Studies of Foraminifera associated with *Gelidium pristoides* (Turner) Keutzing (Gelidiales: Rhodophyta)

Rashieda Toefy

Supervisor : Prof. Mark J. Gibbons (University of the Western Cape)

Co-supervisor: Dr Ian K. McMillan (De Beers Marine)

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I declare that **Studies of Foraminifera associated with *Gelidium pristoides* (Turner) Keutzing (Gelidiales: Rhodophyta)** is my own work and that all the sources I have used or quoted have been indicated and acknowledged by means of complete references.

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Rashieda Toefy

This thesis is dedicated to my family, especially

my late father, Achmat Rashied and my mother, Gafsa Domingo, as well as my husband, Seraj and my children, Rafeeq, Muneeb and Imra.

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I am indebted to my husband, Seraj, without whose support, encouragement and love, I would not have been able to complete this study. To my children, Rafeeq, Muneeb and Imra for being the highlight at the end of grueling days.

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Abstract

Foraminifera of the red seaweed, *Gelidium pristoides* (Turner) Keutzing (Gelidiales: Rhodophyta) were examined on intertidal rocky shores from across its distribution range in South Africa. The aim of this study was to determine the effect of wave exposure and biogeography on assemblage structure, and to compare these results with those of previous macrofaunal studies conducted in the region.

A total of 45 species of foraminifera were identified, of which 15 are potentially new. These species are described and illustrated. Although most species were rare, the common species were typically phytal and were generally ubiquitous. All species had a warm to cold temperature range.

Macrofaunal studies have shown that sheltered shores are more diverse and support a higher biomass of organisms than exposed shores. In order to determine whether foraminifera associated with *G. pristoides* exhibit the same pattern, two exposed and two sheltered shores were examined in False Bay during summer and winter. Multivariate statistics revealed that assemblages from exposed shores were distinct from those of sheltered shores. Only two species were found exclusively on exposed shores. However, the species that were dominant on exposed shores were different to those on sheltered shores; this dominance was independent of plant size. Species of foraminifera found on exposed shores were also larger, independent of season. Although there was no seasonal variation in abundance and diversity, the species composition differed. Foraminifera were more abundant and diverse on exposed shores, and this result contrasts with previous work on macrofauna and meiofauna around South Africa.

Abstract

Biogeographic studies on macrofaunal invertebrates in South Africa have revealed three main biogeographic provinces. In order to determine whether foraminifera associated with *G. pristoides* conform to these provinces, ten exposed shores from Sea Point on the west coast to Port Elizabeth on the south coast were examined. Multivariate statistics revealed that Sea Point samples were distinct from all other shores. Kommetjie, also on the west coast, clustered with the other shores. This result suggests that foraminifera conform to previously established macrofaunal biogeographic provinces. The most common species in the Sea Point samples was *Patellina corrugata* and miliolids dominated the Port Elizabeth samples. There were some species only present in Sea Point and Kommetjie. These species were, however, rare in the samples and may not be an indication of the start of a biogeographic province. Samples from the same shore and coast did not always cluster together. This may be attributed to rarity, patchiness in distribution of intertidal foraminifera as well as differences in the level of exposure on shores.

Algal and sediment weight were significantly correlated and algal weight was significantly greater on exposed than sheltered shores, irrespective of season. Although the algal weight of the groupings identified from the exposure study differed, it was found that algal and sediment weight accounted for only 20 % of the community structure.

Interestingly, in the biogeographic study, algal weight was not significantly correlated with abundance or diversity whereas sediment weight was. Species richness and diversity did not differ between the four coasts (west coast, False Bay, south-west coast and south coast). Abundance differed between False Bay and the south-west coast; this may be the result of the higher sediment weight of False Bay samples. The mean sediment weight of the groupings identified by cluster analysis did not differ significantly between the groups whereas algal weight did. As in the study on exposure, further statistics revealed that algal and sediment weight only accounted for ~3 % of the assemblage structure. Algal and sediment weight play a very small role in determining community structure of foraminiferal assemblages, but they do play an important role in determining diversity and abundance.

Chapter One

General Introduction

Our understanding of the macrofauna of hard intertidal substrata around South Africa is fairly comprehensive, and we have a good understanding of the environmental factors responsible for structuring macrofaunal communities (McQuaid & Branch, 1985; Bustamante *et al.,* 1996; Emanuel *et al.,* 1992). The same cannot be said for meiofaunal communities of rocky shores, which despite their neglect are known to play an important role in the functioning of many intertidal systems (Gibbons & Griffiths, 1986). While macrofauna may dominate rocky shores in terms of biomass, meiofauna are generally more abundant, and because they have faster turnover rates they make an important contribution to secondary production (Gibbons & Griffiths, 1986).

Meiofauna on rocky shores can be found occupying rock crevices and living upon algae and sessile animals (Gibbons & Griffiths, 1986). They can attain high abundances on algae; abundance being dependent on algal morphology, condition and size (Gunnill, 1982; Kangas, 1978). Meiofaunal abundance and diversity among algae reflects the availability of micro-habitats, the amount of sediment trapped and the elevation on rocky shores (Gibbons, 1988a).

Foraminifera form part of the meiofauna (63 μm– 100 μm), although large living Tertiary (up to 5 cm) and Cretaceous (up to 10 cm) species have been reported (Boltovskoy & Wright, 1976). Foraminifera are protozoans, which belong to the sub-phylum Sarcodina (presence of pseudopodia), and are assigned to the class Granuloreticulosea (delicate filiform, granular pseudopodia) (Gooday, 1992). They are primarily marine and hyposaline organisms, although some freshwater forms have been reported (Phleger, 1973). Foraminifera have been reported as part of the plankton (Cifelli, 1982; Cifelli & Smith, 1970; Bé *et al.,* 1971) and the benthos (Buzas & Culver, 1991; Golik & Phleger, 1977). They are specific in their depth ranges and some species can be found exclusively in the intertidal zone (Cooper, 1961; Boltovskoy, 1963; Kitazato, 1988), nearshore (Culver & Buzas, 1999; Lankford & Phleger, 1973) and in deep-sea environments (Bernstein *et al.,* 1978; Gooday, 1999).

Foraminifera have either chitinous, agglutinated, siliceous or calcareous tests (Cushman, 1959). The test preserves well, providing an extensive fossil record, which extends from the Cambrian to the Recent (Buzas & Culver, 1991). It has been found that many foraminifera have definite geological and geographic distribution ranges, which makes them suitable for determining the age of sediments, and thereby of value to mining and geological exploration companies (Cushman, 1959). The accumulation of tests on the sea floor has provided a record of environmental conditions in both the ocean and the sediment at the time of death (Phleger, 1973).

Globally, studies on foraminifera have concentrated on the examination of fossilized material (Boltovskoy & Wright, 1976), though ecological studies on foraminifera have increased since the 1950's (Murray, 1991). Foraminifera are ideal organisms in both geological and ecological studies because of their small size, and their presence in statistically viable numbers, even in small sediment samples (Buzas & Culver, 1991). They are also easily sampled (Culver & Buzas, 1999).

Foraminiferal distribution is influenced by depth, temperature, salinity, pH, oxygen concentration, trace elements and biological interactions (Pielou, 1979). The aforementioned factors affect growth and reproduction; any changes in the levels of these factors would affect whether a species would be present in that environment. Their response to changes in environmental factors make them suitable as indicators of environmental health (Bernhard, 1997; Pielou, 1979; Samir, 2000; Yanko *et al.,* 1994). Assemblages change in abundance and community structure around sewage outfalls (Stott *et al.,* 1996). Morphological test abnormalities have also been reported in areas where there are high levels of trace metal pollutants (Yanko *et al.,* 1994). Therefore, test abnormalities or changes in community structure of foraminifera would be an indication of changed environmental health.

Most research into extant foraminifera in South Africa has been conducted on deep-sea and pelagic forms (e.g. Rogers & Bremner, 1991, Giraudeau, 1993). Fossil material has also been well documented from oil and mineralogical surveys (Dale & McMillan, 1998). The study of intertidal foraminifera, however, has been neglected, this is in spite of the fact that foraminifera have been shown to form a conspicuous component of the meiofauna.

Foraminifera have been retrieved in both intertidal sediments (Boltovskoy, 1963; Boltovskoy & Lena, 1966; Smith, 1968; Boltovskoy & Lena, 1970; Boltovskoy, 1970), and upon intertidal algae (Hedley *et al*., 1967; Atkinson, 1969; Boltovskoy & Wright, 1976). Phytal assemblages of foraminifera are generally richer in species than those of sediments (Boltovskoy & Wright, 1976; Atkinson, 1969).

Phytal foraminifera have been found attached to algal fronds, but are mostly present in the sediment at the base (Atkinson, 1969). Algae that retain more sediment seem to provide more shelter and have richer assemblages than those with less sediment (Boltovskoy & Wright, 1976). Algae and sediment in the intertidal zone also retain water during low tide, which might allow foraminifera to avoid desiccation (Kitazato, 1988). In addition, diatoms and microalgae, which are trapped as water moves amongst the thalli and sediment, provide a source of food for foraminifera (Kitazato, 1988).

This project focuses on the foraminifera of one species of intertidal alga, *Gelidium pristoides*, and attempts to a) explore the environmental factors responsible for structuring communities, and b) document the species present. The specific questions that will be addressed include: (Chapter 1) Are foraminifera more abundant and diverse on sheltered than exposed shores, as has been found in previous studies in South Africa? (Chapter 2) Do foraminifera conform to the biogeographic provinces around South Africa, established by macrofaunal studies?

The structure of *Gelidium pristoides* is suitable as a habitat for foraminifera. It is tuft-like and consists of many fronds, and each plant is approximately 30 mm in height (Carter & Anderson, 1986). *G. pristoides* provides a microenvironment for intertidal fauna; it provides a source of food, shelter from heat build-up and desiccation (Beckley, 1977), as well as protection against wave exposure and predation (Gibbons, 1988c). *G. pristoides* is found in the mid to low intertidal zone, and on exposed and sheltered, warm and cold-water shores as well as on different rock types (McQuaid & Branch, 1984). It is a commercially important mid-shore alga, which is harvested for its agar content (Carter & Anderson, 1986). It is endemic to South Africa and is found from Sea Point in the Western Cape to Port Edward on the East coast (Day, 1969). By confining the study to one algal species, many variables can be eliminated which allows for comparison between the foraminifera of the different shore types (see Gibbons, 1988c).

The thesis is divided into the following sections:

Chapter 2: Gibbons (1988b) studied the effect of wave exposure on meiofaunal communities of *G. pristoides*. This chapter investigates the effect of exposure on the foraminiferal communities of *G. pristoides*. It also compares the findings of Gibbons (1988b) on meiofauna taxa with those of foraminiferal communities.

Chapter 3: Studies on intertidal biogeography in South Africa have concentrated on invertebrate macrofauna, algae and some intertidal fish. The biogeography of intertidal meiofauna has been neglected. Meiofauna and more specifically foraminifera may react in a different way to the generally accepted provinces established in macrofaunal studies. This chapter investigates the biogeographic patterns of foraminifera associated with *G. pristoides* and compares this with the findings of macrofaunal studies.

Appendix: The appendix provides an inventory and a brief description of the species that were recovered from *G. pristoides*. The species are documented here because this is the first study to be conducted explicitly on intertidal foraminifera from the western Cape, South Africa, and as such it acts as a base-line reference for future work. The appendix should not be regarded as a taxonomic treatise of the fauna, as only a few specimens of each species were examined and no examination of type material was undertaken. Furthermore, full taxonomic literature is difficult to obtain in South African libraries. Some errors in identification may have occurred because of either morphological variation attributable to environmental conditions or reproductive states.

Chapter Two

The effect of wave exposure on the foraminifera of the intertidal agarophyte *Gelidium pristoides.*

Abstract

The foraminifera of the red seaweed, *Gelidium pristoides* (Turner) Keutzing (Gelidiales: Rhodophyta) were examined on exposed and sheltered shores around False Bay, South Africa, during summer and winter 1998/1999. Twenty-five species were recognised, seven of which are potentially new. Multivariate statistics indicated that the assemblages on plants from exposed shores were distinct from those on sheltered shores, and two species of foraminifera were confined to exposed shores. Plant size and the quantity of trapped sediment were positively correlated, and plants on exposed shores were significantly bigger than those on sheltered shores. Plant size and sediment weight were linked to assemblage diversity and abundance; assemblages on exposed shores were generally more diverse and abundant than those of sheltered shores. Different species dominated on the two shore types, and larger foraminifera tended to be more common on exposed shores. The response of foraminifera to exposure differs from that of other meiofauna on *G. pristoides* and this is likely a reflection of their more sessile habit.

Introduction

Wave action has long been considered an important factor influencing the community structure of intertidal communities (Lewis, 1964). The coast of the western Cape is generally subject to high wave energy, owing to its essentially linear nature, the absence of protected embayments and to the prevailing winds (Bustamante & Branch, 1996). The effects of wave exposure on macrofaunal communities of rocky intertidal shores have been well-documented (McQuaid & Branch, 1984; McQuaid *et al.,* 1985; Emanuel *et al.,* 1992, Bustamante & Branch, 1996). Exposure appears to influence the biomass, diversity and trophic structure of the community (McQuaid *et al.,* 1985); biomass tends to increase with increased exposure (McQuaid & Branch, 1984). Exposed shores tend to be dominated by filter-feeders, whereas sheltered shores are dominated by grazers and macroalgae (McQuaid & Branch, 1984; McQuaid *et al.,* 1985). More mobile organisms also tend to be less abundant than sessile organisms on wave-beaten shores (Bustamante & Branch, 1996).

Gibbons (1988b), in the only comparable study conducted on meiofauna in South Africa, demonstrated that the meiofauna of *G. pristoides* varied with shore exposure, and that small meiofauna were generally more abundant and diverse on sheltered shores. These observations were based on studies of broad taxic groups (e.g. copepods, nematodes), and lacked the detail inherent in studies of individual species or taxa.

Studies on the effects of exposure on foraminifera have been conducted in Argentina by Thompson (1978 in Murray, 1991). Although Thompson noted that assemblages appeared to differ slightly with exposure, clear differences in structure or composition of assemblages could not be observed as the study was not quantitative.

Thompson also found that the strength of foraminiferal tests from exposed shores was much greater than that on sheltered shores; this is thought to be a result of the higher energy environment of exposed shores (Murray, 1991).

This study aims to investigate the effects of wave exposure on foraminifera associated with *Gelidium pristoides*. It tests whether foraminiferal assemblages follow the same patterns revealed by previous macro- and meiofaunal studies around South Africa, that is, whether the abundance and diversity is higher on sheltered than exposed shores.

Materials and Methods

Sampling site

Sampling took place on the 10/11 August 1998 (austral winter) and 1/2 February 1999 (austral summer) at low tide, ~0.8 m above chart datum. Five of the largest *G. pristoides* plants were collected from two exposed shores [St. James (18.45°E, -34.11°S) and Dalebrook (18.45°E, -34.12°S)] and from two sheltered shores [Froggy Pond (18.45°E, -34.19°S) and Miller's Point (18.45°E, -34.22°S)] around False Bay (Figure 1.1). To investigate the effect of algal size on foraminiferal assemblages, an additional five plants of variable size were collected from each shore in February 1999. All plants were collected on limpets to minimise the disturbance and loss of phytal fauna (as Gibbons, 1988b), and samples were immediately preserved in 70% ethanol.

Laboratory analysis

The alga was scraped off the limpet and agitated in water to remove sediment. The alga was weighed (wet weight) and oven dried at 60 °C to constant mass. The

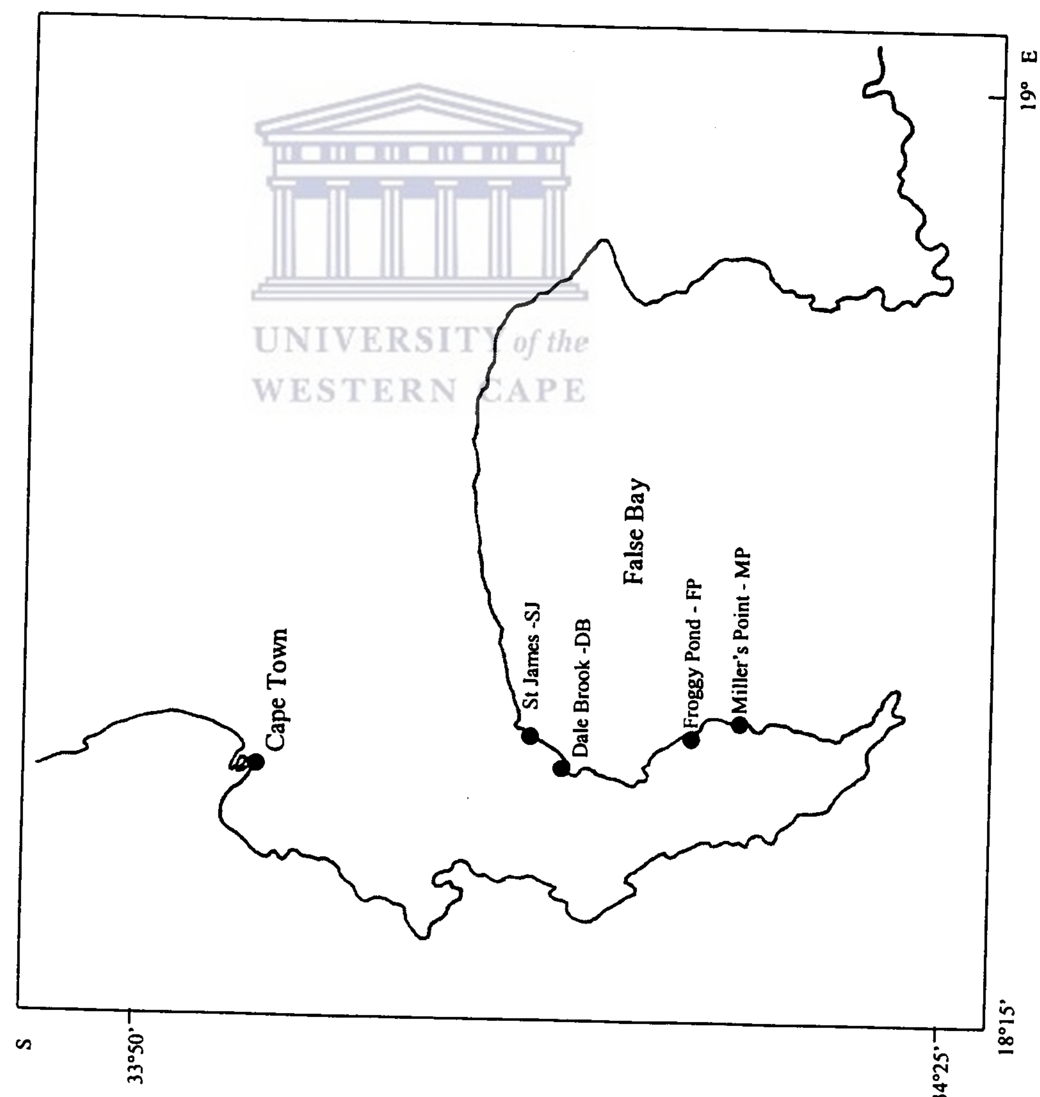

Figure 2.1: Map of False Bay, South Africa illustrating the position of sampling sites

sediment and meiofauna were sieved through a 63 μm mesh and then stained with Rose Bengal for at least 24 h. The carbon tetrachloride flotation method was used for isolating foraminifera from the sediments (Cushman, 1959), but this method is only about 85% efficient and thus the sediments were also visually inspected (as Boltovskoy & Wright, 1976). All live foraminifera were identified and counted using a stereoscopic dissecting microscope at 80x magnification. A representative of each species was measured using scanning electron microscopy. While the use of one representative may bias data, it is useful as an indication of the size structure of assemblages on the two shore types. The mean individual size of foraminifera per plant was calculated by multiplying the number of individuals of a species by the size of the measured representative of that species, the measurements were totalled for the plant and divided by the total number of individuals in the whole sample. The sediment from each sample was then oven dried at 60 °C to constant mass and weighed.

Statistical analysis

Analysis of variance (ANOVA) was used to determine if algal or sediment weight and the abundance and diversity of foraminifera varied with season or shore type. Species diversity was calculated using the Shannon-Wiener Index (H') (Krebs, 1999). Linear relationships between the physical environment and the abundance and diversity of foraminifera were determined using correlation analyses. ANOVA was used to compare the individual size of foraminifera on the two shore types during summer and winter. A significance level of $p < 0.05$ was used in all tests, unless stated otherwise.

The structure of the foraminifera communities on the different shores was investigated using descriptive multivariate statistics. The numerical composition of samples was root-root transformed and a similarity matrix was constructed using the Bray-Curtis Similarity Index (Field *et al.*, 1982). All species from all samples were included in the analysis. Cluster analysis of the samples was undertaken using PRIMER software using group average sorting (Clarke & Warwick, 1997).

The species most responsible for determining similarities between and within the groups identified by the cluster analysis were determined using the SIMPER routine in PRIMER. The BIOENV procedure in PRIMER was used to determine which of the investigated environmental parameters (algal weight and sediment weight) could best explain the structure of the identified foraminiferal assemblages (Clarke & Warwick, 1997).

Results

Two sub-orders, six superfamilies and 25 species of foraminifera were present in the samples. Of these, some were difficult to separate consistently to species level and further analyses were confined to 20 species (Table 2.1 and Appendix 1). The identification of seven of the species was uncertain. These included *Glabratella* sp. A, *Cibicides* sp. A, *Glandulina* sp. A, *Lagenosolenia* sp. A, *Lagena* sp. A, *Oolina* sp. A and *Fissurina* sp. A, which were only identifiable to genus level.

Only two species of foraminifera (*Lagena semilineata* Wright and *Planorbulina mediterranensis* d'Orbigny) were confined to one shore type (exposed) and most were recovered from both shores. Having said that, the species that dominated on exposed

Sub-order	Super-family	Genus	Species
Miliolina	Miliolacea	*Quinqueloculina*	*Quinqueloculina* cf *Q. undulata* d'Orbigny
			Quinqueloculina vulgaris d'Orbigny
			Quinqueloculina dunkerquiana (Heron-Allen & Earland)
			Quinqueloculina isabellei d'Orbigny
			Quinqueloculina seminula (Linné)
		Miliolinella	*Miliolinella subrotundata* (Montagu)
Rotalina	Nodosariacea	*Lagena*	*Lagena semilineata* Wright
			Lagenosolenia sp. *A*
			Lagena sp. *A*
		Oolina	*Oolina* sp. *A*
			Oolina cf *O. melo* d'Orbigny
		Fissurina	*Fissurina* sp. *A*
		Glandulina	*Glandulina* sp. *A*
	Buliminacea	*Bolivina*	*Bolivina "fossa"* McMillan, 1987
			Bolivina pseudoplicata Heron-Allen & Earland
		Brizalina	*Brizalina "rocklandsensis"* McMillan, 1987
	Rotaliacea	*Elphidium*	*Elphidium macellum* (Fichtel & Moll)
			Elphidium cf *E. advenum* (Cushman)
	Discorbacea	*Rosalina*	*Rosalina* cf *R. globularis* (Heron-Allen & Earland
		Glabratella	*Glabratella australensis* (Heron-Allen & Earland)
			Glabratella sp. *A*
	Orbitoidacea	*Cibicides*	*Cibicides* sp. *A*
		Planorbulina	*Planorbulina mediterranensis* d'Orbigny
		Cibicides	*Cibicides lobatulus* (Walker & Jacob)
	Spirillinacea	*Patellina*	*Patellina corrugata* Williamson

Table 2.1: Species of foraminifera identified from samples of *Gelidium pristoides* on exposed and sheltered shores in False Bay, South Africa (Refer Appendix 1).

shores were different to those that dominated on sheltered shores. *Glabratella australensis* (Heron-Allen & Earland), *Rosalina* cf. *R. globularis* d'Orbigny and *Cibicides lobatulus* (Walker & Jacob) were dominant on *G. pristoides* from exposed shores. *Patellina corrugata* Williamson, *Miliolinella subrotundata* (Montagu) and *Bolivina pseudoplicata* Heron-Allen & Earland were dominant on *G. pristoides* from sheltered shores. Patterns of dominance appeared independent of plant size. Foraminifera on exposed shores were significantly larger than those on sheltered shores during both summer (292.18 ± 4.25 µm vs. 213.98 ± 10.94 µm) and winter (308.59 ± 3.55 µm vs. 254.69 ± 8.31 µm).

The results of the cluster analysis revealed that samples from exposed shores were distinct from those on sheltered shores, irrespective of season (Figure 2.2 A and B). Although no seasonal variation in abundance or diversity was observed overall ($p > 0.05$), the specific composition of foraminifera on algae from exposed and sheltered shores did change (Table 2.2). For example, *Fissurina* sp. A was responsible for ~13% of the difference between algae on exposed and sheltered shores during winter, whereas, *Elphidium* cf. *E. advenum* (Cushman) was responsible for ~11% of the difference between assemblages during summer.

Seasonality had no effect on the weight of algae ($p= 0.096$) or sediments ($p= 0.822$) per shore. However, algae were significantly larger on exposed (8.02 ± 0.86 g), than on sheltered shores (4.54 ± 0.37 g), and also trapped more sediment (2.41 ± 0.35 g vs.1.32 ± 0.29 g, respectively), irrespective of season. There was a significant, positive correlation between algal weight and sediment weight ($p < 0.05$).

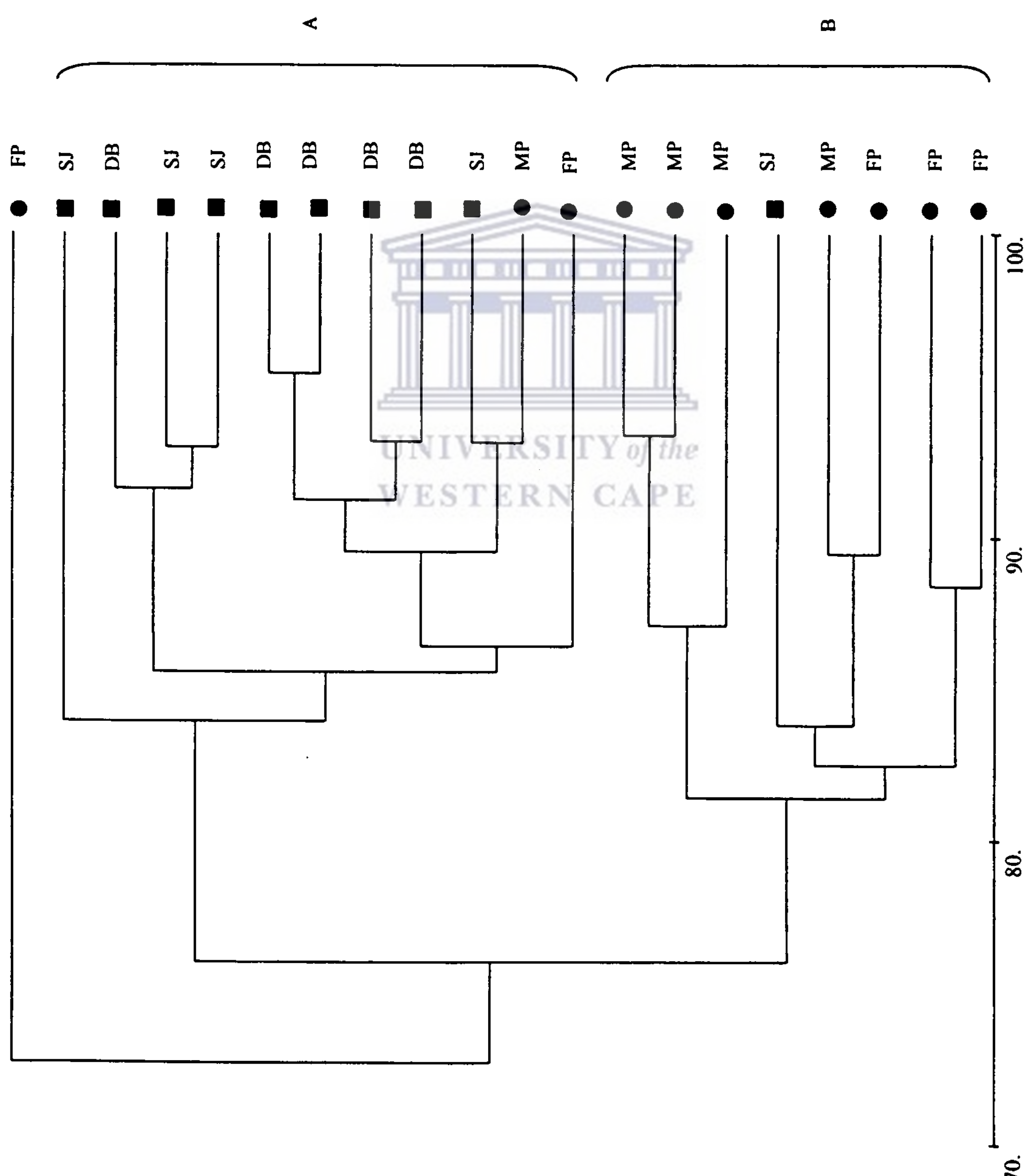

Figure 2.2.A: Dendrogram of the percentage similarity amongst the foraminiferal assemblages found on *Gelidium pristoides* on exposed and sheltered shores in winter. Circles - sheltered shores, squares - exposed shores. Shaded symbols - winter months. FP is Froggy Pond, MP is Millers Point, DB is Dalebrook and SJ is St James.

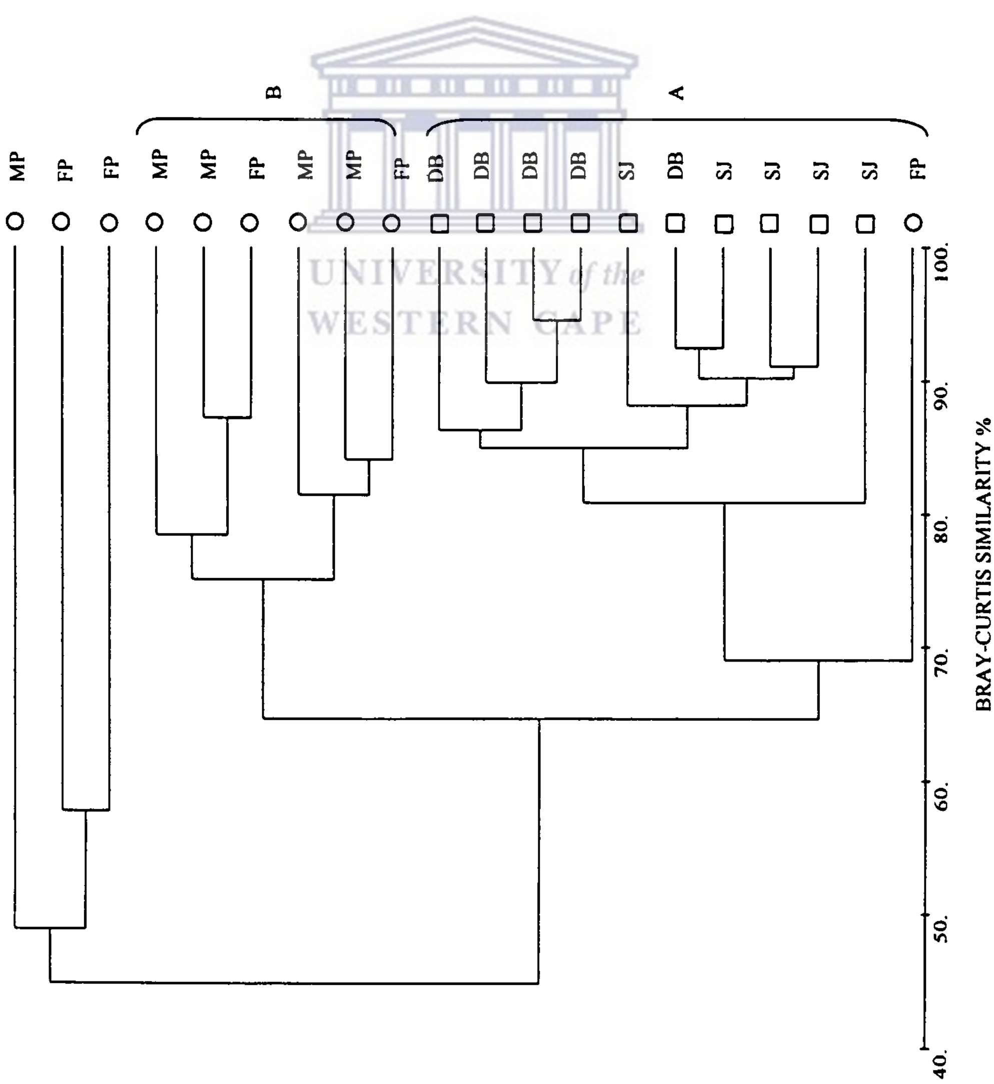

Figure 2.2.B: Dendrogram of the percentage similarity amongst the foraminiferal assemblages found on *Gelidium pristoides* on exposed and sheltered shores in summer. Circles - sheltered shores, squares - exposed shores. Open symbols - summer months. FP is Froggy Pond, MP is Millers Point, DB is Dalebrook and SJ is St James.

Group A (exposed)(87.16%)
winter
Fissurina sp. A (3.27, 0.13) 12.8%
Quinqueloculina cf. *Q. undulata* and *Q.vulgaris* (2.91, 0.13) 11.71%
Elphidium macellum (8.09, 2.13) 9.28%
Cibicides lobatulus and *Cibicides* sp. A (40.64, 11.5) 8.84%
Quinqueloculina dunkerquiana and *Q.isabellei* and *Q.seminulum* (3.27, 1.13) 8.53%
Glabratella australensis (32.91, 10.13) 7.29%
Oolina sp. A (3.36, 0.88) 7.14%

Group A (exposed)(86.39%)
summer
Elphidium cf. *E. advenum* (13, 0.17) 11.13%
Oolina sp. A (4.8, 0) 8.55%
Rosalina cf. *R. globularis* (44.3, 3.5) 7.92%
Cibicides lobatulus and *Cibicides* sp. A (21.6, 1) 7.9%
Glabratella australensis (40.7, 4) 7.33%
Bolivina "fossa" (6.4, 3.33) 6.82%
Planorbulina mediterranensis (2.4, 0.33) 6.4%

Table 2.2: The species of foraminifera identified by the SIMPER routine in PRIMER as being indicative of the two clusters of samples in Figure 2.2 A and B. The average similarity between samples in each group is indicated in parentheses on the title row. The average abundance of each species in the different groups is indicated in brackets, the second value refers to the mean abundance of that species in the contrasted group. The proportion contributed by each species to the difference between the two groups is also shown.

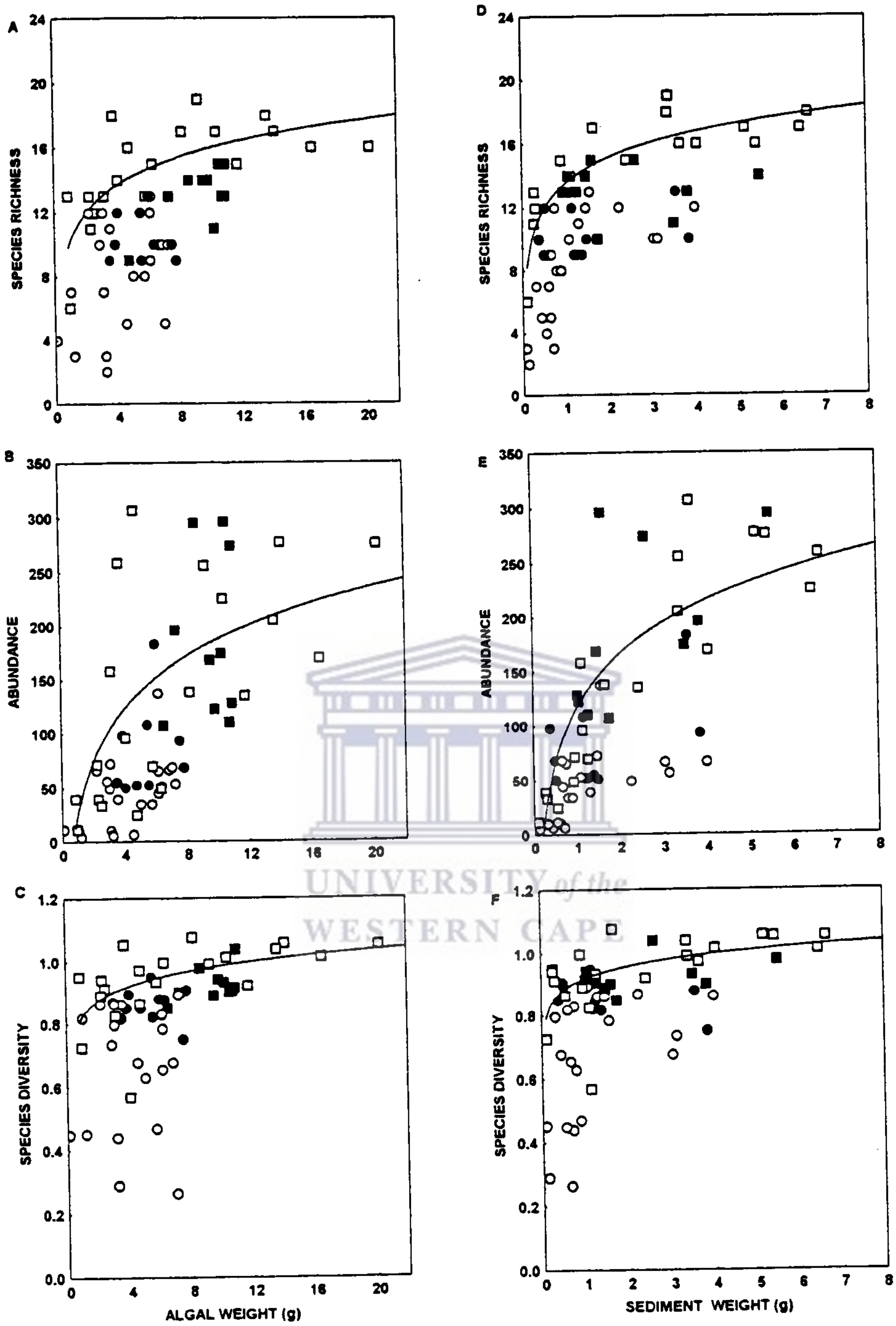

Figure 2.3: Relationships between the weight of *Gelidium pristoides* plants and the richness (Figure 2.3A), abundance (Figure 2.3B) and diversity (Figure 2.3C) of foraminifera. Relationships between the weight of sediment trapped by *Gelidium pristoides* and the richness (Figure 2.3D), abundance (Figure 2.3E) and diversity (Figure 2.3F) of foraminifera. Circles - sheltered shores, squares - exposed shores. Shaded symbols - winter months; open symbols summer months.

Correlations between the abundance, richness and diversity of foraminifera, and algal (Figure 2.3 A, B and C) and sediment (Figure 2.3 D, E and F) weight, were positive and significant. The relationship of algal and sediment weight with species richness and diversity were asymptotic and tended to level off at ~ 9 g algal weight and ~ 3 g sediment weight. Abundance continued to increase at ~ 20 g alga and ~ 8 g sediment.

A reanalysis of all data, including the extra samples collected during summer, revealed three major clusters, or four if all outliers are grouped together. These clusters show a pattern of similarity that was more strongly linked to algal and sediment weight than to exposure *per se* (Figure 2.4). The mean algal weight of the four groups were: Group A (3.25 ± 0. 59 g), Group B (4.32 ±0.55 g), Group C (9.17 ± 0.84 g) and Group D (5.54 ± 0.53 g). Group C differed significantly ($p < 0.05$) from the other three groups, and consisted mainly of exposed shore samples of algae weighing between 8 g and 16 g. Groups A, B and D did not differ significantly from each other and consisted of algae between 0.1 g and 8 g; these were mainly sheltered shore samples, although Group B had a subgroup of exposed shore samples.

The results of the BIOENV procedure in PRIMER indicated that algal weight accounted for only 12% of the pattern in community structure, whilst sediment weight accounted for only 8% of the observed pattern. In other words, the measured environmental variables accounted for a total of 20% of the pattern in the biotic assemblages.

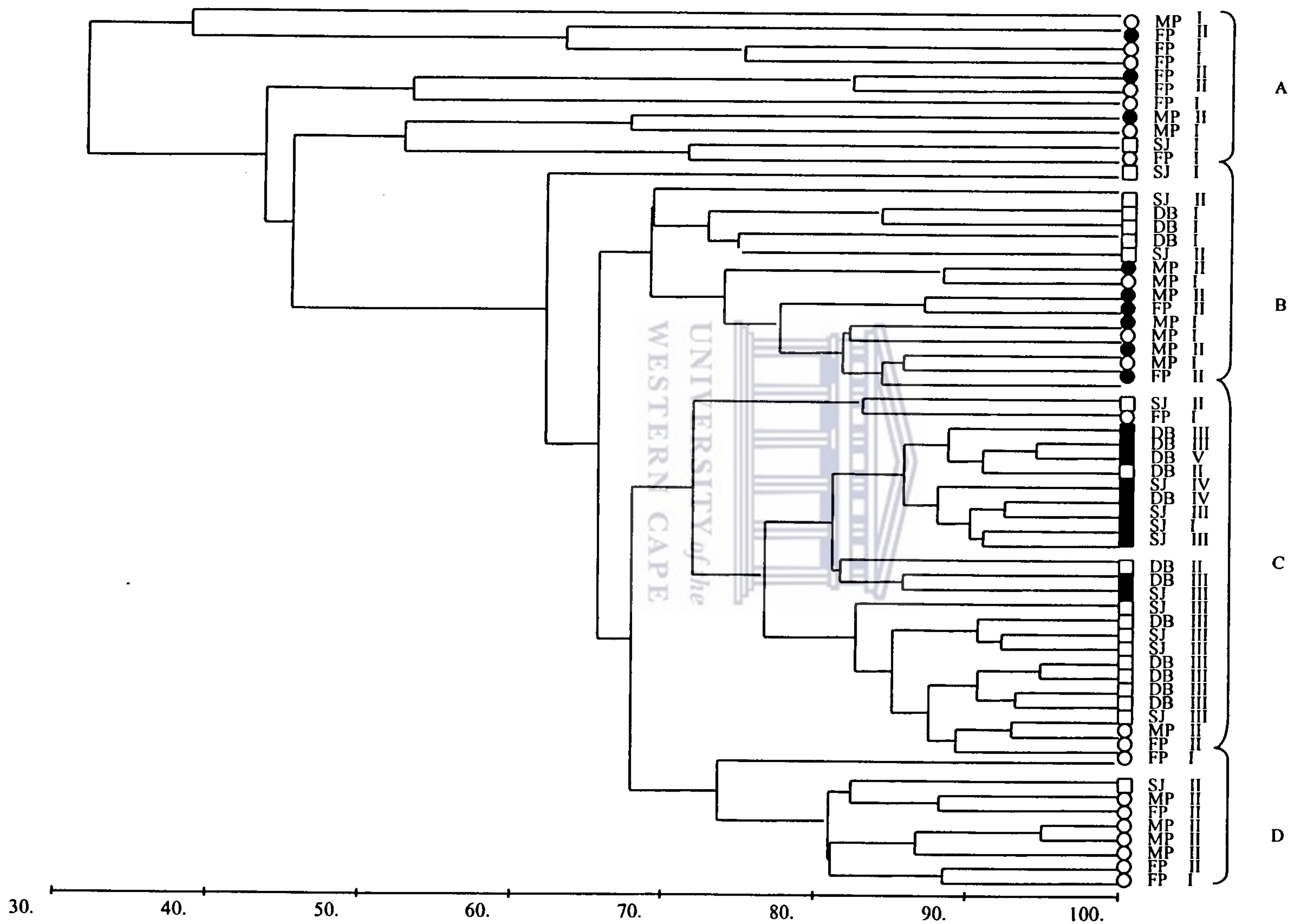

Figure 2.4: Dendrogram of the percentage similarity amongst the foraminiferal assemblages found on all *Gelidium pristoides* samples. Circles - sheltered shores, squares - exposed shores. Shaded symbols represent winter months and open symbols represent summer months. The algal weight classes are I - <4 g, II – 4 – 8 g, III - 8 – 12 g, IV – 12 – 16 g and V - >16 g.

Discussion

Glabratella sp. A, *Cibicides* sp. A, *Glandulina* sp. A, *Lagenosolenia* sp. A, *Lagena* sp. A, *Oolina* sp. A and *Fissurina* sp. A may potentially be new species. The relatively high number of potentially new species reflects the almost complete lack of taxonomic studies of intertidal foraminifera around southern Africa. With the exception of these species, all the other foraminifera have been reported from intertidal phytal communities elsewhere in the world: Argentina (Boltovskoy *et al.*, 1976), New Zealand (Hedley *et al.*, 1967), Japan (Kitazato, 1988) and Wales (Atkinson, 1969).

The species dominant on exposed shores were typical of the environment, and are commonly reported from coarse sands and gravel, while those dominant on sheltered shores are all typically found in fine sediments and mud (Murray, 1991). The genera found in greatest abundance had flat, concave shells with a large surface area for attachment, e.g. *Glabratella, Cibicides* and *Rosalina* (Atkinson, 1969). This implies that most foraminifera found associated with *G. pristoides* are attached to the alga rather than in the trapped sediments. However, *Elphidium, Quinqueloculina, Miliolinella, Bolivina* and *Brizalina* were also common, and these genera are free-living and are typically found in sediments at the base of algae (Kitazato, 1988). In other words, the foraminifera on *G. pristoides* include phytal as well as psammal species. In addition, *Oolina, Lagena* and *Fissurina* were found in smaller quantities (as noted by Boltovskoy *et al.*, 1976).

Lagena sp. A and *Planorbulina mediterranensis* were only found on exposed shores. *Lagena* is a unicameral, flask-shaped calcareous foraminifera and is rare as an epiphytic species (Boltovskoy *et al.*, 1976). Its presence on exposed shores could, therefore, be explained by the greater sediment loads carried by the algae on these shores.

By contrast, *Planorbulina mediterranensis* is an attached species, which clings to hard substrata. It is a passive suspension feeder (Murray, 1991), which might explain why it would "prefer" an exposed shore to assist in filter feeding. Without detailed information on the biology of these species, it is difficult to properly comment on their preference for shore type. Plants from exposed shores were significantly larger than those from sheltered shores, and supported a greater number of foraminifera than those from sheltered shores. Although the implications of this result are discussed in greater detail below, given the rarity of *Lagena* sp. A and *Planorbulina mediterranensis* even on exposed shores, it is possible that their absence from sheltered shores is a reflection of a reduced habitat size.

The bigger individual size of foraminifera on exposed shores could be a reflection of the high-energy environment (Leigh *et al.*, 1987). Sediments from exposed shores are generally coarser than those on sheltered shores (Gibbons, 1988a). Foraminifera living in high-energy environments and in coarse sediments have heavier, more robust tests than foraminifera that live in finer sediments (Murray, 1991). A robust test may be able to withstand the stronger wave action on more exposed shores. Larger individuals may also be more abundant on exposed shores because of the removal of smaller individuals in the more high-energy environment. Small foraminifera (< 200 μm), which are mainly juveniles of larger species or adults of small species, are thrown into suspension in the intertidal zone or by disturbance of sub-tidal sediments during storms (Loose 1970 in Murray, 1973). However, Atkinson (1969) and Murray (1973) are of the opinion that most of this is post-mortem transport taking place when protoplasm has decomposed and shells become gas-filled and weightless.

Effect of exposure on phytal foraminifera

Although seasonality did not have an effect on the overall abundance and diversity of foraminifera on *G. pristoides*, different species dominated during the two seasons. Similar results were recorded by Steinker (1976), who reported seasonal changes in the presence of *Glabratella ornatissima* and *Protelphidium,* despite the absence of overall changes in foraminiferal abundance. Seasonal changes in species dominance were also reported by Murray and Alve (2000), and they suggested this might reflect asynchronous patterns of reproduction (e.g. Murray, 1991).

The numbers of foraminifera per plant were significantly higher on exposed than sheltered shores (Figure 2.3). The differences could be attributed to individual plant weight, which was much greater on exposed than on sheltered shores around False Bay. Beckley & McLachlan (1979) also reported that *Gelidium pristoides* on the sheltered shores off St. Croix Island in Algoa Bay were much smaller than those from exposed shores. Algal weight is thought to be higher on exposed shores because wave action decreases the effect of herbivory, and the plant channels less energy on chemical defense and more on growth (Leigh *et al.*, 1987). Nutrient uptake is also thought to increase with increased wave action (Leigh *et al.*, 1987). The level of exposure could, thus, contribute to the abundance of foraminifera by its effect on algal growth.

The diversity of foraminifera, as in other meiofauna (Gibbons, 1988b; Gunnill, 1982; Edgar, 1983), increased with increasing algal weight. Algal size can be equated to area (Harrod & Hall, 1962, but see Hicks, 1976), and so the relationship between richness and diversity and plant size is subject to the various arguments of the species - area relationship: *viz* the habitat diversity theory, the area-per-*se* theory and the passive sampling theory (Connor & McCoy, 1979; McGuinness, 1984). The habitat diversity theory suggests that larger algae would have a larger number of habitats than would smaller algae, resulting in increased diversity and abundance (Connor & McCoy, 1979; McGuinness, 1984). An increase in the size of *G. pristoides* is due to the growth of distal branches and loss of basal branches (Carter & Anderson, 1986). Smaller compact plants trap more sediments and support more meiofauna per unit area than larger plants (Gibbons, 1991). However, foraminifera are capable of occupying more than just trapped sediments, they can also attach to the algae; therefore an increase in the length of distal branches could mean that more phytal foraminifera are able to inhabit the plant.

The area-*per se* theory is derived from the equilibrium theory of biogeography, and explains species number as a function of immigration and extinction rates (Connor & McCoy, 1979). The larger the plant, the lower the extinction rate and the higher the immigration rate; and consequently the larger the number of species. The passive sampling or random placement model states that because individuals may be randomly placed in a community, the chances are greater of finding more species in a larger sample area (McGuinness, 1984). However, this model is regarded as a Null hypothesis, while all other hypotheses, which take biological processes into account, are regarded as alternatives (McGuinness, 1984).

The surface area of *G. pristoides*, as well as frond length increases with increasing plant weight (Gibbons, 1988c). This increase in surface area could mean a concomitant increase in habitat diversity and this could be used to explain the increase in species richness, species diversity and the abundance of foraminifera. However, in this study, the species richness, abundance and diversity did level off, and did not continue increasing with increasing algal weight. This could be due to the way *G. pristoides* increases in size, i.e. growth in distal branches and loss of basal branches. As the plant grows, the tufts become less dense and offer less shelter against intertidal extremes than a smaller plant would (Gibbons, 1988c).

The difference in the foraminiferal assemblages on exposed and sheltered shores may therefore be due to the fact that sheltered shores have smaller plants. The chances of a high abundance or species richness are thus lower due to fewer habitats being available on smaller plants.

An increase in sediment weight occurred with algal weight, and a significant difference was found between the sediment weights on algae in the two shore types. The sediment on exposed shores is typically coarse (although this was not measured here), since heavy wave action prevents fine materials from settling out (Gibbons, 1988a), Coarse sediment has a relatively large surface area and thus, increased habitat diversity. This would result in an increase in species diversity and abundance. Fine sediment on sheltered shores reduces species diversity and abundance by decreasing surface area and habitat diversity (Gibbons, 1988a).

Although there was a relationship between foraminifera and algal and sediment weight, the BIOENV procedure in PRIMER suggests that these play a relatively minor role in determining foraminiferal assemblages, and that the cluster analyses group samples according to shore type. This suggests that other factors linked to exposure may be more important in determining foraminiferal assemblages than algae and sediment weight directly. Brasier (1975) reported that standing crop of foraminifera is related to turbulence and that weed from exposed areas yield more individuals per gram than weed from protected areas. Besides a higher productivity, predation is also possibly less on exposed shores (Leigh *et al.*, 1987). Predation on foraminifera is sometimes unselective (deposit feeders) but has been found to limit density (Murray, 1991).

It is concluded that foraminiferal assemblages differ between the two shore types, and that these differences can be attributed (in part) to both algal, and trapped sediment, weight. Foraminifera are more abundant and have a higher diversity on exposed shores. This response contrasts with that observed in previous studies of broader, meiofaunal taxa of similar size (Gibbons 1988b), and indicates that concordance need not be expected from studies of exposure across taxa. In this case the difference in results probably reflects a difference in organism habit. Foraminifera are less mobile than most of the taxa studied by Gibbons (1988b), and some have the ability to attach themselves firmly to substrata, and clearly flourish in the face of wave exposure. Copepods and nematodes, by contrast, cannot attach themselves and might therefore be expected to be more abundant on plants in sheltered shores.

Chapter Three

Biogeography of foraminifera associated with the intertidal agarophyte, *Gelidium pristoides,* along the coast of South Africa.

Abstract

Foraminifera of the red seaweed, *Gelidium pristoides* were examined for biogeographic patterns across its distribution range around South Africa in order to test for congruence with observed patterns for macrofauna. Ten exposed shores were sampled; two from along the west coast, three from False Bay, three from the south west coast and two from the south coast. Forty-five species of foraminifera were identified, of which 15 are possibly new. While common species were generally ubiquitous, a large number of rare species were found in samples. Cluster analysis using PRIMER indicated that west coast samples were separated from the balance, which tended to group together. West coast samples included many rare species that were not found in the other samples, which suggests that it is possibly in a different biogeographic province from the other areas considered. The BIOENV procedure in PRIMER showed that the measured environmental variables (sediment and algal weight) accounted for little of the structure in foraminiferal assemblages. Samples from the same shore and those from the same coast did not always cluster together; this may be a result of patchiness in the distribution of intertidal foraminifera, differences in the levels of shore exposure on the shores or rarity of species. The patterns revealed in this study conform to results found in other biogeographic studies around South Africa.

Introduction

Biogeographic studies are useful in understanding present day distributional patterns and in revealing evolutionary patterns of fauna (Briggs, 1974). South Africa is unique from an oceanographic point of view, as it is bathed by both a western boundary current (Benguela Current) and an eastern boundary current (Agulhas Current) (Figure 3.1). These currents have been found to influence the distribution of macrofauna and flora in the region, principally because of their influence on water temperatures. The earliest studies on general intertidal biogeography of South Africa were conducted by Stephenson (1936, 1939, 1944). A number of other biogeographic studies have been conducted subsequently that have focused on specific invertebrate macrofauna: Day (1967) on polychaetes, Griffiths (1974) on amphipods, Millard (1975) on hydrozoans, Gosliner (1987) on opsithobranchs, Thandar (1989) on echinodermata, Williams (1992) on octocorallian coelenterates and Procheş & Marshall (2002) on marine mites. Bolton (1986) and Bolton and Stegenga (2002) have conducted studies on the distribution of marine algae. Zoogeographic studies have also been undertaken in order to determine the placement of marine reserves (Emanuel *et al.*, 1992, Awad *et al.*, 2002, Turpie *et al.*, 2000).

All the aforementioned studies have identified and agreed upon three main biogeographic provinces around the Southern African coast. These are the cold temperate province on the west coast (Namaqua Province – Lüderitz to Cape Point), the warm temperate province on the south coast (Agulhas Province – Cape Point to East London)

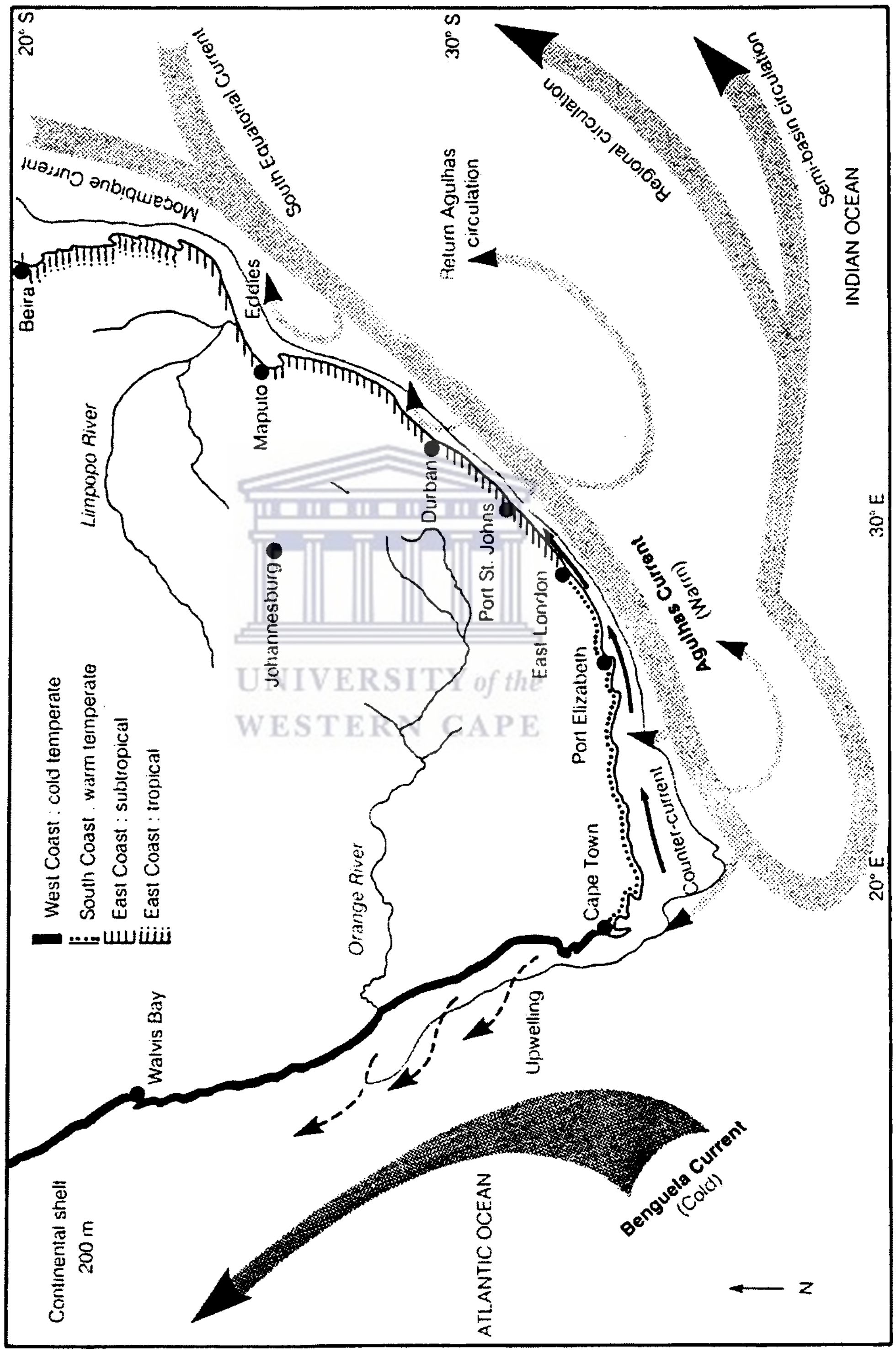

Figure 3.1: Map of South Africa illustrating the ocean currents and the biogeographic provinces (Branch & Branch, 1981).

and the warm subtropical province on the east coast (Natal Province – East London to Maputo) (Emanuel *et al.,* 1992; Bustamante & Branch, 1996). The exact boundaries of these provinces vary slightly depending on the specific taxa studied. Studies on extant benthic foraminifera, and any other meiofaunal taxon, have been neglected in South Africa and their geographical distribution is largely unknown.

Foraminifera have a ubiquitous distribution in the marine environment; they are easily sampled and are usually present in statistically large enough numbers (even in small samples) and these characteristics make them ideal subjects for ecological study (Culver & Buzas, 1999). They also have a well-described, extensive fossil record, so that consequently a number of scientific papers have been published on the global distribution of foraminifera (Culver & Buzas, 1999). Cushman (1948, in Culver & Buzas, 1999) using information from Brady's 1848 *Challenger* reports (Culver & Buzas, 1999), included data from South Africa, but in his analysis of distribution patterns failed to give details of specific genera. More detailed studies have been conducted in North and Central America and the Gulf of Mexico by Culver and Buzas (1981, 1983) and Buzas and Culver (1990, 1991), South America by Boltovskoy and Wright (1976), and New Zealand (Hayward *et al.,* 1999). Murray (1991) attempted to map global distribution by reviewing work conducted by researchers in various parts of the world. However there are still understudied areas, which make this information incomplete.

In reviewing these biogeographic studies it is evident that although water temperature is an important controlling factor, major current systems and water mass distribution, historical factors and "biotic controlling" factors all play a role in determining the present distribution of foraminifera (Culver & Buzas, 1999).

Interestingly, Culver and Buzas (1981, 1983) and Buzas and Culver (1990, 1991), concluded that foraminifera did not generally follow the biogeographic patterns observed in macrofauna but displayed wider distribution ranges. Smaller organisms of most taxa tend to have wider distributions or even cosmopolitan distributions due to higher dispersal (Fenchel, 1993).

The aim of this study is to determine whether the foraminifera associated with *Gelidium pristoides* are distributed in a manner that conforms to the biogeographic provinces proposed by macrofaunal invertebrate studies in South Africa.

Materials and Methods

Sampling site

Sampling took place during October and November 1999 (austral spring) at low tide, ~0.8 m above chart datum. Ten *G. pristoides* plants were collected from ten exposed shores from Sea Point, on the West Coast, to Port Elizabeth, on the South Coast of South Africa. The sites were divided into four regions, namely, the south coast (Victoria Bay and Port Elizabeth), the south west coast (Hermanus, Kleinmond and Pringle Bay), False Bay (Koggelbaai, St James and Buffels Bay) and the west coast (Kommetjie and Sea Point) (Figure 3.2). An attempt was made to collect plants of equal size in order to eliminate algal size as a variable. An approximate size (~ 7 cm width and length) of the algal plant were measured using vernier callipers, however, sizes could only be verified when weighed. All plants were collected on limpets to minimise the disturbance and loss of phytal fauna (as Gibbons, 1988b), and samples were immediately preserved in 70% ethanol.

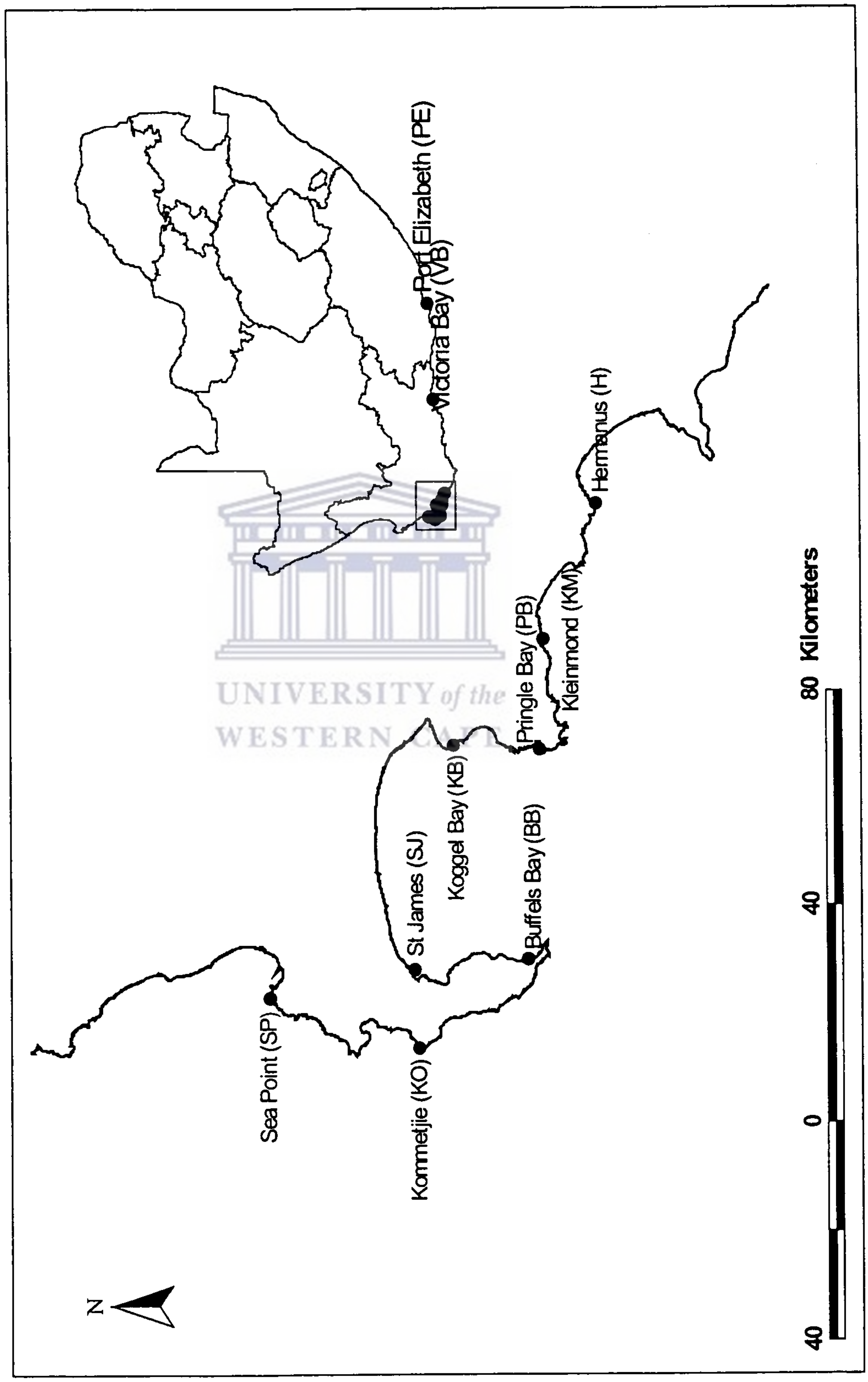

Figure 3.2: A map illustrating the position of the 10 sampling sites

Laboratory analysis

The alga was scraped off the limpet and agitated to remove sediment. The alga was then weighed (wet weight) and oven dried at 60 °C to constant mass and weighed again (dry weight). The sediment and meiofauna were sieved through a 63 μm mesh and then stained in Rose Bengal for at least 24 h. Rose Bengal stains protoplasm pink to provide an indication of which foraminifera were alive at the time of collection (Boltovskoy & Wright, 1976). The carbon tetrachloride flotation method was used for isolating foraminifera from the sediments (Cushman, 1959). However, as this method is only about 85% efficient, the sediments were also visually inspected (Boltovskoy & Wright, 1976). All "live" foraminifera were identified and counted using a stereoscopic dissecting microscope at 80x magnification. The sediment from each sample was then oven dried at 60 °C to constant mass and weighed.

Statistical analysis

Analysis of variance (ANOVA) was used to determine whether algal or sediment weight, and the abundance and diversity of foraminifera varied with geographic location. Species diversity was calculated using the Shannon-Wiener Index (H') (Krebs, 1999). Linear relationships between algal and sediment weight and the abundance and diversity of foraminifera were determined using correlation analyses. A significance level of $p < 0.05$ was used in all tests, unless stated otherwise.

The structure of the foraminiferal communities on the different shores was investigated using multivariate statistics. The numerical composition of samples was root-root transformed and a similarity matrix was constructed using the Bray-Curtis

Similarity Index (Field *et al.*, 1982). All species from all samples were included in the analysis. Cluster analysis of the samples was undertaken using PRIMER software using group average sorting (Clarke & Warwick, 1997).

The BIOENV procedure in PRIMER was used to determine which of the investigated environmental parameters (algal weight and sediment weight) could best explain the structure of the identified foraminiferal assemblages (Clarke & Warwick, 1997).

A second cluster analysis was performed using presence/absence data. The data were changed to assume distribution of species as being uniform on a shore and to assume distribution between two points on the coastline. That is, if a species was present in one sample on a shore, it was regarded as present on that shore and if a species was present in Sea Point and Port Elizabeth, it was regarded as present for all shores in between.

Results and Discussion

Forty-five species, twenty-four genera, fourteen families and five orders of foraminifera were identified (Appendix 1). Species found in large numbers included *Glabratella australensis, Miliolinella subrotundata, Cibicides lobatulus, Pararotalia nipponica, Patellina corrugata* and *Ammonia parkinsoniana*. *Glabratella australensis*, *Cibicides lobatulus, Pararotalia nipponica, Patellina corrugata* are typically attached and can be found attached algae (Murray, 1991). Other species that are typically free-living included infaunal species like *Ammonia* sp., *Bolivina* sp., *Brizalina* sp., *Elphidium* sp., *Quinqueloculina* sp. and *Trochammina* sp. (Murray, 1991). The species present indicate that foraminifera on *G. pristoides* were not only attached to the alga but were also present in the sediment trapped at the base. All of these species, with the exception of *M. subrotundata,* have flat, discoid tests with broad umbilical areas (as Chapter 2) for strong attachment in a wave-exposed environment (Kitazato, 1988). Most of these species (or genera) have been reported from intertidal studies of phytal communities elsewhere in the world (Hedley *et al.*, 1967; Atkinson, 1969; Boltovskoy *et al.*, 1976; Kitazato, 1988).

The species that were found in large numbers were generally ubiquitous in their distribution around the coast (*G. australensis, P. nipponica, A. parkinsoniana* and *P. corrugata)*. Buzas and Culver (1990) made a similar observation in North America, and noted that few commonly occurring species were endemic to a particular province. Buzas and Culver (1990) suggested that this was due to the fact that these species have more opportunity to disperse. Foraminifera disperse in the zygotic stage (Buzas & Culver, 1991). They are able to disperse by attachment to debris or moving organisms. Evidence that foraminifera are able to disperse rapidly has been obtained from fossil records and present day distribution patterns (Buzas & Culver, 1991). Dispersal times in the order of hundreds or thousands of years rather than millions of years have been suggested for foraminifera (Culver & Buzas, 1999). They also showed that 53 species currently present on the North American Atlantic coast are ubiquitous around North and Central America even though they have no fossil record, suggesting an ability to disperse rapidly over a large geographical area (Culver & Buzas, 1999).

Taxa such as *Bolivina, Brizalina, Lagena, Glandulina* and *Oolina* were rare in samples and were found only at one site or in one sample. These are either bilocular or unilocular genera, which are not typical of wave-exposed environments. Similar results were obtained in studies by Boltovskoy *et al.* (1976), from the littoral zone in Argentina.

The results of the cluster analysis of samples (based on abundance data) revealed that Sea Point (Group A) clustered alone at 45 % similarity, while all other shores tended to cluster together (Groups B-E) (Figure 3.3). Kommetjie (Group E), which is also on the west coast, clustered with False Bay samples. Cape Point on the west coast and Port Elizabeth on the east coast are regarded as boundaries for the Agulhas biogeographic province (Stephenson, 1944). The region from Cape Agulhas to False Bay and Kommetjie is regarded as a region of overlap between the Agulhas and Namaqua provinces (Stephenson, 1944). This may explain why Sea Point tends to group on its own while Kommetjie tends to group with False Bay samples. Kommetjie is still in the transition zone and its assemblages appear to have more in common with False Bay than Sea Point, although there were rare genera that were only present on the two west coast shores (*Globigerina, Guttulina, Neogloboquadrina* and *Trochammina)*.

It is possible that the presence of these genera (not found on other shores) is due to the fact that Sea Point and Kommetjie are at the start of a new biogeographic province and that these species are endemics present in low abundance at the edge of their distribution range. Awad *et al.* (2002) reported a low number of endemic species near the boundaries of regional biogeographic provinces. Provinces, based on presence/absence of taxa, can be identified on the basis of endemic species, i.e., particular species that occur nowhere else (Myers & Giller, 1988). Although most species were present in the Port Elizabeth samples, they were dominated by the miliolids. Miliolids are most abundant in shallow warm-water and coral reef regions (Cushman, 1959). The dominance of these

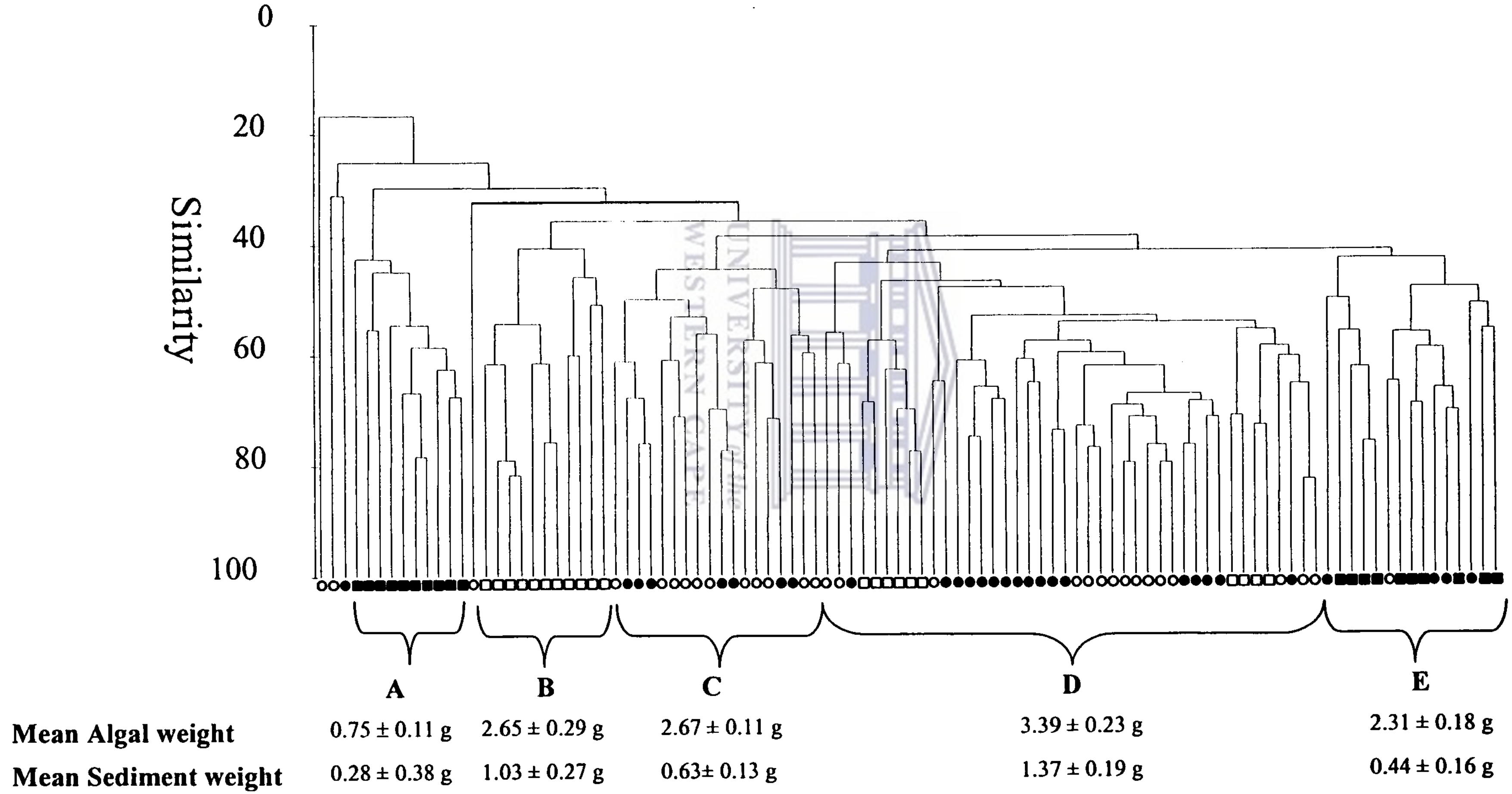

Figure 3.3: Dendrogram of the percentage similarity amongst the foraminiferal assemblages on *Gelidium pristoides* on shores sampled within it distributional range. Shaded squares – West coast, shaded circles – False Bay, open circles – South-west coast and open squares- South coast

types may be an indication of the warmer water temperature or a hypersaline environment at Port Elizabeth.

From the ecological data provided by Murray (1991), it is clear that none of the species recovered are true cold- or warm water species. The study area experiences wide temperature fluctuations throughout the year. Summer upwelling along the west coast can cause water temperatures to drop to as low as 9 °C, while a periodic inflow of warm water from the Agulhas Current sometimes takes place (Branch and Griffiths, 1988). False Bay is generally warm; this is caused by warm surface water from the Agulhas Current, which is advected into False Bay (Day, 1970). False Bay may also be subject to local upwelling in summer, and cold water periodically enters the bay (Day, 1970). The warm temperate south coast has a stable water temperature in winter (15 – 18 °C), but in summer it can be highly variable (10 – 25 °C) (Brown, 1978). Organisms living in these areas would have to be able to tolerate these fluctuations in temperature and would therefore be likely to be eurythermal. Upwelling in the Benguela is geologically recent, dating from the late Miocene (ca 10 million years ago) (Siesser, 1980 in Bolton, 1986), and this may explain why there is no increase in the number of characteristically cold-water species at Sea Point.

Rarity, patchiness in distribution and differences in levels of shore exposure may explain why samples from the same shore and shores in the same region did not cluster together (Figure 3.3). It was found that shores do differ in their levels of exposure despite the fact that all shores are considered exposed, and this could impact on faunal assemblages (Emanuel *et al.*, 1992). However, if this was the most important factor influencing foraminiferal community structure one would still expect samples from the same shore to cluster together. Studies of benthic foraminifera in small areas have generally noted that samples in close proximity exhibit different abundances and relative proportions of species (Boltovskoy & Wright, 1976). In a study on seagrass assemblages, Semeniuk (2000) noted that individual species of foraminifera exhibited high levels of spatial heterogeneity and concluded that algal microhabitats probably generate sporadic patterns in the specific taxa. Patchiness in foraminiferal distribution in the intertidal zone is thought to be a result of patchy food resources, predation, pre-reproductive deaths or disturbance (Murray & Alve, 2000). These factors may lead to clumping of offspring during reproduction, or to the aggregation of foraminifera around food clusters (Boltovskoy & Wright, 1976).

The results of the cluster analysis using presence/absence data reveals that Sea Point clusters on its own while all other shores, including Port Elizabeth cluster together (Figure 3.4). These results are essentially the same as those noted using the abundance data. This analysis assumes uniform distribution between points and eliminates patchiness as a factor influencing distribution. However, species not present in samples in the extremities, may in fact merely have been overlooked as they may be rare species.

There are no sample sites with which to meaningfully compare terminal sites on both sides. The resulting pattern may therefore not be a true reflection of distribution patterns. The levels of shore exposure as well as algal and sediment weight were found to influence assemblage structure of foraminifera (Chapter 2). To investigate whether algal and sediment weight played a role in the biogeography of foraminifera, the mean algal and sediment weight for each cluster group was calculated (Figure 3.3). Although no significant difference between the mean sediment weight of the groups was found, the

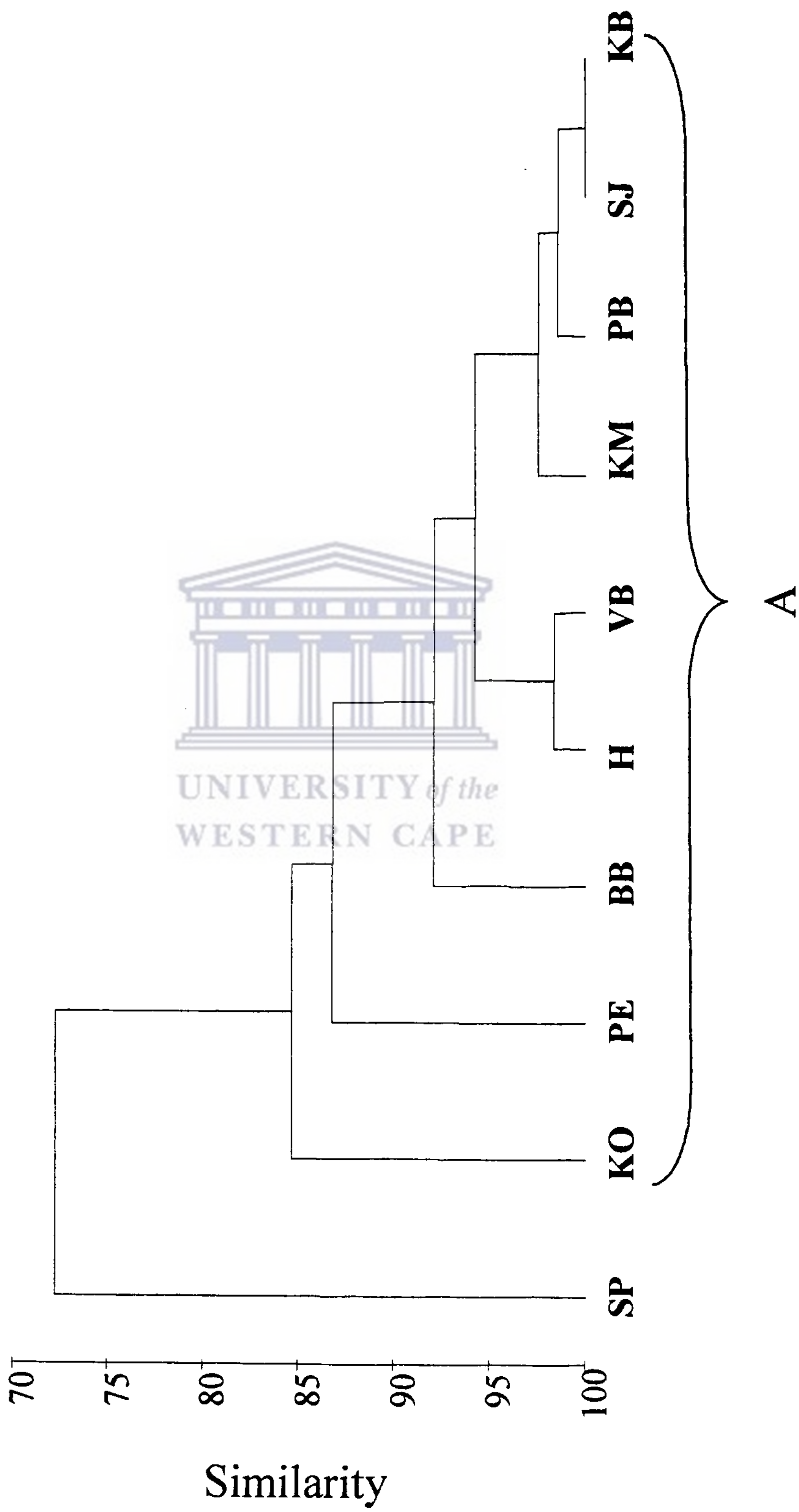

Figure 3.4: Dendogram of the percentage similarity amongst the foraminiferal assemblages, using presence/absence data and assuming uniform distribution, on *Gelidium pristoides* on shores sampled within it distributional range.

mean algal weight of Group A differed significantly from all the other groups. Having said that, the results of the BIOENV procedure in PRIMER revealed that algal weight accounted for only 2.04%, and sediment weight accounted for only 0.55%, of the observed patterns in community structure. These results suggest that other environmental factors (e.g. water temperature, circulation patterns and historical factors) play a greater role in the explanation of observed patterns. This result is even lower than that for the exposure study (Chapter 2). The possible reason for this is that all sites sampled in this study were exposed; exposure was found to have an effect on algal size as well as the amount of sediment trapped (Chapter 2).

Levels of shore exposure, as well as algal and sediment weight, were found to influence foraminiferal abundance and diversity (Chapter 2). To determine whether the same was true in this study, correlations between these data were also performed. Although algal and sediment weight were significantly correlated ($p<0.05$), and sediment weight was correlated with abundance ($p < 0.01$), species richness ($p< 0.01$) and diversity ($p=0.05$) (Figure 3.5), there was no relationship between algal weight and foraminiferal assemblages. The mean weight of algae collected on the west coast (1.54 ± 1.01 g) was only had significantly less than that from the south (2.93 ± 0.86 g), the south west (3.04± 1.3 g) and False Bay (2.87 ± 0.89 g) coasts; despite an attempt to standardize algal weight on small plants available for the collection. The mean sediment weight of False Bay (1.53 ± 1.66 g) and the west coast (0.30± 0.27g) differed significantly ($p<0.01$) from each other. No significant differences were found between the other coasts. This is due to the relationship between algal weight and the amount of trapped sediment. The higher

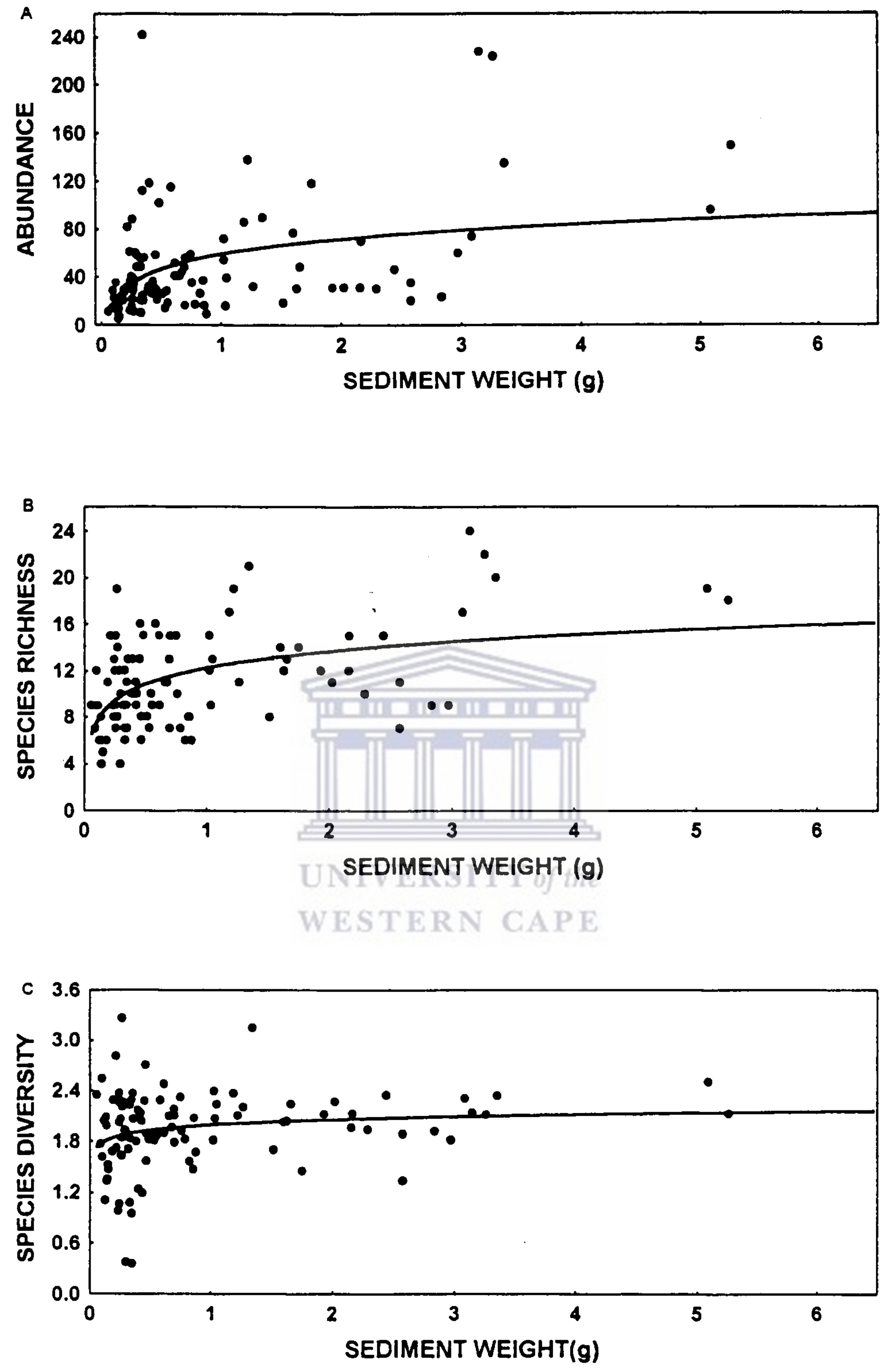

Figure 3.5: Relationships between the sediment weight trapped by *Gelidium pristoides* plants and the abundance (4A), richness (4B) and diversity of foraminifera (4C). Curves were fitted using the best fit line option

sediment load of False Bay samples may reflect the position of the rocky shores in relation to sandy beaches. Although False Bay had highest sediment load, its foraminiferal abundance was only significantly higher than that of the south west coast. Wieser (1959, in McQuaid & Dower, 1990) found that sediment accumulation amongst algae obscured differences in surface morphology resulting in a homogeneity of the habitat and an impoverishment of the epifauna. However, meiofauna have been found to increase in diversity and density with sediment accumulation, owing to increased colonization by non-phytal species (Gibbons, 1988a).

Despite differences recorded in algal and sediment weight, species richness and diversity did not differ significantly between the four areas. Abundance differed significantly between False Bay and the South West coast ($p < 0.05$). The difference in abundance can be related to species area relationships (see Chapter 2). The fact that diversity does not differ amongst shores may be due to the fact that foraminifera have wide distribution ranges and high dispersal abilities. It could also be due to coasts supporting different types of foraminifera, that is, different proportions of psammal to phytal species. Therefore, despite algal and sediment weight playing a small role in determining community structure, these variables do play an important role in determining foraminiferal abundance.

In order to conduct a comprehensive biogeographic study it would be necessary to go beyond the boundaries of the provinces identified here and to investigate further up the west and east coasts of South Africa. To continue this study it would be necessary to find an algal species that has a more ubiquitous distribution around the South African coast. Alternatively, a species with a similar structure to *G. pristoides* could be used. In studies on phytal foraminifera, it was found that foraminifera show no preference for a particular algal type, but that morphology does influence abundance and diversity (Boltovskoy *et al.,* 1976, Atkinson, 1969, Ribes *et al.,* 2000). However, Brasier (1975) suggests that besides a similar structure, one should also consider sediment content and the reaction of the alga to physical conditions like salinity and turbulence, before being able to make a meaningful comparison between different phytal surfaces.

Chapter Four

Conclusions

Forty-five species of foraminifera were identified from a total of 160 *Gelidium pristoides* plants collected around South Africa. Common taxa were all typically phytal and such forms are morphologically structurally suited to wave-exposed environments (Kitazato, 1988; Boltovskoy *et al.*, 1976). Species that were rare were either unilocular (e.g. *Oolina* sp., *Fissurina* sp., *Lagenosolenia* sp.) or not typical of a wave-exposed environment (e.g. *Lagena* sp.) or planktonic (e. g. *Neogloboquadrina* sp., *Globigerina* sp.). The composition of the foraminiferal assemblages is similar to those described from other studies in the intertidal zone (Hedley *et al.*, 1967; Atkinson, 1969; Boltovskoy *et al.*, 1976; Kitazato, 1988). Both psammal and phytal species were recovered, which suggests that the foraminifera of *G. pristoides* occur on both the algal blade and amongst the sediment trapped at the base of the plant. All species are thought to have warm- to cold temperature ranges (Murray, 1991); and can be considered eurythermal, which reflects the variable nature of the thermal environment around South Africa. Fifteen of the species recovered are potentially new (Appendix 1), and this could reflect the lack of studies on extant benthic foraminifera in the region.

Algae that retain sediment seem to provide more shelter and have richer foraminiferal assemblages than those that do not (as Boltovskoy & Wright, 1976). Algae also provide a source of food, and are thought to assist intertidal foraminifera in avoiding desiccation (Kitazato, 1988). Studies on fauna associated with *G. pristoides* in South Africa, have found it to be an ideal habitat (Beckley, 1977; Gibbons, 1988b).

Algal and sediment weight influenced the abundance and diversity of foraminifera (Chapter 2). Algal weight can be equated to area (Harrod & Hall, 1962), and the relationship between algal weight and foraminiferal abundance and diversity thus lends itself to interpretation using the various species-area hypotheses (Connor & McCoy, 1979; McGuinness, 1984). The larger the algal weight, the more sediment was trapped (Chapter 2 & 3) and the higher the foraminiferal abundance and diversity. The habitat diversity theory suggests that larger algae would have a larger number of habitats than would smaller algae, resulting in increased diversity and abundance (Connor & McCoy, 1979; McGuinness, 1984). An increase in sediment weight would also increase the diversity of habitats available (Chapter 2 & 3). When an attempt was made to standardize algal weight, it was noted that sediments strongly influenced assemblage abundance and diversity, which suggests that sediments are the primary factor that influence foraminifera on *G. pristoides*. Having said that, the BIOENV procedure in PRIMER (Chapter 2 & 3) revealed that algal and sediment weight played only a minor role in determining the structure of foraminiferal communities. This suggests that other environmental factors like exposure and biogeographic processes might play a more important role in determining foraminiferal community structure.

Chapter 2 investigated the effect of wave-exposure on phytal assemblages of foraminifera. Multivariate statistics revealed that assemblages on exposed shores were distinct from those on sheltered shores. In general, the abundance and diversity of foraminifera on exposed shores was higher than on sheltered shores; different species dominated the assemblages and larger species were common. These results contrast with macrofaunal (McQuaid & Branch, 1984; McQuaid & Branch, 1985; Emanuel *et al.*, 1992, Bustamante & Branch, 1996) and other meiofaunal studies (Gibbons, 1988b), which indicated that assemblages on exposed shores were less diverse and abundant than those on sheltered shores. It appears that foraminifera are well suited to wave-exposed shores due to their ability to attach firmly to the substrata allowing them to flourish. .

Biogeographic studies on intertidal macrofauna around South Africa consistently identify three main biogeographic provinces, namely, the cold temperate province on the west coast (Namaqua Province – Lüderitz to Cape Point), the warm temperate province on the south coast (Agulhas Province – Cape Point to East London) and the warm subtropical province on the east coast (Natal Province – East London to Maputo) (Emanuel *et al.,* 1992; Bustamante & Branch, 1996). Chapter 3 investigated whether foraminifera associated with *G. pristoides* conformed to these provinces established by previous macrofaunal studies. Multivariate statistics revealed that the foraminiferal assemblages of Sea Point were different from those on the other shores examined, and it is suggested that Sea Point can thus be regarded as part of a different biogeographic province. Samples from the same shore, and from the same coast, did not often cluster together, which is probably due to a number of factors including patchiness, differences in levels of exposure and the large number of rare species in samples. When these factors were eliminated (assuming uniform distribution of species among samples on a shore), the results conform to those of other biogeographic studies of macrofaunal taxa conducted around South Africa.

It can be concluded that the foraminiferal assemblages associated with *Gelidium pristoides* are structured by abiotic factors like the level of shore exposure, water temperatures and current systems.

Appendix One

The foraminifera of *Gelidium pristoides*, South Africa

Introduction

The earliest documented studies of British foraminifera, which used Linnean nomenclature were undertaken by Walker and Jacobs in 1798 (Haynes, 1981). The term Foraminifera was first proposed by d' Orbigny in 1826 in the classic foraminiferal taxonomic work, *Tableau Méthodique* (Loeblich & Tappan, 1964). Dujardin in 1835 first recognised foraminifera as protozoans, prior to this, foraminifera were erroneously described as gastropods, bryozoans, corals, worms or algae (Loeblich & Tappan, 1964). Brady's *Challenger* report was written in 1884, the results of this report were used by Cushman to publish a book on foraminifera in 1928 (Cushman, 1959). German protozoologists (Neumayr, Rhumbler, Eimer & Fickert, Schubert) were the first to base the classification of foraminifera on biology and general morphology (Loeblich & Tappan, 1964). The classification of foraminiferal genera by Loeblich and Tappan (1988) is now widely used in foraminiferal taxonomy.

Foraminifera belong to the phylum Protozoa, the sub-phylum Sarcodina (presence of pseudopodia), and are assigned to the class Granuloreticulosea (delicate filiform, granular pseudopodia) (Gooday, 1992). The order Foraminiferida Eichwald, 1830 is characterized by an alternation of generations and species are classified according to the composition of the test wall, the number and arrangement of their chambers and the nature and location of the aperture (Gooday, 1992). The shells are either unilocular or multilocular and are diverse in shape and form (Loeblich and Tappan, 1964). The wall of the test is composed mainly of calcium carbonate, although some are chitinous, proteinaceous or agglutinated (Albani, 2001). The walls of some calcareous foraminifera are perforated for extension of pseudopodia, while others are smooth or imperforate (Albani, 2001).

Studies on South African foraminifera have been as a result of geological surveys and mineralogical exploration. McMillan (1987) has documented, described and illustrated foraminiferal species that were retrieved from the late Quaternary off the Namibian coast. Dale & McMillan (1998) have documented species retrieved from vibracores, retrieved as a result of diamond exploration by De Beers Marine (Pty) Ltd. These vibracores were from the west coast of South Africa, off southern Namibia and off Sierra Leone. Illustrations of selected species were published. Giraudeau (1993) concentrated on planktonic assemblages on the southwest African continental margin. He reported an assemblage composition of *Globigerina quinqueloba, G. bulloides, Neogloboquadrina pachyderma, Globorotalia inflata* and *Globorotalia truncatulinoides*. Illustrations of these species were not provided. Rogers & Bremner (1991) in studying the marine-geological aspects of the Benguela ecosystem reported on benthic foraminifera retrieved. There were no descriptions or illustrations of the foraminiferal assemblages.

Studies on benthic intertidal and shallow-water forms have been neglected. It is therefore necessary to document species, firstly as a reference for any future work, and secondly as a record of distribution in South Africa. This appendix provides brief descriptions and illustrations of material recovered from *G. pristoides*.

Materials and Methods

All species described were collected from *Gelidium pristoides* following the protocols outlined in Chapters 2 and 3. The specimens were obtained from a total of 160 *G. pristoides* plants, from 13 different shores in South Africa. These shores included Sea Point, Kommetjie, Buffels Bay, St James, Miller's Point, Froggy Pond, Dale Brook, Koggel Bay, Pringle Bay, Kleinmond, Hermanus, Victoria Bay and Port Elizabeth. All "live" foraminifera were identified and counted using a stereoscopic dissecting microscope at 80x magnification. Scanning Electron Microscopy was used to establish a reference collection of illustrated specimens.

The scope of this thesis is ecological and the appendix does not strictly follow the rules of taxonomy. The format of the following descriptions follows that of available literature, using the specimens observed under the Scanning Electron Microscope. Due to the lack of availability of original literature here in South Africa, only restricted synonymies have been used. Details of the fuller synonymies are provided in one of the selected references. Selected references were used for the identification of foraminiferal species, but where species could not be identified using the available literature they were regarded as unknown. The geographic distributions of species were obtained from the selected references. Remarks were not written for species where identification was certain, and they have been confined to species that were unknown or which differed slightly from those described by other authors. Measurements given were of the widest width and the longest height. The following is a list of species found and their classification (following Loeblich & Tappan, 1988).

Sub-order: Lituolida

Family: Trochamminidae Schwager, 1877

Genus: *Trochammina* Parker & Jones, 1859

Species: *Trochammina squamata* Jones & Parker, 1860

Sub-order: Miliolina Delage & Hérouard, 1896

Family: Hauerinidae Schwager, 1876

Genus: *Quinqueloculina* d'Orbigny, 1826

Species: *Quinqueloculina dunkerquiana* Heron-Allen & Earland, 1930

Quinqueloculina isabellei d'Orbigny, 1839

Quinqueloculina seminulum (Linné, 1767)

Quinqueloculina triangularis d'Orbigny, 1846

Quinqueloculina undulata d'Orbigny, 1852

Quinqueloculina vulgaris d'Orbigny 1826

Quinqueloculina sp. "A"

Quinqueloculina sp. "B"

Genus: *Triloculina* d'Orbigny, 1826

Species: *Triloculina trigonula* (Lamarck 1804)

Genus: *Miliolinella* Wiesner, 1931

Species: *Miliolinella subrotundata* (Montagu 1803)

Sub-order: Lagenina Delage and Hérouard, 1896

Family: Lagenidae Reuss, 1862

Genus: *Lagena* Walker & Jacob, 1798

Species: *Lagena semilineata* Wright, 1886

Lagena sp. “A”

Family: Ellipsolagenidae

Genus: *Lagenoso lenia* McCulloch, 1977

Species: *Lagenosolenia* sp. “A”

Genus: *Oolina* sp. “A”

Species: *Oolina melo* d’Orbigny, 1839

Oolina sp. “A”

Genus: *Fissurina* Reuss, 1850

Species: *Fissurina marginata* (Montagu 1803)

Fissurina sp. “A”

Family: Polymorphinidae

Genus: *Globulina* d’Orbigny, 1839

Species: *Globulina* sp. “A”

Family: Glandulinidae Reuss, 1860

Genus: *Glandulina* d’Orbigny, 1839

Species: *Glandulina* sp. “A”

Sub-order: Rotaliina Delage & Hérouard, 1896

Family: Bolivinitidae Cushman, 1927

Genus: *Bolivina* d'Orbigny 1839

Species: *Bolivina "fossa"* McMillan, 1987 m. s.

Bolivina pseudoplicata Heron-Allen and Earland 1930

Bolivina sp. "A"

Bolivina sp. "B"

Bolivina sp. "C"

Genus: *Brizalina* Costa, 1856

Species: *Brizalina pseudopunctata* (Höglund, 1947)

Brizalina "rocklandsensis" McMillan, 1987 m. s.

Family: Rosalinidae Reiss, 1963

Genus: *Neoconorbina* Hofker, 1951

Species: *Neoconorbina* sp. "A"

Genus: *Rosalina* d'Orbigny, 1826

Species: *Rosalina* cf. *R. globularis* d'Orbigny, 1826

Rosalina sp. "A"

Family: Glabratellidae Loeblich & Tappan, 1964

Genus: *Glabratella* Dorreen, 1948

Species: *Glabratella australensis* (Heron – Allen and Earland, 1932)

Glabratella sp. “A”

Family: Patellinidae Rhumbler 1906

Genus: *Patellina* Williamson 1858

Species: *Patellina corrugata* Williamson 1858

Family: Rotaliidae Ehrenberg, 1839

Genus: *Ammonia* Brünnich, 1772

Species: *Ammonia parkinsoniana* (d’Orbigny 1839)

Genus: *Pararotalia* Le Calvez, 1949

Species: *Pararotalia nipponica* (Asano, 1936)

Family: Elphidiidae Galloway,1933

Genus: *Elphidium* de Montfort, 1808

Species: *Elphidium advenum* (Cushman, 1922)

Elphidium articulatum (d’Orbigny, 1839)

Elphidium crispum (Linné, 1758)

Elphidium macellum (Fichtel & Moll, 1798)

Genus: *Elphidiella* Cushman, 1936

Species: *Elphidiella* sp. “A”

Family: Globigerinidae Carpenter, Parker & Jones, 1862

Genus: *Globigerina* d'Orbigny, 1826

Species: *Globigerina bulloides* d'Orbigny, 1826

Genus: *Neogloboquadrina* Bandy, Frerichs and Vincent, 1967

Species: *Neogloboquadrina pachyderma* (Ehrenberg, 1861)

Family: Cibicididae Cushman, 1927

Genus: *Cibicides* de Montfort, 1808

Species: *Cibicides lobatulus* (Walker & Jacob, 1798)

Cibicides sp. "A"

Family: Planorbulinidae Schwager, 1877

Genus: *Planorbulina* d'Orbigny, 1826

Species: *Planorbulina mediterranensis* d'Orbigny, 1826

Trochamminacea Schwager, 1877

Trochamminidae Schwager 1877

Trochammina Parker & Jones, 1859

Trochammina squamata Jones & Parker, 1860

Pl. 1 Fig. 1

Restricted Synonomy: *Trochammina squamata* Jones & Parker, 1860. (Full details of synonymy in Heron-Allen & Earland, 1915).

Selected References: Heron-Allen & Earland, 1915, p 619. Heron-Allen & Earland, 1930, p 70. Parker, 1952, p 70, Pl. 4, Fig.11 & 12. Boltovskoy, 1963, p 64, Pl. 7, Fig. 20. Hedley *et al.*, 1964, p 164, Fig. 1 & 3.

Material Examined: Sea Point

Description: Test almost circular. Agglutinated test. The shell is divided throughout into lunate and flattened chambers. Several chambers present in a whorl, increasing in size as added. Trochospiral chamber arrangement. Outline slightly lobulate. Umbilical side excavated. Radial sutures are distinct and depressed. Aperture is an elongate opening, interiomarginal on the base of the last formed chamber. Test has a yellowish – brown appearance. Width = 241.66 μm, height = 275 μm, width: height ratio = 0.88:1

Global Distribution: Cosmopolitan on the inner-shelf, littoral

Distribution around South Africa: Sea Point. Recorded by McMillan (1987) off the coast of Namibia.

Miliolina Delage & Hérouard, 1896

Hauerinidae Schwager, 1876

Quinqueloculina d'Orbigny, 1826

Quinqueloculina dunkerquiana Heron-Allen & Earland, 1930

Pl. 1, Fig. 2 – 5

Restricted Synonomy: *Miliolina dunkerquiana* Heron-Allen & Earland, 1930. *Quinqueloculina dunkerquiana* (Heron-Allen & Earland), Haynes, 1973. (Full details of synonymy in Haynes, 1973).

Selected References: Heron-Allen & Earland, 1930, p 123, Pl. II. Haynes, 1973, p 4, Pl. 1, Fig. 8. Haynes, 1981, p 65.

Material Examined: Sea Point, Kommetjie, Buffels Bay, St James, Miller's Point, Froggy Pond, Dale Brook, Koggel Bay, Pringle Bay, Kleinmond, Hermanus, Victoria Bay, Port Elizabeth

Description: Ovate to round. Has a calcareous porcelaneous shell, polished wall and is imperforate. Short with angled chambers. Four chambers visible on the one side and three on the other. Coiling is quinqueloculine with each chamber arranged at 144° angle to the previous one.Plano-convex chamber walls. Sutures are flush to weakly depressed. Small oval, terminal aperture with a short wedge-shaped tooth. Width more than 2/3 length. Width = 270 μm, height = 300 μm, width: height = 0.9:1

Global Distribution: Cosmopolitan. Inner shelf, littoral.

Distribution around South Africa: Sea Point to Port Elizabeth. Recorded by McMillan (1987) off the coast of Namibia.

Remarks: Haynes (1973) gives a full description of *Q. dunkerquiana* and *Q. seminulum*. He is of the opinion that there are specimens of *Quinqueloculina,* which are variations of these two species and which may in fact not be true *Q. dunkerquiana* or *Q . seminulum* but actually *Q.dunkerquiana / seminulum* variants.

Quinqueloculina isabellei d'Orbigny, 1839

Pl. 1, Fig. 6 & 7

Restricted Synonomy: *Quinqueloculina isabelleana* d'Orbigny, 1839

Selected References: Hedley *et al.,* 1967, p 26 – 27.

Material Examined: Sea Point, Buffels Bay, St James, Miller's Point, Froggy Pond, Dale Brook, Pringle Bay, Kleinmond, Hermanus, Victoria Bay, Port Elizabeth

Description: Ovate to round, short with angled chambers. Coiling is quinqueloculine. Plano-convex chamber walls. Sutures are depressed. Has a calcareous porcelaneous shell, highly polished wall and is imperforate. Rounded aperture, with a distinct bifid tooth. Measurements: width = 467 µm , height = 600 µm , width: height = 0.78: 1

Global Distribution: Cosmopolitan. Inner shelf, littoral

Distribution around South Africa: Sea Point to Port Elizabeth. First living record of the species from South Africa.

Remarks: *Quinqueloculina isabellei, Q. araucana* d'Orbigny, *Q. magellanica* d'Orbigny are all accepted to be within the range of *Q. seminulum* (Hedley *et al.,* 1967).

Quinqueloculina seminulum (Linné, 1767)

Pl. 1, Fig. 8 & 9

Restricted Synonomy: *Serpula seminulum* Linné, *Miliolina seminulum* (Linné), Heron-Allen & Earland, 1930. *Quinqueloculina seminula* (Linné), Albani *et al.,* 2001. (Full details of synonymy in Loeblich & Tappan, 1988).

Selected References: Heron- Allen & Earland, 1930, p 56. Parker, 1952, Pl. 3, Fig. 21 & 22, Pl.

4, Fig. 1 &2. Hedley *et al.,* 1967, p 26. Haynes, 1973, P1. 17. Loeblich & Tappan, 1988, p 336, Pl. 344, Fig. 8 – 13, 17 – 22. Albani *et al.*, 2001.

Material Examined: Sea Point, Kommetjie, Buffels Bay, St James, Miller's Point, Froggy Pond, Dale Brook, Koggel Bay, Pringle Bay, Kleinmond, Hermanus, Victoria Bay, Port Elizabeth

Description: Elongate to ovate shape. Has a calcareous porcelaneous shell, highly polished wall and is imperforate. Chambers moderately inflated, four visible on one side and three on the other. Rounded to sub-rounded margins in cross-section. Plano-convex chamber walls. Coiling is quinqueloculine. Sutures are flush to weakly depressed. Aperture oval, terminal and small relative to the chamber cross-section with long bifid tooth. Width is ½ to 2/3 length. Width = 208.33 μm Height = 316.67 μm, width: height = 0.66:1.

Distribution: Cosmopolitan. Inner shelf, littoral

Distribution around South Africa: Sea Point to Port Elizabeth. Also recorded by McMillan (1987) off the coast of Namibia.

Remarks: *Q. seminulum* has been widely reported by authors from many parts of the world. However, since Linné's time, widely differing forms have been identified as this species (Hedley *et al.,* 1967).

Quinqueloculina triangularis d'Orbigny, 1846

Pl 1, Fig 10 & 11

Restricted Synonomy: *Quinqueloculina triangularis* d'Orbigny, 1846

Selected References: Hedley *et al.,* 1967, p 26 - 27.

Material Examined: Sea Point.

Description: Shape ovate to round. Has a calcareous porcelaneous shell, highly polished wall and is imperforate. Four chambers visible on one side and three on the other. Coiling is quinqueloculine. Plano-convex chamber walls. Sutures are not depressed. Aperture is oval and elongated with a long bifid tooth. Width = 270 μm, Height = 300 μm, width: height = 0.9: 1.

Distribution: Cosmopolitan. Inner shelf – littoral.

Distribution around South Africa: Sea Point. First living record of the species for South Africa.

Remarks: *Q. triangularis* is also considered by some authors to fall within the range of *Q. seminulum* and is also placed within the synonymy of *Q. akneriana* d'Orbigny by Marks 1951 (in Hedley *et al.,* 1967)

Quinqueloculina undulata d'Orbigny, 1852

Pl. 1, Fig. 12 and 13

Restricted Synonomy: *Miliolina undulata* d'orbigny, 1852. (Full details of synonymy in Heron-Allen & Earland, 1930).

Selected References: Heron-Allen & Earland, 1915, p 573, Pl. XLIII, Fig. 5 - 8. Heron-Allen & Earland, 1930, p 62. Rosset-Moulinier, 1972, p140, Pl. 6, Fig. 5-7.

Material Examined: Sea Point, St James, Miller's Point, Froggy Pond, Dale Brook, Kleinmond.

Description: Elongated shape. Has a calcareous porcelaneous shell, weakly polished, and is imperforate. Four chambers visible on one side, three on the opposing side. Chambers weakly inflated. Coiling is quinqueloculine. Sub-rounded to rounded margins. Sutures are moderately to weakly depressed, sometimes flush. Has fine, strong, longitudinal costae. Aperture is terminal is narrow, bordered by a flange. Has a simple tooth. Width = 350 μm, Height = 566.67 μm, width: height = 0.62:1.

Distribution: Cosmopolitan. Littoral.

Distribution around South Africa: Sea Point to Port Elizabeth. Recorded by McMillan (1987) off the coast of Namibia. First living record of this species for South Africa.

Quinqueloculina vulgaris d'Orbigny, 1826

Pl. 1, Fig. 14

Restricted Synonomy: *Miliolina vulgaris* (d'Orbigny), Heron-Allen & Earland, 1930.

Selected References: Heron-Allen & Earland, 1915, p 569. Heron-Allen & Earland, 1930, p 56. Lankford & Phleger, 1973, p 126, Pl. 2, Fig. 1.

Material Examined: St James, Miller's Point, Froggy Pond, Dale Brook, Koggel Bay, Kleinmond.

Description: Shape is ovate. Has a calcareous porcelaneous shell, highly polished wall and is imperforate. Coiling is quinqueloculine. Plano-convex chamber walls. Sutures are depressed. Has fine irregular costae. Width = 174.99 µm, Height = 150 µm, width: height = 1.17: 1

Distribution: Cosmopolitan. Inner shelf - littoral.

Distribution around South Africa: St. James to Kleinmond. First record of the species for South Africa.

Quinqueloculina sp. "A"

Pl. 1, Fig. 15

Selected References: Loeblich & Tappan (1988) was used for classification into genus.

Material Examined: Sea Point.

Description: Shape is rounded. Coiling is quinqueloculine. Plano-convex chamber walls, chambers are inflated. Sutures are depressed. Has a calcareous porcelaneous shell, highly polished wall and is imperforate. Width = 135 µm, Height = 160 µm, width: height = 1: 1.19.

Distribution around South Africa: Sea Point.

Remarks: *Quinqueloculina* sp. "A" has a smooth, highly polished imperforate shell and the test is round. These characters are similar to those of *Q. dunkerquiana, Q. seminulum, Q isabellei* or

Q. triangularis, however, all the chambers of *Quinqueloculina* sp. "A" are much more inflated and the sutures are more depressed than all the species mentioned. The final chamber also overlaps slightly towards the aperture. Specimens were rare in the samples, and only one specimen was examined on the SEM. It was therefore difficult to determine whether this is a distinct species or merely a variation of a species previously already described.

Quinqueloculina sp. "B"

Pl. 1, Fig. 16

Selected References: Loeblich & Tappan, 1988. Hayward *et al.,* 1999. Albani *et al.,* 2001. References were used to classify the specimen into genus.

Material Examined: Koggel Bay.

Description: Shape is ovate. Coiling is quinqueloculine. Plano-convex chamber walls, the final chamber has an elongated lip around the aperture. Sutures are not depressed. Has a calcareous porcelaneous shell, highly polished wall and is imperforate. Has fine irregular striations. Width = 192.31µm, Height = 223.08 µm, width: height = 0.84:1.

Distribution around South Africa: Koggel Bay.

Remarks: The final chamber has a reflexed lip similar to that of *Quinqueloculina bicostoides* (Hayward *et al.*, 1999), however, the sutures of *Quinqueloculina* sp. "B" are not depressed, the chambers are more inflated and the striae are more irregular than longitudinal. The middle chamber of *Quinqueloculina* sp. "B" is almost obscured whereas the middle chamber of *Q. bicostoides* is clearly visible. *Quinqueloculina bicornis* differs from *Quinqueloculina* sp. "B"in both the visibility of the middle chamber and in the strong and regular, longitudinal costae (Albani *et al.,* 2001). *Quinqueloculina* sp. "B" differs from *Q. undulata* and *Q. flexuosa* (Cushman, 1930) in that the costae of both these species are deeply incised grooves. Although *Q. vulgaris* has less distinct grooves, they are more regular longitudinal and the test shape differs from *Quinqueloculina* sp. "B", that is, no reflexed lip and a central terminal aperture. *Quinqueloculina* sp. "B" can thus be regarded as a species which is distinct from all others examined in the available literature.

Triloculina d'Orbigny, 1826

Triloculina trigonula (Lamarck 1804)

Pl. 1, Fig. 17 & 18

Restricted Synonomy: *Miliolites trigonula* Lamarck, 1804. *Triloculina trigonula* (Lamarck, 1804). (Full details of synonymy in Loeblich & Tappan, 1988).

Selected References: Heron-Allen & Earland, 1915, p 561. Rosset-Moulinier, 1972, p 145, Pl. 7, Fig. 8 – 9. Haynes, 1981, Pl. 176, Fig. 8.12. Loeblich & Tappan, 1988, p 344, Pl. 351, Fig. 19 – 21. Hayward *et al.*, 1999, p 106, Pl. 5, Fig. 31 & 32. Albani *et al.,* 2001.

Material Examined: Buffels Bay, St James, Koggel Bay, Pringle Bay, Victoria Bay, Port Elizabeth.

Description: Test ovoid in side view and sub-triangular in apertural view. Shell is smooth and highly polished. Chambers inflated. Three chambers visible on one side and two-and-a-half chambers visible in the last whorl. Triloculine coiling. Aperture terminal, sub-circular to ovate. Long, prominent tooth, strongly bifid, y-shaped. Width = 230 μm, Height = 290 μm, width:height = 0.79:1.

Global Distribution: Cosmopolitan. Sub-littoral to Littoral.

Distribution around South Africa: Buffels Bay to Port Elizabeth. Reported by McMillan (1987) from samples off the coast of Namibia.

Miliolinella Wiesner, 1931

Miliolinella subrotundata (Montagu 1803)

Pl. 1, Fig. 19 and 20

Restricted Synonomy: *Vermiculum subrotundum* Montagu, 1803, *Miliolina subrotunda* (Montagu), *Miliolinella subrotundata.* (Full details of synonymy in Hayward *et al.*, 1999)

Selected References: Boltovskoy, 1963, p 63, Pl. 7, Fig. 2-3. Haynes, 1981, p 177, Fig. 8.12 (17/18). Hayward *et al.*, 1999, p 96, Pl. 13, Fig. 24. Albani *et al.*, 2001.

Material Examined: Sea Point, Kommetjie, Buffels Bay, St James, Miller's Point, Froggy Pond, Dale Brook, Koggel Bay, Pringle Bay, Kleinmond, Hermanus, Victoria Bay, Port Elizabeth.

Description: Ovate to circular. Wall shiny, smooth and translucent. Test has 3-5 inflated chambers evident in adults. The chambers are arranged almost planispirally, in juveniles the arrangement is triloculine. Sutures depressed in adult and almost flush in juveniles. Aperture is terminal, sub-crescentic to semi-circular, bordered by a lip. Has a flat, semi-circular, flap-like tooth plate, which may conceal the entire aperture. Width = 250 μm, Height = 250 μm, width: height = 1:1

Global Distribution: Cosmopolitan in shallow marine environments.

Distribution around South Africa: Sea Point to Port Elizabeth. Recorded by McMillan (1987) from samples off the coast of Namibia.

Lagenidae Reuss, 1862

Lagena Walker & Jacob, 1798

Lagena semilineata Wright, 1886

Pl. 2, Fig. 1 & 2

Selected Synonymy: *Lagena semilineata* Wright, 1886. (Full details of synonymy in Albani *et al.*, 2001).

Selected References: Earland, 1934, p 161, Pl. 7 Fig. 19 & 20. Albani *et al.*, 2001

Material Examined: Kommetjie, St James, Dale Brook, Hermanus.

Description: Test with elongated neck and globular. Surface of test is smooth and glassy. Straight raised costae on the neck. Unilocular. Neck is almost parallel-sided, Apical end is broadly rounded. Aperture terminal on long neck. Lip around the aperture surrounded by short, blunt spines. Ornamentation is restricted to the lower third of the test and consists of a few depressions, which are almost triangular in shape. Width = 191.67 μm, Height = 291.67 μm, width : height = 0.66:1.

Global Distribution: Australia, Europe. Inner shelf – littoral.

Distribution around South Africa: Kommetjie to Hermanus. Also recorded from samples off the coast of Namibia (McMillan, 1987).

Remarks: Differs from the Australian specimen described by Albani *et al.* (2001) in that it does not have raised costae on the test and costae around the neck do not curve and do not extend the length of the neck. These differences in ornamentation can separate species.

Lagena sp. "A"

Pl. 2, Fig. 3

Selected References: Loeblich & Tappan (1988), Hayward *et al.* (1999) and Albani *et al.* (2001) was used to classify the specimen into genus.

Material Examined: St James.

Description: Test is globular. Test moderately polished A view of the aperture is not available. Ornamentation on the test consist of raised projections. Neck has no costae. Width = 240 μm, Height = 310 μm, width:height = 0.77:1.

Distribution around South Africa: St. James.

Remarks: May be a damaged/broken *Lagena semilineata,* which has regrown in an aberrant way. However, it differs from *L. semilineata* in that the ornamentation is not restricted to the lower third of the test and there is no ornamentation on the neck. The test lacks any ornamentation making it different from *L. hispida* Reuss, *L. laevicostatiformis* McCulloch, *L.spicata* Cushman & McCulloch *or L. spiratiformis* McCulloch. The short costae on the aboral end is similar to those of *L. doveyensis* Haynes, 1973 and *L. crenata* Parker & Jones, 1865, however, both these species have elongated tests with long thin necks which differ from the globular test of *Lagena* sp. "A". *L. flatulenta* has a smooth test, which has a globular shape similar to that of this specimen, however, this species has a rounded aboral end differing from the slightly flattened aboral end of *Lagena* sp. "A". Only one specimen was found and it is therefore difficult to make a proper judgement on the classification.

Ellipsolagenidae

Lagenosolenia McCulloch, 1977

Lagenosolenia sp. "A"

Pl. 2, Fig. 4

Selected References: Loeblich & Tappan (1988), Hayward *et al.* (1999) and Albani *et al.* (2001) were used to classify the specimen to genus.

Material Examined: Buffels Bay, St James, Miller's Point, Froggy Pond, Dale Brook, Victoria Bay, Port Elizabeth.

Description: Elongated ovate shape with definite neck region. Unilocular. Wall is calcareous and hyalinated, central region is perforate, pores are quite large. Double keeled margin. Aperture covered by a laterally flaring lip. Width = 128.5 μm, Height = 275 μm, width:height = 0.47:1.

Distribution around South Africa: Buffels Bay to Port Elizabeth.

Remarks: Only two species were found that were similar in structure to *Lagenosolenia* sp. "A". *L. falcouncinata.* Albani & Yassini, 1989 and *L. largicosta* Albani & Yassini, 1989 both have a neck which terminates in laterally flaring lips and both have a raised margins or keels. However, *L. falcouncinata* has a smooth central region, unlike *Lagenosolenia* sp."A" which has large perforations in the central region. *L. largicosta* has large central pores, however it has a wide rough margin, which extends into a thin keel. Both these species have a distinctive neck region, which is absent in *Lagenosolenia* sp. "A". The species recovered here is therefore very different to similar species examined.

Oolina d'Orbigny, 1839

Oolina sp. "A" McMillan, 1987 m. s.

Pl. 2, Fig. 8 & 9

Selected References: Dale & McMillan, 1999, p65, Pl. 30, Fig. 3. McMillan, 1987, p 220-221, Pl. 6, Fig. 13 & 14.

Material Examined: Sea Point, Kommetjie, Buffels Bay, St James, Miller's Point, Froggy Pond, Dale Brook, Pringle Bay, Kleinmond, Hermanus, Port Elizabeth

Description: Test ovoid to elongate-ovoid. Unilocular. Wall ornamented by raised, rounded ribs, which are highly polished, flat areas are matt. Ribs in elongate hexagonal pattern, pattern can become irregular. Neck surrounded by subcircular ribs. Apical region has a slight depression surrounded by a thick, circular rib. Aperture terminal, circular to sub-circular on a short dome-shaped neck. Width = 155.55 μm, Height = 161.11 μm, width:height = 0.97:1.

Distribution around South Africa: Sea Point to Port Elizabeth. Also recorded off the coast of

Namibia by McMillan (1987).

Remarks: Similar to *Oolina hexagona* as described by Hayward *et al.* (1999). Differs in the ornamentation around the neck region and the lack of a narrow, distinct neck. Also differs in the irregular pattern on the test. *O. scalariformis* (Albani *et al.,* 2001) also has raised longitudinal and transverse costae, however these are more square than the irregular shape of *Oolina* sp. "A". *O. melo* also has raised longitudinal and transverse costae. This species was first identified by McMillan (1987) as being different, however, the species was not named as the author was not entirely sure that the species was new.

***Oolina melo* d'Orbigny, 1839**

Pl. 2, Fig. 10

Restricted Synonymy: *Oolina melo d'Orbigny* 1839. (Full details of synonymy in Hayward *et al.*, 1999).

Selected References: Boltovskoy, 1963, p 64 Pl. 7, Fig. 17. Lankford & Phleger, 1973, p 123, Pl. 13, Fig. 8, 9. Hayward *et al.*, 1999. Albani *et al.*, 2001.

Material Examined: Buffels Bay, St James, Koggel Bay, Pringle Bay.

Description: Test ovoid and elongated with rounded aboral end. Unilocular. Apical end has a shallow depression. Thick raised longitudinal costae with thick flattened transverse costae, arranged in an almost arch shape. Aperture terminal, small, circular on a short neck. Width = 106.25 μm, Height = 178.13 μm, width:height = 0.6:1.

Global Distribution: Cosmopolitan. Inner shelf – littoral.

Distribution around South Africa: Buffels Bay to Pringle Bay. Reported by McMillan (1987) from the coast of Namibia.

Remarks: This species has been widely reported by different authors. The descriptions given correspond with the descriptions of the specimens examined here, however, differences in test shape were found. The test was more elongated and the costae were not as well-defined compared to the specimen illustrated by Hayward *et al.* (1999). The specimen is very similar to the species illustrated by Albani *et al.,* 2001.

Fissurina Reuss, 1850

Fissurina marginata (Montagu 1803)

Pl. 2, Fig. 11 & 12

Restricted Synonomy: *Vermiculum marginatum* Montagu, 1803. (Details of full synonymy in Hayward *et al.*, 1999).

Selected References: Hayward *et al.*, 1999, p 119, Pl. 7, Fig. 22-23. Dale & McMillan, 1999, Pl. 29, Fig. 2 & 3.

Material Examined: Sea Point, Kommetjie, St James, Miller's Point, Froggy Pond, Dale Brook, Koggel Bay, Pringle Bay, Kleinmond, Hermanus, Victoria Bay, Port Elizabeth

Description: Circular, compressed. Unilocular. Apical point indicated by faint circular mark, frequently slightly depressed. Thin keel. Test smooth and polished, finely perforate. Aperture terminal, narrow slit in plane of compression of the test. Width = 110 μm, Height = 145 μm, width:height = 0.76:1.

Distribution: Cosmopolitan. Inner shelf – littoral.

Distribution around South Africa: Sea Point to Port Elizabeth.

Remarks: Differs from that described by Hayward *et al.*, 1999, in that the keel is not as distinctive but is quite narrow.

***Fissurina* sp. "A"**

Pl.2, Fig. 13

Selected References: Hayward *et al.*, 1999. Albani *et al.*, 2001. References were used to classify the specimen into genus.

Material Examined: Buffels Bay, St James, Koggel Bay, Pringle Bay, Kleinmond, Hermanus, Victoria Bay, Port Elizabeth.

Description: Test circular to ovate, moderately compressed. Unilocular. Short neck, ovate chamber. Strong marginal keel, with weaker secondary keels on inner margin. Terminal aperture. Width = 200 μm, Height = 233.33 μm, width:height = 0.86:1.

Distribution around South Africa: Buffels Bay to Port Elizabeth

Remarks: Species differs from *F. marginata* due to the presence of a double keel and a distinctive short neck. *Fissurina orbignyana* Seguenza described by Hayward *et al.* (1999) has a similar shape to *Fissurina* sp. "A", however, it differs in that the neck region is less distinctive and there is a spine on the aboral end. *F. claricurta* McCulloch also has a double keel, however, it does not have a distinct neck region and the secondary keel is not as distinctive as in *Fissurina* sp. "A". *Lagenosolenia bradii* (Silvestri) (Albani *et al.*, 2001) is similar to this species in that it has a double keel and a distinctive neck region, however it differs from *Fissurina* sp. "A" in that it has an aboral spine. *Lagenosolenia bradii* (Silvestri) is however, the most similar to this species than any other *Fissurina* species examined.

Polymorphinidae d'Orbigny, 1839

Guttulina d'Orbigny, 1839

Guttulina irregularis (d'Orbigny, 1846)

Pl. 2, Fig. 5

Restricted Synonomy: *Globulina irregularis* d' Orbigny, 1846

Selected References: Hayward *et al.*, 1999, p 117, Pl. 7, Fig. 10 – 11. Albani *et al.,* 2001. (Details of full synonymy in Hayward *et al.,* 1999).

Material Examined: Sea Point.

Description: Test ovate to round. Test is rounded at the base and tapers slightly towards aperture. Wall calcareous and perforate. Surface smooth. Sutures flush. Aperture terminal and radiate. Width = 241.67 μm, Height = 266.67 μm, width: height = 0.9: 1.

Global Distribution: West Pacific.

Distribution around South Africa: Sea Point. First record of the species for South Africa.

Glandulinidae Reuss, 1860

Glandulina d'Orbigny, 1839

Glandulina sp. "A"

Pl. 2, Fig. 6 & 7

Selected References: Loeblich & Tappan (1988) was used to classify the specimen into genus.

Material Examined: Sea Point, Kommetjie, Buffels Bay, St James, Port Elizabeth.

Description: Circular test. Raised costae on the lower half of the test and around the aperture. Width = 193.75, Height = 196.88, width:height = 0.98:1.

Distribution around South Africa: Sea Point to Port Elizabeth.

Remarks: The only other specimen of *Glandulina* examined was *G. antarctica*. This species has an elliptical test shape whereas the species examined here has a round shape. No ornamentation was present on the test or around the aperture as in *Glandulina* sp. "A".

Rotaliina Delage & Herouard, 1896

Bolivinitidae Cushman, 1927

Bolivina d'Orbigny 1839

Bolivina "fossa" McMillan, 1987 m. s.

Pl. 2 Fig. 14 & 15

Restricted Synonymy: McMillan, 1987 m. s.

Selected References: McMillan, 1987, p285-286, Pl. 10, Fig. 9-13.

Material Examined: Sea Point, Kommetjie, Buffels Bay, St James, Miller's Point, Froggy Pond, Dale Brook, Koggel Bay, Pringle Bay, Kleinmond, Hermanus, Victoria Bay, Port Elizabeth

Description: Test slightly compressed, increasing in width in the early part of the test, becoming almost parallel-sided, maximum width at the final chambers. Wall has moderate to coarse perforations. Periphery broadly rounded with outline irregular becoming lobate near final chambers. Chambers arranged biserially. Sutures initially indistinct becoming distinct and depressed. Aperture sub-terminal, narrow and elongate-ovate shape. Channel-like depression from proloculus to final pair of chambers. Width = 73.33 μm, Height = 120 μm, width:height = 0.61:1.

Distribution around South Africa: Sea Point to Port Elizabeth. This species was first described and named by McMillan (1987) from samples retrieved off the coast of Namibia.

Bolivina pseudoplicata Heron-Allen and Earland 1930

Pl. 2, Fig. 16

Restricted Synonomy: *Bolivina plicata* Brady, 1870. (Full details of synonymy in Heron-Allen & Earland, 1930).

Selected References: Heron-Allen & Earland, 1930, p 81, p 84, Pl. III. Boltovskoy, 1963, p 60, Pl. 6, Fig. 4. Hedley *et al.,* 1967, p 30, Pl. 9, Fig. 4A, B. Hayward *et al.*, 1999, p 126, Pl. 8, Fig. 14 & 15. Albani *et al.,* 2001.

Material Examined: Sea Point, Kommetjie, Buffels Bay, St James, Miller's Point, Froggy Pond, Dale Brook, Koggel Bay, Pringle Bay, Kleinmond, Hermanus, Port Elizabeth.

Description: Test slightly compressed, increasing rapidly in width in the early part of the test, with maximum test width at the final chambers. Periphery broadly rounded. Chambers biserially arranged. Last formed chambers are slightly inflated. Distinguished by pronounced sutural excavations near midline. Strong ornamentation of depressions encircling the coarse perforations on the test wall. Aperture subterminal, small and ovate in shape. It varies greatly in the strength and shape of the markings also in size. Width: 75 μm, Height = 135 μm, width:height = 0.55:1.

Global Distribution: Typical of inner shelf to littoral environments.

Distribution around South Africa: Sea Point to Port Elizabeth. Recorded by McMillan (1987) from samples off the coast of Namibia.

Bolivina sp. "A"

Pl. 2, Fig. 17 & 18

Selected References: Loeblich & Tappan, 1988. Hayward *et al.*, 1999. Albani *et al.*, 2001. References were used to classify the specimen into genus.

Material Examined: Sea Point.

Description: Triangular appearance. Depressed sutures. Wall has small pores and larger pores along the sutures. Aperture is terminal. Width = 80 μm, Height = 150 μm, width:height = 0.53:1.

Distribution around South Africa: Sea Point.

Remarks: *Bolivina* sp. "A" lacks the coarse perforations found on *B. fossa*. *B. fossa* also has sutures that are initially indistinct becoming distinct towards the final chambers, whereas *Bolivina* sp. "A" has sutures which are quite distinct. *Bolivina* sp. "A" also differs from *B. pseudoplicata* which has strong excavations and ornamentations especially near the midline. *Bolivina* sp. "A" has a similar triangular shape to *B. compacta* and the wall is coarsely perforate, however, the pores are much larger and less dense and the sutures are more distinct than *Bolivina* sp. "A".

Bolivina sp. "B"

Pl. 2, Fig 19

Selected References: Loeblich & Tappan, 1988. Hayward *et al.*, 1999. References were used to classify the specimen into genus.

Material Examined: Sea Point.

Descriptions: Test elongate. Sutures indistinct becoming distinct towards the final chamber. Wall is perforated with large pores. Aperture is slit-like. Width = 125 μm, Height = 316.67 μm, width:height = 0.39:1.

Distribution around South Africa: Sea Point.

Remarks: *Bolivina* sp. "B" differs from *Bolivina pseudoplicata* and *Bolivina "fossa"* in the lack of excavations and depressions, these two species are also coarsely perforate whereas *Bolivina* sp. "B" has small pores which are densely distributed. *Bolivina* sp. "A" and *Bolivina* sp. "C" both have large pores. Sutures of *Bolivina* sp. "B" are indistinct only becoming distinct towards the last chamber unlike the sutures of *Bolivina* sp. "A" and *Bolivina* sp. "C", *B. pseudoplicata* and *B. "fossa"*. *B. neocompacta, B. cacozela* and *B. spathulata* (Hayward *et al.,* 1999) all have elongated tapering tests much like *Bolivina* sp. "B". However, *B. cacozela* and *B. spathulata* have distinct sutures which curve towards the periphery, they also do not have lobular final chambers. *B. neocompacta* has a lobular final chamber but the rest of the chambers are also inflated and the test is coarsely perforate unlike that of *Bolivina* sp. "B".

Bolivina sp. "C"

Pl. 2, Fig. 20

Selected References: Loeblich & Tappan, 1988. Hayward *et al.*, 1999. References were used to classify the specimen into genus.

Material Examined: Port Elizabeth

Description: Elongated and gently tapering. Sutures not strongly depressed. Wall is coarsely perforate. Width = 73.33 μm, Height = 110 μm, width:height = 0.67:1.

Distribution around South Africa: Port Elizabeth.

Remarks: *Bolivina* sp. "C" differs from *Bolivina pseudoplicata* and *Bolivina "fossa"* in its lack of coarse excavations. It differs from *Bolivina* sp. "A" in that the pores are not arranged as densely. *Bolivina* sp. "B" is more elongated and tapered with very fine dense pores. *Brizalina pseudopunctata* has large pores like *Bolivina* sp. "C" but differs in the distinct curved arrangement of the pores. *B. compacta* differs from *Bolivina* sp. "C" in its more lobular periphery and larger more dense perforations, *B. compacta* is also more elongated than *Bolivina* sp. "C.

Brizalina Costa, 1856

Brizalina pseudopunctata (Höglund, 1947)

Pl. 3, Fig. 1 & 2

Restricted Synonomy: *Bolivina pseudopunctata* Höglund, 1947. *Brizalina pseudopunctata* (Höglund), Murray, 1970.

Selected References: Parker, 1952, Pl. 5, Fig. 20 & 21. Murray, 1970, p 484, Pl. 1, Fig. 15 & 16. Dale & McMillan, 1999, p 63, Pl. 28, Fig. 1.

Material Examined: Sea Point, Kommetjie, Buffels Bay, St James, Dale Brook, Koggel Bay, Pringle Bay, Kleinmond, Hermanus, Victoria Bay, Port Elizabeth

Description: Elongate, increasing rapidly and regularly in width in early part becoming almost parallel in final part of the test. Periphery broadly rounded, becoming lobate in final chambers. Chambers arranged biserially. Large pores arranged along the sutures of the chambers. Sutures are curved and overlap at their ends. Subterminal, aperture, narrow and elongate to ovate shape. Width = 125 µm, Height = 145 µm, width:height = 0.86:1.

Global Distribution: Cosmopolitan. Innershelf – littoral.

Distribution around South Africa: Sea Point to Port Elizabeth. Recorded off the west coast of South Africa by Dale & McMillan (1998).

***Brizalina "rocklandsensis"* McMillan, 1987 m. s.**

Pl. 3, Fig. 3

Selected References: McMillan, 1987, p 299, Pl. 11, Fig 3 – 9.

Material Examined: St James, Miller's Point, Froggy Pond, Pringle Bay, Kleinmond, Port Elizabeth.

Description: Test initially weakly compressed becoming strongly compressed in final part. Test increases rapidly in width in early part, maximum width in final chambers. Periphery rounded becoming sub-acute. Elongate and tapering strongly. Smooth wall with very large pores, does not appear to be arranged in a particular way. Aperture is terminal. Width = 250 µm, Height = 362.5 µm, width:height =0.69:1.

Distribution around South Africa: St James to Port Elizabeth. This species was first examined and described by McMillan (1987) from vibracores retrieved off the coast of Namibia.

Rosalinidae Reiss, 1963

***Neoconorbina* Hofker, 1951**

***Neoconorbina* sp. "A"**

Pl. 3, Fig. 4

Selected References: Loeblich & Tappan (1988) was used to classify the specimen into genus.

Material Examined: St James, Pringle Bay, Kleinmond, Port Elizabeth.

Description: Test round, trochsospiral. Early chambers subglobular, increasing in breadth, final chamber extends almost half the periphery. Radial sutures raised and curved, suture of final chamber almost completely horizontal. Wall is finely perforate. Width = 124 µm, Height = 150 µm, width:height = 0.83:1.

Distribution around South Africa: St James to Port Elizabeth.

Remarks: The identification of this specimen as *Neoconorbina* is not entirely certain, may also be *Gavelinopsis* sp. or *Pileolina* sp. All three of these genera have chambers which enlarge as they are added, so that the final sutures become strongly oblique. *Gavelinopsis hamatus* (Hayward *et al.,* 1999) has an umbilical plug and is finely perforate whereas *Neoconorbina* sp. "A" has enlarged dense pores on the central chambers. *Neoconorbina terquemi* (Hayward *et al.,* 1999) is smooth to finely perforate lacking rows of large pores or papillae. *Pileolina zealandica* (Hayward *et al.,* 1999) has a flat umbilical side with strong central tubercles with numerous branching striae towards the periphery, it is more finely perforate than *Neoconorbina* sp. "A".

Rosalina d'Orbigny, 1826

Rosalina cf. *R. globularis* d'Orbigny, 1826

Pl. 3, Fig. 5,6 & 7

Restricted Synonomy: *Rosalina globularis* d'Orbigny, 1826

Selected References: Loeblich & Tappan, 1988, p 561, Pl. 610, Fig. 1 – 5, Pl 611, Fig. 1 – 6., Fig. 459, 1a-c. Levy *et al.*, 1979, p 78, Pl. 4, Fig. 41, 44 & 45. Haig, 1997, p 275, Fig. 5,6.

Material Examined: Sea Point, Kommetjie, Buffels Bay, St James, Miller's Point, Froggy Pond, Dale Brook, Koggel Bay, Pringle Bay, Kleinmond, Hermanus, Victoria Bay, Port Elizabeth

Description: Rounded to lobate shape. Dorsal side convex while ventral side is flat and slightly concave. Test smooth with prominent coarse perforations. Dorsal view is finely perforate with an almost smooth central region. Large pores on the ventral side, which are absent near the periphery. Chambers are strongly inflated on dorsal side. Radial sutures on dorsal side are curved towards the periphery. Aperture is interio-marginal on the ventral side. Aperture is elongated extending from periphery to the umbilicus. Umbilicus wide and deep, partially obscured by umbilical flaps.Width = 138 μm, Height = 116 μm, width:height = 1.19: 1

Global Distribution: Widespread in shallow marine environments.

Distribution around South Africa: Sea Point to Port Elizabeth. Recorded by McMillan (1987) off the coast of Namibia.

Rosalina sp. "A"

Pl. 3, Fig. 8

Selected References: Loeblich & Tappan (1988) was used to classify the specimen into genus.

Material Examined: Kommetjie, Koggel Bay, Pringle Bay, Kleinmond, Victoria Bay.

Description: Rounded. No chambers visible on the dorsal side, ventral side unknown. Margin is rounded but not regular. Finely perforate with depressed areas. Width = 140 μm, Height = 145 μm, width:height = 1:1.03

Distribution around South Africa: Kommetjie to Victoria Bay.

Remarks: Differs from *Rosalina globularis,* which has coarse perforations and inflated chambers which give the test a lobate shape. It also has distinct curved radial sutures absent in *Rosalina* sp. "A". *R. bradyi* has flush limbate sutures and dorsal perforations which disappear towards the periphery differing from *Rosalina* sp. "A". *R. irregularis* has irregular chambers which are longer than wide with each successive whorl. The position of chambers is uncertain because of the lack of distinct sutures. This species could possibly be *Glabratellina kermadecensis* (Hayward *et al.,* 1999) as both these species have coarsely peforate test walls which obscure chamber arrangements and sutures.

Glabratellidae Loeblich & Tappan, 1964

Glabratella Dorreen, 1948

Glabratella australensis (Heron – Allen and Earland)

Pl. 3, Fig. 9, 10 & 11

Restricted Synonymy: *Discorbis australensis* (Heron-Allen & Earland, 1932), *Pileolina australensis* (Heron-Allen & Earland). (Full details of synonymy in Albani *et al.*, 2001).

Selected References: McMillan, 1987, p 363, Fig. 14 –18, Pl. 15, Fig. 2 - 4. Lankford & Phleger, 1973, p 121, Pl. 4, Fig. 26. Albani *et al.*, 2001

Material Examined: Sea Point, Kommetjie, Buffels Bay, St James, Miller's Point, Froggy Pond, Dale Brook, Koggel Bay, Pringle Bay, Kleinmond, Hermanus, Victoria Bay, Port Elizabeth.

Description: Large test. Lobulate shape, dorsal side strongly convex while ventral side is flat to weakly concave. Shell is calcareous, hyaline and highly polished. Chambers are elongate and crescentic shaped. Dorsal view has radial sutures, which are thick and raised and curve towards the periphery, it is coarsely perforate. Central umbilical region surrounded by thick raised sutures, and is also perforate. Ventral side has numerous small papillae, which are smaller at the periphery and become thicker towards the central region. Aperture is an irregular elongate opening on the umbilical region. Width = 516.67 μm, Height = 516.67 μm, width:height = 1:1

Global Distribution: Australia, also reported off the west coast of North America.

Distribution around South Africa: Sea Point to Port Elizabeth. Reported by McMillan from samples collected off the coast of Namibia

Remarks: Differs from the specimen illustrated by Albani *et al.* (2001) in that the shape is more lobulate and surface is more perforate. The South African species of *G. australensis* differs from that of the Australian and S. American species in the shape of the shell.

Glabratella sp. "A"

Pl. 3, Fig. 12

Selected References: Loeblich & Tappan (1988) was used to classify the specimen into genus.

Material Examined: Sea Point, Kommetjie, Buffels Bay, St James, Miller's Point, Froggy Pond, Dale Brook, Koggel Bay, Pringle Bay, Kleinmond, Hermanus, Victoria Bay, Port Elizabeth

Description: Round shape. Hyaline calcareous shell. Perforate dorsal side with thick sutures which are curved towards the periphery. Central umbilical area is not perforate or circular. Ventral side has many papillae. Width = 213.33 μm, Height = 200 μm, width: height = 1.07:1.

Distribution around South Africa: Sea Point to Port Elizabeth.

Remarks: May be a juvenile *Glabratella australensis.* Similar in ornamentation, that is, in radial sutures but lacks the lobulate outline which is a distinguishing character for *Glabratella*. According to Hayward *et al.* (1999), a rounded periphery is a distinguishing character of the genus *Glabratellina* so this species may in fact be *Glabratellina* sp.

Patellinidae Rhumbler, 1906

Patellina Williamson 1858

Patellina corrugata Williamson 1858

Pl. 3, Fig. 13 & 14

Restricted Synonymy: *Patellina corrugata* Williamson, 1858. (Full details of synonymy in Hayward *et al.*, 1999).

Selected References: Cushman, 1930, p 15, Pl. 3, Fig. 5a-c. Hedley *et al.,* 1967, p 46. Boltovskoy & Lena, 1966, p 147-148, Pl. 13, Fig. 15. Hayward *et al.*, 1999 p 93, Pl. 3, Fig. 11 – 13. Albani *et al.* 2001.

Material Examined: Sea Point, Kommetjie, Buffels Bay, St James, Miller's Point, Froggy Pond, Dale Brook, Koggel Bay, Pringle Bay, Kleinmond, Hermanus, Victoria Bay, Port Elizabeth.

Description: Conical test, circular in outline. Umbilical side weakly concave to flat. Test surface smooth and moderately polished. Finely and sparsely perforated on the dorsal side. Two chambers per whorl, each chamber overlapping and occupying more than half the whorl as seen from the spiral side. Moderate to low trochospiral. Periphery angular and carinate (keel or flange). On the spiral side a distinct line of pores parallel to the sutures. Pores accentuate the coiled proloculus (initial chamber of foraminiferal test). Aperture curved along the internal edge of the chamber on the umbilical side. Width = 100 μm, Height = 96.67 μm, width: height = 1.03:1.

Global Distribution: Cosmopolitan.Littoral and sub-littoral environments.

Distribution around South Africa: Sea Point to Port Elizabeth. Recorded by McMillan (1987) from samples retrieved off the coast of Namibia.

Remarks: Species widely reported by many authors. Differs from that described by Hayward *et al* (1999) in that tests are more compressed.

Rotaliidae Ehrenberg, 1839

Ammonia Brünnich, 1772

Ammonia parkinsoniana (d'Orbigny 1839)

Pl. 3, Fig. 15

Restricted Synonymy: *Rosalina parkinsoniana* d'Orbigny 1839. (Full details of synonomy in Hayward *et al.,* 1999).

Selected References: Boltovskoy, 1970, p 338. McMillan, 1987, p 439, Pl. 20, Fig. 6-12. Hayward *et al.,* 1999, p 162, Pl. 16. Dale & McMillan, 1999, Pl. 27, Fig. 2-7.

Material Examined: Sea Point, Kommetjie, Buffels Bay, St James, Koggel Bay, Pringle Bay, Kleinmond, Hermanus, Victoria Bay, Port Elizabeth

Description: Biconvex, trochospiral with low conical test. Test smooth and polished, densely covered with pores. Periphery circular in outline becoming lobate in the final whorl. Chambers on dorsal side semi-circular. Chambers on ventral side broadly wedge-shaped. Sutures on dorsal side spiral and distinct, on ventral side they are straight to weakly curved. Umbilicus open. Aperture is a low, elongate arch at the interior margin of the final chamber. Width: 250 μm , Height = 291.67 μm, width:height = 0.86:1.

Global Distribution: Cosmopolitan. Hyposaline, estuarine and inner shelf environments

Distribution around South Africa: Sea Point to Port Elizabeth. Recorded by McMillan (1987) from the coast of Namibia and Dale & McMillan (1999) from the west coast of South Africa.

Remarks: May be similar to *Ammonia parkinsoniana* f. *aoteana* (Finlay, 1940) as described by Hayward et al. (1999), however a view of the dorsal side was not obtained.

Pararotalia Le Calvez, 1949

Pararotalia nipponica (Asano, 1936)

Pl. 3, Fig. 16 – 20

Restricted Synonomy: *Calcarina rotula* sensu Chapman, 1923. *Rotalia nipponica* Asano, 1936, *Pararotalia nipponica* (Asano). (Full details of synonymy in McMillan, 1987).

Selected References: McMillan, 1987, p 443, Pl. 20, Fig. 13 – 17, Pl. 21, Fig. 1 - 3. Kitazato, 1988, p 824, Pl. 11, Fig. 1 – 4. Dale & McMillan, 1999, p 18 Pl. 2, Fig. 5 – 8.

Material Examined: Sea Point, Kommetjie, Buffels Bay, St James, Koggel Bay, Pringle Bay, Kleinmond, Hermanus, Victoria Bay, Port Elizabeth

Description: Test biconvex. Periphery rounded to lobate. Chambers round to ovate and slightly inflated in dorsal view and in ventral view are wedge-shaped. Chambers may have smoothly rounded periphery or blunt peripheral spine on each chamber. Trochospiral coiling. Umbilicus filled by plug, which varies in size. Sutures on ventral side depressed and almost triangular, while they are almost flush on the dorsal side. Wall is calcareous and perforate. Aperture is an elongate, round opening and is interiomarginal on the last chamber. Width = 281.82 µm, Height = 272.73 µm, width:height = 1.03:1

Global Distribution: Indo-Pacific and off the east coast of the Atlantic. Inner shelf – littoral.

Distribution around South Africa: Sea Point to Port Elizabeth. Recorded by McMillan (1987) from the coast of Namibia and Dale & McMillan (1999) from the west coast of South Africa.

Remarks: Tests very greatly morphologically, chambers can have well defined sutures, be smooth or spined and sutures and umbilical plug on the umbilical side can also be well-defined or smooth.

Elphidiidae Galloway,1933

Elphidium de Montfort, 1808

Elphidium advenum (Cushman, 1922)

Pl. 4, Fig. 1 & 2

Restricted Synonymy: *Polystomella advena* Cushman, 1922. (Full details of synonymy in Hayward *et al.*, 1997).

Selected References: Haynes, 1981, pl. 8. Hayward *et al.*, 1997, p 64. Haig, 1997, p 276, p 268, Fig. 6 (19, 20). Dale & McMillan, 1999, p 63, Pl. 28, Fig. 4. Albani *et al.*, 2001

Material Examined: Sea Point, Kommetjie, Buffels Bay, St James, Koggel Bay, Pringle Bay, Kleinmond, Hermanus, Victoria Bay, Port Elizabeth

Description: Biconvex profile, circular test with strong rounded keel. Calcareous hyaline shell. 10- 20 chambers. Planispiral. Radial sutures with narrow septal bridges. Aperture consists of a row of pores. Width = 231.25 μm, Height = 187.5 μm, width:height = 1.23:1.

Global Distribution: Pacific, Indian and western Atlantic Oceans. Inner to outer shelf.

Distribution around South Africa: Sea Point to Port Elizabeth. Recorded by McMillan (1987) from the coast of Namibia and Dale & McMillan (1999) from the west coast of South Africa.

Elphidium articulatum (d'Orbigny, 1839)

Pl. 4, Fig. 3 & 4

Restricted Synonomy: *Polystomella articulata* d'Orbigny, 1839. *Nonion orbiculare* Cushman, 1944. (Full details of synonomy in Parker, 1952).

Selected References: Parker, 1952, p 411, Pl. 5, Fig. 5 – 7. Boltovskoy, 1963, Pl. 6, Fig. 15. Dale & McMillan, 1999, Pl. 28, Fig. 5 & 6.

Material Examined: Sea Point, Kommetjie, Buffels Bay, St James, Koggel Bay, Pringle Bay, Kleinmond, Hermanus, Victoria Bay, Port Elizabeth

Description: Test biconvex, circular shape. Planispiral coiling. Chambers are weakly inflated, ten to twelve may be present in the final whorl. Has a smooth margin. Radial sutures slightly curved, with narrow septal bridges. Central boss ornamented with granulations and other spinose structures. Aperture with small opening across the interior margin of the final chamber. Width = 280 μm, Height = 290 μm, width:height = 0.97:1.

Global Distribution: From Indian and Atlantic Oceans, no reports from the Pacific.

Distribution around South Africa: Sea Point to Port Elizabeth. Recorded by McMillan (1987) from the coast of Namibia and Dale & McMillan (1999) from the west coast of South Africa.

Elphidium crispum (Linné, 1758)

Pl. 4, Fig. 5 & 6

Restricted Synonymy: *Nautilus crispus* Linné, 1758, *Elphidium crispum* (Linné) Cushman, 1933. (Full details of synonymy in Hayward *et al.*, 1997).

Selected References: Heron-Allen & Eardland, 1915, p 733. Haynes, 1981, p 272, Fig. 12.9(22/23). Kitazato, 1988, Pl. 11, Fig. 8,9. Hayward *et al.*, 1997, p 74. Albani *et al.*, 2001.

Material Examined: Kommetjie, Buffels Bay, St James, Koggel Bay, Pringle Bay, Kleinmond, Victoria Bay, Port Elizabeth

Description: Large circular test. Biconvex to rhomboidal profile. Has a large number of chambers, can vary from 20 to 40. Margin is not smooth but radial sutures continue around the edge. Many radial sutures with numerous narrow septal bridges. Central umbilical region is covered by a raised rounded boss with pores. Row of pores at the base of the apertural face. Width = 362.5 μm, Height = 387.5 μm, width:height = 0.94:1.

Distribution: Indo-pacific and Mediterranean. Inner shelf to littoral.

Distribution around South Africa: Kommetjie to Port Elizabeth. Recorded by McMillan (1987) from the coast of Namibia and Dale & McMillan (1999) from the west coast of South Africa.

Elphidium macellum (Fichtel & Moll, 1798)

Pl. 4, Fig. 7 & 8

Restricted Synonymy: *Nautilus macellus* varietas ß Fichtel & Moll, 1798. *Elphidium macellum* (Fichtel & Moll), Cushman, 1939. (Full details of synonymy in Hayward *et al.*, 1997)

Selected References: Heron-Allen & Earland, 1915, p 734. Boltovskoy, 1963, p 62, Pl. 6, Fig. 16. Brasier, 1975, p 199, Pl. 1, Fig. 7. Hayward *et al.*, 1997, p 84, Pl. 13, Fig. 9 – 14.

Material Examined: Kommetjie, Buffels Bay, St James, Koggel Bay, Pringle Bay, Kleinmond, Hermanus, Victoria Bay and Port Elizabeth.

Description: Large test, involute. Test round to lobulate. Compressed with biconvex to flat sides. Has 15 to 22 chambers in the adult. The margin has a narrow rounded keel. Radial sutures are depressed and curve towards the periphery. Septal bridges are wide extending most of the width of the chamber. The umbilical region is open and has many papillae. Width = 254.54 μm, Height = 345.45 μm, width:height = 0.74:1.

Global Distribution: Indo-Pacific and Mediterranean.

Distribution around South Africa: Kommetjie to Port Elizabeth. Recorded by McMillan (1987) from the coast of Namibia and Dale & McMillan (1999) from the west coast of South Africa.

Elphidiella Cushman, 1936

Elphidiella sp. "A"

Pl. 4, Fig. 9

Selected References: Loeblich and Tappan (1988) was used to classify the specimen into genus.

Material Examined: Port Elizabeth

Description: Rounded test, involute. Chambers inverted v-shape. Raised radial sutures with raised septal bridges. Sutures on final chamber do not radiate from the centre but are peripheral. Pores along radial sutures. Umbilicus with many papillae. Marginal aperture. Width = 375 μm, Height = 375 μm, width:height = 1:1.

Distribution around South Africa: Port Elizabeth

Remarks: Similar to a species of *Elphidiella* examined by Dale & McMillan (1999) retrieved in the Saldanha Bay region off the west coast of South Africa.

Globigerinidae Carpenter, Parker & Jones, 1862

Globigerina d'Orbigny, 1826

Globigerina bulloides d'Orbigny, 1826

Pl. 4, Fig. 10 & 11

Restricted Synonymy: *Globigerina bulloides* d'Orbigny, 1826.

Selected References: Cushman, 1914, p 6, Pl. 2, Fig. 7 – 9. Bé *et al.,* 1971, p 38, Pl. 1, Fig. 4. Cifelli, 1982, p 7, Pl. 8, Fig. 1 & 2, Pl. 9. Kemle-von Mücke and Hemleben, 1999, p 61, Fig. 6.3.

Material Examined: Kommetjie.

Description: Biconvex, globular. Test trochospiral inflated. Wall not extensively porous or pitted, but is smooth with a few pores. Early chambers small while chambers of final whorl are large and lobate. Sutures are depressed. Aperture umbilical. Aperture from each chamber open into central umbilical depression. Width = 205.56 μm, 147.22 μm, width:height = 1.4:1.

Global Distribution: Abundant in subpolar and temperate waters. Cosmopolitan.

Distribution around South Africa: Kommetjie. Recorded by McMillan (1987) from the coast of Namibia and Dale & McMillan (1999) from the west coast of South Africa.

Neogloboquadrina Bandy, Frerichs and Vincent, 1967

Neogloboquadrina pachyderma (Ehrenberg, 1861)

Pl. 4, Fig. 12 & 13

Restricted Synonymy: *Globigerina pachyderma* (Ehrenberg, 1861), Cifelli, 1982.

Globoquadrina pachyderma , Kemle-von Mücke and Hemleben, 1999

Selected References: Bé, 1960, p 64-68. Cifelli, 1982, p 9, Pl. 12, Fig. 2 & 3. Dale & McMillan, 1999, p 65, Pl. 30, Fig. 1. Kemle-von Mücke and Hemleben, 1999, p 66, Fig. 6.27.

Material Examined: Sea Point.

Description: Test globose. Low trochospiral coiling. Multilocular. Chambers round and inflated. Wall perforate to give a pitted appearance, with no spines. Sutures depressed, straight to weakly curved. Aperture is a low, wide arch opening into the umbilicus.Width = 231.25 μm, Height = 181.25 μm, width:height = 1.28:1

Global Distribution: This species is nearly restricted to polar water masses, and is often the only planktic species in Antarctic and Arctic waters.

Distribution around South Africa: Sea Point. Recorded by McMillan (1987) from the coast of Namibia and Dale & McMillan (1999) and Rogers & Bremner (1991) from the west coast of South Africa.

Cibicididae Cushman, 1927

Cibicides de Montfort, 1808

Cibicides lobatulus (Walker & Jacob)

Pl. 4, Fig. 14 & 15

Restricted Synonymy: *Nautilus lobatulus,* Walker & Jacob, 1798. (Full details of synonymy in Rosset-Moulinier, 1972).

Selected References: Parker, 1952, Fig. 26. Cushman, 1959, p 551, Pl. 36, Fig. 11. Rosset-Moulinier, 1972, p 181, Pl. 11, Fig. 9 – 10. Haynes, 1981, p 268, Fig. 8 – 10.

Material Examined: Sea Point, Kommetjie, Buffels Bay, St James, Koggel Bay, Pringle Bay, Kleinmond, Hermanus, Victoria Bay and Port Elizabeth.

Description: Plano-convex to convex. Completely perforate. Spiral dorsal side flattened may even be concave. Chambers of final whorl inflated. Evolute ventral side is porous, chambers are inflated and lobulate. Apertural face is smooth. Trochospiral coiling. Radial sutures swept back and raised on the involute side. Aperture is a slit-like opening surrounded by a narrow lip and is interio-marginal extending to the ventral side. Width = 228.57 μm, Height = 214.29 μm, width:height = 1.07:1.

Global Distribution: Cosmopolitan. Shelf to littoral.

Distribution around South Africa: Sea Point to Port Elizabeth. Recorded by McMillan (1987) from the coast of Namibia and Dale & McMillan (1999) from the west coast of South Africa.

Cibicides sp. "A"

Pl. 4, Fig. 16

Selected References: Loeblich & Tappan (1988) was used to classify the specimen into genus.

Material Examined: Sea Point, Buffels Bay, St James, Pringle Bay, Kleinmond, Victoria Bay.

Description: Flattened shape. Evolute side is almost completely smooth. Trochospiral coiling. Spiral side flattened, radial sutures and perforate. Aperture extends to spiral side, no lip surrounding aperture. Width = 237.5 μm, height = 175 μm, width:height = 1.36:1.

Distribution around South Africa: Sea Point to Victoria Bay.

Remarks: Appears to be similar to *Cibicides lobatulus,* however radial sutures are not as distinct especially on the ventral side, chambers are not as inflated and there is no lip on the apertural face. Also differs from *C. corticatus, C. dispars, C. marlboroughensis* and *C. praecursorius* (Hayward *et al.,* 1999) in their distinct curved sutures and coarsely perforate test walls. More detailed taxonomic work is required before naming this species as new.

Planorbulinidae Schwager, 1877

Planorbulina d'Orbigny, 1826

Planorbulina mediterranensis d'Orbigny, 1826

Pl. 4, Fig. 17 & 18

Restricted Synonymy: *Planorbulina mediterranensis* d'Orbigny, 1826. (Full details of synonymy in Albani *et al.*, 2001).

Selected References: Cushman, 1959, p 552, Pl. 37, Fig 1 & 2. Cifelli & Smith, 1970, p 42. Brasier, 1975, Pl. 1, Fig. 5. Albani *et al.*, 2001

Material Examined: Sea Point, Kommetjie, Buffels Bay, St James, Miller's Point, Froggy Pond, Dale Brook, Koggel Bay, Pringle Bay, Kleinmond, Hermanus, Victoria Bay, Port Elizabeth.

Description: Test low trochospiral in the early stage, becoming irregular. Attached spiral side is flat with distinct, thickened sutures. Free side has inflated chambers with depressed sutures. Single aperture in early stage, later chambers show two opposite apertures with thin lip. Width = 914.9 μm, Height = 885.71 μm, width: height = 1.03:1.

Global Distribution: Cosmopolitan. Inner shelf to littoral.

Distribution around South Africa: Sea Point to Port Elizabeth. Recorded by McMillan (1987) from the coast of Namibia and Dale & McMillan (1999) from the west coast of South Africa.

Remarks: Wide variation in shape and number and arrangement of chambers in specimens.

Plates 1 to 4

Plate 1:

1.	*Trochammina squamata* Jones & Parker, 1860
2 - 5.	*Quinqueloculina dunkerquiana* Heron-Allen & Earland, 1930
6 – 7.	*Quinqueloculina isabelleana* d'Orbigny, 1839
8 – 9.	*Quinqueloculina seminulum* (Linné, 1767)
10 -11.	*Quinqueloculina triangularis* d'Orbigny, 1846
12 – 13.	*Quinqueloculina undulata* d'Orbigny, 1852
13 – 14.	*Quinqueloculina vulgaris* d'Orbigny, 1826
15.	*Quinqueloculina* sp. "A"
16.	*Quinqueloculina* sp. "B"
17 – 18.	*Triloculina trigonula* (Lamarck, 1804)
19 – 20.	*Miliolinella subrotundata* (Montagu, 1803)

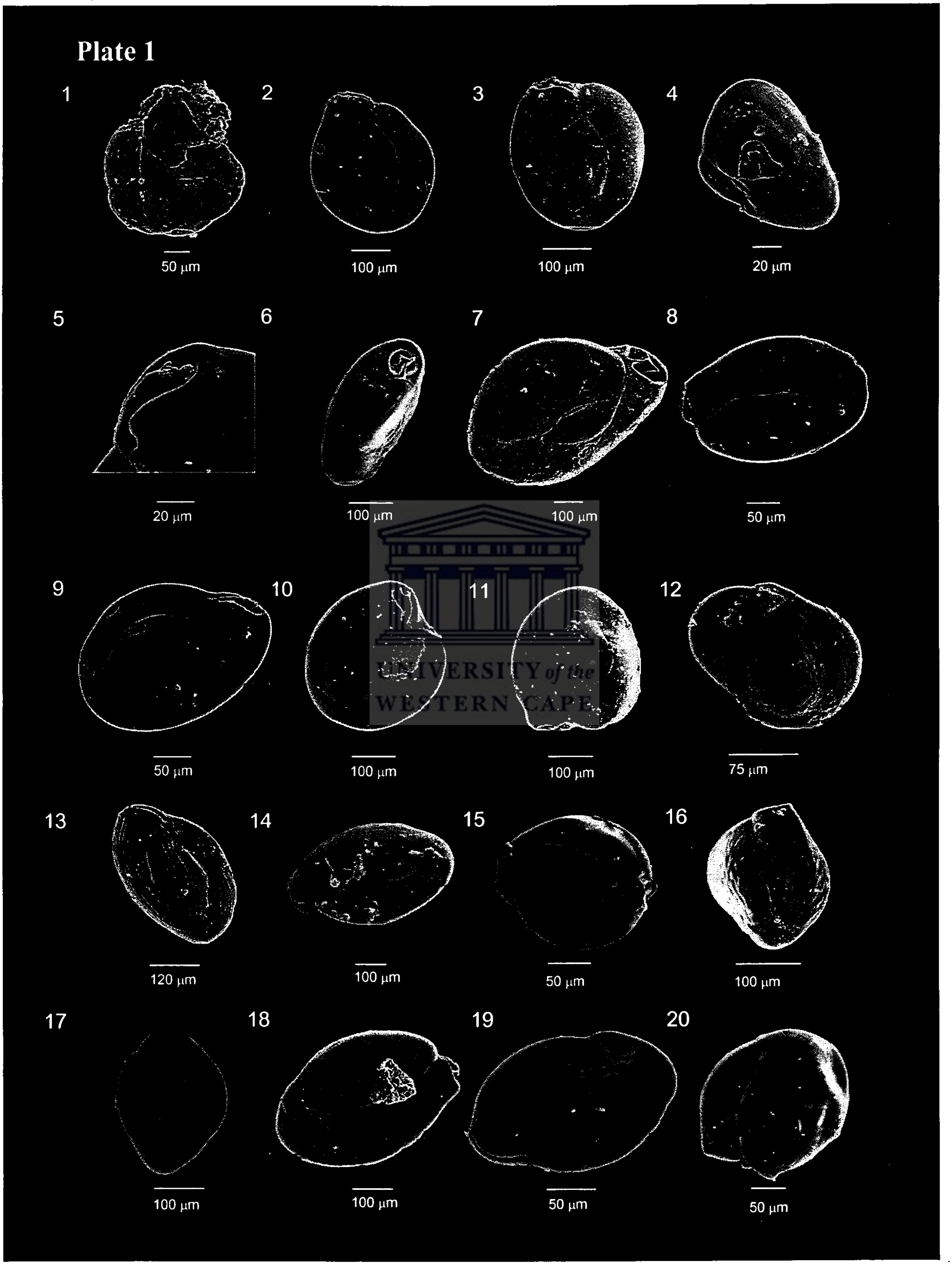
Plate 1
1
50 µm
2
100 µm
3
100 µm
4
20 µm
5
20 µm
6
100 µm
7
100 µm
8
50 µm
9
50 µm
10
100 µm
11
100 µm
12
75 µm
13
120 µm
14
100 µm
15
50 µm
16
100 µm
17
100 µm
18
100 µm
19
50 µm
20
50 µm

Plate 2:

1 – 2.	*Lagena semilineata* Wright, 1886
3.	*Lagena* sp. "A"
4.	*Lagenosolenia* sp. "A"
5.	*Guttulina irregularis* (d' Orbigny, 1846)
6 – 7.	*Glandulina* sp. "A"
8 – 9.	*Oolina* sp "A"
10.	*Oolina melo* d'Orbigny, 1839
11 – 12.	*Fissurina marginata* (Montagu, 1803)
13.	*Fissurina* sp. "A"
14 – 15.	*Bolivina "fossa"* McMillan, 1987 m.s.
16.	*Bolivina pseudoplicata* Heron-Allen & Earland, 1930
17 – 18.	*Bolivina* sp. "A"
19.	*Bolivina* sp. "B"
20.	*Bolivina* sp. "C"

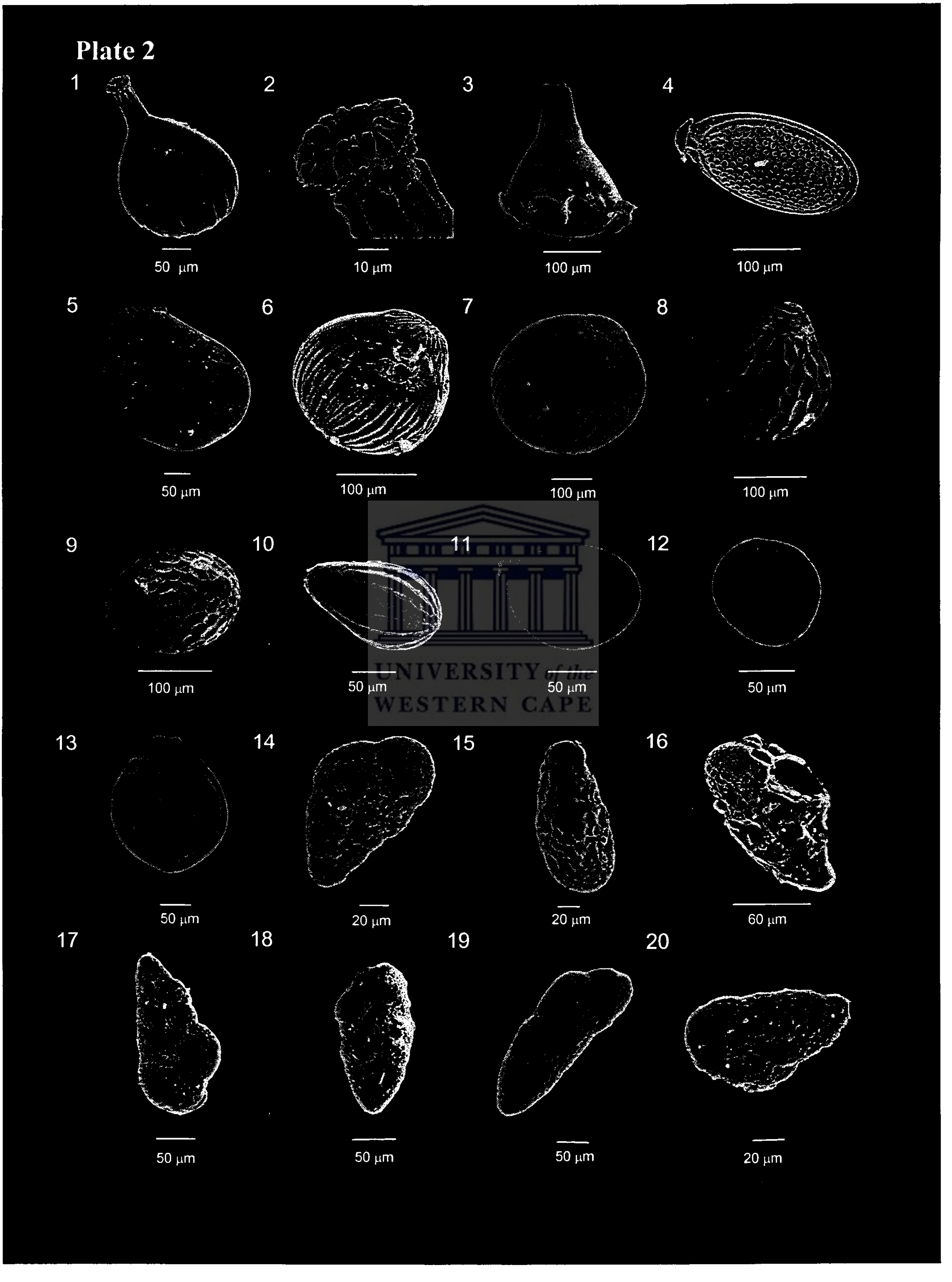
Plate 2
1
50 μm
2
10 μm
3
100 μm
4
100 μm
5
50 μm
6
100 μm
7
100 μm
8
100 μm
9
100 μm
10
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11
50 μm
12
50 μm
13
50 μm
14
20 μm
15
20 μm
16
60 μm
17
50 μm
18
50 μm
19
50 μm
20
20 μm

Plate 3:

1 – 2.	*Brizalina pseudopunctata* (Höglund, 1947)
3.	*Brizalina "rocklandsensis"* McMillan, 1987 m.s.
4.	*Neocorbina* sp. "A"
5 – 7.	*Rosalina* cf. *R. globularis* d'Orbigny, 1826
8.	*Rosalina* sp. "A"
9 – 11.	*Glabratella australensis* (Heron-Allen & Earland, 1932)
12.	*Glabratella* sp. "A"
13 – 14.	*Patellina corrugata* Williamson, 1858
15.	*Ammonia parkinsoniana* (d'Orbigny, 1839)
16 – 20.	*Pararotalia nipponica* (Asano, 1936)


Plate 3
1
50 μm
2
20 μm
3
100 μm
4
20 μm
5
50 μm
6
20 μm
7
50 μm
8
50 μm
9
100 μm
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11
50 μm
12
100 μm
13
20 μm
14
20 μm
15
100 μm
16
50 μm
17
100 μm
18
100 μm
19
100 μm
20
100 μm

Plate 4:

1 – 2.	*Elphidium advenum* (Cushman, 1922)
3 – 4.	*Elphidium articulatum* (d'Orbigny, 1839)
5 – 6.	*Elphidium crispum* (Linné, 1758)
7 – 8.	*Elphidium macellum* (Fichtel & Moll, 1798)
9.	*Elphidiella* sp. "A"
10 – 11.	*Globigerina bulloides* d'Orbigny, 1826
12 – 13.	*Neogloboquadrina pachyderma* (Ehrenberg, 1861)
14 – 15.	*Cibicides lobatulus* (Walker & Jacob, 1798)
16.	*Cibicides* sp. "A"
17 – 18.	*Planorbulina mediterranensis* d'Orbigny, 1826

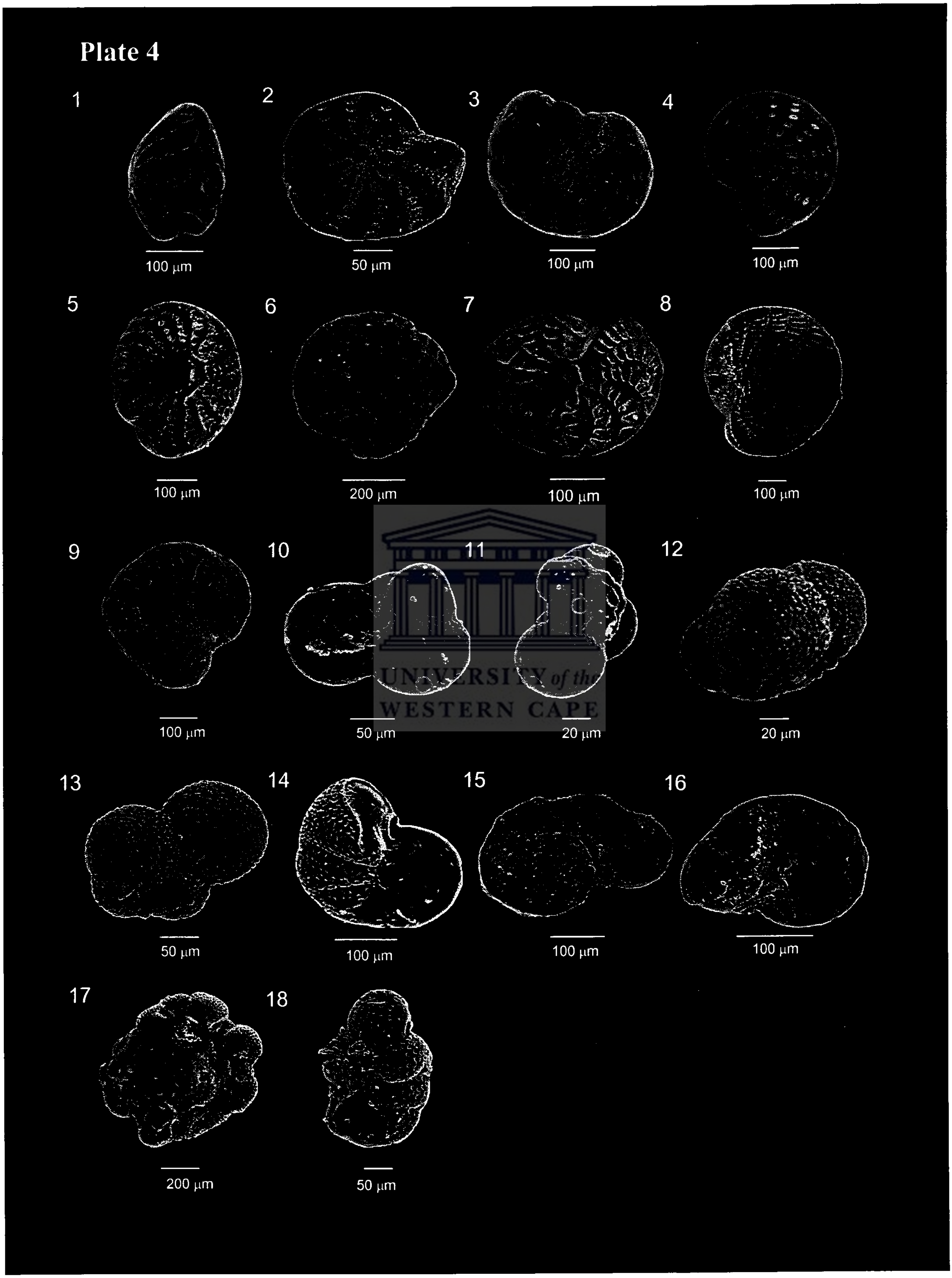
Plate 4
1
100 µm
2
50 µm
3
100 µm
4
100 µm
5
100 µm
6
200 µm
7
100 µm
8
100 µm
9
100 µm
10
50 µm
11
20 µm
12
20 µm
13
50 µm
14
100 µm
15
100 µm
16
100 µm
17
200 µm
18
50 µm

Appendix 2

Appendix Two

The appendix that follows consists of raw data counts of foraminiferal species associated with *Gelidium pristoides* as well as tables of algal and sediment weight.

Symbols used in the tables are:

Sites	DB	Dalebrook
	SJ	St James
	FP	Froggy Pond
	MP	Miller's Point
	SP	Sea Point
	KO	Kommetjie
	BB	Buffel's Bay
	KB	Koggel Bay
	PB	Pringle Bay
	KM	Kleinmond
	H	Hermanus
	VB	Victoria Bay
	PE	Port Elizabeth

The following are the data sets:

Shore	DB1	DB2	DB3	DB4	DB5	DB6	DB7	DB8	DB9
season	s	s	s	s	s	s	s	s	s
G.australensis	41	23	64	52	46	72	4	6	45
E.macellum	3	3	5	5	3	16	0	0	2
Glabratella sp. A	14	14	13	20	8	19	2	4	7
R. cf. globularis	14	24	48	56	42	68	13	8	48
M. subrotundata	3	2	14	8	17	25	4	2	6
B. "fossa"	10	7	7	9	10	4	1	0	2
C. lobatulus/ Cibicides sp. A	2	16	31	41	20	34	3	7	23
Q. cf. undulata/vulgaris	1	8	10	9	4	6	1	1	2
Fissurina sp. A	5	2	9	7	4	1	2	0	2
Q. dunkerquiana/seminulum/isabellei	5	7	17	17	7	15	1	2	2
B. "rocklandsensis"	11	12	16	21	10	7	1	4	5
B. pseudoplicata	5	1	6	4	7	8	0	0	2
Oolina sp "A"	0	2	2	1	1	2	0	1	0
L. semilineata	5	4	15	11	7	4	2	3	0
P. corrugata	6	5	3	2	1	1	0	0	0
P. mediterranensis	0	1	2	0	2	0	1	0	0
Lagenosolenia sp. A	0	0	0	0	1	0	0	0	0
Glandulina sp. A	0	0	0	0	0	0	0	1	0
Oolina cf melo	10	7	15	13	15	25	4	0	12
E. advenum	0	0	0	0	0	0	0	0	0

Table of data used in the exposure study (Chapter 2)

Shore	DB10	DB11	DB12	DB13	DB14	DB15	SJ1	SJ2	SJ3
season	s	w	w	w	w	w	s	s	s
G.australensis	8	21	22	20	55	41	64	37	26
E.macellum	1	15	11	6	4	6	8	2	2
Glabratella sp. A	1	2	6	4	9	7	8	9	6
R. cf. globularis	8	5	6	5	15	11	69	62	48
M. subrotundata	1	3	2	2	7	1	10	19	16
B. "fossa"	1	14	6	12	72	17	3	9	4
C. lobatulus/ Cibicides sp. A	5	40	39	36	51	49	18	35	13
Q. cf. undulata/vulgaris	1	2	2	1	2	4	8	8	3
Fissurina sp. A	0	2	4	2	1	1	3	3	3
Q. dunkerquiana/seminulum/isabellei	1	4	3	1	1	2	7	14	10
B. "rocklandsensis"	1	8	4	9	39	8	7	4	7
B. pseudoplicata	0	2	2	4	6	2	7	11	2
Oolina sp "A"	0	0	3	0	3	2	2	0	0
L. semilineata	2	10	12	8	30	17	20	10	9
P. corrugata	0	0	0	0	1	0	2	2	0
P. mediterranensis	0	0	0	0	0	0	2	4	0
Lagenosolenia sp. A	0	0	0	0	0	0	3	5	2
Glandulina sp. A	0	0	0	0	0	0	1	2	6
Oolina cf melo	3	0	0	0	0	0	14	23	12
E. advenum	0	0	0	0	0	0	0	0	0

Table of data used in the exposure study (Chapter 2)

Shore	SJ4	SJ5	SJ6	SJ7	SJ8	SJ9	SJ10	SJ11	SJ12
season	s	s	s	s	s	s	s	w	w
G.australensis	38	16	13	10	4	18	3	36	21
E.macellum	1	1	0	1	0	1	0	9	5
Glabratella sp. A	10	5	3	0	2	3	0	6	4
R. cf. globularis	55	25	20	13	7	20	3	4	3
M. subrotundata	13	4	4	2	1	2	1	5	0
B. "fossa"	3	2	0	1	0	2	0	54	9
C. lobatulus/ Cibicides sp. A	30	10	3	4	3	8	2	36	34
Q. cf. undulata/vulgaris	6	1	5	3	2	4	0	4	0
Fissurina sp. A	5	2	0	1	1	0	0	2	0
Q. dunkerquiana/seminulum/isabellei	5	5	6	4	1	0	1	7	4
B. "rocklandsensis"	11	8	2	3	0	3	0	20	11
B. pseudoplicata	5	0	2	2	0	1	0	1	2
Oolina sp "A"	0	0	0	0	0	0	0	0	0
L. semilineata	19	13	8	2	3	0	1	12	14
P. corrugata	2	1	1	1	0	0	0	0	0
P. mediterranensis	0	0	0	0	0	0	0	0	0
Lagenosolenia sp. A	1	0	0	1	0	1	0	0	0
Glandulina sp. A	3	0	0	0	0	1	0	0	0
Oolina cf melo	18	3	1	1	0	7	0	0	0
E. advenum	0	0	1	0	0	0	0	0	0

Table of data used in the exposure study (Chapter 2)

Shore	SJ13	SJ14	SJ15	MP1	MP2	MP3	MP4	MP5	MP6	
season	w	w	w	s	s	s	s	s	s	
G.australensis	34	54	49	2	0	2	7	2	2	
E.macellum	3	17	14	0	1	1	1	0	1	
Glabratella sp. A	16	19	12	2	0	1	4	2	0	
R. cf. globularis	8	12	10	3	2	4	2	1	2	
M. subrotundata	4	14	10	7	1	13	6	5	9	
B. "fossa"	16	24	62	1	0	0	2	0	1	
C. lobatulus/ Cibicides sp. A	41	47	61	0	0	1	2	1	1	
Q. cf. undulata/vulgaris	0	9	4	1	0	0	3	1	0	
Fissurina sp. A	9	5	6	1	0	0	1	0	0	
Q. dunkerquiana/seminulum/isabellei	8	5	4	4	1	6	2	4	10	
B. "rocklandsensis"	14	20	20	3	1	2	6	3	3	
B. pseudoplicata	0	5	12	0	0	0	0	0	0	
Oolina sp "A"	0	4	6	0	0	0	0	0	0	
L. semilineata	21	35	25	14	0	34	29	25	25	
P. corrugata	0	4	0	0	0	2	0	0	2	
P. mediterranensis	0	0	0	1	0	0	0	0	0	
Lagenosolenia sp. A	0	0	0	0	0	0	0	0	0	
Glandulina sp. A	0	0	0	0	0	0	0	0	0	
Oolina cf melo	0	0	0	0	0	0	0	0	0	
E. advenum	0	0	0	0	0	0	0	0	0	

Table of data used in the exposure study (Chapter 2)

Shore	MP7	MP8	MP9	MP10	MP11	MP12	MP13	MP14	MP15
season	s	s	s	s	w	w	w	w	w
G.australensis	1	5	11	1	1	6	6	22	13
E.macellum	1	0	1	0	0	0	0	2	3
Glabratella sp. A	1	2	2	0	7	4	7	8	3
R. cf. globularis	0	5	6	0	3	1	2	4	1
M. subrotundata	2	3	20	1	1	1	3	8	3
B. "fossa"	0	4	1	0	10	12	35	42	11
C. lobatulus/ Cibicides sp. A	0	1	2	0	9	5	2	32	3
Q. cf. undulata/vulgaris	0	1	3	0	0	0	0	2	0
Fissurina sp. A	0	1	0	0	0	0	0	1	0
Q. dunkerquiana/seminulum/isabellei	2	8	3	0	0	0	2	1	1
B. "rocklandsensis"	1	11	2	0	10	10	9	23	5
B. pseudoplicata	0	0	0	0	2	1	1	1	0
Oolina sp "A"	0	0	0	0	0	0	0	0	0
L. semilineata	2	24	19	2	9	12	26	37	8
P. corrugata	0	1	0	0	0	0	0	0	0
P. mediterranensis	0	0	2	0	0	0	0	0	0
Lagenosolenia sp. A	0	0	0	0	0	0	0	0	0
Glandulina sp. A	0	0	0	0	0	0	0	0	0
Oolina cf melo	0	0	0	0	0	0	0	0	0
E. advenum	0	0	0	0	0	0	0	0	0

Table of data used in the exposure study (Chapter 2)

Shore	FP1	FP2	FP3	FP4	FP5	FP6	FP7	FP8	FP9
season	s	s	s	s	s	s	s	s	s
G.australensis	5	6	1	1	10	1	2	0	1
E.macellum	0	1	3	2	1	0	1	0	0
Glabratella sp. A	1	1	0	0	0	0	0	0	0
R. cf. globularis	5	6	3	3	1	3	1	0	1
M. subrotundata	8	12	0	0	2	1	0	0	0
B. "fossa"	0	17	2	0	18	1	2	1	0
C. lobatulus/ Cibicides sp. A	1	1	1	0	2	0	1	2	0
Q. cf. undulata/vulgaris	4	1	0	0	1	0	0	0	0
Fissurina sp. A	0	1	0	0	1	0	1	0	0
Q. dunkerquiana/seminulum/isabellei	5	9	2	0	2	1	0	0	0
B. "rocklandsensis"	8	13	0	4	5	0	0	0	2
B. pseudoplicata	0	0	0	0	1	0	0	0	0
Oolina sp "A"	0	0	0	0	0	0	0	0	0
L. semilineata	15	64	20	58	4	2	25	3	7
P. corrugata	0	0	0	0	1	1	0	0	0
P. mediterranensis	0	5	2	0	0	0	1	0	0
Lagenosolenia sp. A	0	0	0	0	0	0	0	0	0
Glandulina sp. A	0	0	0	0	0	0	0	0	0
Oolina cf melo	1	0	0	0	0	0	0	0	0
E. advenum	0	0	0	0	0	0	0	0	0

Table of data used in the exposure study (Chapter 2)

Shore	FP10	FP11	FP12	FP13	FP14	FP15
season	s	w	w	w	w	w
G.australensis	0	8	4	11	6	17
E.macellum	0	2	3	3	1	5
Glabratella sp. A	0	14	6	3	4	4
R. cf. globularis	0	2	0	1	4	2
M. subrotundata	0	8	0	1	2	1
B. "fossa"	0	20	18	6	13	24
C. lobatulus/ Cibicides sp. A	0	15	3	5	21	13
Q. cf. undulata/vulgaris	0	2	2	1	0	0
Fissurina sp. A	0	3	0	0	0	1
Q. dunkerquiana/seminulum/isabellei	0	0	1	2	0	0
B. "rocklandsensis"	3	20	12	6	11	14
B. pseudoplicata	0	2	0	1	0	0
Oolina sp "A"	0	0	0	0	0	0
L. semilineata	2	12	6	10	6	17
P. corrugata	0	0	0	0	0	0
P. mediterranensis	0	0	0	0	0	0
Lagenosolenia sp. A	0	0	0	0	0	0
Glandulina sp. A	0	0	0	0	0	0
Oolina cf melo	0	0	0	0	0	0
E. advenum	0	0	0	0	0	0

Table of data used in the exposure study (Chapter 2)

Shore	algal wt(g)	sediment wt(g)	Shore	algal wt(g)	sediment wt(g)
DB1	11.7577	2.42	MP1	3.5389	1.298
DB2	8.2012	1.6604	MP2	4.5412	0.4283
DB3	14.1371	5.1644	MP3	6.8302	3.0259
DB4	20.239	5.4266	MP4	6.1407	0.7494
DB5	13.6312	3.3598	MP5	6.1407	0.6597
DB6	4.7393	3.6447	MP6	2.8823	3.1197
DB7	0.8459	0.2694	MP7	1.0287	0.5994
DB8	2.3184	0.2565	MP8	2.2004	3.9806
DB9	3.1626	1.114	MP9	3.0807	1.47
DB10	2.5076	0.3018	MP10	1.201	0.0716
DB11	10.9035	1.0119	MP11	4.7663	1.2556
DB12	9.8121	1.0507	MP12	5.5507	1.1883
DB13	10.727	1.2613	MP13	7.5076	3.8305
DB14	10.5398	1.6099	MP14	6.0012	3.5423
DB15	9.5208	1.4641	MP15	6.3508	1.4799
SJ1	9.2354	3.3907	FP1	7.227	1.073
SJ2	3.761	6.6454	FP2	6.197	1.565
SJ3	16.5554	4.0335	FP3	5.0273	0.7865
SJ4	10.3722	6.4661	FP4	7.0167	0.6459
SJ5	4.0604	1.1297	FP5	3.0215	2.2431
SJ6	5.8084	1.2594	FP6	3.1048	0.3123
SJ7	6.3032	0.9053	FP7	5.7325	0.887
SJ8	4.7416	0.5499	FP8	3.1987	0.7006
SJ9	2.2363	0.9512	FP9	0.08966	0.5326
SJ10	0.9452	0.0997	FP10	3.2299	0.1238
SJ11	7.315	3.8174	FP11	5.481	1.1429
SJ12	6.509	1.7466	FP12	3.515	1.3793
SJ13	10.211	3.49	FP13	4.027	0.5049
SJ14	10.952	2.6013	FP14	7.771	0.4855
SJ15	8.615	5.4874	FP15	3.874	0.3807

Table of algal dry weight and sediment weight used in the exposure study

SHORE	VB1	VB2	VB3	VB4	VB5	VB6	VB7	VB8	VB9	VB10	PE1	PE2	PE3	PE4	PE5	PE6	PE7	PE8	PE9	PE10
G. australensis	0	0	0	1	0	0	0	0	0	0	0	1	1	1	0	2	0	0	1	0
E. macellum	0	0	1	2	0	0	0	0	0	0	1	0	1	0	0	1	4	1	0	0
Glabratella sp. A	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	1	0	3	0
Rosalina sp. A	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
R. globularis	7	1	1	1	1	2	1	1	1	1	2	1	1	2	2	1	1	2	1	1
M. subrotunda	0	0	0	0	0	0	0	2	5	5	4	11	1	13	23	3	4	1	9	10
B. fossa	0	0	1	0	0	1	0	0	0	0	0	0	1	1	0	0	1	0	0	0
C. lobatulus	4	1	1	1	10	4	0	0	3	4	1	0	0	1	0	0	1	0	1	1
Cibicides	1	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Q.undulata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Q.vulgaris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fissurina sp. A	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0
F.marginata	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	1	2
Q.dunkerquiana	0	0	1	1	0	0	0	7	2	0	10	3	7	0	0	18	22	16	2	1
Q.issabellei	0	0	0	0	0	5	0	0	0	0	0	0	0	1	5	0	0	0	2	2
Q.seminulum	1	0	0	0	1	6	1	0	0	1	7	2	1	0	0	5	8	8	4	0
Q.triangularis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Quinqueloculina sp A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Quinqueloculina sp B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T. trigonula	0	0	0	0	0	0	0	1	0	0	7	2	4	3	3	0	0	0	1	0
B. rocklandsensis	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	10
B. pseudoplicata	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1	0	0	0	0
Bolivina sp. A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bolivina sp. B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bolivina sp. C	0	0	0	0	0	0	0	0	0	0	4	0	1	4	0	3	4	0	0	10
Oolina sp. A	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
L. semilineata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
P. corrugata	0	10	3	0	14	1	3	0	1	0	1	3	2	3	0	3	2	0	9	0
P. mediterranensis	3	2	0	18	13	4	6	1	1	1	5	0	0	0	8	4	1	0	2	14
Lagesolenia sp. A	0	3	1	1	2	0	2	0	0	0	1	0	1	0	3	2	1	0	0	0
Glandulina sp A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Oolina cf *melo*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E. advendum	2	0	1	9	0	0	4	1	0	2	0	0	0	0	1	0	1	0	0	0
Lagena sp. A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
B. pseudopunctata	0	0	1	1	0	0	1	0	2	0	0	1	2	0	0	0	0	0	2	0
E. crispum	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0
Elphidiella sp. A	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	1	0	0
P. nipponica	5	5	10	21	14	2	10	5	8	7	7	2	2	5	9	3	2	4	5	4
A. parkinsoniana	0	4	6	14	4	0	13	2	11	0	1	0	1	0	0	0	2	3	7	1
E. articulatum	0	0	2	1	0	0	0	2	0	0	1	0	1	1	1	0	0	0	0	0
G. bulloides	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N. pachyderma	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T. squamata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Neocorbina sp. A	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
G. irregularis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table of data used in the biogeographic study (Chapter 3)

SHORE	SJ1	SJ2	SJ3	SJ4	SJ5	SJ6	SJ7	SJ8	SJ9	SJ10	BB1	BB2	BB3	BB4	BB5	BB6	BB7	BB8	BB9	BB10
G. australensis	5	1	2	3	12	5	2	7	11	8	12	8	2	11	2	2	0	1	1	3
E. macellum	1	4	0	0	2	0	1	1	0	1	2	0	0	1	0	1	0	0	1	0
Glabratella sp. A	2	1	0	2	2	4	1	0	0	7	5	5	3	6	0	0	0	2	0	0
Rosalina sp. A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R. globularis	2	0	0	0	5	0	2	3	0	1	1	1	0	0	0	0	0	0	0	0
M. subrotunda	2	6	2	2	4	0	12	4	1	2	4	2	0	5	1	0	0	5	0	1
B. fossa	1	0	0	0	1	0	5	1	1	0	4	1	3	1	0	0	0	1	0	0
C. lobatulus	11	4	2	0	4	2	5	7	2	4	2	3	0	3	2	0	0	1	0	1
Cibicides	0	1	0	0	0	0	0	3	1	0	0	0	0	0	0	1	0	0	0	0
Q.undulata	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Q.vulgaris	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fissurina sp. A	0	2	2	1	2	0	0	4	0	3	0	0	0	0	0	0	0	0	0	1
F.marginata	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Q.dunkerquiana	0	14	1	3	1	2	0	6	2	7	0	3	2	11	0	1	0	2	0	0
Q.issabellei	0	2	0	0	1	0	3	0	0	0	0	1	0	4	0	0	0	0	0	0
Q.seminulum	0	2	2	2	3	0	5	2	0	0	1	8	0	8	0	0	0	0	0	0
Q.triangularis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Quinqueloculina sp A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Quinqueloculina sp B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T. trigonula	0	7	1	0	0	0	2	0	0	2	0	0	0	1	0	0	0	0	0	0
B. rocklandsensis	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
B. pseudoplicata	1	0	0	0	0	0	0	1	0	0	8	4	2	0	0	0	0	0	0	0
Bolivina sp. A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bolivina sp. B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bolivina sp. C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oolina sp. A	1	6	1	0	7	0	5	3	1	2	0	0	0	1	0	0	0	0	0	0
L. semilineata	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
P. corrugata	4	1	0	1	4	2	85	67	11	2	19	10	10	23	47	14	2	2	44	25
P. mediterranensis	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0
Lagesolenia sp. A	0	0	2	1	1	0	0	3	0	0	0	0	0	1	1	0	0	0	0	1
Glandulina sp A	0	0	0	0	0	0	1	0	0	2	0	2	0	0	0	0	0	0	0	0
Oolina cf *melo*	0	0	0	2	0	0	1	1	0	1	0	0	0	1	0	0	0	0	0	0
E. advendum	4	4	8	4	0	1	18	14	6	6	0	0	0	0	2	0	0	0	2	0
Lagena sp. A	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
B. pseudopunctata	0	2	0	0	0	0	9	9	2	1	0	0	5	4	1	1	1	0	0	1
E. crispum	0	0	0	0	0	0	0	1	1	1	0	0	0	2	0	0	0	0	0	0
Elphidiella sp. A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
P. nipponica	9	57	19	7	24	15	39	65	50	14	0	0	0	0	4	0	0	0	0	0
A. parkinsoniana	0	10	18	13	0	4	23	23	9	11	0	0	1	0	1	0	1	0	0	0
E. articulatum	0	25	9	7	0	6	0	1	3	21	0	0	0	3	0	0	0	0	0	1
G. bulloides	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N. pachyderma	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T. squamata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Neocorbina sp. A	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
G. irregularis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table of data used in the biogeographic study (Chapter 3)

SHORE	SP1	SP2	SP3	SP4	SP5	SP6	SP7	SP8	SP9	SP10	KO1	KO2	KO3	KO4	KO5	KO6	KO7	KO8	KO9	KO10
G. australensis	0	0	2	0	1	0	1	0	0	0	2	0	2	3	1	3	2	0	3	0
E. macellum	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
Glabratella sp. A	0	3	0	0	0	0	0	0	0	0	0	2	1	0	0	0	0	0	0	0
Rosalina sp. A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
R. globularis	0	1	0	0	0	0	0	0	0	0	0	0	0	9	3	0	0	0	0	0
M. subrotunda	0	5	0	4	0	0	0	0	4	1	1	1	0	0	0	3	1	0	1	0
B. fossa	0	2	3	1	0	0	0	0	0	0	0	0	0	2	0	0	1	0	2	0
C. lobatulus	0	16	3	3	0	1	0	3	1	5	9	1	1	6	2	2	3	0	5	1
Cibicides	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Q.undulata	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Q.vulgaris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fissurina sp. A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F.marginata	0	0	0	0	0	1	1	0	1	0	0	0	0	1	0	1	2	2	0	0
Q.dunkerquiana	0	4	1	3	0	1	1	0	4	3	0	0	0	0	0	5	0	2	0	0
Q.issabellei	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Q.seminulum	0	3	0	3	1	0	0	1	6	2	0	0	0	0	0	0	3	0	0	1
Q.triangularis	1	1	1	1	0	1	1	1	4	1	0	0	0	0	0	0	0	0	0	0
Quinqueloculina sp A	2	1	1	2	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0
Quinqueloculina sp B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T. trigonula	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B. rocklandsensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B. pseudoplicata	0	4	5	0	0	0	0	1	0	6	0	1	0	0	0	3	3	2	4	2
Bolivina sp. A	0	4	1	1	0	1	0	1	2	0	0	0	0	0	0	0	0	0	0	0
Bolivina sp. B	0	4	5	1	1	1	2	0	1	2	0	0	0	0	0	0	0	0	0	0
Bolivina sp. C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oolina sp. A	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
L. semilineata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
P. corrugata	3	8	3	3	1	3	3	3	2	6	225	26	4	81	11	3	47	87	10	13
P. mediterranensis	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Lagesolenia sp. A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Glandulina sp A	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0
Oolina cf *melo*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E. advendum	0	3	2	2	0	0	0	0	0	0	1	1	3	3	2	1	0	0	0	0
Lagena sp. A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B. pseudopunctata	2	4	1	4	0	1	0	1	1	0	2	0	0	9	1	3	3	7	1	0
E. crispum	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	2	2
Elphidiella sp. A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
P. nipponica	0	0	2	0	1	0	0	0	1	1	0	0	0	0	0	2	7	2	2	1
A. parkinsoniana	0	0	2	0	0	0	0	0	0	0	0	0	0	1	0	0	2	0	0	1
E. articulatum	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	5	3	5	4
G. bulloides	0	0	0	0	0	0	0	0	0	0	2	1	2	3	1	1	1	6	4	2
N. pachyderma	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T. squamata	5	19	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Neocorbina sp. A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
G. irregularis	0	1	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0

Table of data used in the biogeographic study (Chapter 3)

SHORE	PB1	PB2	PB3	PB4	PB5	PB6	PB7	PB8	PB9	PB10	KB1	KB2	KB3	KB4	KB5	KB6	KB7	KB8	KB9	KB10
G. australensis	2	1	2	2	4	5	2	12	1	8	1	1	0	2	2	2	1	2	2	1
E. macellum	0	2	1	3	2	2	1	8	3	2	0	2	0	0	0	0	0	0	0	0
Glabratella sp. A	2	1	0	0	2	2	0	0	0	1	0	0	0	1	0	1	2	1	1	1
Rosalina sp. A	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
R. globularis	0	1	0	0	5	0	0	0	0	0	2	0	1	0	0	0	0	0	0	0
M. subrotunda	1	3	1	0	2	0	3	1	2	0	1	4	0	1	0	1	1	0	0	1
B. fossa	0	3	0	0	0	0	0	0	0	5	0	0	0	1	1	0	1	0	0	0
C. lobatulus	4	3	1	0	6	3	1	5	3	9	0	4	1	3		2	3	2	0	4
Cibicides	0	0	1	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	3	0
Q.undulata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Q.vulgaris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Fissurina sp. A	0	0	0	0	0	0	0	0	0	2	1	0	0	0	0	0	0	0	0	0
F.marginata	1	0	0	0	0	0	0	0	0	1	0	0	0	0	2	1	0	0	0	0
Q.dunkerquiana	0	0	1	5	0	3	7	6	3	7	0	0	0	0	0	1	0	0	0	3
Q.issabellei	0	0	0	2	0	1	1	2	0	0	0	0	0	0	0	0	0	0	0	0
Q.seminulum	0	3	0	0	0	0	0	10	0	12	0	0	1	0	0	1	0	1	0	0
Q.triangularis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Quinqueloculina sp A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Quinqueloculina sp B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
T. trigonula	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0
B. rocklandsensis	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
B. pseudoplicata	3	4	0	0	0	0	1	0	1	0	0	0	0	0	0	0	1	0	0	0
Bolivina sp. A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bolivina sp. B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bolivina sp. C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oolina sp. A	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
L. semilineata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
P. corrugata	0	0	3	2	1	5	1	2	5	35	3	4	12	0	16	1	0	4	1	0
P. mediterranensis	0	2	0	0	0	0	1	0	1	0	0	1	1	0	0	0	0	1	0	0
Lagesolenia sp. A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Glandulina sp A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oolina cf *melo*	0	0	1	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
E. advendum	0	1	1	0	3	2	2	1	2	0	1	0	0	1	0	1	0	1	1	1
Lagena sp. A	0	0	1	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
B. pseudopunctata	0	0	1	0	0	1	0	1	0	10	0	4	0	0	2	0	0	3	0	0
E. crispum	0	0	0	0	0	1	0	1	0	1	1	2	0	0	4	5	0	2	1	5
Elphidiella sp. A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
P. nipponica	0	0	5	6	0	7	9	7	10	13	3	6	3	0	2	13	0	11	8	11
A. parkinsoniana	0	0	0	0	0	1	1	1	2	3	0	2	1	0	0	0	0	0	1	2
E. articulatum	0	0	0	0	0	3	0	1	0	5	3	0	0	0	1	2	0	2	0	0
G. bulloides	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N. pachyderma	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T. squamata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Neocorbina sp. A	2	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0
G. irregularis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table of data used in the biogeographic study (Chapter 3)

SHORE	H1	H2	H3	H4	H5	H6	H7	H8	H9	H10	KM1	KM2	KM3	KM4	KM5	KM6	KM7	KM8	KM9	KM10
G. australensis	1	1	0	2	0	1	2	1	1	4	1	0	0	0	1	4	7	2	3	7
E. macellum	0	0	0	1	1	0	0	0	0	0	1	0	0	1	1	9	4	5	1	2
Glabratella sp. A	0	0	1	0	0	0	0	1	0	3	0	0	0	0	0	0	0	0	2	3
Rosalina sp. A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	0
R. globularis	0	0	4	2	0	0	1	4	1	0	7	4	1	1	0	0	0	2	0	0
M. subrotunda	0	0	0	2	3	3	0	1	0	0	1	1	1	1	0	2	2	0	1	1
B. fossa	4	1	1	1	0	3	0	0	0	1	0	0	0	3	0	1	0	1	0	0
C. lobatulus	7	4	0	0	1	8	0	5	1	6	4	4	4	5	3	9	11	11	6	13
Cibicides	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	2	0	0	0	0
Q.undulata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2
Q.vulgaris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Fissurina sp. A	2	0	1	1	1	1	0	0	1	0	1	0	0	0	0	2	1	0	0	0
F.marginata	3	1	0	0	1	1	0	0	0	0	0	0	0	0	1	2	0	0	0	3
Q.dunkerquiana	3	2	0	0	5	9	0	0	0	3	0	1	0	0	0	1	2	0	1	1
Q.issabellei	2	0	0	0	1	0	0	0	0	3	0	1	0	0	0	2	0	0	0	1
Q.seminulum	3	1	0	0	0	18	0	0	0	5	0	0	2	0	0	2	0	0	2	2
Q.triangularis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Quinqueloculina sp A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Quinqueloculina sp B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T. trigonula	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B. rocklandsensis	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	2	0	0
B. pseudoplicata	0	0	2	0	0	3	0	0	0	2	0	0	2	5	0	1	0	0	0	1
Bolivina sp. A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bolivina sp. B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bolivina sp. C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oolina sp. A	0	0	2	1	0	0	2	0	0	1	0	0	0	0	0	0	0	0	1	1
L. semilineata	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
P. corrugata	23	3	2	2	9	20	0	23	3	27	0	3	3	5	0	37	4	2	1	18
P. mediterranensis	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Lagesolenia sp. A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Glandulina sp A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oolina cf *melo*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E. advendum	1	3	0	0	6	0	0	0	0	0	1	0	0	1	0	2	4	3	0	1
Lagena sp. A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B. pseudopunctata	3	1	0	0	1	9	0	0	0	0	0	0	0	0	3	2	1	0	0	2
E. crispum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	12	3	0	11	6
Elphidiella sp. A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
P. nipponica	2	0	0	0	0	8	0	0	0	4	1	0	0	6	0	28	32	3	75	55
A. parkinsoniana	0	0	0	0	1	2	0	0	0	1	0	0	4	0	3	7	2	0	7	3
E. articulatum	2	0	0	0	1	1	0	0	0	0	0	0	0	0	0	9	3	0	6	16
G. bulloides	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N. pachyderma	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T. squamata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Neocorbina sp. A	0	0	0	0	0	1	1	0	0	0	1	0	0	1	0	0	0	0	1	0
G. irregularis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table of data used in the biogeographic study (Chapter 3)

Shore	Algal wt (g)	Sediment wt (g)	Shore	Algal wt (g)	Sediment wt (g)
H1	4.2446	0.3552	PE1	3.4843	1.0234
H2	1.9011	0.1149	PE2	3.4352	0.5427
H3	2.8993	0.2512	PE3	1.8269	0.4562
H4	2.648	0.2397	PE4	2.9868	1.0466
H5	1.6124	0.3933	PE5	2.655	0.3176
H6	3.5194	0.256	PE6	4.5466	0.6912
H7	2.8426	0.1414	PE7	3.9358	0.6999
H8	2.3738	0.1233	PE8	4.1884	0.851
H9	2.8623	0.1517	PE9	3.3752	0.61016
H10	1.9583	0.2828	PE10	2.5728	0.4506
KM1	2.3922	0.5525	SJ1	2.746	2.4416
KM2	2.3207	0.6984	SJ2	3.2615	5.25713
KM3	2.748	0.7852	SJ3	3.3032	2.1646
KM4	2.6323	1.2662	SJ4	3.2367	1.6537
KM5	5.57	0.2564	SJ5	2.963	3.0833
KM6	1.4126	3.3563	SJ6	1.7332	0.612
KM7	1.948	1.5984	SJ7	3.1677	3.2624
KM8	3.087	0.6548	SJ8	2.8485	3.1465
KM9	1.9797	1.7501	SJ9	2.8067	0.4821
KM10	3.1996	1.2197	SJ10	1.7954	5.0886
PB1	2.3181	0.8611	BB1	2.8198	0.2941
PB2	2.8997	0.3421	BB2	2.7742	0.328
PB3	3.8136	0.352	BB3	1.8317	0.2641
PB4	0.8571	0.1818	BB4	4.2032	1.1867
PB5	2.1203	0.4249	BB5	2.3283	0.2319
PB6	2.0814	0.2405	BB6	5.1935	0.3304
PB7	2.5785	0.2698	BB7	4.2121	0.138
PB8	1.9069	0.7471	BB8	2.015	0.0895
PB9	2.594	0.4195	BB9	2.0642	0.2926
PB10	4.8825	0.579	BB10	2.1644	0.2396
KB1	3.9695	1.0357	SP1	0.9144	0.148
KB2	3.0608	2.0199	SP2	1.3461	1.3419
KB3	3.0912	2.574	SP3	1.1988	0.263
KB4	2.9801	0.3288	SP4	1.0879	0.2127
KB5	3.029	2.574	SP5	0.6211	0.1376
KB6	4.2652	2.1582	SP6	0.5462	0.0596
KB7	2.4883	0.8764	SP7	0.5827	0.2686
KB8	6.1902	1.9284	SP8	0.472	0.1349
KB9	6.8536	1.5115	SP9	0.4209	0.0963
KB10	5.6416	2.2901	SP10	0.4086	0.1893
VB1	1.7808	0.4623	KO1	3.6065	0.3487
VB2	2.0928	0.8232	KO2	2.0593	0.4296
VB3	1.7305	1.6257	KO3	3.229	0.5291
VB4	4.0551	1.0202	KO4	2.8302	0.4017
VB5	2.4869	2.9672	KO5	2.1805	0.1024
VB6	1.7624	0.5091	KO6	1.1241	0.1902
VB7	2.5584	0.6728	KO7	2.7595	0.2181
VB8	2.692	2.8334	KO8	2.3054	0.3419
VB9	3.5099	0.7568	KO9	2.0959	0.2492
VB10	2.8769	0.4623	KO10	0.9533	0.3832

Table of algal dry weight and sediment weight used in the biogeographic study

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