0	5
4/9/94	0.2	0	17.1	10.1	13.6	2.1	0.2
5/9/94	0.2	0	18.4	11	14.7	5.9	0.2
6/9/94	0	0	17.4	10.5	14	2.9	0

7/9/94	11.8	0	17	10.8	13.9	6.8	11.8
8/9/94	16.8	1.5	15	11	13	4.2	18.3
9/9/94	3.4	0	15.8	11.3	13.5	5.5	3.4
10/9/94	2.6	0.2	16.1	8.8	12.4	9	2.8
11/9/94	0	0.2	16.6	11.4	14	2	0.2
12/9/94	12.2	1	16.1	12.5	14.3	9.7	13.2
13/9/94	0.5	0.1	16.4	10.5	13.5	4.6	0.6
14/9/94	16.3	0.2	16.6	10.5	13.5	4.3	16.5
15/9/94	0.3	2.9	13.1	9	11	2.7	3.2
16/9/94	0.6	0	14.7	9.9	12.3	7.3	0.6
17/9/94	0	0	15	7.9	11.4	5.7	0
18/9/94	0	0	14.5	9.3	11.9	0.1	0
19/9/94	16.7	0.6	15.2	11.9	13.5	0	17.3
20/9/94	0.5	0	15.3	10.2	12.8	8	0.5
21/9/94	1	0	15.3	10.6	12.9	5.7	1
22/9/94	0	0	18.1	12.5	15.3	9.1	0
23/9/94	0	0	18.1	13.6	15.8	0	0
24/9/94	2.4	0	16.9	13.9	15.4	0.5	2.4
25/9/94	0	17.2	16	14	15	0	17.2
26/9/94	0	0	18.3	8.9	13.6	2.6	0
27/9/94	0	0	16.7	9.2	13	5.2	0
28/9/94	0	0	16.1	8.1	12.1	0.9	0
29/9/94	0	0	14.3	11	12.6	0	0
30/9/94	0	0	15	11.5	13.2	0	0
1/10/94	0	0	17	13.3	15.1	1.4	0
2/10/94	0	2.2	14.3	11.3	12.8	0	2.2
3/10/94	0	0	14.3	3.3	8.8	8.5	0
4/10/94	0	0	12	3	7.5	10.7	0
5/10/94	0	0	13.9	4.1	9	9.8	0
6/10/94	0	0	14.1	7	10.5	6.7	0
7/10/94	0	0	15.2	5.8	10.5	8.2	0
8/10/94	0	0	16	6.3	11.1	9.2	0
9/10/94	0	0	17.3	10.5	13.9	9.9	0
10/10/94	0	0	17.5	10.5	14	9.9	0
11/10/94	0	0	20	11.4	15.7	5.3	0
12/10/94	0	0	19.2	11.2	15.2	1.6	0
13/10/94	0	0	16.6	11	13.8	8.1	0
14/10/94	0	0	16.8	7.5	12.1	7.2	0
15/10/94	0	0	18.6	10.4	14.5	5.5	0
16/10/94	0	0	15.5	10.7	13.1	5.9	0
17/10/94	0	0	12.3	8.9	10.6	3.3	0
18/10/94	0	0	13.6	9.4	11.5	3.5	0
19/10/94	6	0	16.5	11.3	13.9	3.3	6
20/10/94	0	0	15.6	11.5	13.5	3.4	0
21/10/94	4.7	0	14.6	12.7	13.6	5.5	4.7
22/10/94	4.6	3.6	14.5	9.3	11.9	1.9	8.2
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24/10/94	1.8	0	13.9	8.1	11	7.1	1.8
25/10/94	4.3	0.6	12.9	7.9	10.4	6.5	4.9
26/10/94	0.2	1.2	11.3	6.2	8.7	5.9	1.4

27/10/94	5	0.5	12.3	5.4	8.8	7.5	5.5
28/10/94	0.2	0	12.5	7	9.7	6.3	0.2
29/10/94	11	3.4	13.6	11.4	12.5	0.4	14.4
30/10/94	9.4	15	13.8	11.4	12.6	0	24.4
31/10/94	25.2	0.3	14.2	8.4	11.3	3.9	25.5
1/11/94	0	0	14	6.6	10.3	4.2	0
2/11/94	0.3	0.2	14.6	11	12.8	7.9	0.5
3/11/94	8.2	4	15	11.9	13.4	0.7	12.2
4/11/94	1.3	0	14.5	7.3	10.9	3.8	1.3
5/11/94	0	0	12.2	7.6	9.9	1.9	0
6/11/94	0.2	0	13.5	10.8	12.1	3.3	0.2
7/11/94	1.8	0	13.4	12	12.7	0.3	1.8
8/11/94	0.2	3.2	14	11.7	12.9	0	3.4
9/11/94	8	6.5	14	9	11.5	0.2	14.5
10/11/94	1.5	0	12.7	10.4	11.5	0	1.5
11/11/94	0	0	13.4	10.5	11.9	0.9	0
12/11/94	29.4	0.6	14	9.6	11.8	1.7	30
13/11/94	0.2	0	13.5	13	13.2	0	0.2
14/11/94	0.8	1	13.8	11	12.4	0	1.8
15/11/94	2	0	14	8.6	11.3	4.8	2
16/11/94	0.8	0.2	12.8	7.1	9.9	1.4	1
17/11/94	0.4	0	13.7	8.5	11.1	3.7	0.4
18/11/94	6	2.9	14.7	12.9	13.8	0	8.9
19/11/94	1.6	0	13.5	12.8	13.1	0	1.6
20/11/94	0	1	13.5	9	11.2	0	1
21/11/94	0.8	1.5	13.1	8.4	10.7	0	2.3
22/11/94	1	1	13.5	12.2	12.9	0.4	2
23/11/94	0	0	13.4	11.5	12.4	0	0
24/11/94	0	0	13.1	11	12	0	0
25/11/94	0	0	13.1	9.7	11.4	0	0
26/11/94	0	0	11.5	9.5	10.5	0	0
27/11/94	0	0	11.8	8.3	10	0	0
28/11/94	0	0	12.1	8.7	10.4	0	0
29/11/94	0	0	10.9	9.3	10.1	0.1	0
30/11/94	0	0	12.4	10.1	11.2	0	0

Appendix 8

Genus 3 unidentified

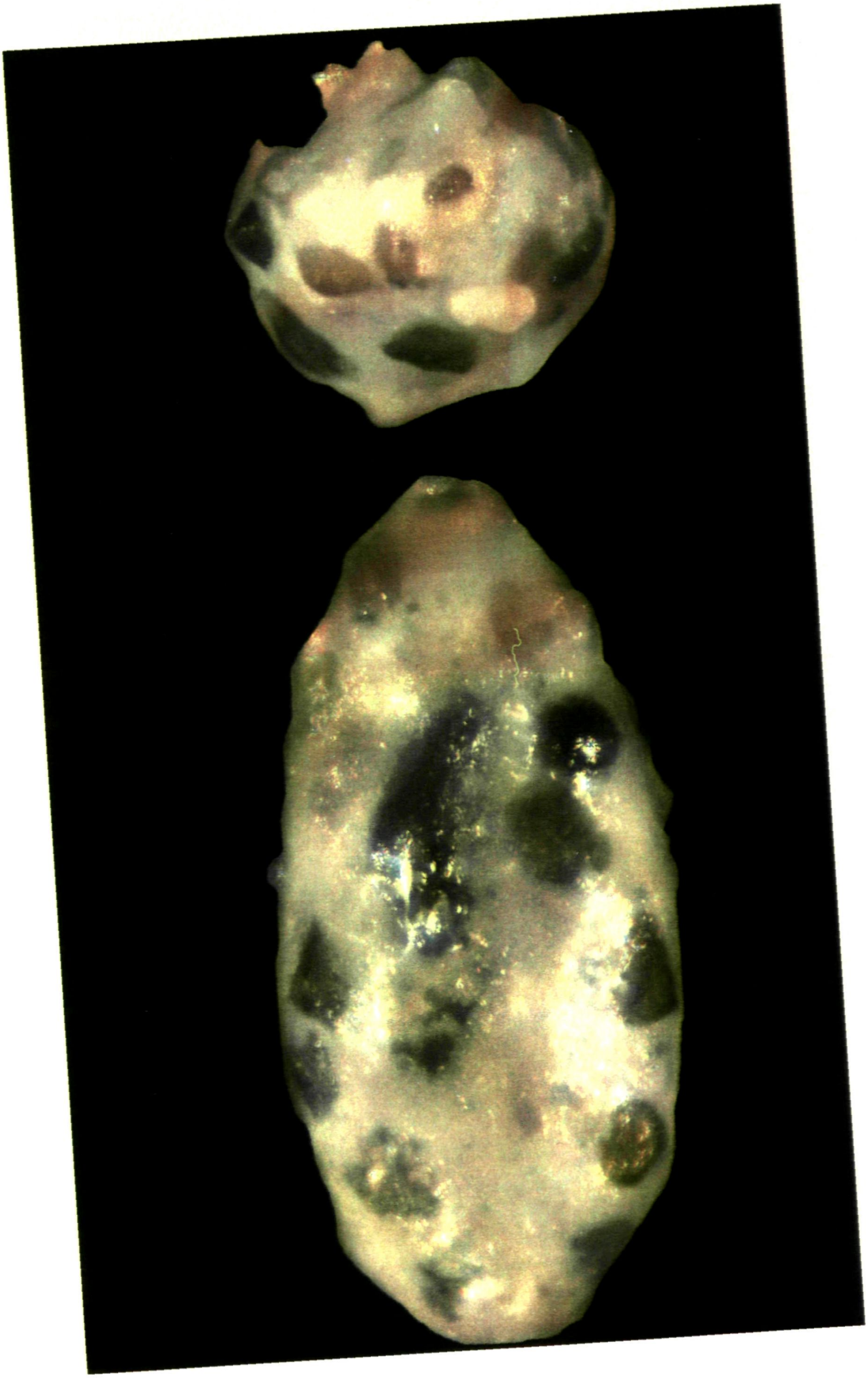
Description

Test elongate, oval to fusisform, round in section, very finely agglutinated almost tectinous, with some larger, often brightly coloured angular glassy mineral grains, regularly distributed throughout the surface. The aperture is terminal, round and simple. The test is fragile often partially collapsed. The chamber arrangement is unclear and may be uniserial composed of one larger chamber or unilocular.

The photograph taken using the Natural History Museum's Palaeovision system. It shows two views, the top shows an apertural view exhibiting a central, simple, round aperture, the bottom (side view) shows the elongate fusiform morphology and unusual glassy mineral fragments used in the construction of the test.

It is rare in occurrence and is limited to the more marine southern Sound and generally muddy areas. Several stained and presumed living individuals were recorded from Location 9

An extensive review of literature and specimens at the Natural History Museum failed to identify similar species and it is suspected that this may be a previously unrecorded species. Unfortunately it is rare and few specimens are available for study a situation which was made worse by the destruction of several specimens send for analysis



Appendix 9

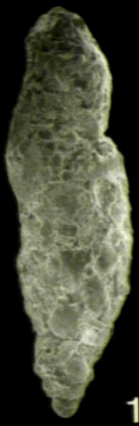
Decca Coordinates for Sample sites

Location 1	South of the Breakwater, fine sorted sands	**C 31.1**	**B 58.6**
Location 3	Within view of the Hotel on Mount Edgecombe	**C 32.5**	**B 62.8**
Location 4	South of Drake's Island	**C 31.3**	**B 62.45**
Location 8	Off Ramscliff	**B 47.5**	**B 60.5**
Location 9	North of the Breakwater	**C 31.4**	**B 60.45**
Location 11	South-East Sound	**C 31.8**	**B 63.35**
Location 12	Barn Pool	**C 34.0**	**B 65.6**
Location 14	Drake's Island (near the end of the pier)	**C 32.0**	**B 65.0**
Location 14	Mountbatten Breakwater	**B 47.9**	**B 64.3**
Location 16	Queen's Ground	**C 33.6**	**B 61.6**
Location 17	Anchorage Beacons	**B 47.25**	**B 60.9**
Location 18	Withyhedge Beacon	**B 47.0**	**B 61.3**

Plate 1

1	***Reophax fusiformis*** (Williamson)	x 250
2	***Reophax fusiformis*** (Williamson), view of aperture	x 250
3	***Reophax*** cf. ***R. fusiformis*** (Williamson)	x 250
4	***Reophax moniliformis*** (Siddall)	x 100
5	***Reophax moniliformis*** (Siddall), constructed with a high percentage of sponge spicules	x 200
6	***Reophax scottii*** Chaster	x 100
7	***Reophax scottii*** Chaster, detail of wall showing overlapping arrangement of mica flakes	x 750
8	**Genus I**	x 150
9	**Genus 2**	x 150
10	**Genus 2** , detail of wall showing abundant coccoliths	x1000
11	***Miliammina fusca*** (Brady)	x 200
12	***Miliammina fusca*** (Brady), view of aperture	x 200

Plate 1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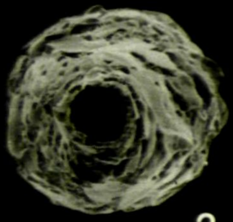
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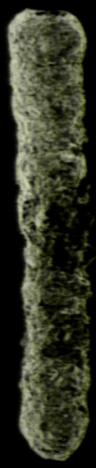
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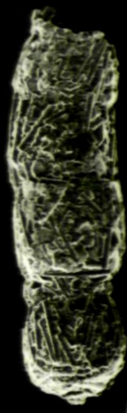
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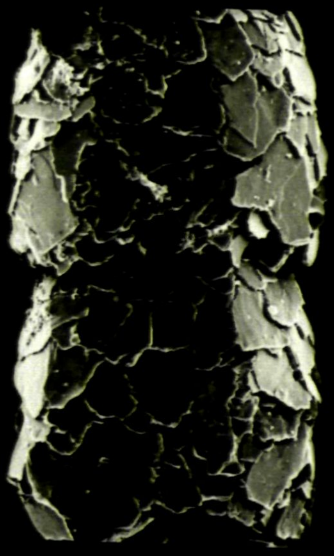
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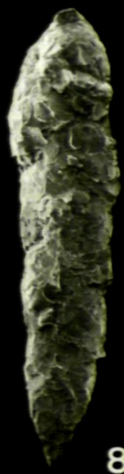
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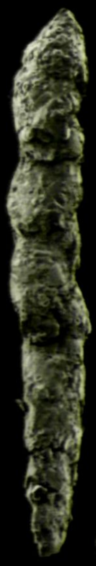
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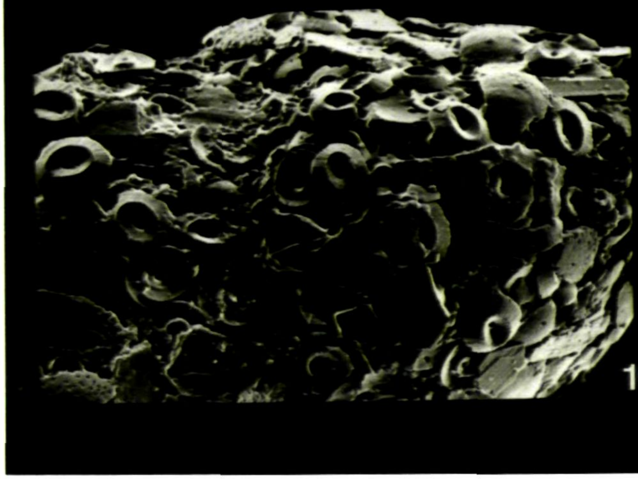
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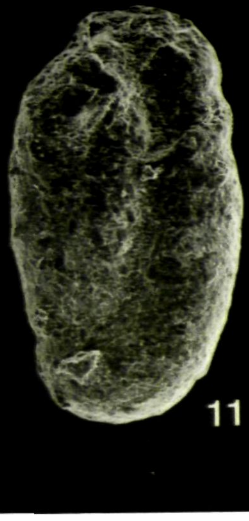
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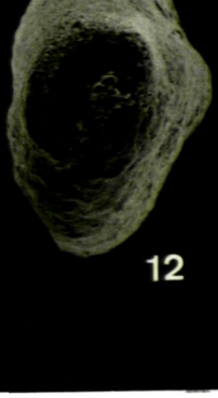
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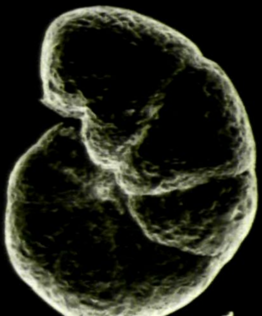
Plate 2

1	***Cribrostomoides jeffreysii*** (Williamson)	x 200
2	***Cribrostomoides jeffreysii*** (Williamson), apertural view	x 200
3	***Ammoscalaria pseudospiralis*** (Williamson)	x 50
4	***Ammoscalaria pseudospiralis*** (Williamson), apertural view	x 150
5	***Ammoscalaria pseudospiralis*** (Williamson), view of aperture showing a simple peg like tooth	x 500
6	***Ammoscalaria pseudospiralis*** (Williamson), view of planispiral early stage of chamber arrangement	x 100
7	***Textularia sagittula*** Defrance group	x 100
8	***Textularia sagittula*** Defrance group	x 75
9	***Textularia sagittula*** Defrance group, side view	x 100
10	***Textularia sagittula*** Defrance group, apertural view	x 100
11	***Textularia earlandi*** Parker	x 200
12	***Textularia earlandi*** Parker	x 200
13	***Textularia earlandi*** Parker, side view	x 150

Plate 2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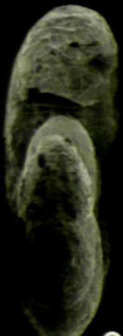
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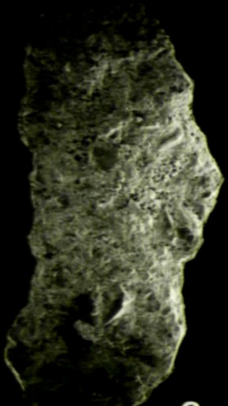
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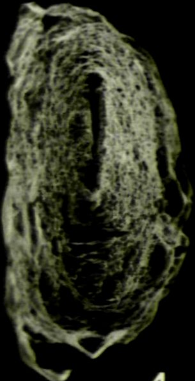
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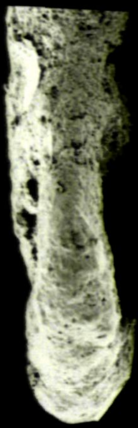
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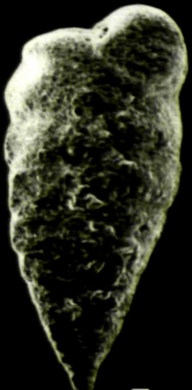
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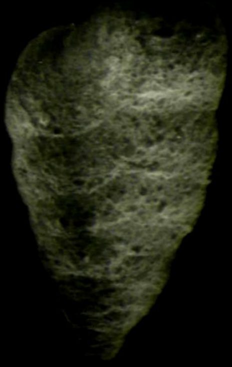
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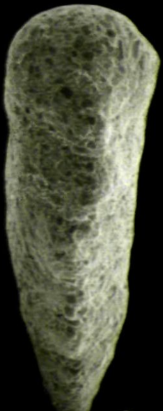
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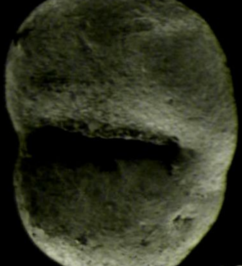
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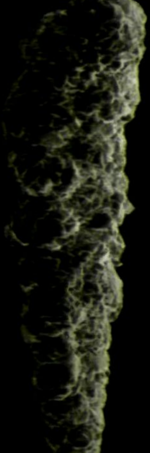
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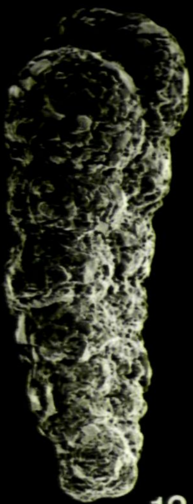
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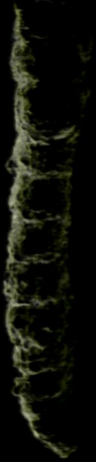
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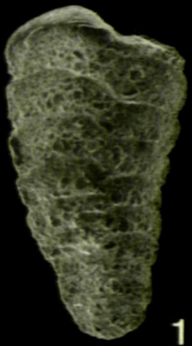
Plate 3

1	***Spiroplectammina wrightii*** (Silvestri)	x 100
2	***Spiroplectammina wrightii*** (Silvestri), side view	x 150
3	***Spiroplectammina wrightii*** (Silvestri), apertural view	x 150
4	***Deuterammina (Lepidodenterammina) ochracea*** (Williamson) ***sinuosa*** Brönniman, dorsal view	x 200
5	***Deuterammina (Lepidodenterammina) ochracea*** (Williamson) ***sinuosa*** Brönniman, ventral view	x 200
6	***Deuterammina rotaliformis*** (Heron-Allen and Earland), two forms attached to each other	x 350
7	***Deuterammina rotaliformis*** (Heron-Allen and Earland), two forms attached to each other, side view	x 350
8	***Remaneica helgolandica*** Rhumbler, dorsal view	x 200
9	***Remaneica helgolandica*** Rhumbler, ventral view	x 200
10	***Jadammina macrescens*** (Brady)	x 150
11	***Jadammina macrescens*** (Brady), exhibiting collapsed chambers	x 150
12	***Jadammina macrescens*** (Brady), side view	x 200

Plate 3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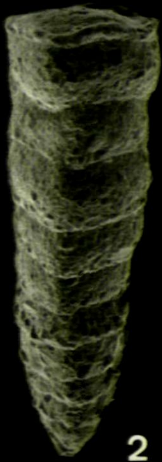
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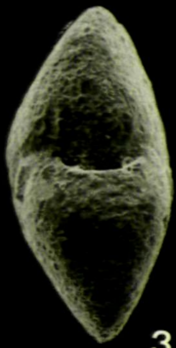
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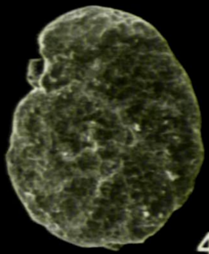
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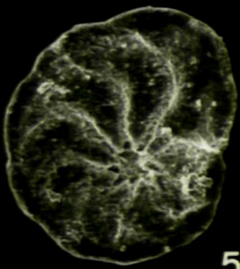
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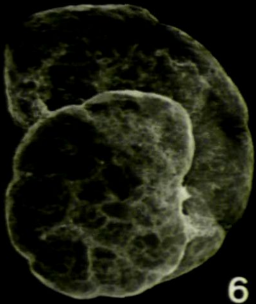
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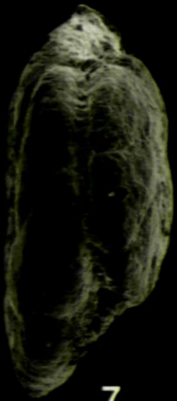
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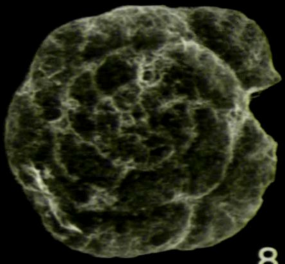
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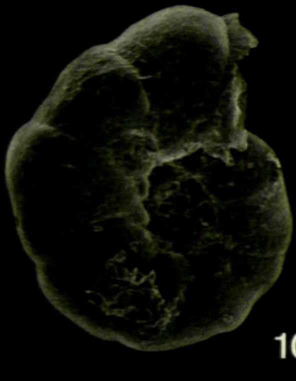
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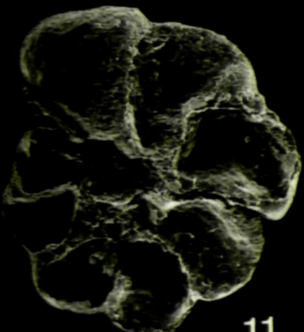
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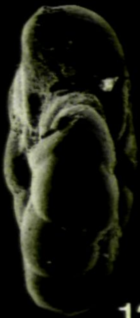
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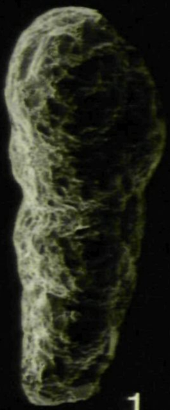
Plate 4

1	***Eggerelloides scabrum*** (Williamson)	x 100
2	***Eggerelloides scabrum*** (Williamson)	x 75
3	***Eggerelloides scabrum*** (Williamson), apertural view	x 150
4	***Eggerelloides scabrum*** (Williamson), view of aperture	x 250
5	***Clavulina obscura*** Chaster	x 200
6	***Clavulina obscura*** Chaster	x 200
7	***Clavulina obscura*** Chaster, view of slit-like aperture	x 500
8	***Psammosphaera bowmani*** Heron-Allen and Earland	x 100
9	***Psammosphaera bowmani*** Heron-Allen and Earland	x 100
10	***Psammosphaera bowmani*** Heron-Allen and Earland, detail of very fine intergranular material	x3500
11	***Psammosphaera bowmani*** Heron-Allen and Earland, detail of fine intergranular material	x2000
12	***Psammosphaera bowmani*** Heron-Allen and Earland, exhibiting large translucent mica face used with the construction of the test	x 100

Plate 4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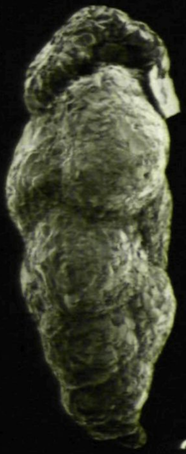
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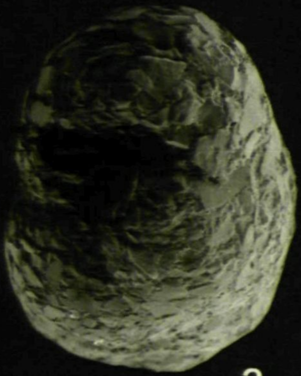
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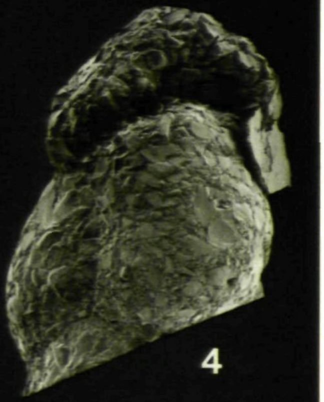
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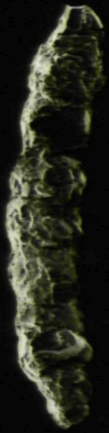
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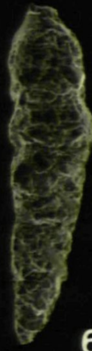
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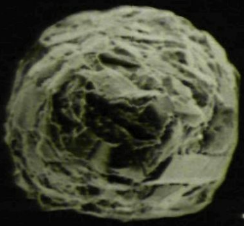
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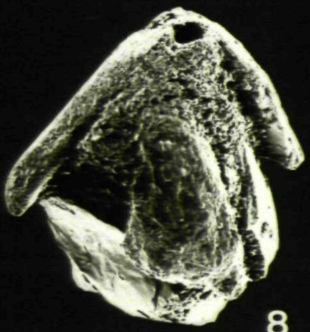
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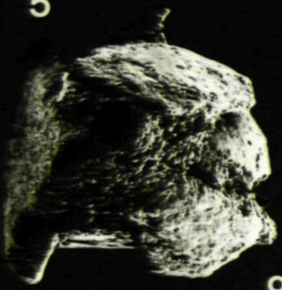
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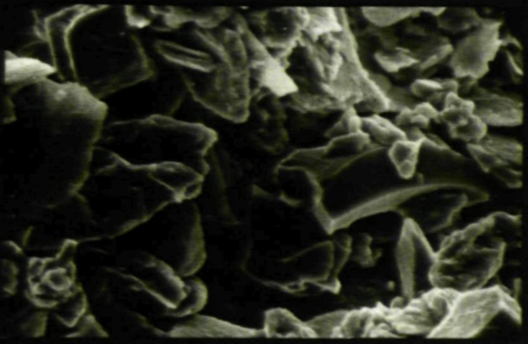
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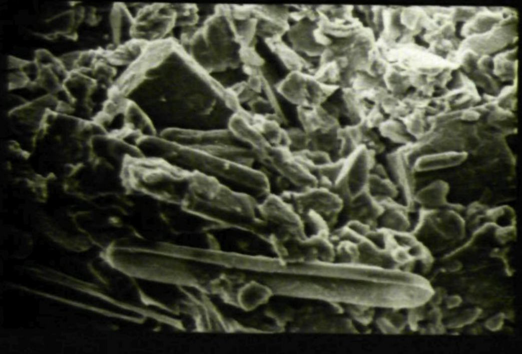
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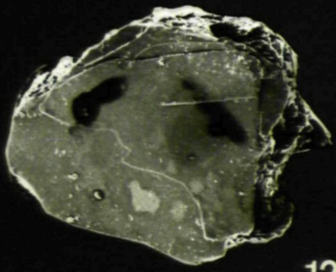
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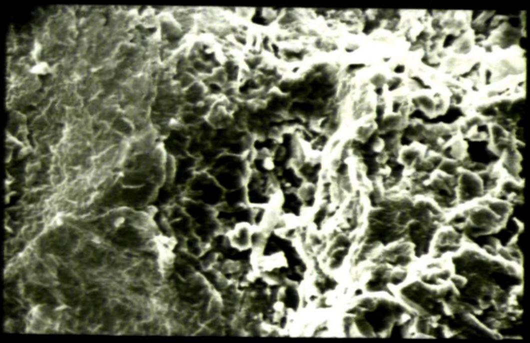
Plate 5

1	***Psammosphaera bowmani*** Heron-Allen and Earland, detail of wall, junction of a mica flake with cement/intergranular material	x2000
2	***Psammosphaera bowmani*** Heron-Allen and Earland, an unusual form constructed from shell fragments	x 100
3	***Psammosphaera bowmani*** Heron-Allen and Earland, apertural view of an unusual form constructed from shell fragments	x 100
4	***Psammosphaera bowmani*** Heron-Allen and Earland, detail of aperture	x 500
5	***Psammosphaera*** ? aff ***P bowmani*** Heron-Allen and Earland, an untidy collection of cemented shell fragments with a large aperture visible at the top of the micrograph	x 100
6	***Psammosphaera*** ? aff ***P bowmani*** Heron-Allen and Earland, detail of organic cement of specimen described above	x1000

Plate 5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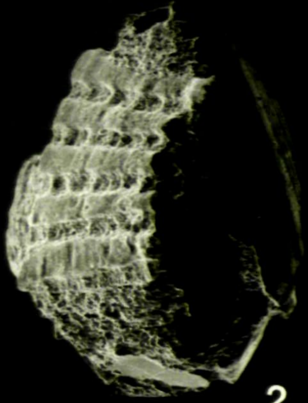
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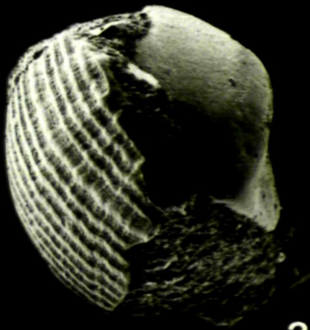
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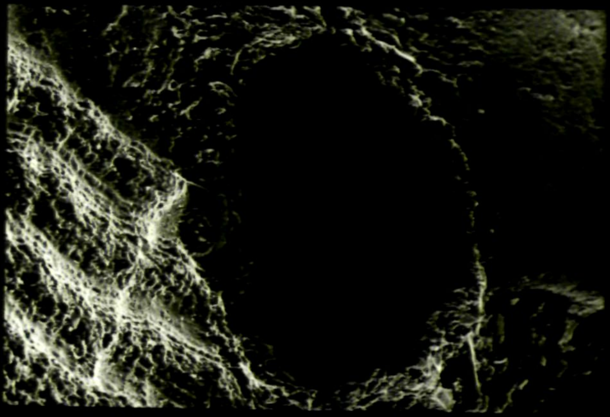
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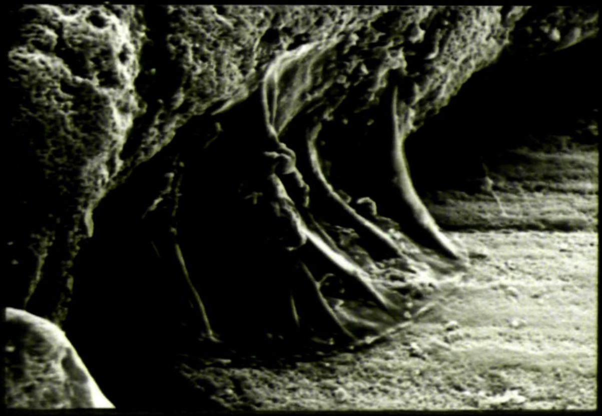
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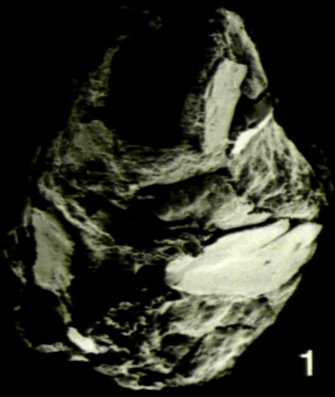
Plate 6

1	***Lagenammina arenulata*** (Skinner)	x 150
2	***Lagenammina arenulata*** (Skinner), view of aperture	x 150
3	***Hemisphaerammina bradyi*** Loeblich and Tappan	x 200
4	***Technitella teivyense*** Haynes, side view, constructed from simple, smooth sponge spicules	x 150
5	***Technitella*** sp. 1 (Ear bud form), spherical mass of smooth sponge spicules which have knobs at either end	x 150
6	***Technitella*** sp. 1 (Ear bud form), detail of sponge spicules, the rounded knobs at the ends clearly visible	x1500
7	***Technitella*** cf. ***T. teivyense*** Haynes, similar to *T. teivyense* but does not display the classic form, rather irregular and untidy, the sponge spicules differ in being more robust and having a thorny appearance	x 150
8	***Technitella*** cf. ***T. teivyense*** Haynes, detail of sponge spicules from the species described above, exhibiting the thorny nature of the sponge spicules	x1000

Plate 6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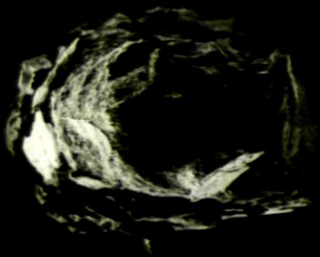
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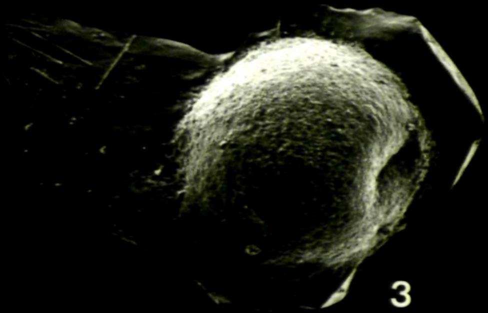
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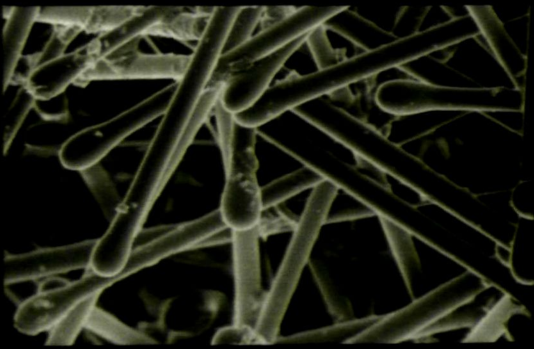
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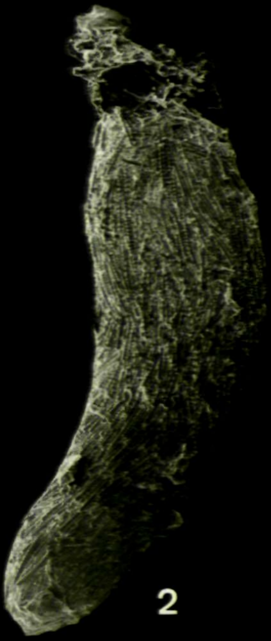
Plate 7

1	***Technitella legumen*** Brady, smaller fusiform/oval form	x 100
2	***Technitella legumen*** Brady, larger curved form	x 75
3	***Technitella legumen*** Brady, detail of wall structure showing sponge spicules embedded within the finer granular material of the wall	x2000
4	***Technitella legumen*** Brady, view of aperture showing the characteristic smooth lip	x 200
5	***Technitella legumen*** Brady, detail of external wall entirely composed of sponge spicules	x1500
6	***Cyclogyra involvens*** (Reuss)	x 200
7	***Cyclogyra involvens*** (Reuss), apertural view, showing the simple round aperture and the raised proloculus visible on the left hand side	x 250
8	***Cornuspirella diffusa*** (Heron-Allen and Earland)	x 100
9	***Cornuspirella diffusa*** (Heron-Allen and Earland), exhibiting arcuate growth rings	x 100

Plate 7

1



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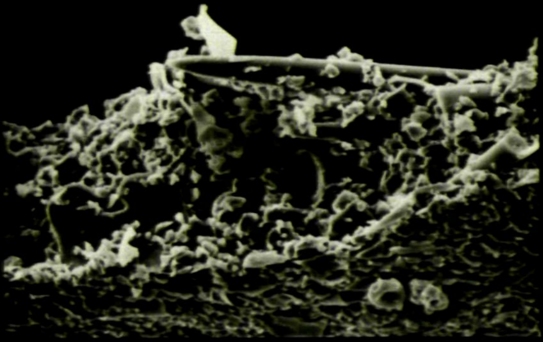

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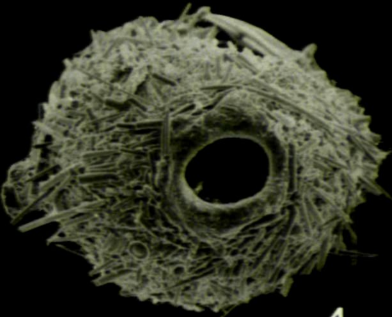

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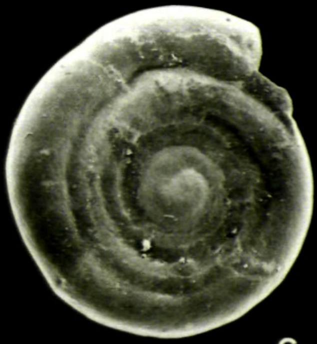

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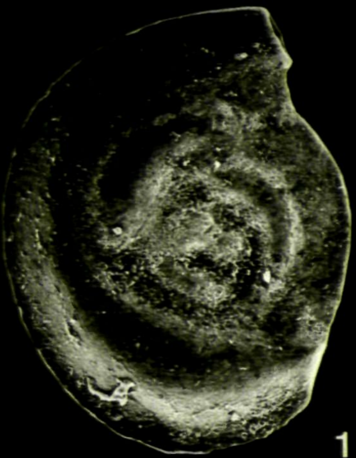
Plate 8

1	***Cornuloculina balkwilli*** (Macfadyen)	x 500
2	***Cornuloculina balkwilli*** (Macfadyen)	x 500
3	? ***Spiroloculina*** sp.	x 150
4	***Spiroloculina depressa*** d'Orbigny	x 150
5	***Spiroloculina depressa*** d'Orbigny, apertural view	x 200
6	***Spiroloculina*** cf. ***rotunda*** d'Orbigny	x 100
7	***Spiroloculina*** cf. ***rotunda*** d'Orbigny, apertural view	x 150
8	? ***Spiroloculina*** sp. 1, showing a coarse roughened surface characteristic of this species within this study	x 75
9	? ***Spiroloculina*** sp. 1, apertural view	x 100
10	? ***Spiroloculina*** sp. 1, view of aperture, showing an unusual asymmetrical tooth	x 350
11	***Spiroloculina cf. S. grata*** Terquem	x 200

Plate 8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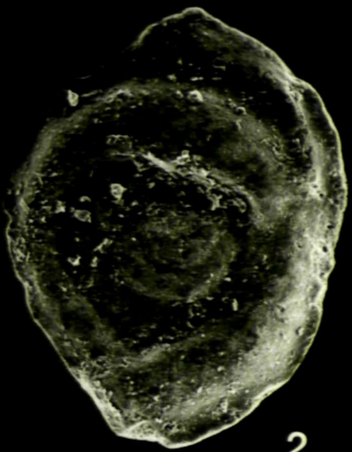
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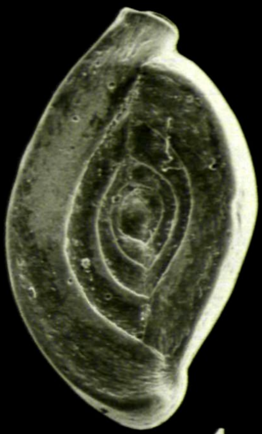
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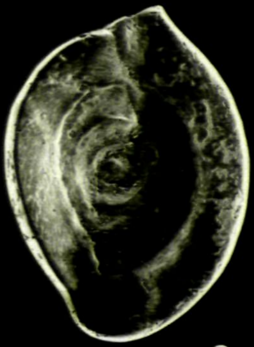
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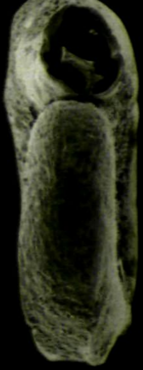
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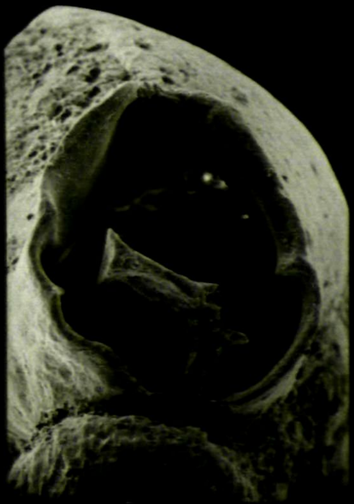
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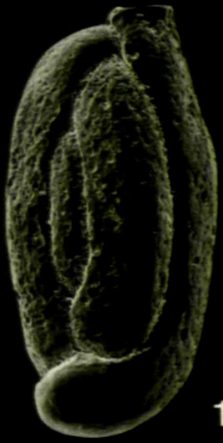
Plate 9

1	***Quinqueloculina aspera*** d'Orbigny var. 2, exhibiting a roughened surface characteristic to this variety	x 100
2	***Quinqueloculina aspera*** d'Orbigny var. 2	x 200
3	***Quinqueloculina aspera*** d'Orbigny var. 2	x 750
4	***Quinqueloculina aspera*** d'Orbigny var. 4, displaying the costae characteristic of this variety	x 100
5	***Quinqueloculina aspera*** d'Orbigny var. 3	x 100
6	***Quinqueloculina aspera*** d'Orbigny var. 3, apertural view, also showing angular chamber edges	x 100
7	***Quinqueloculina aspera*** d'Orbigny var. 3, view of aperture showing simple robust tabular tooth	x 100
8	***Quinqueloculina aspera*** d'Orbigny var. 3	x 100
9	***Quinqueloculina aspera*** d'Orbigny var. 3, view of aperture showing a slender bifid tooth	x 500

Plate 9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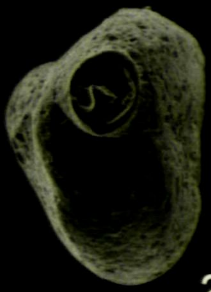
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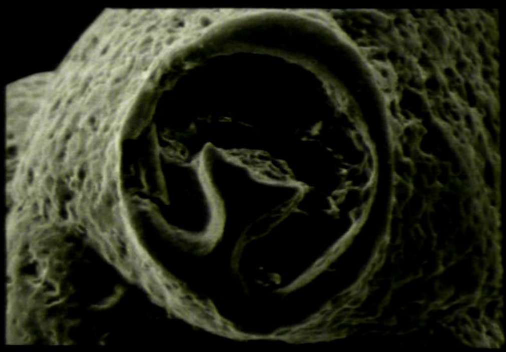
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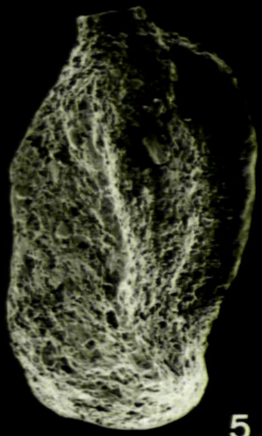
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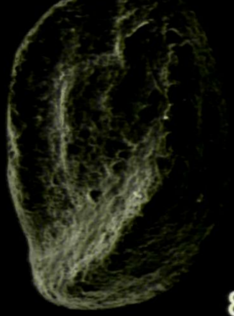
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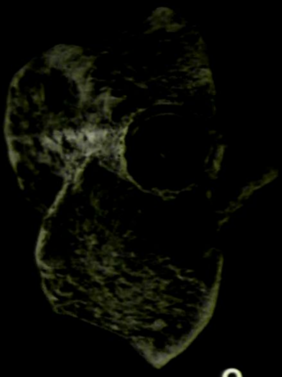
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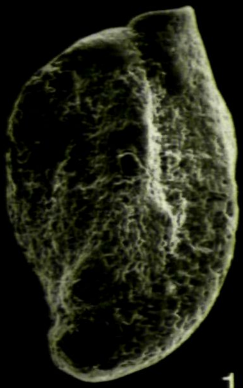
Plate 10

1	***Quinqueloculina aspera*** d'Orbigny var.3	x 200
2	***Quinqueloculina aspera*** d'Orbigny var.1	x 75
3	***Quinqueloculina aspera*** d'Orbigny var.1	x 75
4	***Quinqueloculina aspera*** d'Orbigny var.1	x 100
5	***Quinqueloculina aspera*** d'Orbigny var.1, apertural view, showing highly bifurcating tines	x 100
6	***Quinqueloculina bicornis*** (Walker and Jacob)	x 100
7	***Quinqueloculina bicornis*** (Walker and Jacob), apertural view	x 100
8	***Quinqueloculina oblonga*** var. ***lata*** (Terquem)	x 100
9	***Quinqueloculina oblonga*** var. ***lata*** (Terquem)	x 100
10	***Quinqueloculina oblonga*** var. ***lata*** (Terquem), apertural view	x 200

Plate 10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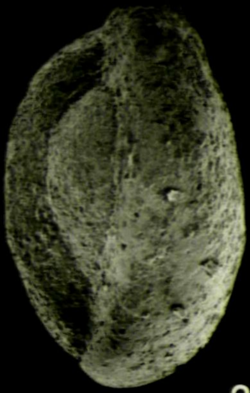
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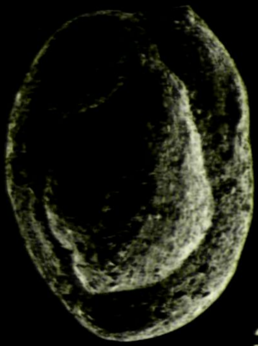
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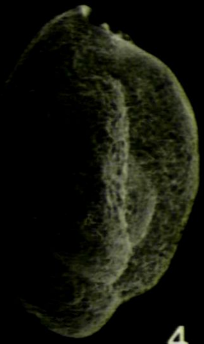
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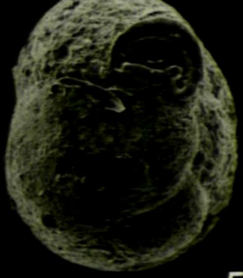
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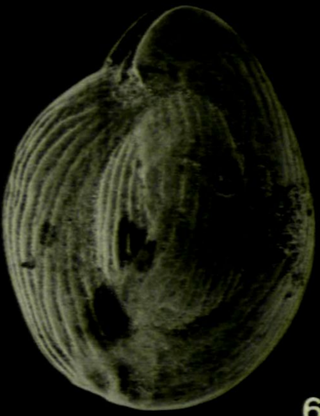
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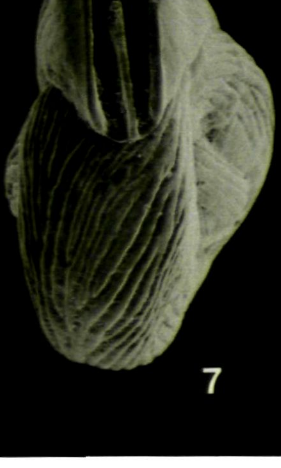
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Plate 11

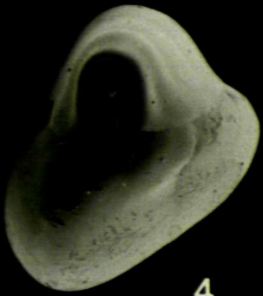
1	***Quinqueloculina lata*** Terquem	x 100
2	***Quinqueloculina lata*** Terquem	x 100
3	***Quinqueloculina lata*** Terquem	x 100
4	***Quinqueloculina lata*** Terquem, apertural view	x 150
5	***Quinqueloculina seminulum*** (Linné)	x 100
6	***Quinqueloculina seminulum*** (Linné)	x 75
7	***Quinqueloculina seminulum*** (Linné), apertural view	x 100
8	***Quinqueloculina seminulum*** (Linné), view of aperture	x 350

Plate 11


1


2


3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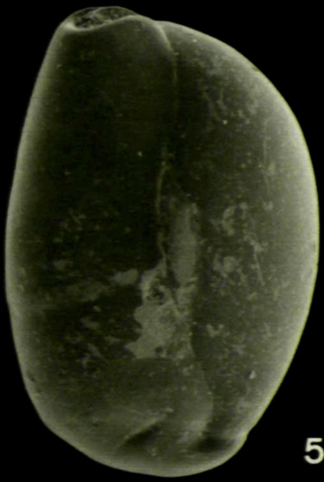
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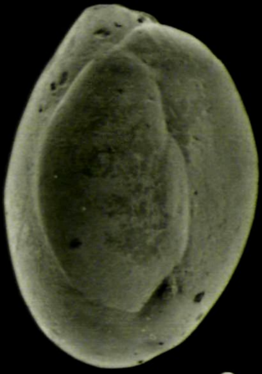
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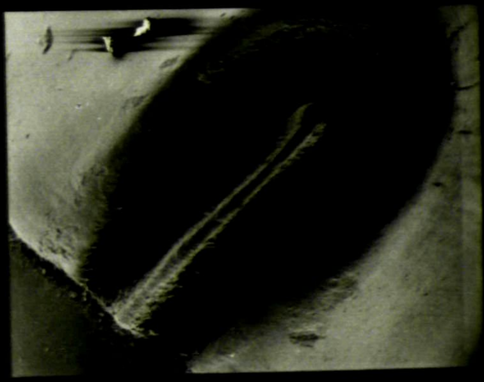
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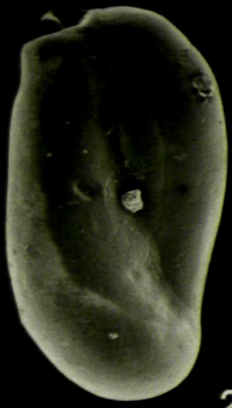
Plate 12

1	***Quinqueloculina oblonga*** (Montagu)	x 100
2	***Quinqueloculina williamsoni*** (Terquem)	x 100
3	***Quinqueloculina williamsoni*** (Terquem)	x 100
4	***Quinqueloculina williamsoni*** (Terquem)	x 100
5	***Quinqueloculina williamsoni*** (Terquem), apertural view	x 100
6	***Quinqueloculina williamsoni*** (Terquem), view of aperture	x 200
7	***Quinqueloculina horrida*** Cushman	x 200

Plate 12

1



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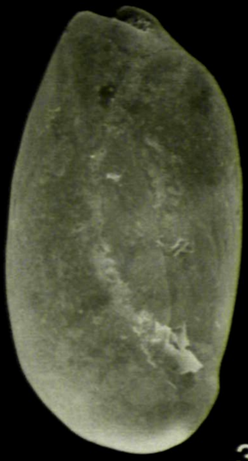

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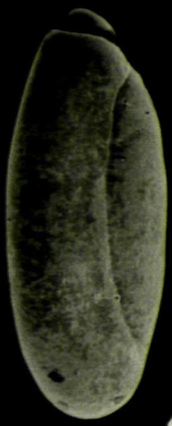

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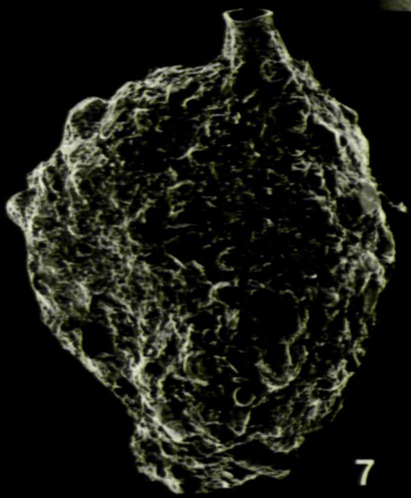

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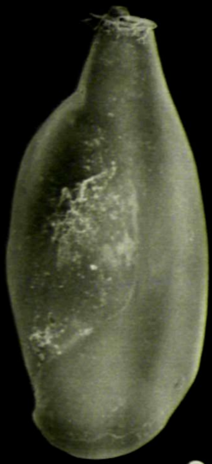
Plate 13

1	***Quinqueloculina*** cf. ***Q. cliarensis*** Heron-Allen and Earland	x 100
2	***Quinqueloculina*** cf. ***Q. cliarensis*** Heron-Allen and Earland	x 150
3	***Quinqueloculina*** cf. ***Q. cliarensis*** Heron-Allen and Earland	x 200
4	***Quinqueloculina*** cf. ***Q. cliarensis*** Heron-Allen and Earland	x 200
5	***Quinqueloculina mediterranensis*** Le Calvez and Le Calvez	x 100
6	***Quinqueloculina mediterranensis*** Le Calvez and Le Calvez	x 75
7	***Quinqueloculina mediterranensis*** Le Calvez and Le Calvez	x 75
8	***Quinqueloculina mediterranensis*** Le Calvez and Le Calvez	x 100
9	***Quinqueloculina mediterranensis*** Le Calvez and Le Calvez	x 100
10	***Quinqueloculina mediterranensis*** Le Calvez and Le Calvez	x 100

Plate 13


1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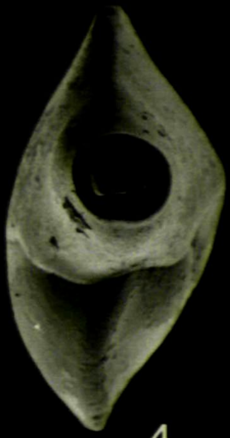
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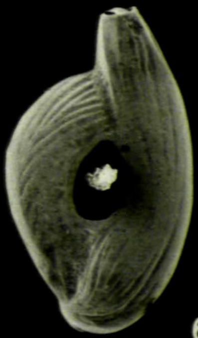
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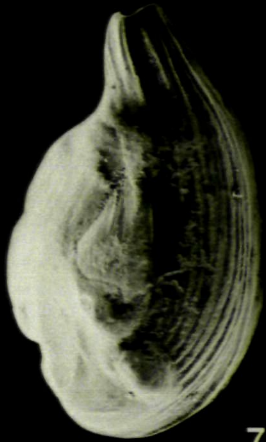
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Plate 14

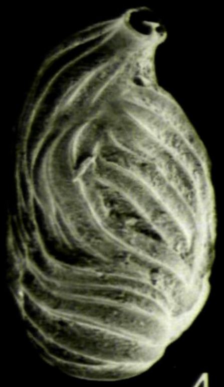
1	***Quinqueloculina intricata*** Terquem	x 100
2	***Quinqueloculina*** cf. ***Q mediterranensis*** Le Calvez and Le Calvez	x 100
3	***Quinqueloculina*** cf. ***Q mediterranensis*** Le Calvez and Le Calvez	x 100
4	***Quinqueloculina*** sp. 1	x 100
5	***Quinqueloculina*** sp. 1	x 100
6	***Quinqueloculina*** sp. 1, view of aperture	x 350
7	***Quinqueloculina*** sp. 2	x 100
8	***Quinqueloculina*** sp. 2, view of aperture	x 350
9	***Quinqueloculina*** sp. 3	x 75
10	***Quinqueloculina*** sp. 3	x 35

Plate 14


1


2


3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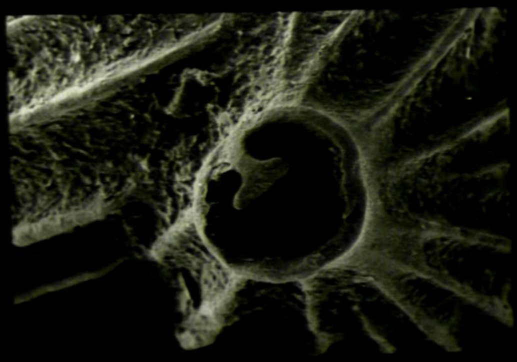
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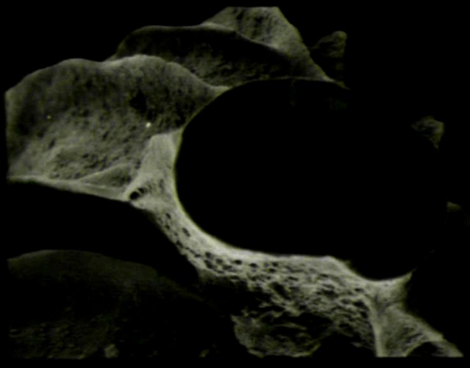
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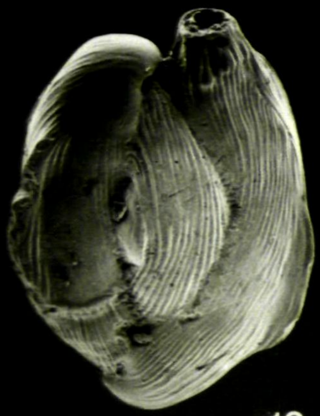
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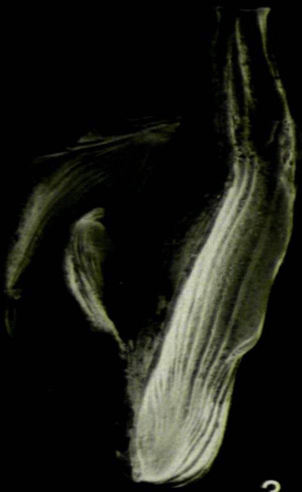
Plate 15

1	***Quinqueloculina*** sp. 4	x 50
2	***Quinqueloculina*** sp. 4	x 75
3	***Quinqueloculina*** sp. 4, an atypical specimen with an irregular form	x 50
4	***Quinqueloculina cliarensis*** Heron-Allen and Earland	x 200
5	***Quinqueloculina cliarensis*** Heron-Allen and Earland	x 200
6	***Quinqueloculina cliarensis*** Heron-Allen and Earland, apertural view	x 350
7	***Quinqueloculina cliarensis*** Heron-Allen and Earland, side view	x 200
8	***Massilina secans*** (d'Orbigny)	x 35
9	***Massilina secans*** (d'Orbigny), juvenile exhibiting basal spine	x 75
10	***Massilina secans*** (d'Orbigny),sub-adult	x 75

Plate 15


1


2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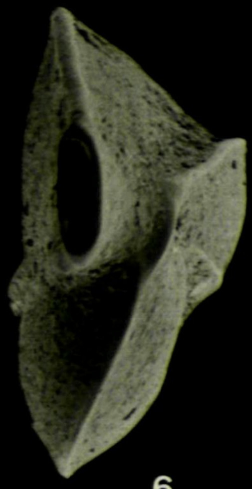
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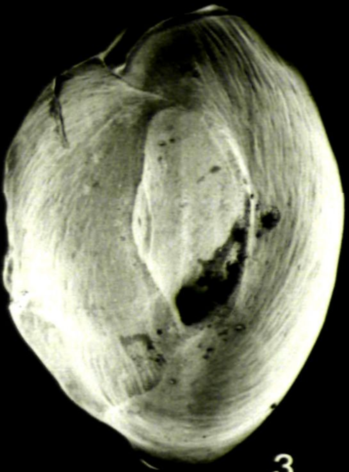
Plate 16

1	***Massilina secans*** (d'Orbigny), apertural view showing the compressed form of an adult specimen	x 50
2	***Massilina secans*** (d'Orbigny), detail of tooth	x 150
3	***Massilina secans*** (d'Orbigny) var. ***tenuistriata*** Earland	x 35
4	***Pyrgo depressa*** (d'Orbigny)	x 100
5	***Pyrgo depressa*** (d'Orbigny)	x 100
6	***Pyrgo depressa*** (d'Orbigny) side view	x 150
7	***Pyrgo williamsoni*** (Silvestri)	x 100
8	***Pyrgo williamsoni*** (Silvestri), apertural view	x 150

Plate 16


1


2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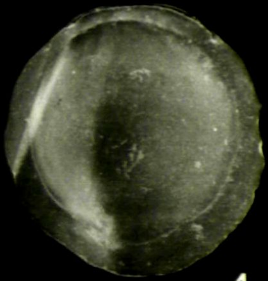
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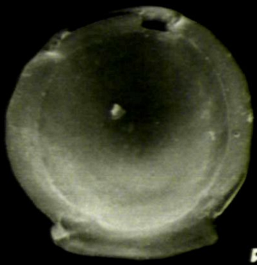
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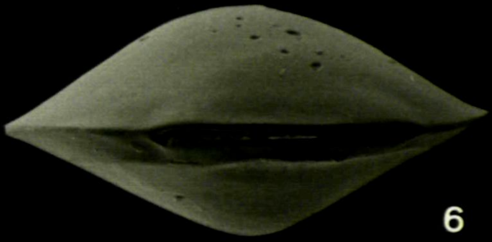
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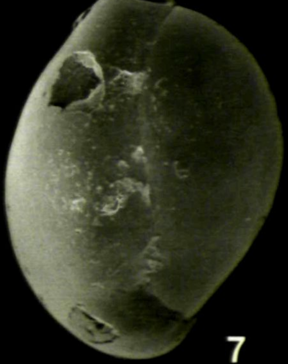
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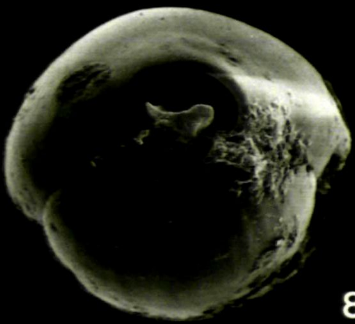
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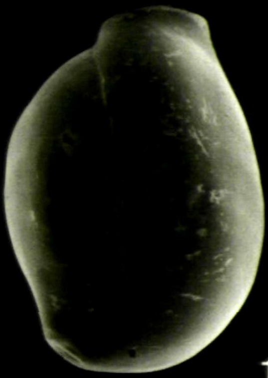
Plate 17

1	***Quinqueloculina*** sp. 5	x 150
2	***Quinqueloculina*** sp. 5, apertural view	x 100
3	***Quinqueloculina*** sp. 6, apertural view	x 100
4	***Quinqueloculina auberiana*** d'Orbigny	x 100
5	***Quinqueloculina auberiana*** d'Orbigny	x 100
6	***Quinqueloculina auberiana*** d'Orbigny, apertural view	x 150
7	***Miliolinella circularis*** (Borneman)	x 150
8	***Miliolinella circularis*** (Borneman), apertural view	x 200
9	***Miliolinella subrotunda*** (Montagu)	x 150
10	***Miliolinella subrotunda*** (Montagu), apertural view	x 150
11	***Pateoris hauerinoides*** (Rumbler)	x 100
12	?***Adelosina*** sp.	x 200
13	?***Adelosina*** sp., apertural view	x 250
14	?***Adelosina*** sp., detail of aperture showing bifid tooth	x 750

Plate 17



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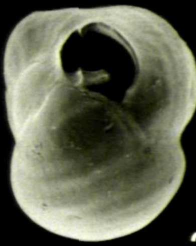

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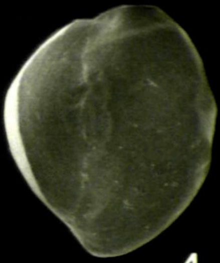

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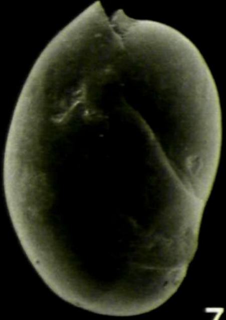

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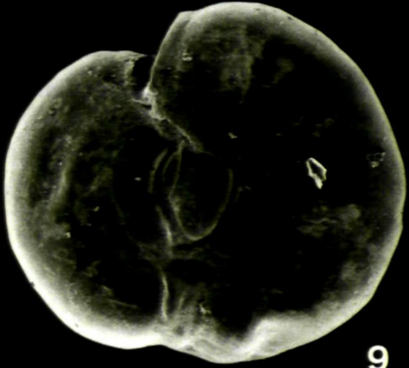

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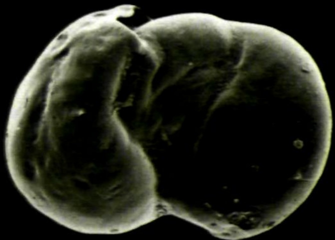

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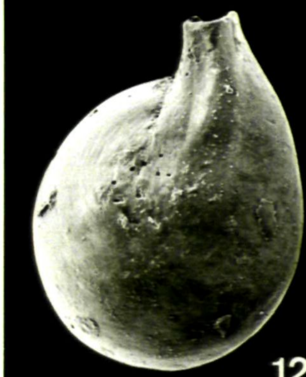

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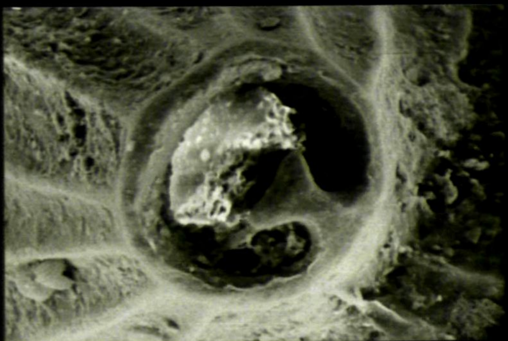

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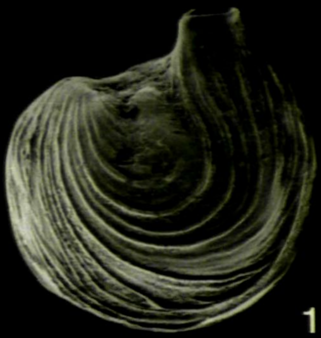
Plate 18

1	?***Adelosina*** sp., a sub-adult costate form,	x 100
2	?***Adelosina*** sp., keeled form	x 150
3	?***Adelosina*** sp., twinned form exhibiting an unusually elongate neck	x 200
4	?***Adelosina*** sp., detail of aperture	x1000
5	***Spiropthalmidium acutimargo*** Brady var. ***emaciatum*** Haynes	x 200
6	***Spiropthalmidium acutimargo*** Brady var. ***emaciatum*** Haynes, apertural view	x 350
7	***Amphicoryna*** cf. ***A. scalaris*** (Batsch)	x 350
8	***Amphicoryna*** cf. ***A. scalaris*** (Batsch)	x 200
9	***Amphicoryna*** cf. ***A. scalaris*** (Batsch), detail of aperture	x 2000
10	***Amphicoryna*** cf. ***A. scalaris*** (Batsch), last chamber deformed	x 200
11	***Astacolus crepidulus*** (Fichtel and Moll)	x 150
12	***Astacolus crepidulus*** (Fichtel and Moll), apertural view	x 200
13	***Astacolus crepidulus*** (Fichtel and Moll), detail of aperture	x 350

Plate 18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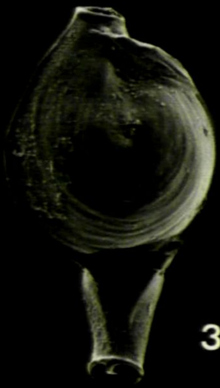
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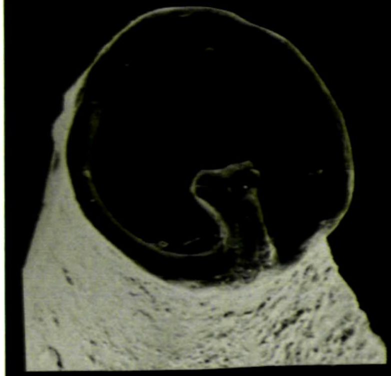
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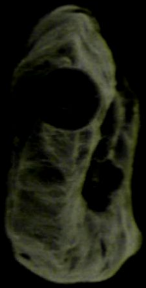
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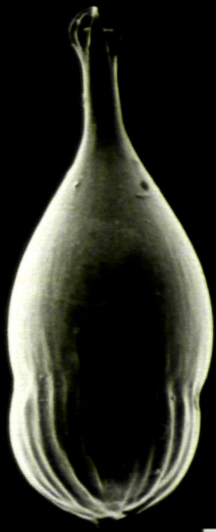
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Plate 19

1	***Dentalina*** cf. ***trondheimensis*** Feyling-Hanssen	x 100
2	***Dentalina*** sp. 1	x 100
3	**?** ***Dentalina*** sp. 2	x 100
4	**?** ***Dentalina*** sp. 2, detail of aperture	x 100
5	***Nodosaria pyrula*** d'Orbigny	x 75
6	***Nodosaria pyrula*** d'Orbigny, detail of aperture	x1500
7	***Nodosaria*** cf. ***N. pyrula*** d'Orbigny	x 150
8	***Nodosaria*** cf. ***N. pyrula*** d'Orbigny, view of aperture	x1000
9	***Lagena clavata*** (d'Orbigny)	x 350
10	***Lagena clavata*** (d'Orbigny), apertural view	x 350
11	***Lagena clavata*** (d'Orbigny)	x 200
12	***Lagena laevis*** (Montagu)	x 200
13	***Lagena laevis*** (Montagu), view of plications on neck	x1000
14	***Lagena gracilis*** Williamson	x 200

Plate 19

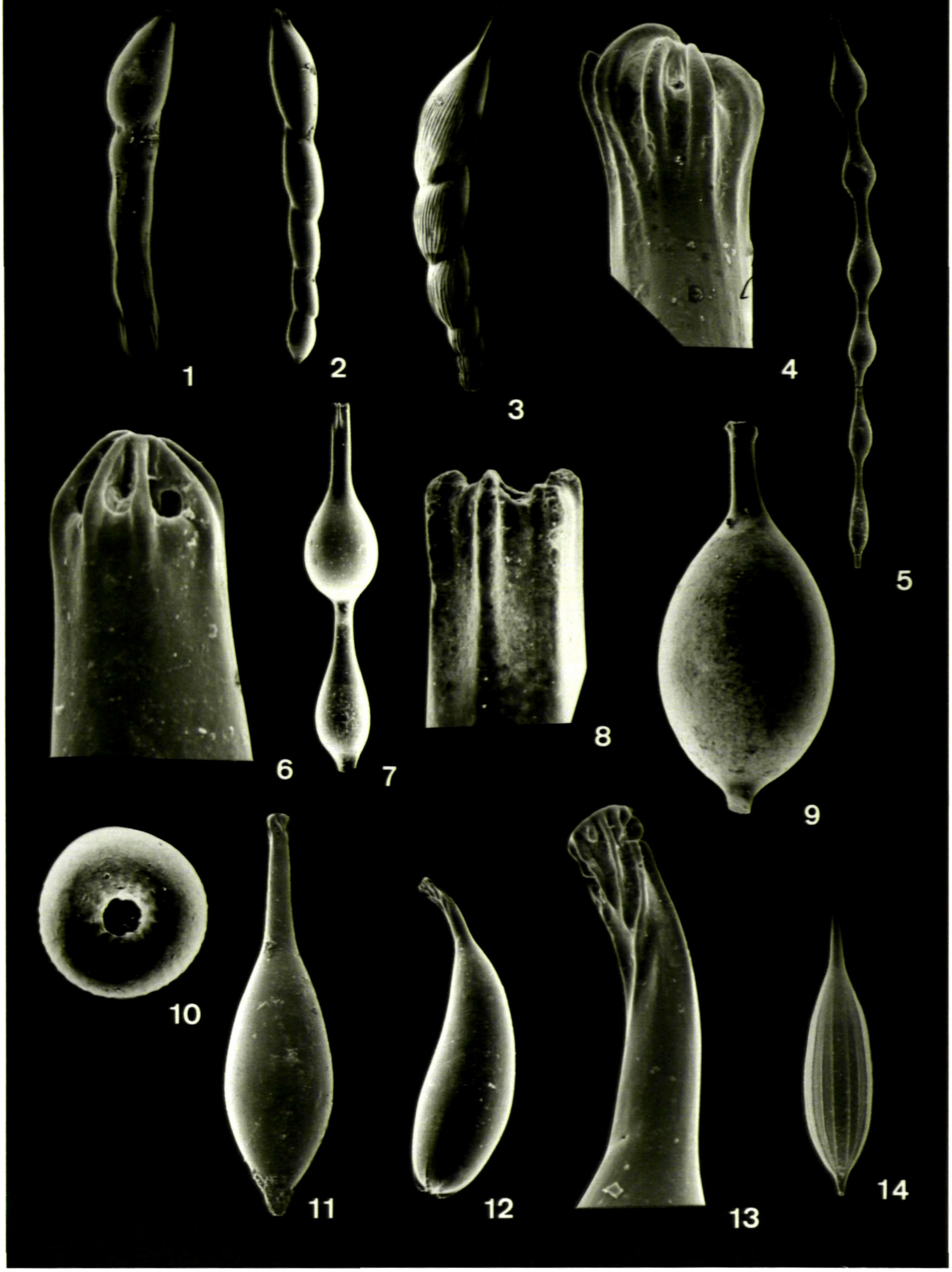


Plate 20

1	***Lagena lyellii*** (Sequenza)	x 200
2	***Lagena lyellii*** (Sequenza), detail of neck	x 750
3	***Lagena lyellii*** (Sequenza)	x 200
3a	***Lagena lyellii*** (Sequenza), detail of neck	x 750
4	***Lagena lyellii*** (Sequenza)	x 350
5	***Lagena lyellii*** (Sequenza), detail of neck	x1000
6	***Lagena perlucida*** (Montagu)	x 200
7	***Lagena perlucida*** (Montagu), detail of neck	x 350
8	***Lagena perlucida*** (Montagu), this specimen has an unusually elongate chamber	x 200
9	***Lagena perlucida*** (Montagu), apertural view	x 350
10	***Lagena semistriata*** Williamson	x 200
11	***Lagena semistriata*** Williamson, detail of neck	x 750
12	***Lagena substriata*** Williamson	x 200
13	***Lagena substriata*** Williamson, detail of neck	x 750

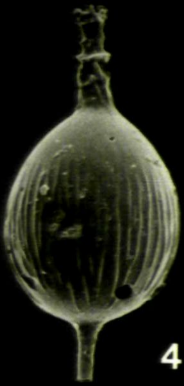
Plate 20


1


2


3


3A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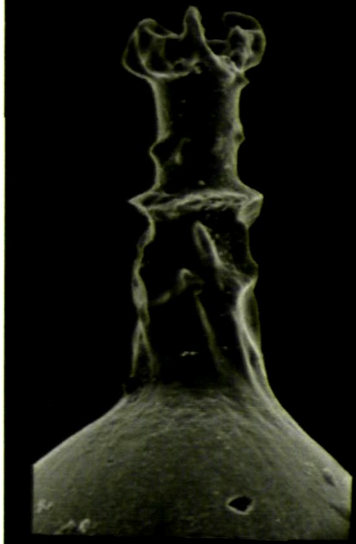
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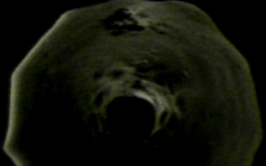
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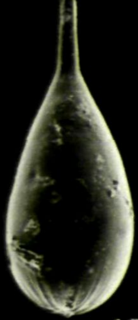
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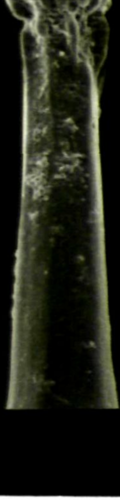
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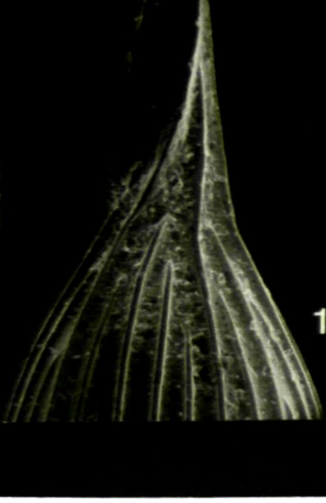
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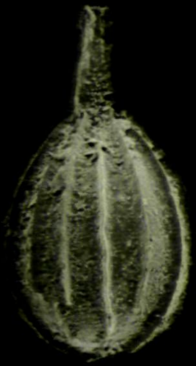
Plate 21

1	***Lagena sulcata*** (Walker and Jacob), exhibiting slight twisting of the neck	x 200
2	***Lagena sulcata*** (Walker and Jacob), showing an untwisted neck	x 150
3	***Lagena sulcata*** (Walker and Jacob), apertural view	x 200
4	***Lagena*** cf. ***L. vulgaris*** Williamson	x 350
5	***Lagena*** sp. 1	x 350
6	***Oolina hexagona*** (Williamson)	x 350
7	***Oolina hexagona*** (Williamson), view of aperture	x 500
8	***Oolina hexagona*** (Williamson)	x 200
9	***Oolina hexagona*** (Williamson)	x 350
10	***Oolina squamosa*** (Montagu), with broad and rounded raised network of ribs	x 350
11	***Oolina squamosa*** (Montagu), view of aperture	x 500
12	***Oolina squamosa*** (Montagu), longitudinal rigs joined by arching interconnections	x 200
13	***Oolina squamosa*** (Montagu), a slightly irregular form with very fine ornament	x 200

Plate 21


1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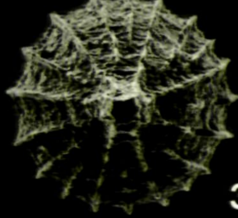
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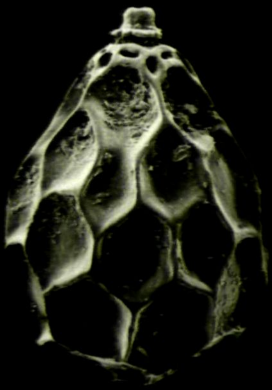
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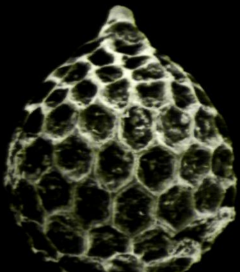
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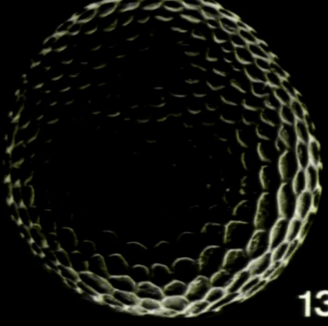
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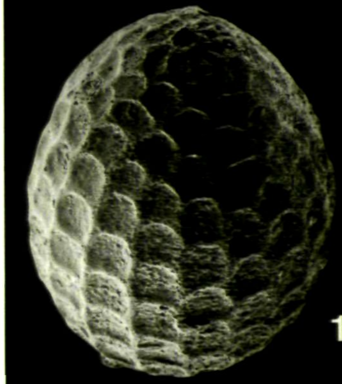
Plate 22

1	***Oolina melo*** d'Orbigny	x 350
2	***Oolina williamsoni*** (Alcock)	x 200
3	***Oolina williamsoni*** (Alcock), apertural view	x 350
4	***Fissurina lucida*** (Williamson)	x 350
5	***Fissurina lucida*** (Williamson), apertural view	x 350
6	***Fissurina lucida*** (Williamson), an unusually broad form with a smooth surface.	x 350
7	***Parafissurina malcolmsoni*** (Wright)	x 350
8	***Fissurina marginata*** (Montagu)	x 500
9	***Fissurina marginata*** (Montagu), apertural view	x 500
10	***Fissurina orbignyana*** Sequenza, side view	x 350
11	***Fissurina orbignyana*** Sequenza, apertural view	x 200
12	***Fissurina orbignyana*** Sequenza, apertural view	x 200
13	***Fissurina quadrata*** Williamson	x 350
14	***Fissurina*** sp. 1	x 500

Plate 22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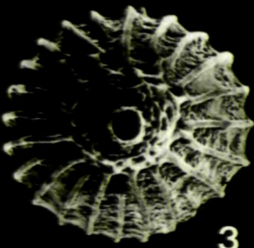
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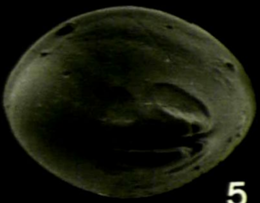
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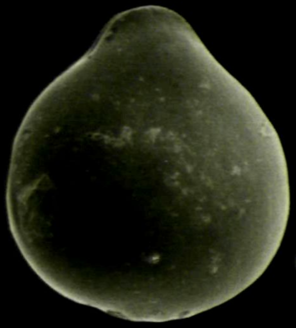
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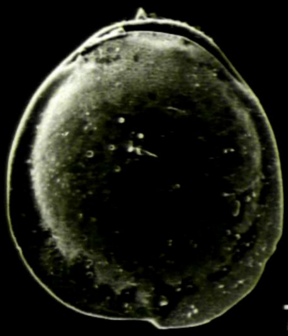
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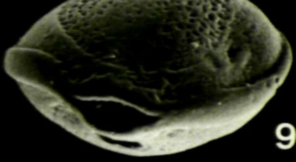
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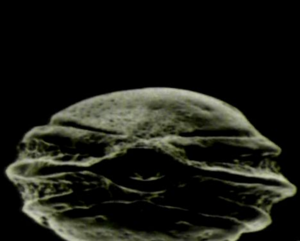
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Plate 23

1	***Globulina gibba*** d'Orbigny var. ***myristiformis*** (Williamson)	x 150
2	***Globulina gibba*** d'Orbigny var. ***myristiformis*** (Williamson) dorsal view	x 150
3	***Globulina gibba*** d'Orbigny var. ***myristiformis*** (Williamson) ventral view showing ring of circular openings	x 150
4	***Globulina gibba*** d'Orbigny var. ***myristiformis*** (Williamson) an aberrant specimen which is unusually long	x 200
5	***Globulina gibba*** d'Orbigny	x 150
6	***Globulina gibba*** d'Orbigny, view of aperture	x 500
7	***Globulina gibba*** d'Orbigny	x 150
8	***Globulina gibba*** d'Orbigny	x 150
9	***Globulina gibba*** d'Orbigny, sub-adult composed of two chambers	x 200
10	***Globulina gibba*** d'Orbigny, sub-adult composed of three chambers	x 200
11	***Bolivina pseudoplicata*** Heron-Allen and Earland	x 200
12	***Bolivina pseudoplicata*** Heron-Allen and Earland	x 200
13	***Brizalina spathulata*** (Williamson), exhibiting slight twisting	x 200
14	***Brizalina spathulata*** (Williamson), exhibiting a slightly serrated periphery	x 200
15	***Brizalina spathulata*** (Williamson)	x 200

Plate 23


1


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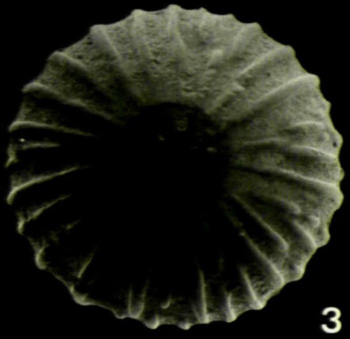
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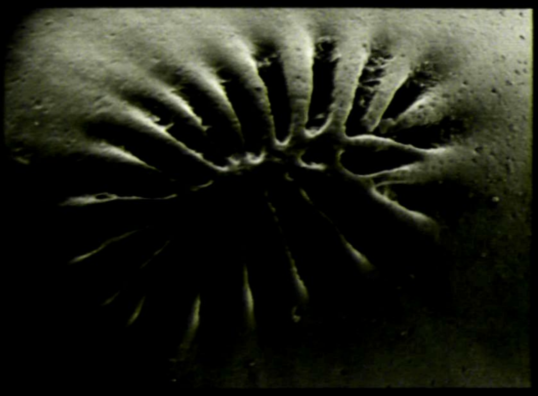
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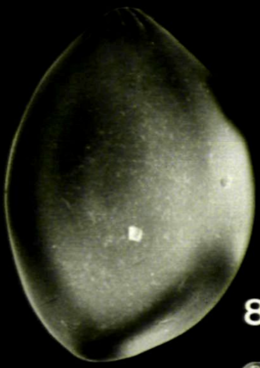
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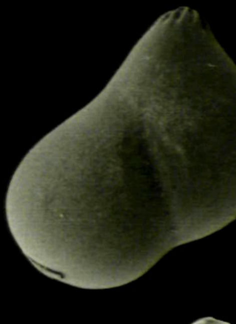
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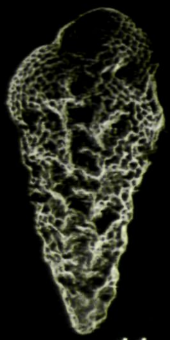
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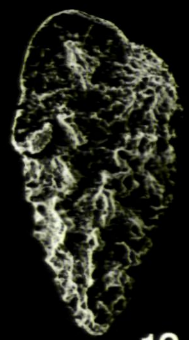
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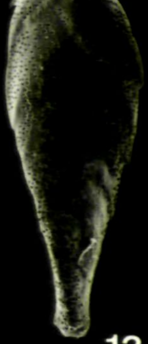
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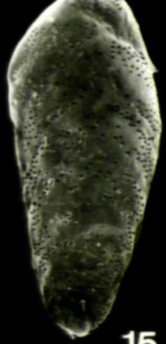
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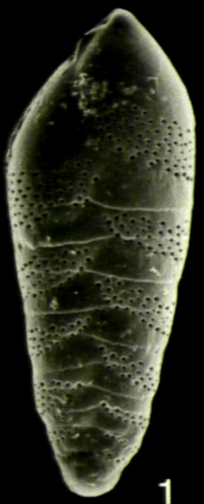
Plate 24

1	***Brizalina pseudopunctata*** Högland	x 200
2	***Brizalina striatula*** (Cushman)	x 200
3	***Brizalina subaenariensis*** (Cushman)	x 200
4	***Brizalina variabilis*** (Williamson)	x 250
5	***Brizalina variabilis*** (Williamson)	x 200
6	***Bulimina marginata*** d'Orbigny, slender specimen	x 150
7	***Bulimina marginata*** d'Orbigny, well inflated specimen	x 200
8	***Bulimina marginata*** d'Orbigny	x 150
9	***Bulimina marginata*** d'Orbigny, apertural view	x 150
10	***Bulimina*** sp.	x 200
11	***Bulimina gibba*** Fornasini	x 150
12	***Bulimina elongata*** d'Orbigny, typical form	x 150
13	***Bulimina elongata*** d'Orbigny, elongate form	x 200
14	***Bulimina elongata*** d'Orbigny, apertural view	x 350

Plate 24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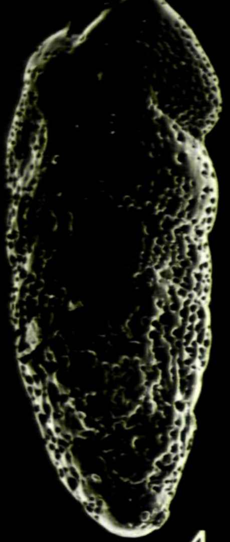
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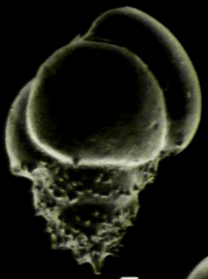
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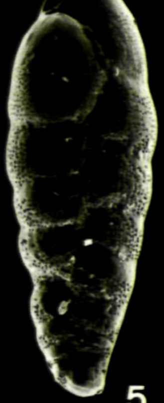
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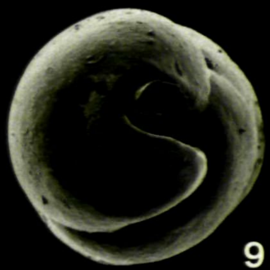
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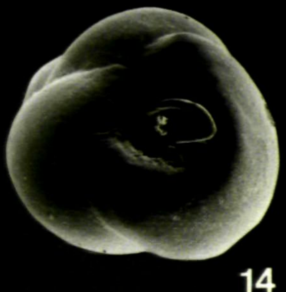
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Plate 25

1	***Stainforfia concava*** var. ***loeblichi*** (Feyling-Hanssen)	x 100
2	***Stainforfia concava*** var. ***loeblichi*** (Feyling-Hanssen)	x 100
3	***Stainforfia concava*** var. ***loeblichi*** (Feyling-Hanssen)	x 100
4	***Stainforfia concava*** var. ***loeblichi*** (Feyling-Hanssen)	x 100
5	***Uvigerina*** sp.	x 350
6	***Uvigerina*** sp.	x 350
7	***Trifarina angulosa*** (Williamson)	x 350
8	***Trifarina angulosa*** (Williamson), apertural view	x 500
9	***Rosalina*** cf. ***R. globularis*** d'Orbigny, dorsal view	x 100
10	***Rosalina*** cf. ***R. globularis*** d'Orbigny, ventral view	x 100
11	***Rosalina*** cf. ***R. globularis*** d'Orbigny, side view	x 100
12	***Rosalina anomala*** Terquem, dorsal view	x 100
13	***Rosalina anomala*** Terquem, side view	x 100
14	***Rosalina anomala*** Terquem, ventral view	x 100
15	***Rosalina williamsoni*** (Chapman and Parr), dorsal view	x 150

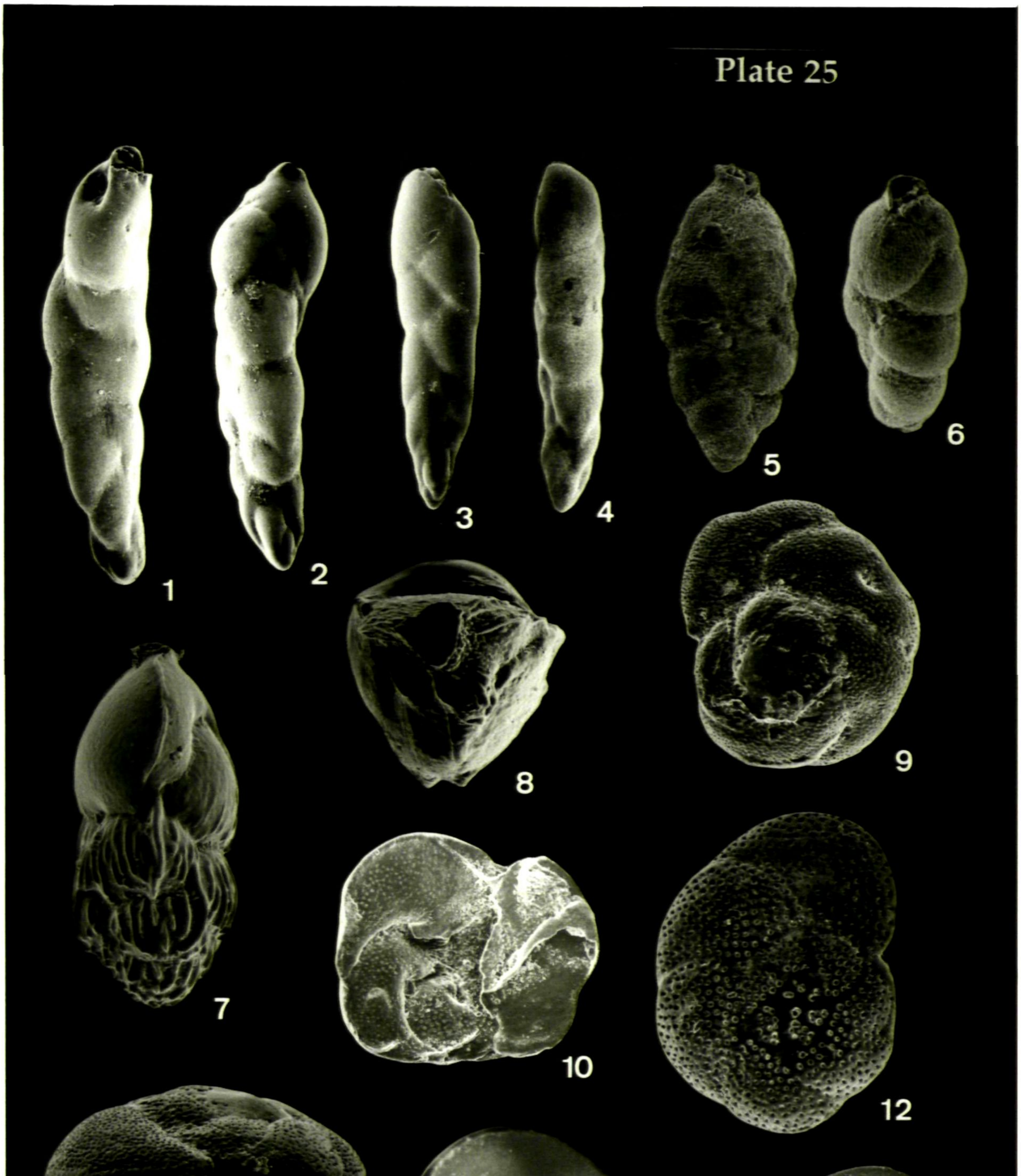
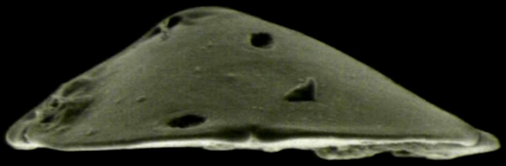


Plate 25

Plate 26

1	***Rosalina williamsoni*** (Chapman and Parr), side view	x 350
2	***Rosalina williamsoni*** (Chapman and Parr), ventral view	x 150
3	***Gavelinopsis praegeri*** (Heron-Allen and Earland), this specimen was live (stained) at the time of collection and is attached to a *Quinqueloculina* sp. test (Pl.15, Fig 1)	x 350
4	***Asterigerinata mamilla*** (Williamson)	x 150
5	***Asterigerinata mamilla*** (Williamson), ventral side showing aperture	x 200
6	***Asterigerinata mamilla*** (Williamson), side view showing aperture	x 150
7	***Lamarckina haliotidea*** Heron-Allen and Earland, dorsal view	x 350
8	***Lamarckina haliotidea*** Heron-Allen and Earland, ventral view	x 200
9	***Cibicides lobatulus*** (Walker and Jacob), a large specimen initially trochospiral (some chambers broken), later becoming irregular biserial and uniserial	x 75
10	***Cibicides lobatulus*** (Walker and Jacob), ventral side	x 100
11	***Cibicides*** cf. ***C. pseudoungerianus*** (Cushman)	x 150

Plate 26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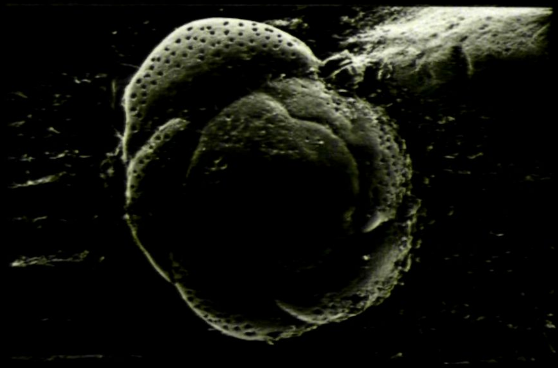
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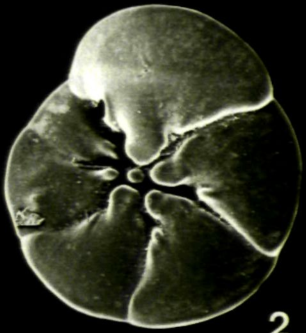
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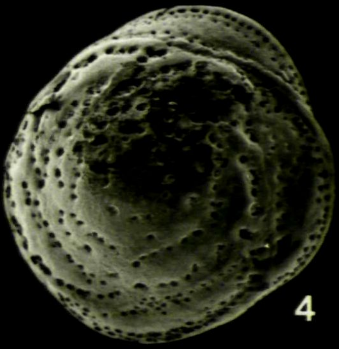
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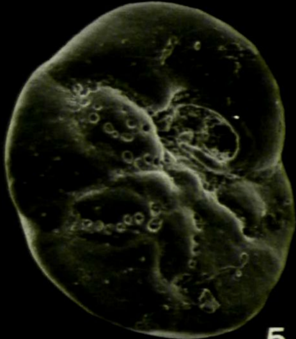
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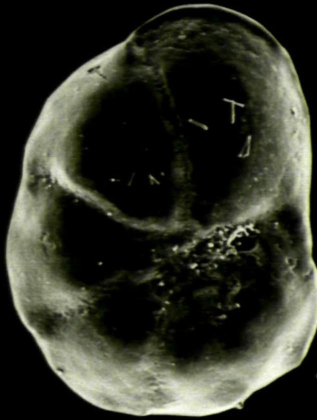
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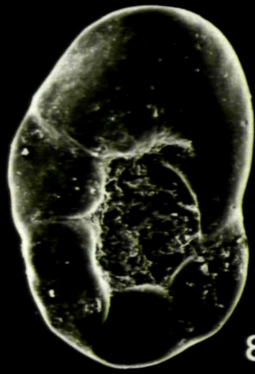
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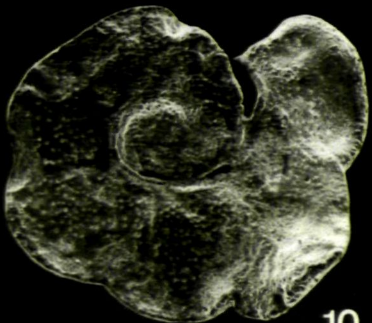
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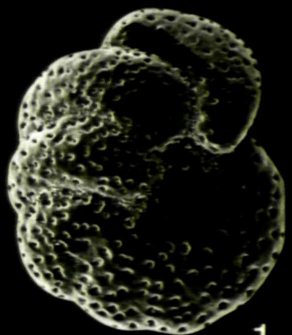
Plate 27

1	***Cibicides pseudoungerianus*** (Cushman)	x 200
2	***Acervulina inhaerens*** Schultze, dorsal side	x 75
3	***Acervulina inhaerens*** Schultze, ventral side	x 50
4	***Planorbulina mediterranensis*** d'Orbigny, dorsal side	x 100
5	***Planorbulina mediterranensis*** d'Orbigny, ventral side	x 100
6	***Acervulina inhaerens*** Schultze, encrusting a bryozoa stem	x 50
7	***Spirillina*** cf. ***vivipara*** Ehrenberg	x 200
8	***Spirillina*** cf. ***vivipara*** Ehrenberg, oblique view show low trochospiral coiling	x 200
9	***Spirillina*** cf. ***vivipara*** Ehrenberg, side view showing low trochospiral coiling	x 200
10	***Spirillina wrightii*** Heron-Allen and Earland	x 150
11	***Patellina corrugata*** Williamson	x 200
12	***Patellina corrugata*** Williamson	x 350
13	***Patellina*** cf. ***P. corrugata*** Williamson	x 200

Plate 27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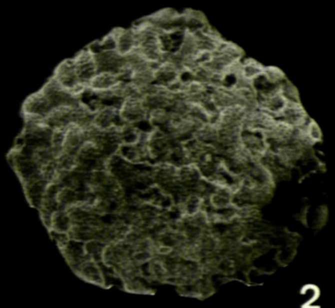
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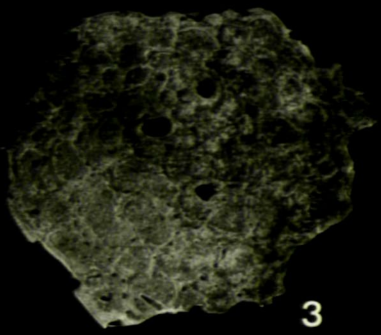
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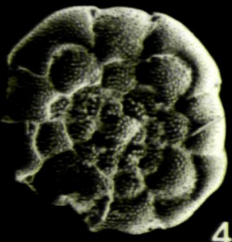
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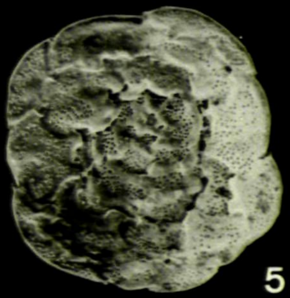
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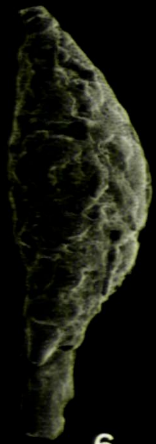
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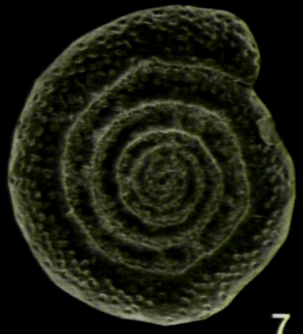
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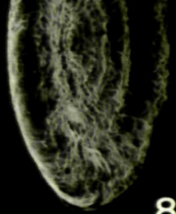
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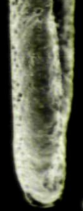
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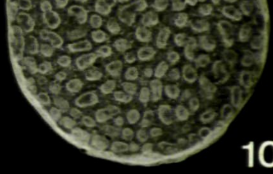
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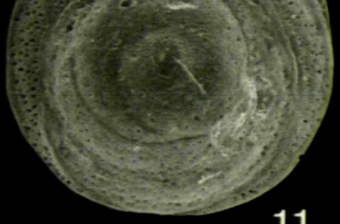
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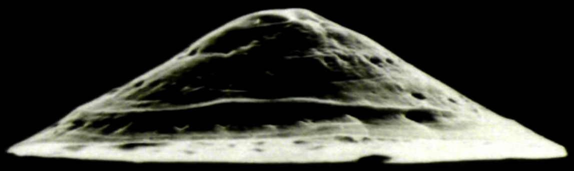
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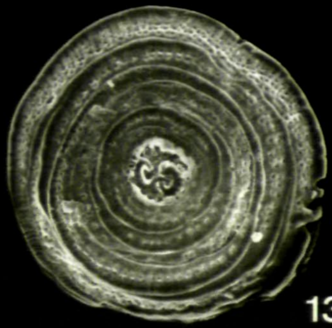
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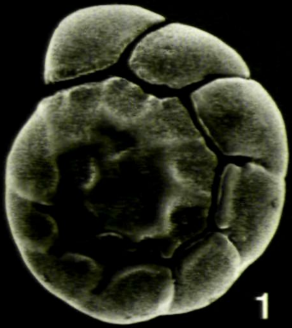
Plate 28

1	***Ammonia beccarii*** (Linné) var. ***batavus*** Hofker	x 100
2	***Ammonia beccarii*** (Linné) var. ***batavus*** Hofker	x 150
3	***Ammonia beccarii*** (Linné) cf. ***A. b***. var. ***batavus*** Hofker	x 100
4	***Ammonia beccarii*** (Linné) cf. ***A. b.*** var. ***batavus*** Hofker	x 100
5	***Ammonia beccarii*** (Linné) cf. ***A. b.*** var. ***limnetes*** Todd and Brönnimann	x 100
6	***Ammonia beccarii*** (Linné) cf. ***A. b.*** var. ***limnetes*** Todd and Brönnimann	x 100
7	***Ammonia beccarii*** (Linné) var. ***limnetes*** Todd and Brönnimann	x 200
8	***Ammonia beccarii*** (Linné) var. ***limnetes*** Todd and Brönnimann	x 150
9	***Ammonia beccarii*** (Linné) var. ***limnetes*** Todd and Brönnimann	x 150
10	***Ammonia beccarii*** (Linné) cf. ***A. b.*** var. ***limnetes*** Todd and Brönnimann	x 100
11	***Ammonia beccarii*** (Linné) cf. ***A. b***. var. ***limnetes*** ? Todd and Brönnimann	x 200
12	***Ammonia beccarii*** (Linné) cf. ***A. b***. var. ***limnetes*** ? Todd and Brönnimann	x200

Plate 28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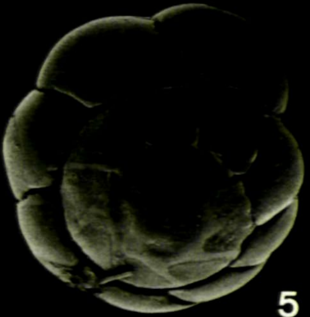
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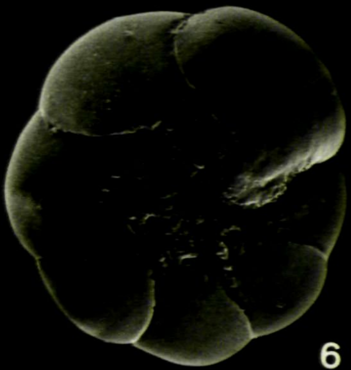
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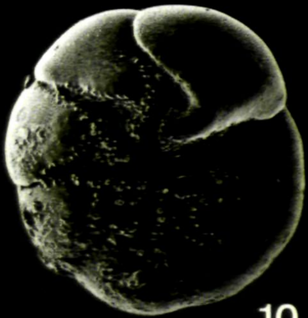
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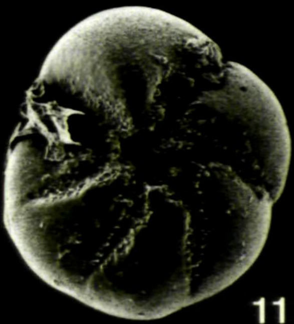
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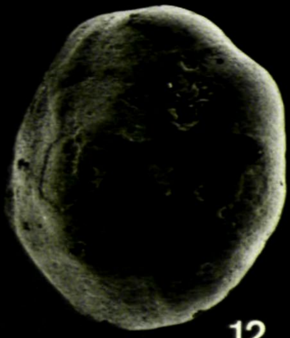
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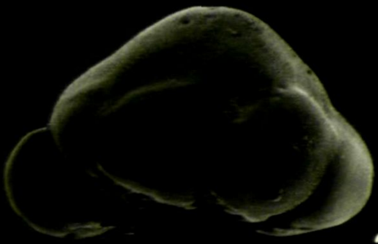
Plate 29

1	***Ammonia beccarii*** (Linné) var. ***batavus*** Hofker, side view of a typical specimen	x 150
2	***Ammonia beccarii*** (Linné) var. ***batavus*** Hofker, side view of an unusually high trochospire	x 200
3	***Ammonia beccarii*** (Linné) var. ***batavus*** Hofker exhibiting test dissolution except for the terminal chamber which was stained red	x 150
4	***Elphidium cuvillieri*** Lévy	x 150
5	***Elphidium cuvillieri*** Lévy, side view	x 200
6	***Elphidium crispum*** (Linné), bearing a turbelarian egg case	x 75
7	***Elphidium crispum*** (Linné)	x 75
8	***Elphidium macellum*** (Fichtel and Moll)	x 200
9	***Elphidium earlandi*** Cushman	x 200
10	***Elphidium earlandi*** Cushman, side view	x 200
11	***Elphidium exoticum /gerthi*** Haynes	x 200
12	***Elphidium exoticum /gerthi*** Haynes	x 150

Plate 29


1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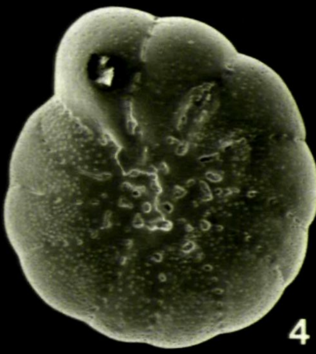
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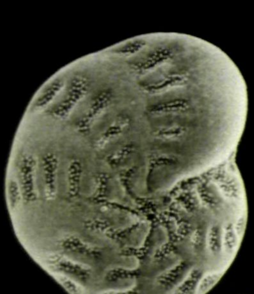
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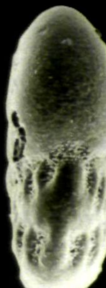
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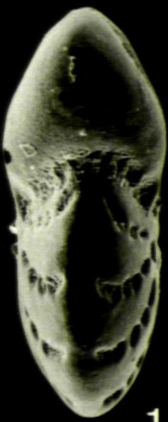
Plate 30

1	***Elphidium exoticum /gerthi*** Haynes, side view	x 200
2	***Elphidium margaritaceum*** Cushman	x 200
3	***Elphidium margaritaceum*** Cushman	x 200
4	***Elphidium margaritaceum*** Cushman	x 200
5	***Elphidium williamsoni*** Haynes	x 150
6	***Elphidium williamsoni*** Haynes, side view	x 150
7	***Haynesina germanica*** (Ehrenberg), bearing a turbelarian egg case	x 150
8	***Haynesina germanica*** (Ehrenberg), side view	x 200
9	***Nonion depressulus*** (Walker and Jacob)	x 200
10	***Nonion depressulus*** (Walker and Jacob), side view	x 350
11	***Nonionella*** sp. 1	x 200
12	***Nonionella*** sp. 1, side view	x 150

Plate 30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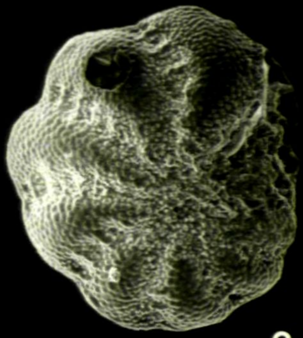
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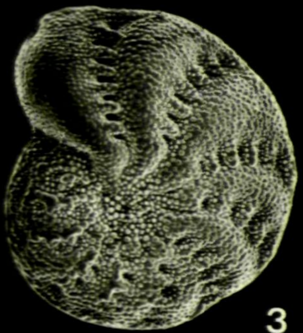
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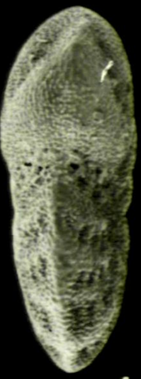
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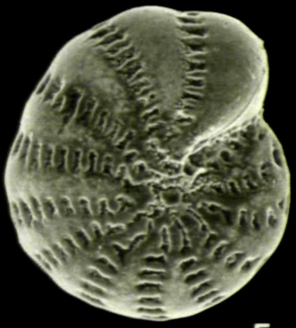
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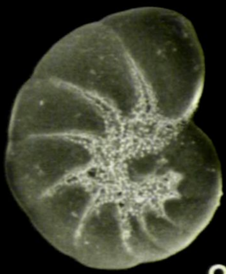
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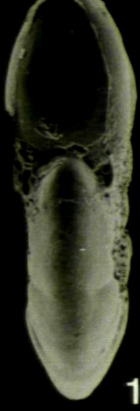
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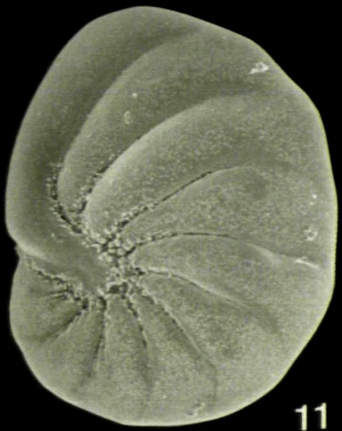
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Plate 31

1	***Nonionella turgida*** (Williamson) var. ***digitata*** Nørvang, ventral side	x 350
2	***Nonionella turgida*** (Williamson) var. ***digitata*** Nørvang, side view	x 350
3	***Nonionella turgida*** (Williamson) var. ***digitata*** Nørvang, dorsal side	x 350
4	***Fursenkoina fusiformis*** (Williamson)	x 150
5	***Pseudopolymorphina*** cf. ***P. novangliae*** Cushman	x 150
6	***Lenticulina*** sp.	x 200
7	***Lenticulina*** sp., side view	x 200
8	***Lenticulina crepidula*** (Fichtel and Moll)	x 100
9	***Laryngosigma lactea*** var. ***concava*** Williamson	x 200
10	***Laryngosigma lactea*** var. ***concava*** Williamson, detail of aperture	x1000

Plate 31


1


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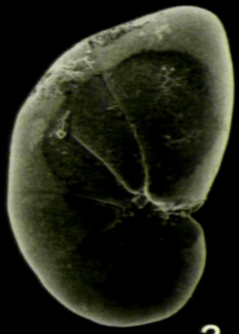
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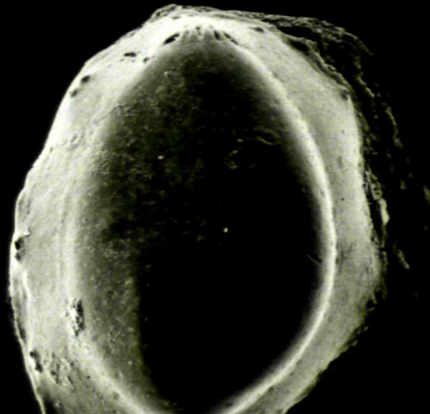
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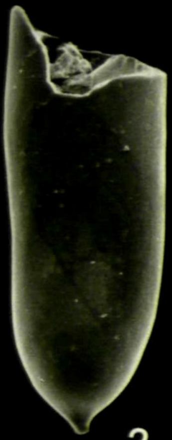
Plate 32

1	***Vaginulina*** sp.		x 35
2	***Vaginulina*** sp.		x 50
3	***Lenticulina orbiculatis*** (d'Orbigny)		x 150
4	***Lenticulina orbicularis*** (d'Orbigny), side view showing multiple slit-like apertures of a juvenile specimen		x 200
5	***Lenticulina orbicularis*** (d'Orbigny), side view showing sieve-like aperture of an adult specimen		x 200
6	***Lenticulina orbicularis*** (d'Orbigny), side view showing single slit-like aperture of juvenile specimen		x 200
7	***Siphogenerinoides* sp.**		x 150
8	***Siphogenerinoides* sp.**		x 150
9	***Siphogenerinoides* sp.**		x 200
10	***Siphogenerinoides* sp.**	an aberrant specimen	x 150
11	***Siphogenerinoides* sp.**	detail of wall	x 350
12	***Siphogenerinoides* sp.**	apertural view	x 150
13	***Siphogenerinoides* sp.**	detail of aperture	x 150

Plate 32


1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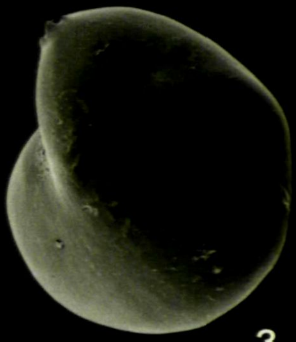
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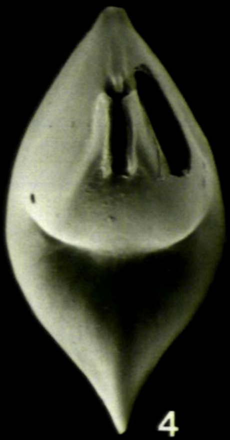
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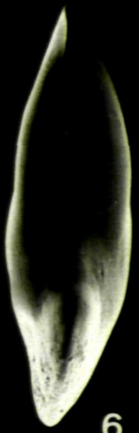
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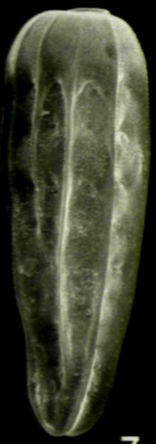
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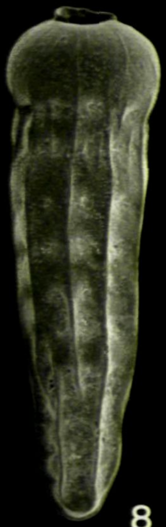
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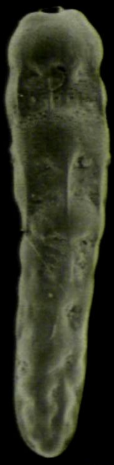
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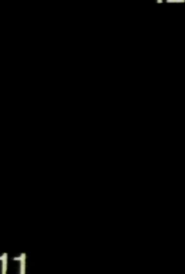
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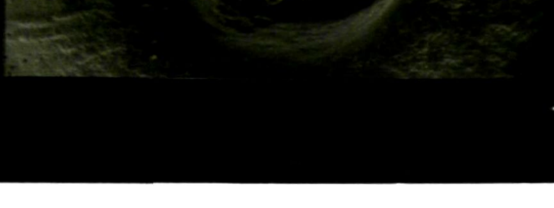
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Plate 33

Common deformities of aberrant specimens.

1 ***Eggerelloides scaber*** (Williamson), exhibiting a marked change in the direction of growth x 150

2 ***Eggerelloides scaber*** (Williamson), exhibiting a marked change in the direction of growth x 150

3 ***Eggerelloides scaber*** (Williamson), twinned specimen x 150

4 ***Quinqueloculina*** sp. the ultimate chamber is twinned x 75

5 ***Quinqueloculina cliarensis*** (Heron-Allen and Earland), twin composed of the ultimate and penultimate chambers x 100

6 ***Quinqueloculina seminulum*** (Linné), test exhibiting borings of unknown origin x 350

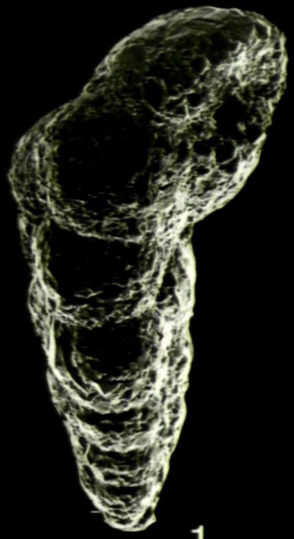
7 ***Amphicoryna scalaris*** (Batsch) & ***Lagena sulcata*** (Walker and Jacob) The specimens were firmly attached together, the protoplasm at the base of the *Lagena* and in the neck and ultimate chamber of the *Amphicoryna* were brightly stained (live), this may represent a possible predatory situation. x 150

8 ***Bulimina elongata*** d'Orbigny, exhibiting a period of single growth before becoming twinned. x 100

9 ***Bulimina elongata*** d'Orbigny, showing an inflection in test growth direction x 100

10 ***Bulimina elongata*** d'Orbigny, unusually elongate test composed of a very high number of chambers x 75

Plate 33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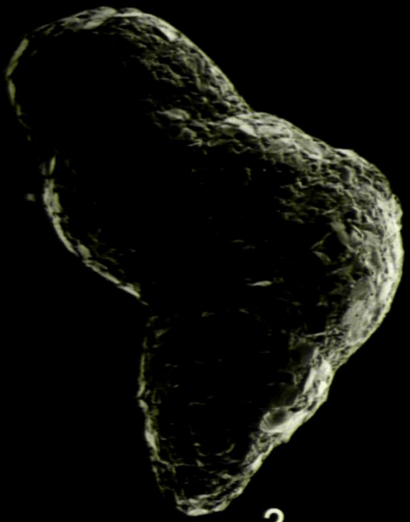
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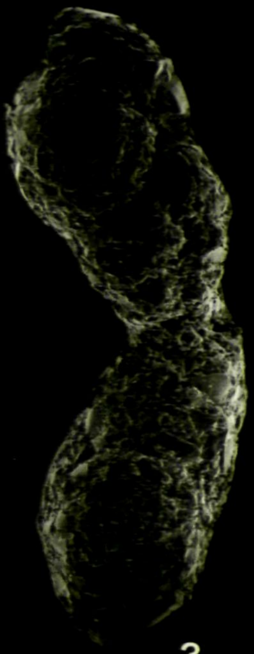
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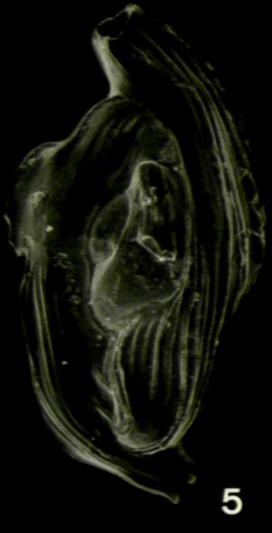
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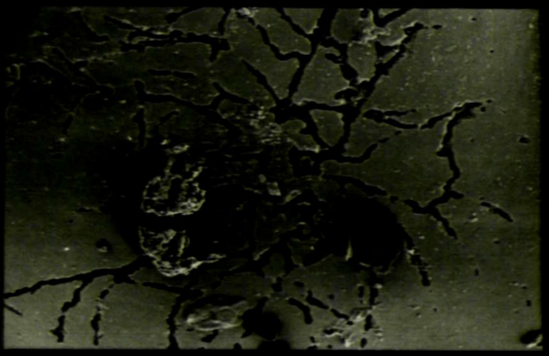
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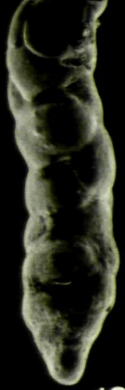
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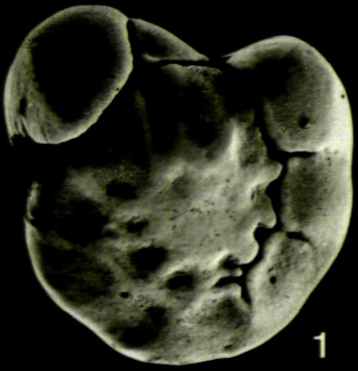
Plate 34

Common deformities of aberrant specimens

1	***Ammonia beccarii*** (Linné), aberrant penultimate chamber	x 150
2	***Ammonia beccarii*** (Linné), aberrant additional chamber on ventral side of final whorl.	x 100
3	***Ammonia beccarii*** (Linné), aberrant plane of coiling	x 150
4	***Ammonia beccarii*** (Linné), aberrant plane of coiling	x 200
5	***Elphidium crispum*** (Linné), twinned form	x 75
6	***Elphidium crispum*** (Linné), twinned form	x 75
7	***Elphidium crispum*** (Linné), twinned form	x 75
8	***Elphidium crispum*** (Linné)	x 75
9	***Elphidium crispum*** (Linné)	x 50
10	***Elphidium crispum*** (Linné)	x 150
11	***Elphidium crispum*** (Linné), notched periphery reflects changes in growth rates	x 50

Plate 34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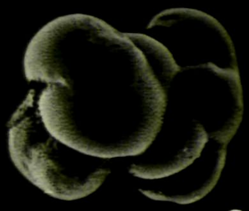
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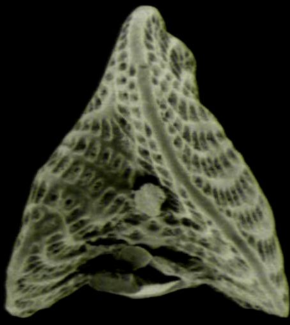
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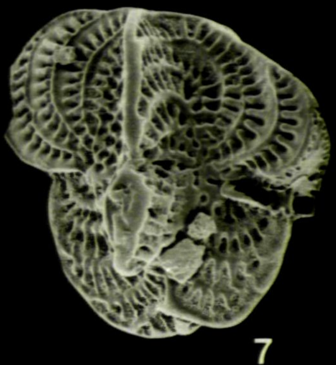
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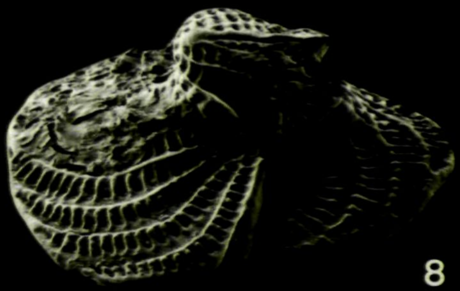
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Plate 35

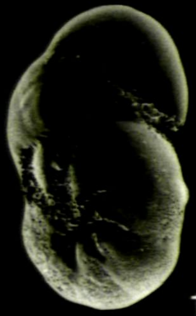
Common deformities of aberrant specimens

1	***Haynesina germanica*** (Ehrenberg), aberrant last chambers	x 150
2	***Haynesina germanica*** (Ehrenberg), change in coiling direction	x 150
3	***Haynesina germanica*** (Ehrenberg), change in coiling direction and an aberrant early chamber	x 150
4	***Haynesina germanica*** (Ehrenberg), an aberrant ultimate chamber	x 150
5	***Elphidium williamsoni*** Haynes, last two chambers are well inflated and poorly ornamented with a loss of retral processes and fossettes	x 150
6	***Elphidium williamsoni*** Haynes, a sharp inflection of the suture around a deformed area of test, this may represent a previous injury	x 150
7	***Elphidium williamsoni*** Haynes, detail of the above described feature	x 350
8	***Lenticulina orbiculatis*** Heron-Allen and Earland, the last two chambers seem to have initially been attached as part of a planispire but have subsequently detached	x 100

Thecomoebians

9	***Arcella*** Ehrenberg	x 200
10	***Pontigulasia*** Rhumbler	x 200

Plate 35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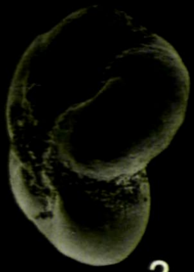
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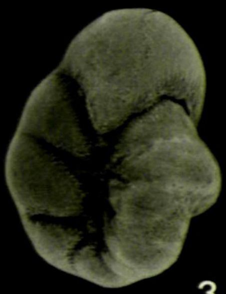
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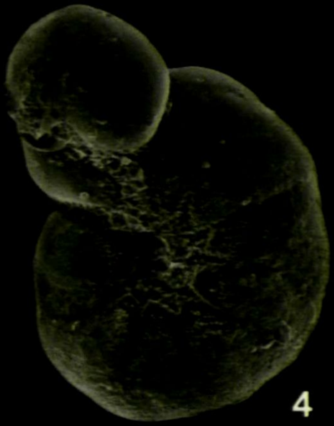
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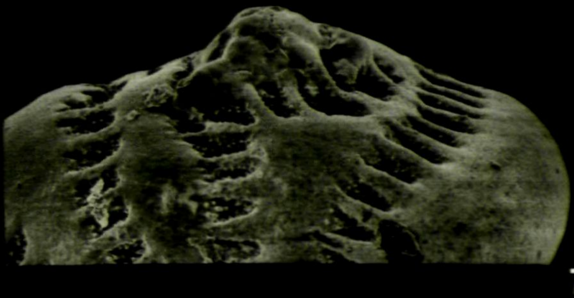
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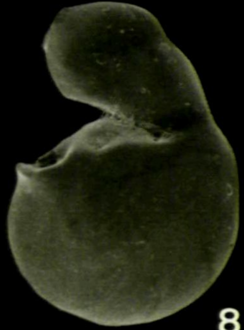
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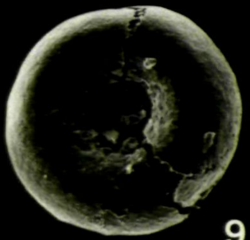
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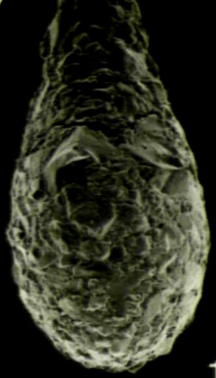
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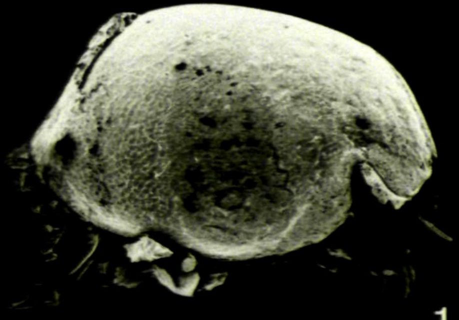
Plate 36

Ostracoda

1	*Cypridina* sp.	x 75
2	***Loxoconcha rhomboidea*** (Fischer)	x 100
3	***Loxoconcha rhomboidea*** (Fischer)	x 100
4	***Loxoconcha rhomboidea*** (Fischer), Male valve	x 200
5	***Costa runcinata*** (Baird)	x 100
6	***Costa runcinata*** (Baird)	x 100
7	***Costa runcinata*** (Baird)	x 100
8	***Semicytherura acuticostata*** (Sars)	x 150
9	***Semicytherura acuticostata*** (Sars)	x 150
10	***Semicytherura*** sp.	x 100

Plate 36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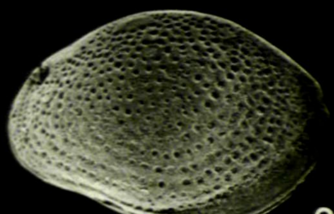
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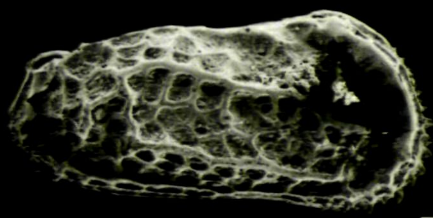
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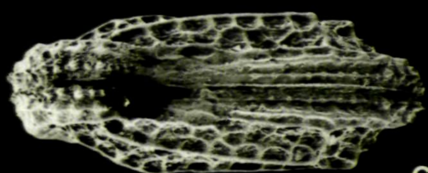
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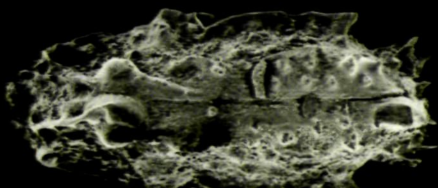
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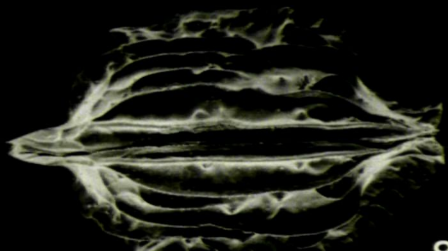
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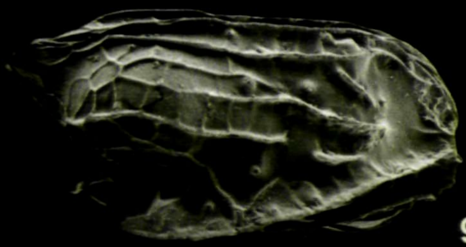
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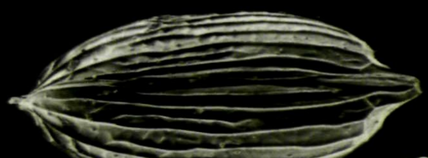
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Plate 37

Crustacea

1 **Copepod** x 150

2 **Isopod** x 35

3 **Sea spider** x 50

Polycheata

4 **Worm tube sp. 1**, this species constructed almost entirely from shell fragments was rare occurring only in sandy facies x 35

5 **Worm tube sp. 2**, a species constructed of very fine sand , generally uncommon occurring in sandy or silty substrates x 50

6 **Worm tube sp. 3**, very common in silty substrates, varying greatly in particle size of grains used, often very fine grained with occasional coarse fragments, this specimen is relatively coarse grained and has utilised various shell material in its construction, clearly visible are the tests of *Q. seminulum* (centre) and *E. crispum* (left). x 35

7 **Worm tube sp. 5**, planispirally coiled, free living form x 100

8 **Worm tube sp. 4**, a species associated with hard surfaces, this specimen is attached to a bryozoa stem x 100

Others

9 **Sponge spicule ?** x 200

10 **Sponge spicule,** trilete form x 75

Plate 37


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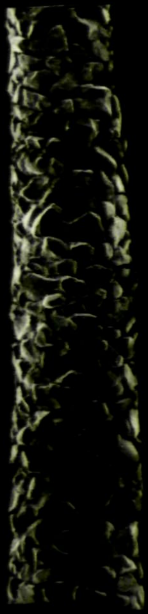
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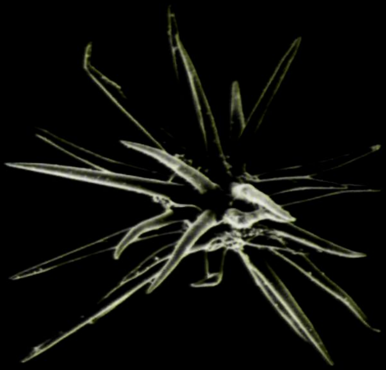
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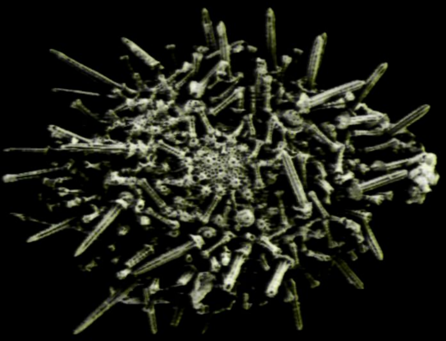
10

Plate 38

1	**micro-echinoid**	x 50
2	**micro-echinoid**	x 200
3	**Ophiuroid ?**	x 150
4	**Ophiuroid ?**, detail of appendages	x 500
5	**Bryozoa - *Cellaria* sp**	x 100
6	**Bryozoa - *Crisia* sp**	x 75
7	**Bryozoa - *Crisia* sp**, exhibiting a brood chamber	x 75
8	**Scale ?** of unknown affinity, the attachment point appears to be an rough round area at the top of the specimen	x 200

Plate 38



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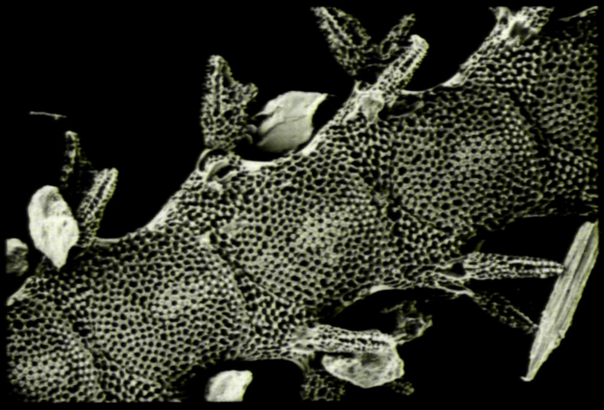

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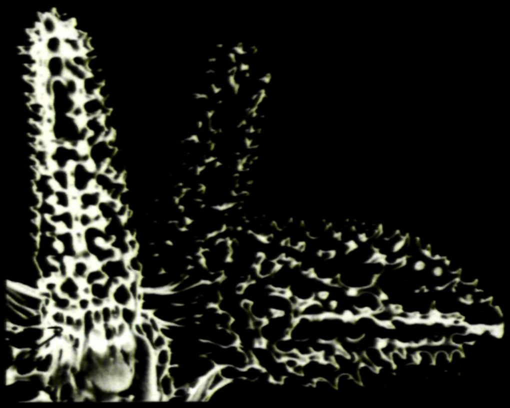

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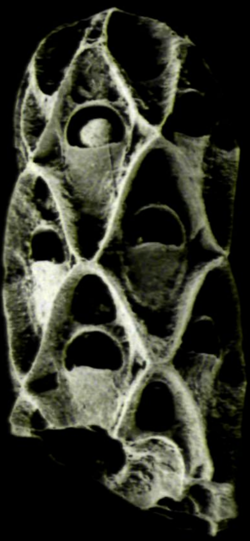

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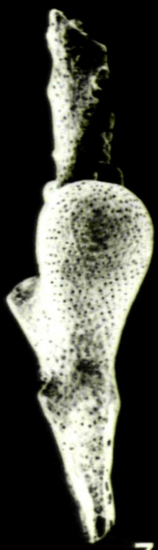

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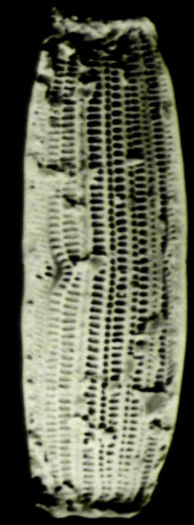
Plate 39

1	**Bivalve** sp. exclusively found within shell gravels, small (never exceeding 5 mm length), often taking a good stain of Rose Bengal, the specimens of this species are characterised by small protruding spines at the extremities of the valves, which suggests that they are positioned within the sediment as figured, the spines acting as hold-fasts. This individual exhibits a large round boring probably due to gastropod predation	x 75
3	**Gastropod** containing *Quinqueloculina seminulum* within its aperture	x 50
3	**Diatom**, originally attached to siliceous spherules (Fig. 6)	x2000
4	**Coccoliths**, utilised in the construction of an agglutinated foraminifera (Plate 1 Figs 9-10)	x5000
5	**Jaw? like structure** perhaps of polychaete origin?	x 150
6	**Siliceous blob,** several different forms were common at most stations, they ranged in shape from perfectly spherical (sometimes twinned) to irregular, and in colour from white, to orange to mottled black/grey and white. The specimen figured is slightly irregular, mottled grey and damaged revealing its vesicular nature. Possibly fly ash ?	x 150
7	**Concentrically ringed disc** of unknown affinity, consistently encountered, always stained vivid red with Rose Bengal	x 100

Plate 39


1


2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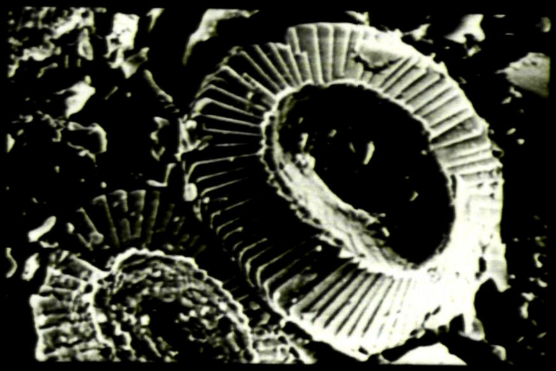
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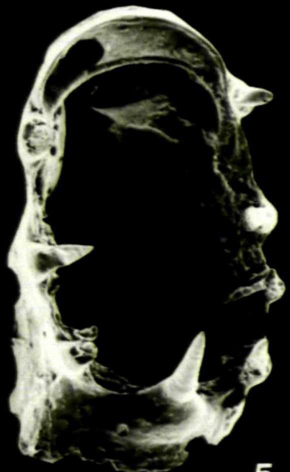
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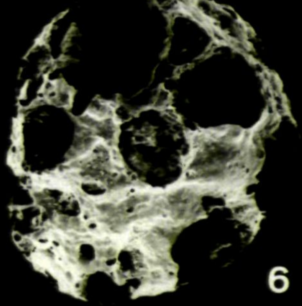
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A TIME-SERIES STUDY OF FORAMINIFERAL ASSEMBLAGES OF THE PLYM ESTUARY, SOUTH-WEST ENGLAND

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Monthly samples retrieved from the previously unstudied Plym Estuary, from January 1994 to November 1994, were analysed for living and dead Foraminifera. An assemblage composed of three hyaline species; *Haynesina germanica, Elphidium williamsoni* and *Ammonia beccarii* var. *batavus,* was identified. Further samples were taken to assess depth distribution, microdistribution and lateral distribution, to compliment the original sample suite. A comparison of the dead assemblage to the live assemblage revealed similar species proportions in both assemblages, reduced test abundance in the dead assemblage, and the presence of rare estuarine and marine species in the dead assemblage. This study has revealed a complex interplay of species resulting in several foraminiferal blooms throughout the year; the largest occurring in May.

INTRODUCTION

The Plym Estuary (Figure 1), is a relatively small shallow estuary whose low tidal power (Fitzpatrick, personal communication), results in partial segregation of water masses north of the Laira Bridge. According to Dyer (1979) the estuary may be classified as microtidal. Its maximum and minimum recorded inflows of 31·01 $m^3 s^{-1}$ and 0·12 $m^3 s^{-1}$ respectively (South West Water Authority, Public Records, 1979), imply that at high tide, salinities are only slightly brackish (salinities of 34‰ being common). The presence of the common British upper-middle shoreface seaweed, *Ascophyllum nodosum,* attached to rocks in the high water zone, indicates near normal marine salinities at high tide.

The purpose of this study was to reveal the living and dead foraminiferal assemblages of the Plym Estuary and to understand the taphonomic processes which may be acting on the foraminiferal tests.

MATERIALS AND METHODS

Three stations in the Plym Estuary, all on the eastern side, between Saltram Point and the Laira Bridge, were initially sampled on the 21 June 1993 (Figure1). Stations 1 and 2 are located by Saltram point, station 3 is located 400 m north of the Laira Bridge. Only station 3 was sampled every month for 11 months (1994). In addition a transect of the estuary was sampled near station 3, and three other locations within the estuary sampled.

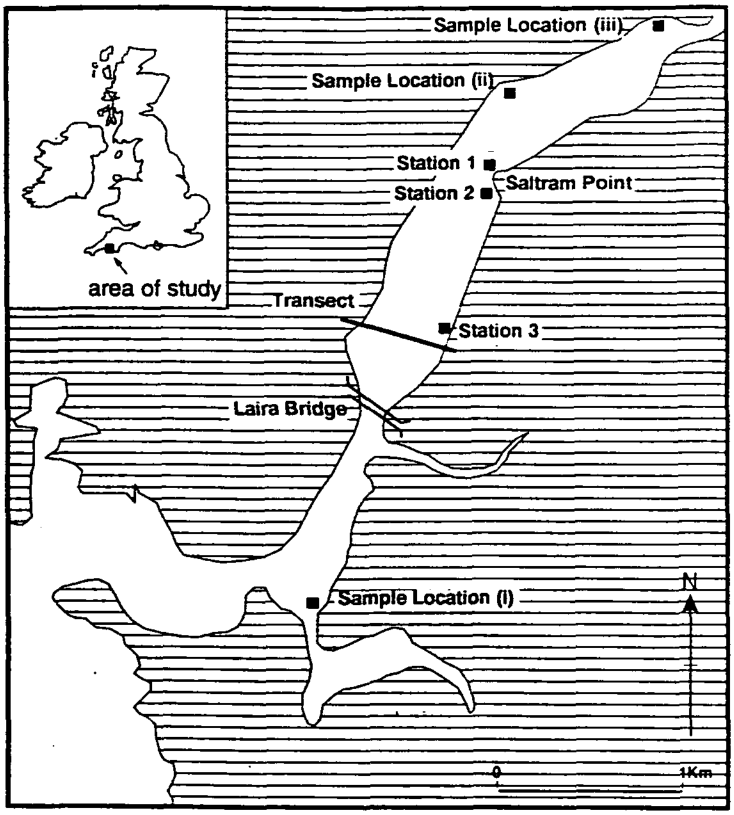

Figure 1. Location of sample sites within the Plym Estuary, Plymouth, south-west England.

Samples were obtained from the top 1 cm of sediment to a fixed volume of 100-cm^3. The recovered samples were wet-sieved over a 63-µm mesh to remove the clay fraction, and were stained with rose Bengal (Walton, 1952) for half an hour. The staining agent was then rinsed out on a 63-µm sieve and the sample dried in an oven at 60°C. The samples were floated in carbon tetrachloride to separate the Foraminifera from sediment. All Foraminifera which were stained vivid red in the ultimate or penultimate chambers were assumed to have been living at the time of collection, and were picked out and mounted onto microfossil slides. Foraminifera stained partially or totally pink were discarded, as this may be bacterial contamination, or represent recently dead membrane and/or cytoplasm The empty tests (unstained and thus assumed to be dead) were abundant in the sediment and 300 were picked out from each sample. The empty tests represent the dead assemblage, which may differ from the living assemblages through processes of postmortem alteration, discussed later.

Annual production was calculated (Table 1) using the following method:

$$N_{i+1} = N_i + B - D \qquad (1)$$

production = sum of values from the simplified population dynamics equation (where N_{i+1}, the new population size; N_i, the original population size; B, births and D, deaths) over a period of 1 y (after Murray, 1983).

Table 1. *Annual production of live Foraminifera from station 3.*

	Total Live Foraminifera	Gains	Losses
December	46	0	0
January	288	242	0
March	374	86	0
April	399	25	0
May	4125	3726	0
June	1055	0	3070
July	1066	11	0
August	1063	0	3
September	82	0	981
October	986	904	0
November	79	0	907
Total	9563	4997	4961

gains, births >deaths; losses, deaths >births.

RESULTS

The substrate at station 1 consisted of a medium to coarse grained sand of granitic origin; station 2, a medium grained muddy sand; and station 3, a soft muddy sediment. The same species were present at all three stations, although most abundant at station 3 which was then sampled every month when exposed at low tide. This study is not presumed to be representative of the entire estuary.

Live populations

A core (length 8 cm; diameter 8 cm) was taken at station 3. Analysis of the samples at 3 mm intervals showed that most live Foraminifera (97%) occurred within the top 1 cm of sediment, whilst 94% occurred in the uppermost 3 mm. The sediment is a micaceous mud with a pronounced orange-brown oxic layer 2–6 mm thick. Below this oxic layer, the mud is charcoal-black and probably anoxic (hydrogen sulphide detected), although polychaete bioturbation is observed down to at least 8 cm depth, accounting for patchy areas of oxic mud in this zone. The polychaete bioturbation may explain the rare occurrence of live Foraminifera observed below the oxic layer.

Analysis of the samples from station 3, presented as yearly average percentages, revealed a restricted foraminiferal fauna consisting of *Haynesina germanica* (Ehrenberg), which was dominant (89%); *Elphidium williamsoni* Haynes, which was subordinate (10%); and *Ammonia beccarii batavus* Hofker which was very sparse (1%) (Figure 3). In this study *Ammonia beccarii* (Linné) always refers to the variant *batavus*; its paucity may be due to the variant *batavus* being the more marine form of the *A. beccarii* species (Murray, 1979).

Haynesina germanica was present in very low numbers during the winter months, but it increased slowly during late winter and early spring. The abundance increased

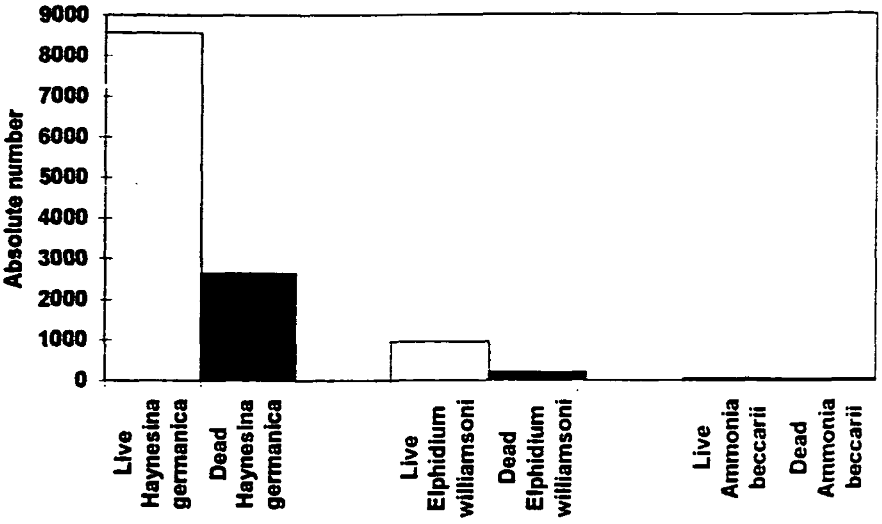

Figure 2. Comparison of yearly average species composition of dead and live Foraminifera.

sharply to its maximum (>4000 individuals per 100-cm^3) in May (Figure 3A,B). The abundance then decreased and levelled off, but remained at an elevated level for the summer months. Populations of *E. williamsoni* experienced a minor peak during January as did *A. beccarii* (Figure 3A), before *H. germanica* became abundant. The two minor species then exhibited a negative correlation with *H. germanica* throughout the summer, and reached low numbers during May and June (Figure 3A). During September,

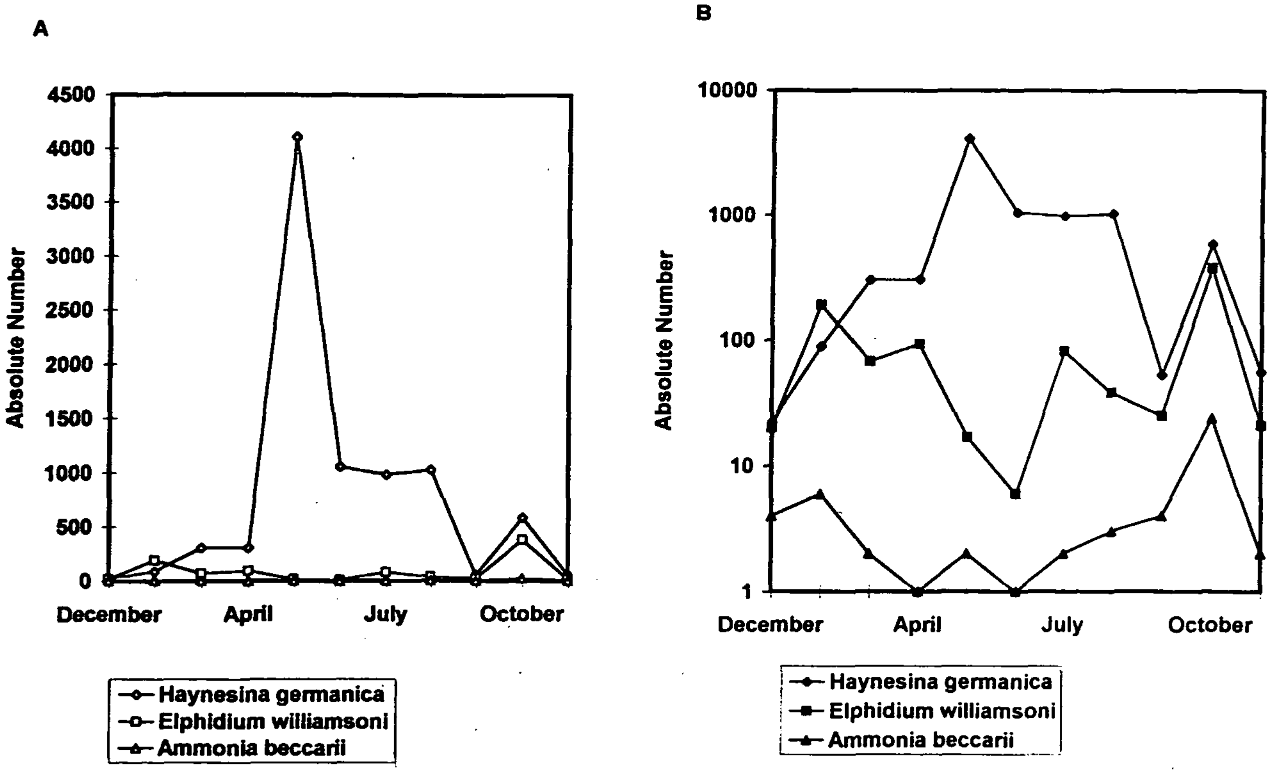

Figure 3. (A) Annual variation of live foraminiferal abundance from station 3. (No data for February). (B) Annual variation of live foraminiferal abundance from station 3, plotted on a logarithmic scale. (No data for February).

Table 2. *Live and dead foraminiferal assemblages from station 3.*

	Haynesina germanica Live	*Elphidium williamsoni* Live	*Ammonia beccarii* Live	Total
December	22	20	4	46
January	90	192	6	288
March	304	68	2	374
April	305	93	1	399
May	4106	17	2	4125
June	1048	6	1	1055
July	982	82	2	1066
August	1022	38	3	1063
September	53	25	4	82
October	584	378	24	986
November	56	21	2	79
Total	8572	940	51	9563
%	89	10	1	
	Haynesina germanica Dead	*Elphidium williamsoni* Dead	*Ammonia beccarii* Dead	
December	172	38	1	211
January	299	20	5	324
March	277	27	7	311
April	290	13	4	307
May	229	10	3	242
June	148	28	1	177
July	285	14	6	305
August	248	12	4	264
September	207	14	3	224
October	220	17	6	243
November	274	14	2	290
Total	2649	207	42	2898
%	92	7	1	

numbers of *H. germanica* and *E. williamsoni* dropped to very low levels, but in October abundances of all three species exhibited a positive correlation and increased dramatically. *Haynesina germanica* experienced a relatively small abundance increase in October in comparison with its summer values, but *E. williamsoni* and *A. beccarii* attained their largest numbers during that month. After October, all three species declined once again. Of the three species only *H. germanica* bloomed during spring and summer, but all three species bloomed in the autumn.

Most live Foraminifera recovered from the September sample exhibited a prominent green coloration (throughout the test), particularly evident in *E. williamsoni*. This was assumed to be caused by algal chloroplasts; either symbiotic, or representing the food type consumed during this period.

Dead assemblages

The dead foraminiferal assemblage was very similar to the living, in terms of species relative abundance (Figure 2). This suggests similar rates of test production among these species in the past, and uniform taphonomic alteration. Some tests exhibited frosted surfaces, punctures and occasionally broken ultimate chambers, indicating abrasion and/or possible dissolution (Murray, 1989). The dead assemblage exhibited a wide range of test sizes with little evidence of sorting. Empty tests of *H. germanica* were dominant forming 92% of the dead assemblage, with minor dead assemblages of *E. williamsoni* (7%) and *A. beccarii* (1%). Other species represented in the dead assemblage were very rare, usually forming far less than 1%. The rare forms included brackish water species such as *Miliamina fusca* (Brady) and *Jadammina macrescens* (Brady), and extremely rare marine forms such as *Elphidium crispum* (Linné), *Brizalina pseudopunctata* (Höglund) and *Quinqueloculina* sp. Apart from these rare species the dead assemblage accurately reflects the live species abundance. The dead assemblage remained relatively constant throughout the year as it represented the sum of past test production.

Palaeontological implications

A core (length 40-cm) was taken from station 3 for the purpose of identifying the fossil potential of Foraminifera in the very early stages of burial. The three species present are similar in morphology and composition, they have perforate walls composed of radial laminated calcite; *H. germanica* and *E. williamsoni* are moderately inflated planispiral forms, whilst *A. beccarii* is a very low trochospiral form. Test size range from 63 to 300 µm. These similarities in size, composition and morphology, suggest that they will be subject to similar hydrodynamic and taphonomic treatment.

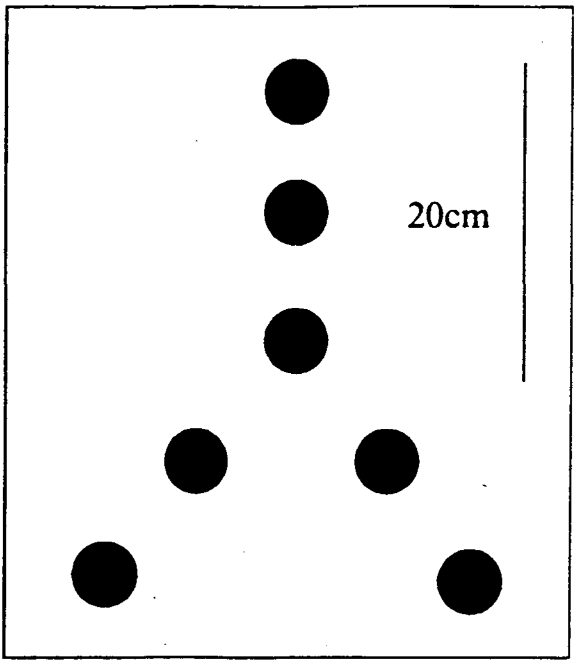

Figure 4. Sample pattern of microlateral distribution for live Foraminifera from station 3. Each circle represents the individual position and distance of sub-samples.

Table 3. *Depth distribution of live Foraminifera from station 3.*

Depth	*Haynesina germanica*	*Elphidium williamsoni*	*Ammonia beccarii*	Total
0	447	354	3	804
3	12	12	1	25
6	2	3	0	5
10	1	2	0	3
15	1	0	0	1
20	2	2	0	4
25	2	0	0	2
30	1	4	0	5
35	1	0	0	1
40	1	1	0	2
45	1	0	0	1

Foraminifera were preserved in the same relative abundances as observed in the living assemblage, but absolute abundance was lower in the dead assemblage suggesting a high test loss of 73% through destruction (which include mechanical abrasion, dissolution and predation) and/or transportation (which include bioturbation). In an example empty foraminiferal tests were picked out of one subsample (100-cm^3) taken from the core, and compared to other subsamples from the core, which showed similar abundances of empty tests. The total number of dead tests in one subsample was 1368, whereas the total annual production of live Foraminifera collected within 100-cm^3 samples was 4997. Hence the successfully buried Foraminifera represent only 27% of annual production at station 3.

Lateral variation across the channel

Six samples of 100-cm^3 from the top 1 cm of the sediment surface, were retrieved from an east-west transect 400 m north of the Laira Bridge (Figure 1). They revealed that the Plym Estuary displays a normally graded sedimentary profile consisting of three distinct sedimentological facies. Facies A, a very soft sticky mud contained a large living assemblage and a very sparse exotic dead assemblage. Live and dead Foraminifera were abundant in facies B, a partially consolidated silty mud with a small element of the dead assemblage (<2%) representing an exotic fauna of essentially marine origin. Both facies A and B represent an estuarine mudflat deposit. Facies C, a shelly sand, represents the channel deposit, which, because of its nature, experienced large salinity fluctuations, live Foraminifera were sparse or absent. The dead assemblage was dominated by large *E. williamsoni* tests which may represent a current-altered deposit, or be the product of a highly stressed environment, exotic species were rare, and thecamoebians were present (although these may have been transported down river). All live Foraminifera were picked out and the dead assemblage analysed qualitatively.

Microlateral variation

Station 3 was sampled on 12 March 1995 and three samples were taken radiating out 10 cm from this point and three radiating out 20 cm from the original point, (Figure 4) with an additional two samples taken at 1 m and 10 m distances. The samples were collected during the spring bloom, and hence exhibited the largest assemblage densities and numerical variations. The samples of 15 cm^3 showed considerable assemblage variation on a centimetre scale within a uniform substrate yielding between 400 and 1300 live Foraminifera per 100 cm^3. Despite this, the proportions of species throughout all the samples remained similar 58–75% of *H. germanica*, 42–25% of *E. williamsoni*, and 1% or less of *A. beccarii*. Samples from 1 m and 10 m distances showed similar abundances and species proportions. The retrieval of one sample per month at station 3, may result in significant variation in the absolute number of live Foraminifera (although the use of relatively large samples may have reduced some microlateral variation). It was concluded that this area of tidal mudflat showed reasonable, but not extreme numerical variation, but relative species proportions remained fairly constant microlaterally.

Macrolateral variation

Samples taken from other locations, i–iii (Figure 1) provide additional information regarding foraminiferal distributions within the estuary. Samples close to the mouth of the estuary (i) exhibited a normal estuarine foraminiferal fauna. Sediment coarser than the 125 m fraction was dominated by *H. germanica* and *E. williamsoni* in both the live and dead assemblages, but in sediment finer than 125 m, the estuarine dead assemblage was greatly enriched by a diverse exotic marine fauna which probably resulted from transportation in suspension. A sample recovered 2 km upstream from the Laira bridge (ii) contained a fauna that was essentially the same as station 3. A final sample from the uppermost part of the estuary (iii), displayed a very sparse live fauna of *H. germanica* and *M. fusca*. The dead assemblage, also sparse, was dominated by the agglutinated Foraminifera *M. fusca* and *J. macrescens* with minor amounts of *H. germanica*.

DISCUSSION

The live and dead foraminiferal fauna of the Plym Estuary is typical of estuarine environments in Britain. These are characterized by low diversity calcareous assemblage, and in the high estuary and marsh environments, increasingly by agglutinated species.

Previous studies of estuaries in southern England, such as the Hamble (Alve & Murray, 1994), the Exe (Murray, 1983) and the mouth of the Tamar (Ellison, 1984) have shown similar low diversity faunas, typified by two or three calcareous forms, and the presence of agglutinated forms (Boltovskoy & Wright, 1976).

The Plym Estuary is an estuary of low tidal power, north of the Laira Bridge, the virtual absence of exotic species implies it is microtidal (Wang & Murray, 1983), hence the dead assemblage accurately reflects the mean live assemblage. However, close to the mouth of the Plym Estuary (sample location, i) the assemblage was enriched by the addition of small transported marine forms, probably suspended in the water column during high tides and storms (Murray, 1987).

The live foraminiferal species from station 3 generally display a negative correlation throughout the spring and summer (Figure 3A,B). *Haynesina germanica* appears to increase numerically as *Elphidium williamsoni* and *Ammonia beccarii* decrease. This trend suggests that these species may be competing with each other; alternatively physiochemical environmental differences may explain *H. germanica* being dominant and more successful for the spring and summer months. The exception to this occurs in the autumn when a positive correlation is observed in all three species.

The green coloration in living tests which is so prominent during the autumn bloom, is assumed to be caused by algal chloroplasts (symbiotic or simply as a food type). Leutenegger (1984) discussed a known chloroplast association with the Elphidiids and the Nonionids to which *E. williamsoni* and *H. germanica* belong. Lopez (1979) compared the efficiency of use of chloroplasts harboured by these two species; *E. williamsoni* needed to replace 65 chloroplasts per h and *H. germanica* 20 chloroplasts per h in order to maintain a constant assemblage of chloroplasts. The photosynthetic activity of the chloroplasts could account for 40–100% of respiratory needs in *E. williamsoni,* and 10–20% in *H. germanica* (Lopez, 1979).

The study of the green coloration is beyond the scope of this paper, further research is needed to determine the exact nature of the green inclusions as they may be an important factor during the October bloom for *E. williamsoni*. Their presence may explain how it apparently manages to compete with *H. germanica* with greater success during this period. The presence of green inclusions are believed to be less important for *H. germanica,* because far larger assemblages of this species are present when the green coloration is not evident (during the summer). *Elphidium williamsoni* exhibits maximum numbers in the autumn when the green inclusions are particularly prominent. This is the only season when *E. williamsoni* blooms while the abundance of *H. germanica* is elevated.

CONCLUSIONS

(1) The Plym Estuary is microtidal and relatively small, the low rates of freshwater inflow result in near normal salinities at high tide. (2) Monthly samples retrieved over one year at station 3, revealed a low diversity live assemblage composed of three hyaline rotaliid species: *Haynesina germanica* (89%); *Elphidium williamsoni* (10%); and *Ammonia beccarii* var. *batavus* (1%). (3) The dead assemblage was remarkably similar to the live assemblage, implying uniform taphonomic processes. Exotic species were generally very rare. (4) A transect across the estuary revealed three sedimentological facies, two tidal mudflat facies (A & B) showed high foraminiferal assemblage densities. A shelly sand facies (C) representing the channel, contained very sparse foraminiferal assemblages. (5) Microlateral distribution of total specimens was quite variable, although the relative proportions of live species were fairly constant on the tidal mudflat.

(6) At macrolateral distances agglutinated Foraminifera were more common in the uppermost part of the estuary, whereas small (<125 m) exotic marine Foraminifera formed a significant proportion of the dead assemblage near the mouth of the estuary. (7) *Elphidium williamsoni* bloomed in October; *H. germanica* bloomed in May and again in the October. *Ammonia beccarii* var. *batavus* remained sparse throughout the year.

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FORAMINIFERAL ANALYSIS OF BOREHOLES FROM PLYMOUTH SOUND

P. CASTIGNETTI

Castignetti, P. (1993). Foraminiferal analysis of boreholes from Plymouth Sound. *Proceedings of the Ussher Society.* **8**, 189-192.

Two boreholes drilled into the sediment infill of the palaeo-Tamar rock valley during 1988 are analysed sedimentologically and palaeontologically. The palaeontology is predominantly concerned with foraminifera. The data, so obtained, are used to reconstruct the palaeoenvironmental history of Plymouth Sound. The sedimentological correlation of the boreholes is poor, but the foraminiferal evidence makes for a good correlation of the environments represented by the cores. Six taxa of foraminifera are dominant, they define three sub-environments, the boundaries of which correlate almost perfectly with prominent seismic reflectors.

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INTRODUCTION

Plymouth Sound is an area of shallow shelf sea directly south of the City of Plymouth. A series of high-resolution seismic surveys carried out in the 1980s by Dr J. M. Reynolds and various students of the then-Polytechnic culminated in the publication of a paper by Eddies and Reynolds (1988). In this they described the existence of a system of buried rock channels below Plymouth Sound. In January 1988 two boreholes (Figure 1) were drilled to assess the nature of the infilling sediment and provide ground-truth for the seismic sections. A preliminary investigation of one of these boreholes (Borehole 1) was described by Eddles and Hart (1989).

Since that time the boreholes have been further investigated and their microfaunas examined. Borehole 1 reached the valley bedrock of Devonian slates (Figure 2) at -39 m O.D., with an almost complete sediment core being recovered. Borehole 2, drilled approximately 300 m north-north-west of Borehole 1, was plagued by bad weather conditions which resulted in rather poor recovery of core down to -25.7 m O.D.

SEDIMENTARY RECORD OF BOREHOLE 1

The top of the succession consists of fine silty sands, although the top few metres of the sequence may be artificial. Between -10 m O.D. and -19 m O.D. are fine to medium-grained sands, coarsening upwards to coarse sands. Between -19 m O.D. and -35 m O.D. are mainly silts and clays, with occasional, localised, pebbles. Between -35 m O.D. and approximately -39.4 m O.D. are coarse gravels ranging from rounded to sub-

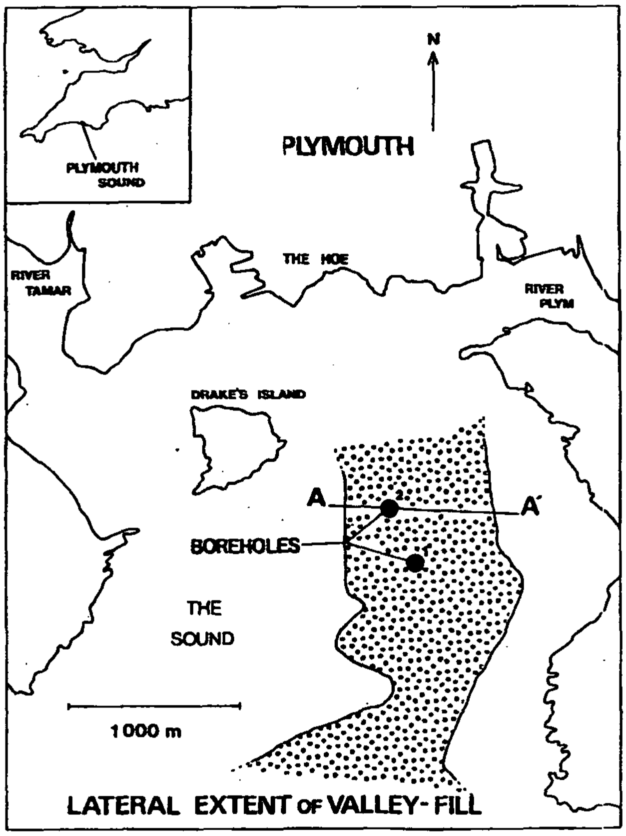

Figure 1: Map of the infilled valley system of the palaeo-Tamar showing location of the two boreholes.

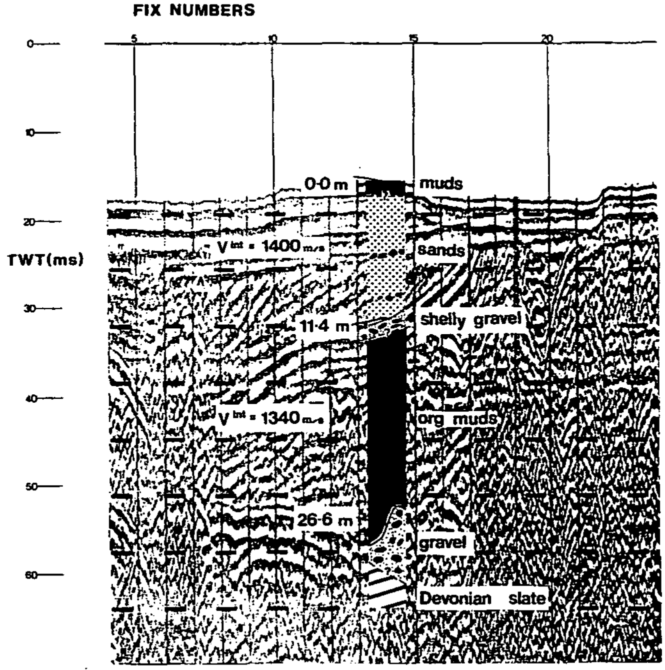

Figure 2: Seismic profile across the palaeo-Tamar together with the outline log of Borehole 1.

TABLE 1

Borehole No 1	21.3-23.0		22.7-22.8		22.3-22.8		23.1-23.8		23.8-24.4		24.3-25.0	
In metres	Aba.	%	Aba.	%	Aba.	%	Aba.	%	Aba.	%	Aba.	%
A. beccarii	42	15	63	33	29	10	7	15	40	25	22	11
Quinqueloculina spp.	4	1	17	9	2	1	0	0	4	3	13	7
E. crispum	8	3	42	22	0	0	2	4	4	3	4	2
H. germanica	36	13	31	16	163	57	26	54	61	38	111	55
E. williamsoni	189	68	39	20	94	33	13	27	50	31	43	22
C. lobatulus	0	0	0	0	0	0	0	0	3	1	6	3
Textularia	0	0	0	0	0	0	0	0	0	0	1	1
S. vivipara	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	279	100	192	100	288	101	48	100	162	101	200	101

Borehole No 1	1.2		1.4		4.25 6-6.9		6.0-7.7		8.3-9.9		9.9-10.9		13.4-13.85			
In metres	Aba.	%	Aba.	%	Aba.	%	Aba.	%	Aba.	%	Aba.	%	Aba.	%	Aba.	%
A. beccarii	107	37	67	16	92	32	122	35	108	39	106	30	169	39	87	48
Quinqueloculina spp.	75	26	175	41	100	36	86	25	46	16	60	17	62	14	17	8
E. crispum	63	22	118	27	85	30	141	40	123	44	185	53	202	47	13	7
H. germanica	4	1	4	1	0	0	0	0	1	0	0	0	1	0	0	0
C. lobatulus	31	11	65	15	6	2	0	0	0	0	0	0	1	0	0	0
Textularia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S. vivipara	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
TOTAL	287	99	429	100	286	100	349	100	278	100	352	100	434	100	182	99

Borehole No 1	14.1-14.6		14.8-15.3		14.8-15.3		16.3-17.1		17.1-18.3		18.3-19.1		19.9-20.7		20.7-21.2	
In metres	Aba.	%	Aba.	%	Aba.	%	Aba.	%	Aba.	%	Aba.	%	Aba.	%	Aba.	%
A. beccarii	128	42	166	41	96	45	161	44	108	40	80	36	18	9	24	16
Quinqueloculina spp.	27	9	29	7	31	15	61	17	50	19	20	9	1	1	2	2
E. crispum	43	14	19	5	40	19	96	26	58	22	42	19	2	1	2	1
H. germanica	60	20	92	23	32	15	39	11	92	16	36	16	60	30	29	36
E. williamsoni	48	16	91	23	13	6	12	3	7	3	39	18	118	59	74	51
C. lobatulus	0	0	6	2	0	0	1	0	2	1	2	1	0	0	1	1
Textularia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S. vivipara	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1
TOTAL	306	101	403	101	212	100	370	101	267	101	220	100	199	100	146	100

Borehole No 2	?-1.35		2.05-3.10		3.1-4.3		4.3		4.6		5.8		5.8-7.0		7.0	
In metres	Aba.	%	Aba.	%	Aba.	%	Aba.	%	Aba.	%	Aba.	%	Aba.	%	Aba.	%
A. beccarii	168	53	141	50	159	41	150	55	150	58	94	48	51	33	108	54
Quinqueloculina spp.	61	19	29	10	63	16	17	6	30	11	16	8	33	21	33	17
E. crispum	89	28	108	38	61	16	100	37	49	19	16	8	40	26	31	16
H. germanica	0	0	3	1	66	17	4	1	23	9	40	20	15	10	21	10
E. williamsoni	1	0	1	0	35	9	3	1	9	3	26	13	17	11	7	3
C. lobatulus	0	0	0	0	4	1	0	0	0	0	6	3	0	0	0	0
S. vivipara	0	0	0	0	3	1	0	0	0	0	0	0	1	1	0	0
Textularia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	319	100	282	99	391	101	274	100	261	100	198	100	156	101	200	101

Borehole No 2	7.1-8.3		8.3-9.5		9.5-10.2		9.5-10.7		10.7-11.9		11.9-12		14.5-15		15.1-15.4		15.4-15.7	
In metres	Aba.	%	Aba.	%	Aba.	%	Aba.	%	Aba.	%	Aba.	%	Aba.	%	Aba.	%	Aba.	%
A. beccarii	167	64	4	36	4	20	0	0	12	12	15	45	2	11	1	4	2	9
Quinqueloculina	32	12	1	9	3	15	39	18	7	7	7	21	6	33	4	17	7	30
E. crispum	47	18	1	9	8	40	31	14	24	23	5	15	8	44	5	22	3	13
H. germanica	16	6	2	18	4	20	102	46	38	36	0	0	1	6	10	44	8	35
E. williamsoni	1	0	3	27	0	0	28	12	20	19	6	18	0	0	3	13	3	13
C. lobatulus	0	0	0	0	1	5	18	8	2	2	0	0	1	6	0	0	0	0
S. vivipara	0	0	0	0	0	0	2	1	1	1	0	0	0	0	0	0	0	0
Textularia	0	0	0	0	0	0	3	1	0	0	0	0	0	0	0	0	0	0
TOTAL	268	100	11	99	20	100	223	100	104	100	33	99	18	100	23	100	23	100

Aba. Absolute amount.

angular, these contain moderate amounts of slate.

No foraminifera were found in the coarse gravels which mark the bottom part of the sequence. With the exception of the gravels at its base, Borehole 1 has a fine-grained lower sequence, and a coarsening-upwards sandy upper sequence.

SEDIMENTARY RECORD OF BOREHOLE 2

The lack of sharpness in identifying sediment boundaries is due largely to the nature of the material, the softness of the sediment and its post-drilling storage in bags. The lower part of the succession is generally coarse-grained while the upper part is fine-grained.

From the sediment/water interface (-10m O.D.) to -11.35 m are poorly sorted sands, granules and pebbles, with abundant shells. This zone may be artificial (dredging). Equally it could represent a high energy area in which active deposition has not occurred for some considerable time, so excluding much of the more recent normal marine sequence/fauna.

Between -12 m O.D. and -19 m O.D., grey and brown coloured clays and silts with occasional pebbles and shells are found.

Between -19 m O.D., to -23 m O.D. there are poorly sorted pebbly sands, silts, and clays. At -20 m O.D. is a pebble bed; its exact thickness, and the nature of upper and lower boundaries are not known. At -22 m O.D. a poorly defined pebble bed exists. The sediment has a strong ochre colouring. Well-cemented aggregates of sand containing numerous shells are common; it is probable that the shell material is the source of this very localised carbonate cement. The basal part of the sequence, from -23 m O.D. to -25 m O.D., consists of fine-grained well-sorted sands, with small cemented aggregates of sand, and thin shell fragments.

The sediment correlation between Borehole 1 and Borehole 2 is poor, but this is not surprising, assuming and considering a valley infill depositional setting.

FORAMINIFERAL ANALYSIS

A total of 46 samples were taken from Borehole 1, and 22 from Borehole 2, approximately $^2/_3$ which contained foraminifera. The samples were dried and sieved, foraminifera were picked using a fine paint brush from the >500, >250 and the >125 micrometres size fractions, 350 individuals were picked where possible from each sample (Table 1).

It was found that 6 taxa represented over 98% of the fauna, one of which, *Cibicides lobatulus* (Walker and Jacob), is relatively abundant in the top one or two metres of Borehole 1 (Eddles and Hart, 1989). This may suggest that this taxon is only a relatively recent inhabitant of the Sound. The remaining

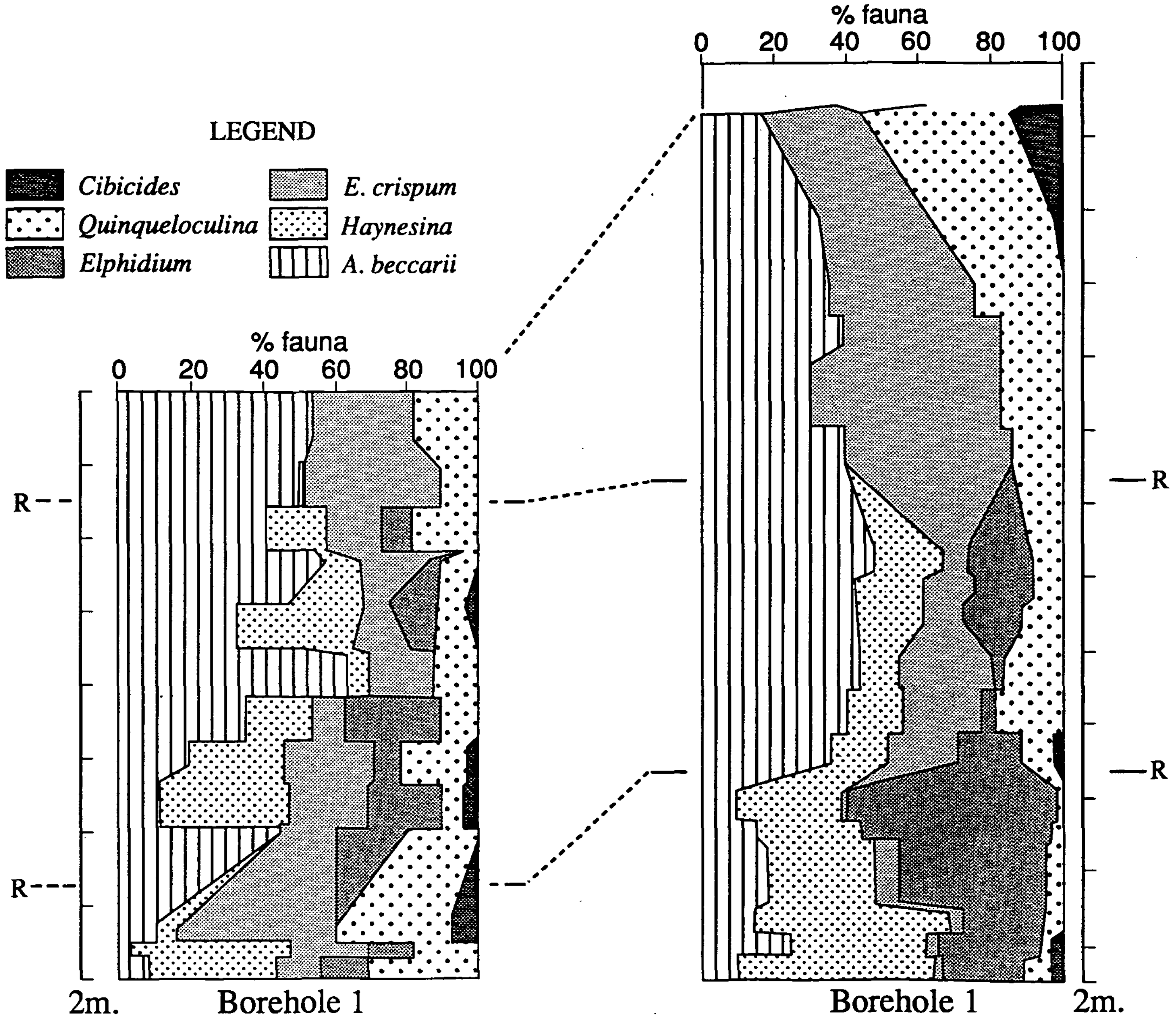

Figure 3: Foraminiferal analysis of the two boreholes. [R=geophysical reflection surface].

five species, making up over 95% of the foraminiferal assemblage, are as follows:-

Haynesina germanica (Ehrenberg) is a euryhaline taxon often found in hyposaline lagoons and estuaries. This species can tolerate salinities down to 1 per mille (Murray, 1991).

Elphidium williamsoni (Haynes) is very similar to *H. germanica* in terms of its living environment and salinity tolerance.

In this work *Elphidium crispum* (Linné) includes all varieties such as *E. macellum* (Fitchel and Moll); for discussion see Murray (1971)

Ammonia beccarii (Linné) is an important taxon in estuarine and near-shore marine environments.

Quinqueloculina spp. in this work include several species and sub-species. All members of this genus in temperate latitudes are regarded as representative of marine, inner-shelf, environments.

In Borehole 1 three distinct sub-environments are present (Figures 2 and 3). The topmost 12 m of sediment are dominated by *E. crispum, A. beccarii* and *Quinqueloculina*, with a lesser percentage of *C. lobatulus.* This environment is open-marine to slightly brackish. Below approximately -22 m O.D.to -29 m O.D. the fresh or brackish water foraminifera, *H. germanica* and *E. williamsonii* occur in moderate percentages, at the expense of the more normal marine types, with *A.beccarii* remaining roughly of the same percentage abundance throughout. This environment is typically brackish water, characteristic of most United Kingdom estuarine settings.

Between -29 m O.D. to -35 m O.D. a sharp change occurs. *E. williamsonii* and *H. germanica* become dominant, making up approximately 80% of the species; much of the remainder is *A. beccarii.* This is a very low salinity environment. The seismic boundaries can be matched to the faunal sub-environments at -22 m O.D. and -29 m O.D.

In Borehole 2 foraminifera become very sparse below 10 m, with only 20 to 30 per sample. In the sample at 14 m only 18 individuals were found. The small size of samples not only causes loss of detail, but may result in erroneous interpretations (anomalies) below the 10 m point. However a distinct trend is present. The two fresh to brackish water foraminifera gradually increase in percentage abundance down the borehole sequence, while *A. beccarii* decreases relatively. *Quinqueloculina* and *E. crispum* are still relatively abundant, and this may be due to the low percentage of the *H. germanica* and *E. williamsonii.*

In Borehole 1, for example, *E. crispum* and *Quinqueloculina* are present in moderate percentages in the lower part of the sequence, but a percentage decrease of *H. germanica* and *E. williamsonii*, causes a relative increase in the marine foraminifera. This process is accentuated at a depth of 14 m where a poor sample contains very few *H. germanica* and *E. williamsonii*, so causing an apparent localized increase in the percentage number of normal marine foraminifera. Equally it may represent a pulse of normal marine fauna, maybe by a change in physical parameters which effect salinity and transportation direction, such as windspeed and/or wind direction, tides, rainfall etc.

INTERPRETATION

Both Boreholes 1 and 2 show a similar trend, in that the top of each sequence has a normal marine fauna which becomes more brackish and freshwater downwards. Accepting that detail will be lost due to the sparsity of the fauna in parts of Borehole 2, Borehole 1 and Borehole 2 can be tentatively correlated in terms of their foraminiferal content. This correlation suggests that much of the upper sequence is not present in Borehole 2, which fits a valley-infill type of setting. The 12 m marker in Borehole 1 correlates approximately with that of 2 m depth in Borehole 2, in terms of seismic reflectors and foraminifera. This implies that approximately 10 m of the Borehole 2 sequence is absent, possibly due to erosion, non-deposition or both.

It is interesting to note that seismic reflectors correlate very well with the boundaries of the microfaunal sub-environments of both of the two boreholes, suggesting that these reflectors represent time gaps through non-deposition or erosion or both.

In the late Quaternary this area of the Sound was within a fluvially-dominated regime, at which time coarse clastics were deposited and foraminifera were absent. A relative sea-level rise occurred, creating 'fresh/brackish' conditions, in which the *E. williamsonii* and *H. germanica* became very abundant. Sea level continued to rise, and this was reflected in typical estuarine conditions in which all of the main species were present (except *C. lobatulus*), with *A. beccarii* being most abundant (approx. 40% of the fauna). Subsequently, a normal marine environment prevailed as sea level continued to rise, and *E. crispum, Quinqueloculina* and *C. lobatulus* grew in abundance, *A. beccarii* became sparse, and *H. germanica* and *E. williamsonii* were absent (See figure 3). The maximum age of the sediment is estimated, using various sea level curves, at between 12000 and 18000 years (Fairbridge 1961; Kidson and Heyworth 1973).

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