ASSESSING THE RATE OF RECOVERY OF BENTHIC MACROFAUNA AFTER MARINE MINING OFF THE NAMIBIAN COAST

BY

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DECLARATION

This thesis reports the results of original research which I carried out under the auspices of the Marine Biology Research Institute, University of Cape Town. All assistance that I received has been fully acknowledged. This work has not been presented for a degree at any other university.

Signed by candidate

Karen van der Merwe

13/11/1996

Date

CONTENTS

Abstract

ABSTRACT. van der Merwe, K. 1996. *Assessing the rate of recovery of benthic macrofauna after marine mining off the Namibian coast.* M.Sc thesis. University of Cape Town. pp179.

The primary aim of this study was to assess the rate of recovery of macrobenthic communities after offshore marine mining. Three techniques, namely univariate, distributional and multivariate, were used to make this assessment. Two distinct areas, the northern and southern research areas, were investigated, and statistical and numerical analyses were conducted for each area independently. Data were aggregated to, and analysed at, the genus level. Replicates were arranged in temporal categories according to recent mining history. The northern research area appears to be affected by mining activity in terms of species composition, but not species diversity. Statistical testing detected significant differences between unmined replicates and all other temporal categories for this area, and this was also discernable in the cluster analysis and ordination plots. The overall picture generated suggests that the northern research area is affected immediately and severely by mining activity, resulting in rapid changes in species composition. However, the period of 15-19 months subsequent to mining is insufficient to allow the community to recover to a stable state. The southern research area, on the other hand, shows a slightly different scenario, with mining activity having a severe and immediate impact on both species composition as well as species diversity. Recently mined sites were found to be significantly different from both unmined sites and sites mined 43-51 months ago. The latter two categories were not found to be significantly different from each other. The results suggest that the road to recovery in the southern research area is a slow, but steady one in terms of species composition. This was particularly apparent in the results of the "SIMPER" analysis where the level of similarity between temporal categories increased steadily with time after mining. The overall picture suggests that the area has recovered substantially after 43-51 months, and that the community approximates that of the unmined area with regard to species composition. Geological analyses were also conducted, with results indicating a prevalence of fine surficial sediment particles in unmined sites, and coarse surficial sediment particles in recently mined sites. Percentage gravel, in particular, was found to be a reliable indicator of the condition of a site with regard to the level of disturbance. Altered stratigraphy and changes in particle size distribution as a result of mining activity are considered to have a noticeable effect on the structure of benthic communities. A number of taxa were found to be particularly reliable as indicator species. In both the northern and southern research areas, polychaetes (specifically *Prionospio pinnata* and the *Lumbrineris* genus) were abundant in unmined sites as well as in sites mined 43-51 months ago in the southern research area. Individuals of the genus *Nassarius*, on the other hand, were scarce in unmined sites, but abundant in recently mined sites. These taxa appear to be reliable indicators of the level of recovery attained in previously mined areas.

CHAPTER ONE:

INTRODUCTION

1.1 Background

One of the primary focuses of offshore investigations has been on marine minerals most likely to be commercially developed in the near future (Drucker 1995). The immediate effect of dredging or mining for minerals will involve some level of disturbance to the habitat of marine macrobenthos. Biological concerns include habitat removal, habitat burial, changes in flow-patterns, increased turbidity of waters, resuspension of pollutants and sediments, and direct physical damage to benthic organisms (Charlier and Charlier 1992). However, there appears to be little information with regard to the degree to which mining, and resultant changes in the sea-bottom, affect benthic communities and the rate at which macrobenthos repopulate a mined area.

The most commonly used component of marine biota in environmental impact studies are the soft-bottom macrobenthos (Warwick 1993). These organisms can integrate environmental conditions over a period of time rather than reflect conditions only at the time of sampling since they have a relatively long generation time (Gray *et al.* 1990). They are therefore suitable for a study of this nature. Furthermore, benthic organisms have advantages over pelagic organisms as the former are predominantly sessile (i.e. immobile) and are thus more useful in assessing local effects (Warwick 1993; Warwick *et al.* 1990). The disadvantages of using macrobenthos in impact studies are primarily practical. A large research vessel is required for the necessary equipment, and the identification of organisms is time consuming. Furthermore, sieving must be conducted at sea as large volumes of sediment are collected, and it is not practical to

bring such large volumes back to the laboratory for processing (Warwick 1993).

One of the primary methods used to detect and monitor biological effects of marine pollution and disturbance is by analysis of changes in benthic community structure (Warwick and Clarke 1993). There are presently a number of statistical and numerical techniques available for this purpose and they are broadly classified as:

1. Univariate techniques such as diversity indices, which reduce the abundances of the species in each sample to a single coefficient.

2. Distributional techniques such as k-dominance curves, which summarise the abundance and biomass data in each sample by means of a curve.

3. Multivariate techniques, which base their comparisons of samples on many species. The raw data are reduced to a graphical form of few dimensions which allows for the detection of patterns in the community data.

Univariate and distributional techniques are species-independent and may produce anomalous results as two communities with different taxonomic compositions may be found to have the same diversity indices or dominance curves. Multivariate techniques, on the other hand, are species-dependent and take into account the fact that different organisms produce disparate responses to disturbance. In this regard, these techniques are more sensitive than the two former techniques. However,

multivariate techniques are used primarily to assess community change, and do not provide insight into whether that change is detrimental or not (Warwick and Clarke 1991). Such information may be obtained from the results of univariate and distributional techniques. It may therefore be necessary to consider all three techniques in order to assess changes in benthic communities as a result of mining, and to make a judgement with regard to whether or not those changes are detrimental.

1.2 Mining operation

Offshore mining is conducted on the continental shelf off the coast of Namibia in waters ranging in depth from 85 to 200 metres below mean sea level. Two mining techniques are utilised and are considered to result in similar levels of disturbance (M. Mittelmeyer from Savage 1996). The two techniques referred to are the underwater "crawler" and the large rotating "drill". Both methods make use of high-powered air-lift suction to transport the gravel to the mining vessel. Compressed air is pumped down to the mining apparatus, which is situated on the sea-floor, in order to attain the "airlift". The air then bubbles up a thick-walled pipe and a suction is created by the difference between external and internal fluid densities. Gravel is sucked up from the sea-floor by the vacuum which has been produced. Once on board the mining vessel, this gravel is screened and treated to extract diamonds. Processed gravel and silt are released overboard in the form of tailings.

During the mining process, all sediments, except for the largest boulders, are removed to the level of bedrock. According to sedimentological studies, the unmined sediment consisted of a stratified sequence of gravels overlain by very fine sand. This sequence is disturbed as a result of mining, and the sediment that is returned to the sea-floor is a mixture of these strata. Although the gravel quickly sinks to the sea-floor, the fine sand component remains suspended in the water column for longer and gradually disperses over a wide area as a result of the prevailing currents. This results in a net increase in the relative percentages of the larger mud and gravel components (Rogers 1995).

1.3 Approach

The necessary background information and various techniques used in the investigation of changes in macrobenthic communities with mining activity have been outlined in the present chapter. Following this, chapter 2 deals with the field work involved in the data collection, as well as the subsequent laboratory work. It also provides information regarding the level of taxonomic resolution at which the analyses were conducted, and addresses the problems encountered in the sampling strategy.

The various techniques used to assess the changes in benthic communities in this study are presented in separate chapters. Both chapters 3 and 4 discuss the use of species-independent techniques incorporated into the study. In chapter 3, univariate techniques are used to assess the changes in diversity at different times after mining.

Chapter 4 uses distributional techniques to judge the condition of a site, with regard to the level of disturbance, subsequent to mining.

Species-dependent multivariate methods are discussed in chapter 5. Background information is provided, and reasons for the selected transformations and similarity coefficients are given. Chapter 5 also presents details regarding the flexibility of multivariate techniques, as well as a description of the use of various tools accounting for this flexibility.

Chapter 6 is devoted entirely to the use of formal statistical testing as a means of detecting the presence of statistical differences between temporal categories in terms of their biotic (species) composition. Groups of samples comprising temporal categories are identified *a priori* based on their putative levels of disturbance. The formal statistical test is referred to as ANOSIM (analysis of similarities), and is analogous to the parametric ANOVA (analysis of variance). Results and interpretation of these statistical tests are also presented in this chapter.

Chapter 7 presents results of the multivariate analysis in the form of hierarchical agglomerative clustering and ordination plots. The relative importance of each species to the overall multivariate analysis is assessed using the program SIMPER ("similarity percentages"). A number of species can then be identified as indicator species which are characteristic of areas disturbed by mining activity, or of undisturbed areas.

In order to detect any relations between sedimentology and the observed biotic patterns, chapter 8 attempts to link environmental variables to changes in the benthic community. This is achieved by (a) assessing changes in particle size with time after mining, and (b) superimposing the environmental parameters (I.e. %gravel, %sand and %mud) on the biological ordinations presented in chapter 7.

Chapter 9 summarises the conclusions reached in the previous chapters regarding the rate of recovery of macrobenthic organisms after mining disturbance.

1.4 Aims

The main aims of the study were to assess if the two research areas (i.e. northern and southern) recovered after mining in terms of their species composition, and if so, then how long after mining this recovery was achieved. Furthermore, geological analyses were conducted and incorporated into the study in an attempt to link changes in community structure after mining with changes in sedimentology.

CHAPTER TWO:

SAMPLING AND

LABORATORY METHODS

2.1 Study Area

Mining is conducted by De Beers Marine in concession areas off the west coast of southern Africa. Mining activity, which is limited to the Namibian continental shelf off the Orange River, takes place at depths ranging from 110 to 135m. Six sampling sites were selected north of the Orange River approximately 20-30km off the coast of Namibia. Each site consists of a continuous area with a similar mining history. Sites in the northern research area (sites one to four) were situated at a mean depth of 130m, while those in the southern research area (sites five and six) were at a mean depth of 110m. Northern and southern research areas were separated by approximately 30km (see Figure 2.1).

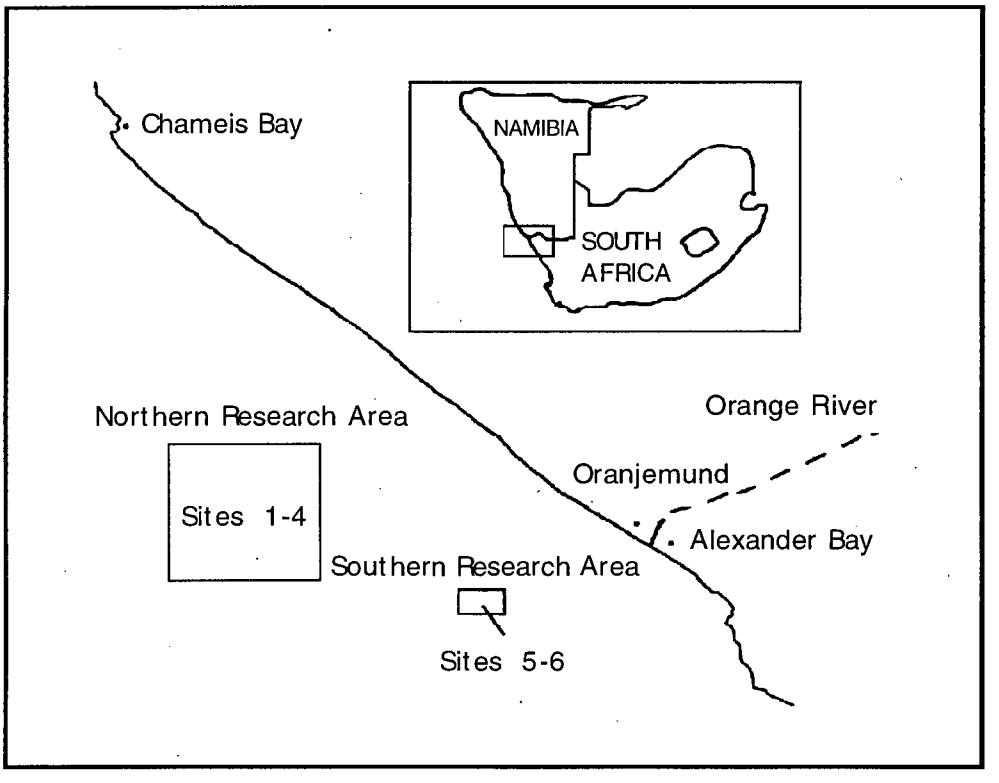

Figure 2.1: Map of study area off the west coast of Southern Africa.

The six sites were sampled from the same vessel on three separate occasions; June 1994, February 1995 and January 1996. During the first sampling cruise (on board the "*Rockfish*"), ten samples were taken from each site. The same six sites were revisited during the cruise on board the renamed "*Pentow Salvor*", at which time six samples were taken from each area. During the most recent cruise on board the "*Pentow Salvor*", five to six samples were taken from each of the original six sites. The final cruise is referred to as the "*De Beers*" cruise to avoid confusion with the second cruise.

Each sample is represented by a letter and a 2-digit number. The letter indicates during which cruise the sample was taken. "R" refers to samples taken during the *"Rockfish"* cruise, "S" refers to samples taken during the "*Pentow Salvor*" cruise, and "D" refers to samples taken during the third "*De Beers*" cruise. The first digit indicates the site from which the sample was taken, while the second digit indicates the number of the replicate taken at that particular site. As an example, D5.6 refers to the sixth sample taken at site five during the third ("*De Beers*") cruise. Sample numbers are not necessarily consecutive as they are numbered according to the grab attempt number.

Five of the six sites sampled had been mined at different times in the past and this provided a quasi-time series of recovery after mining. One of the sites (a reference site) had not been mined in the past and was not likely to be mined in the near future. It should be noted that sites were not the same on each cruise, for example site 1 in the first cruise was not necessarily the same as site 1 in the second cruise.

Furthermore, the exact position of each grab sample could not be determined as ocean currents often caused the grab, which was located at the end of a 120m wire, to drift slightly off the proposed co-ordinates. There were also problems with the accuracy of the navigation equipment during the "*Rockfish*" cruise owing to radio interference. As a result of these navigational limitations samples which were to be located in unmined areas were sometimes found to be in mined areas and vice versa. Subsequently, replicates were organised into temporal categories according to how long ago the area was mined. The exact position and mining status of several replicates could not be determined with certainty, and these sample were excluded from the study. These replicates are R6.1, R6.2, R6.3, R6.4 and R6.5. Table 2.1 shows temporal categories into which the replicates were divided for both the northern and southern research areas.

Table 2.1: Temporal categories of replicates taken from northern and southern research areas.

CONDITION	AREA	SAMPLES	N
Never mined	north	**R**: 1.1 - 1.11/ 2.1 - 2.10/ 3.1/ 3.3/ 3.5 - 3.10/ 4.1/ 4.3 - 4.5 **S**: 1.15/ 2.2 - 2.7/ 3.5	41
	south	**R**: 5.1/ 5.4 - 5.10/ 6.6/ 6.7 **S**: 5.2/ 5.3/ 5.5/ 5.6/ 5.9/ 5.11/ 6.2/ 6.4/ 6.6 **D**: 4.1 - 4.6	25
Mined 1-3 months ago	north	**R**: 3.2/ 3.4 **S**: 1.1/ 1.11/ 1.14/ 1.17/ 3.1/ 3.2	8
	south	**D**: 5.1 - 5.6	6
Mined 7-9 months ago	north	**R**: 4.2/ 4.6 - 4.10 **S**: 1.5/ 3.3/ 3.4/ 3.7	10
	south	**D**: 1.1 - 1.6	6
Mined 15-19 months ago	north	**S**: 4.2/ 4.6/ 4.8/ 4.9/ 4.13 - 4.15	7
	south	**R**: 5.3 **D**: 2.1 - 2.6	7
Mined 22-24 months ago	south	**D**: 3.1 - 3.6	6
Mined 43-51 months ago	south	**R**: 6.8 - 6.10 **S**: 6.1/ 6.3/ 6.5	6

R: "*Rockfish*" cruise (June 1994)

S: "*Pentow Salvor* " cruise (February 1995)

D: "*De Beers*" cruise (January 1996)

2.2 Faunal Analysis

2.2.1 Field and Laboratory Work

A 0.2m^2 Van Veen grab was used to collect data with regard to the density and diversity of the benthic macrofauna. The volume of each grab sample was estimated and a sample of the sediment taken for later geological analysis. Each sample was sieved through a 1mm^2 sieve and the organisms found on the sieve were fixed in 10% formalin and taken back to the laboratory for further analysis.

In the laboratory, samples were rinsed in freshwater to remove formalin as this dissolves the calcium carbonate in shells. Samples were then transferred to 1% phenoxatol in preference to alcohol which leaches the colour from the organisms and makes identification more difficult. Samples were hand sorted to remove organisms from the sediment. Any which were dead (e.g. empty *Nassarius* shells) at the time of sampling were discarded. The remainder were classified to the lowest possible taxon, counted, blot-dried and weighed (see Appendix A for abundance and biomass data).

2.2.2 Taxonomic Resolution

An important consideration in benthic surveys is the level of taxonomic discrimination necessary to detect changes in community structure. The classification and identification of organisms requires a high level of taxonomic expertise and is often a very time-consuming procedure. Organisms need only be identified to a taxonomic level that will indicate the response of a community to disturbance (Ellis 1985). Although the organisms were identified to the lowest possible taxon in the present

study, this information was not used in the numerical analyses as an important finding is that the types of analyses used in this report often detect the effects of disturbance at a relatively high taxonomic level (e.g. family level) without the significant loss of any information (Savage 1996). Furthermore, results obtained from analysing data at a higher taxonomic level may more closely reflect anthropogenic disturbances than those obtained from analyses based on species data as species may be more affected by natural environmental variation (Warwick 1993). Moreover, a large degree of standardisation provides data which are comparative (Warwick and Clarke 1993). The present study is based on data at the genus level.

2.3 Sampling Problems

Scientific investigations are fraught with problems regarding the selection of suitable control sites for environmental studies. This is particularly true for benthic studies as macrobenthic communities display a large degree of natural spatial patchiness on a local scale. As a result, these studies often fall prone to the problem of 'pseudoreplication' (Hurlbert 1984). 'Pseudoreplication' is defined as testing for treatment effects with an error term inappropriate to the hypothesis being considered (Hurlbert 1984). A suitable sampling design should include samples replicated in time and at appropriate spatial scales.

The present study has included reference replicates (i.e. replicates from unmined stations) from different stations in both the northern and southern research areas in an

attempt to overcome the problem of 'pseudoreplication'. The inclusion of these replicates allows for the assessment of natural heterogeneity within sites.

Navigational limitations posed definite problems in this study. Navigation was theoretically accurate to the nearest 5m, but during the *"Rockfish"* cruise was found to be far less accurate owing to radio-interference. This often resulted in samples being taken in unmined areas instead of mined areas and vice versa. However, with the use of Microfix and by taking into account the prevailing wind direction during sampling, the sample positions can be plotted to within 5-10m accuracy. Grab sample co-ordinates were plotted onto a map of the mined areas by a surveyor from De Beers Marine. Using this map, it was possible to verify which samples were taken in mined and unmined areas.

Another problem in the design of macrobenthic studies relates to the number of replicates which should be taken in order for the community structure to be properly represented. Benthic studies are typically expensive as a result of the heterogeneity of the communities and the intensity of labour involved in sampling in order to account for this. It is therefore often necessary to compromise between the practical considerations and statistical validity when deciding on the number of replicates to be taken.

A mathematical method for calculating the minimum sampling area based on macrobenthic species richness has been proposed by Karakassis (1995). This

method, which takes the form of an algorithm, was used in the study preceding the present one in order to judge how many sample replicates should be taken in order to adequately represent benthic community structure. The following results were obtained (Savage 1996):

- A minimum of 31 grab samples from unmined areas was found to be necessary to obtain a reliable estimate of the total number of species (S_∞) for all the unmined stations in the northern and southern research areas together.
- A minimum of 23 grab samples from mined areas was found to be necessary for S_∞ to be adequately estimated for the pooled mined areas.
- 10 grab samples from a particular area were found to account for natural heterogeneity within an area.

2.4 Statistical and Numerical Analyses

Preliminary cluster analyses indicated that the northern and southern research areas differed in community structure. As a result, all statistical and numerical analyses were conducted separately on data from the two areas. The three cruises, on the other hand, were not separated as the object of the study was to analyse a time series of data. Data from the three cruises together provided this time series.

Although both abundance and biomass were measured in the current study, the component that best represents the community patterns was assessed in a previous study aimed at assessing the effect of mining (Savage 1996). Results of the study indicated that the two components showed remarkably similar results when

incorporated into multivariate analyses, and it was therefore concluded that either aspect of the biological data could be used to reveal patterns in the community data. As a result, it was decided to use only the abundance data for multivariate analyses in the current study.

CHAPTER THREE:

UNIVARIATE TECHNIQUES

3.1 Introduction

The species distribution of individuals is generally fairly regular, and such regularity allows the use of simplified expressions as indices of diversity (Margalef 1968). Much has been written regarding the effect of disturbance on diversity measures, and while the response of communities is not necessarily unidirectional, it is expected that diversity rises at intermediate levels of disturbance and then decreases at gross levels of disturbance (Clarke and Warwick 1994). Univariate techniques, or diversity measures, are generally used as a means of simplifying data into single indices (Gray and Pearson 1982).

A variety of indices can be used as measures of community structure. These include the total number of species/taxa (*S*), the total number of individuals (*N*), the total biomass (B), and ratios such as *N*/*S* (the average number of individuals per species/taxon) (Clarke and Warwick 1994).

There are two aspects of community structure which contribute to community diversity. The first, species richness, is a measure relating to the total number of species present. Clearly, in a pair of contrasting communities, the one with the greater number of species (denoted by *S*) would be considered to have a greater diversity than the other. A measure of the number of species is consequently used as an index of diversity. However, two communities with the same *S* value may differ in their diversities as some species in one community may be dominant with only a few scattered individuals of other species, while the other community may have equal

proportions of the same number of species. Measures of diversity have therefore been devised which take into account the relative abundances of the species forming a community (Pielou 1974). This concept, which is referred to as equitability, expresses how evenly the individuals are distributed among the different species, and is often referred to as evenness (Pielou 1974).

The most commonly used index for measuring diversity is the Shannon-Wiener diversity index, which is a function of the relative abundances of the species in a community (Pielou 1974). The Shannon-Wiener Index (H'), which is particularly appropriate for measuring ecological diversity, is defined as:

$$H' = -\sum_{i=1}^{s} p_i \log p_i \quad \text{(Pielou 1974)},$$

where p_i is the proportion of the community that belongs to the ith species. This index incorporates both species richness and evenness.

Although species richness is often considered to be merely the total number of species (S), this is heavily dependent on the size of the sample. In view of this, it is often preferable to use Margalef's index (d) which incorporates a measure of the total number of individuals (N), and is consequently a measure of the number of species present for a given number of individuals. The equation used is (Clarke and Warwick 1994):

$$d = (S\text{-}1) / \log N.$$

Equitability is most commonly referred to as Pielou's evenness index (Margalef 1958 as cited in Pielou 1974). Evenness, J', is given by the ratio:

$$J' = H' \text{(observed)} / H'_{max} \text{ (Pielou 1974)},$$

where H' is the observed diversity and H'_{max} is the maximum value H' could have in a community with the same number of species.

It has been suggested that increased disturbance results in a decrease in diversity (i.e. H'), a decrease in species richness (i.e. d), and a decrease in evenness (i.e. J'). This ultimately results in an increase in dominance (Clarke and Warwick 1994). However, this interpretation may be an over-simplification of the situation. More recently, it has been suggested that in areas of minimal disturbance, species diversity will decrease due to competitive exclusion between species. Competition decreases to some extent in moderately disturbed areas, resulting in an increase in diversity. In grossly disturbed areas, species are slowly eliminated by stress and diversity decreases again as a result (Clarke and Warwick 1994). This is the basis of the intermediate disturbance hypothesis which suggests that diversity is highest at intermediate levels of disturbance (Huston 1979). Increasing levels of disturbance may therefore either result in an increase **or** a decrease in diversity, depending on the condition of the community prior to an increase in disturbance. In effect, changes in diversity can only be assessed by comparing replicates of different conditions.

3.2 Diversity indices: Methods

The following diversity indices were calculated for each temporal category in both the northern and southern research areas:

- Total number of taxa (*S*)
- Total number of individuals (*N*)
- Margalef's index of taxon richness (*d*)
- Shannon-Wiener index (*H'*)
- Pielou's index of evenness (*J'*)

Means and confidence intervals were calculated for each of the above indices for each temporal category. These results were then plotted for each index. The existence of replicates from each of the temporal categories allows for formal statistical testing. ANOVA (Analysis of Variance) was conducted using the computer package STATGRAPHICS (Statistical Graphics System) to assess if there are significant differences between results obtained for each temporal category. This was followed by Tukey multiple range analysis to assess where these differences lie. A prerequisite for standard ANOVA is that the univariate index is normally distributed and that there is an approximately constant variance across replicates. These prerequisites are automatically met by diversity indices and transformation of data is therefore not necessary (Clarke and Warwick 1994).

3.3 Results

3.3.1 Northern Research Area

Plots of the means and confidence intervals of the indices for each temporal category (Figure 3.1) suggest that replicates from the unmined areas are different to those from areas mined 15-19 months ago. This holds true for all indices with the exception of Pielou's index of evenness. There are, however, no distinct graphical differences between unmined areas and those recently mined (i.e. 1-3 months ago) for any of the indices, which is unusual as one might expect mining activity to have a severe and immediate impact on the community. One-way ANOVA only detects a significant difference between temporal categories for the Shannon-Wiener index (F=3.050; d.f.=3, 62; p=0.035). When Tukey multiple range tests were conducted, a significant difference was detected between replicates from unmined areas and those mined 15-19 months ago.

From interpretation of these results, it is possible that the northern research area has not been affected by mining activity with respect to diversity. Although there are no significant differences in diversity between unmined areas and those mined recently, this technique does not take species composition into account. It is possible that although the diversity and evenness of the four temporal categories are not different, there is a difference in species composition. This can only be tested by means of multivariate techniques, which are discussed in chapters 5,6 and 7. Alternately, in accordance with the intermediate disturbance hypothesis, the area mined 15-19 months ago has a very low diversity suggesting that it is grossly disturbed. Given this

interpretation, it is possible that the impact of mining activity is not immediate in the northern research area, and that a much longer period is needed in order for the community to recover. However, it may be necessary to use distributional and multivariate techniques together before any conclusion can be reached in this regard.

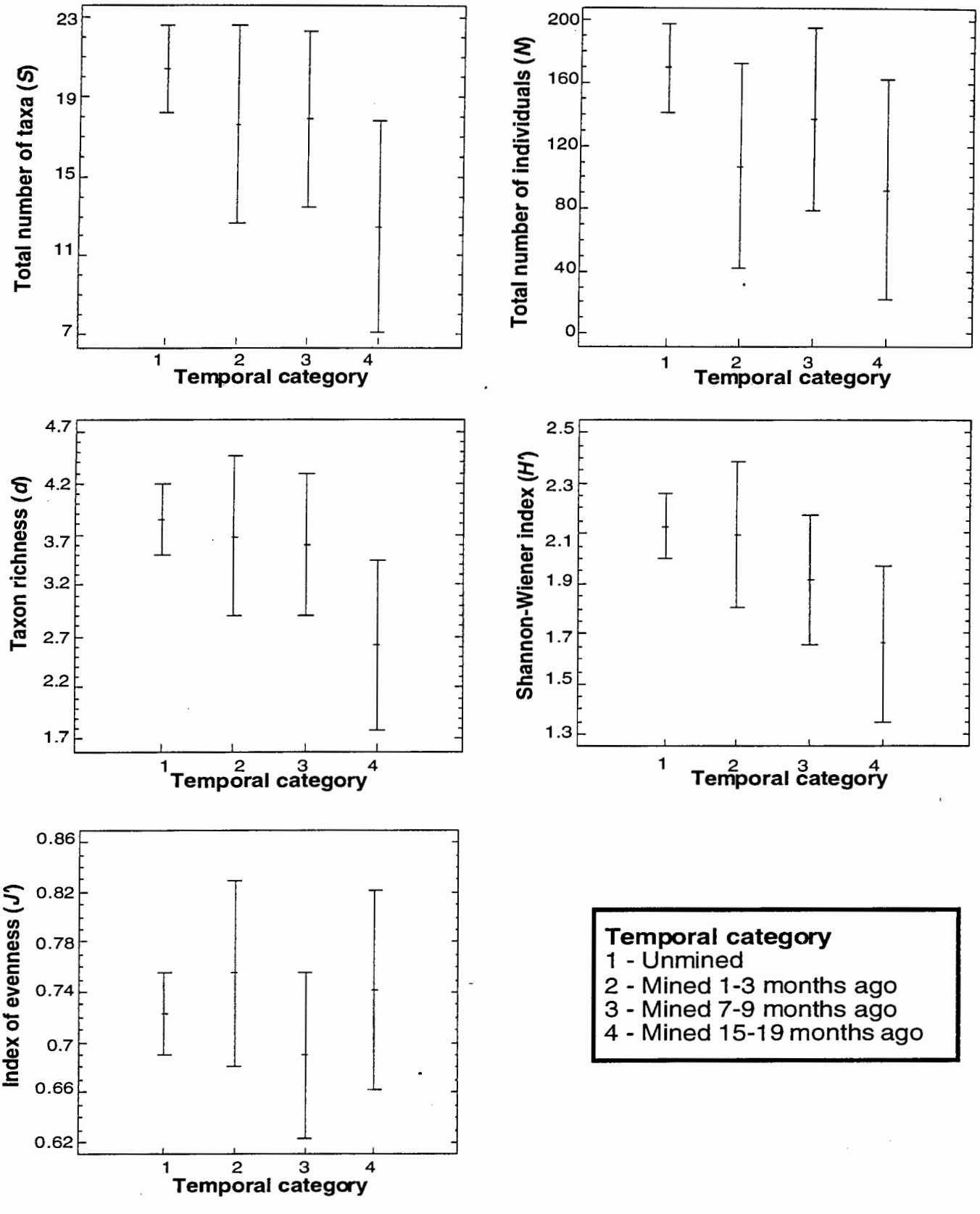

Figure 3.1: Northern research area: Means and confidence intervals of diversity indices.

Table 3.1: Northern research area: Results of one-way ANOVA for diversity indices where * denotes a significant difference at the 5% significance level.

DIVERSITY INDEX	D.F.	*F*-RATIO	SIGNIFICANCE LEVEL
TOTAL NUMBER OF TAXA	3, 62	2.721	0.052
TOTAL NUMBER OF INDIVIDUALS	3, 62	2.152	0.103
TAXON RICHNESS	3, 62	2.547	0.064
SHANNON-WIENER INDEX	3, 62	3.05	0.035*
INDEX OF EVENNESS	3, 62	0.666	0.576

3.3.2 Southern Research Area

The graphical representation of means and confidence intervals of diversity indices for temporal categories in the southern research (Figure 3.2) area provide a much clearer picture than the northern research area. There are distinct graphical differences between temporal categories for all indices with the exception of the total number of individuals. Replicates from unmined areas and those from areas mined 43-51 months ago appear similar. Furthermore, replicates from areas mined 1-3 months ago appear to be distinctly different from both unmined areas and areas mined 43-51 months ago.

Results of one-way ANOVA (Table 3.2) indicate that there are very significant differences between temporal categories for all diversity indices except the measure of the total number of individuals, where no significant difference was detected between the categories. Results of Tukey multiple range tests to detect where these differences lie are presented in Table 3.3 for all indices except that of the total number of species.

Results obtained lend statistical support to the observations made regarding the graphical representation of the data. Replicates from unmined areas are significantly different to areas mined 1-3 months ago, 7-9 months ago, and 22-24 months ago for all indices. Replicates from areas mined 15-19 months ago are significantly different to both unmined areas and areas mined 43-51 months ago for all indices except the measure of the total number of taxa. Replicates from areas mined 43-51 months ago are significantly different to those mined 1-3 months ago, 7-9 months ago and 22-24 months ago for all indices, with the exception of Pielou's index of evenness.

These results suggest that the impact of mining was severe and immediate, having a detrimental effect on the diversity and evenness of communities in the relevant areas. Communities show a drastic decrease in species diversity 1-3 months after mining has taken place, and there is also a drop in the total number of taxa after mining. Species richness and evenness of the representation of species decreases with the impact of mining. All these factors increase again 43-51 months subsequent to mining activity, suggesting that the communities have recovered to an undisturbed state, or are at least moving back through a moderately disturbed condition en route to recovery.

However, given that these techniques are species-independent, it is not feasible to make any assumptions regarding the state to which these communities have recovered. Species composition may have returned to its original state comprising the same species as prior to mining activity, but may equally well have reached a different

state with an entirely different complement of species. This is explored in greater depth in chapters 5,6 and 7 which concentrate on (species-dependent) multivariate techniques of analysis.

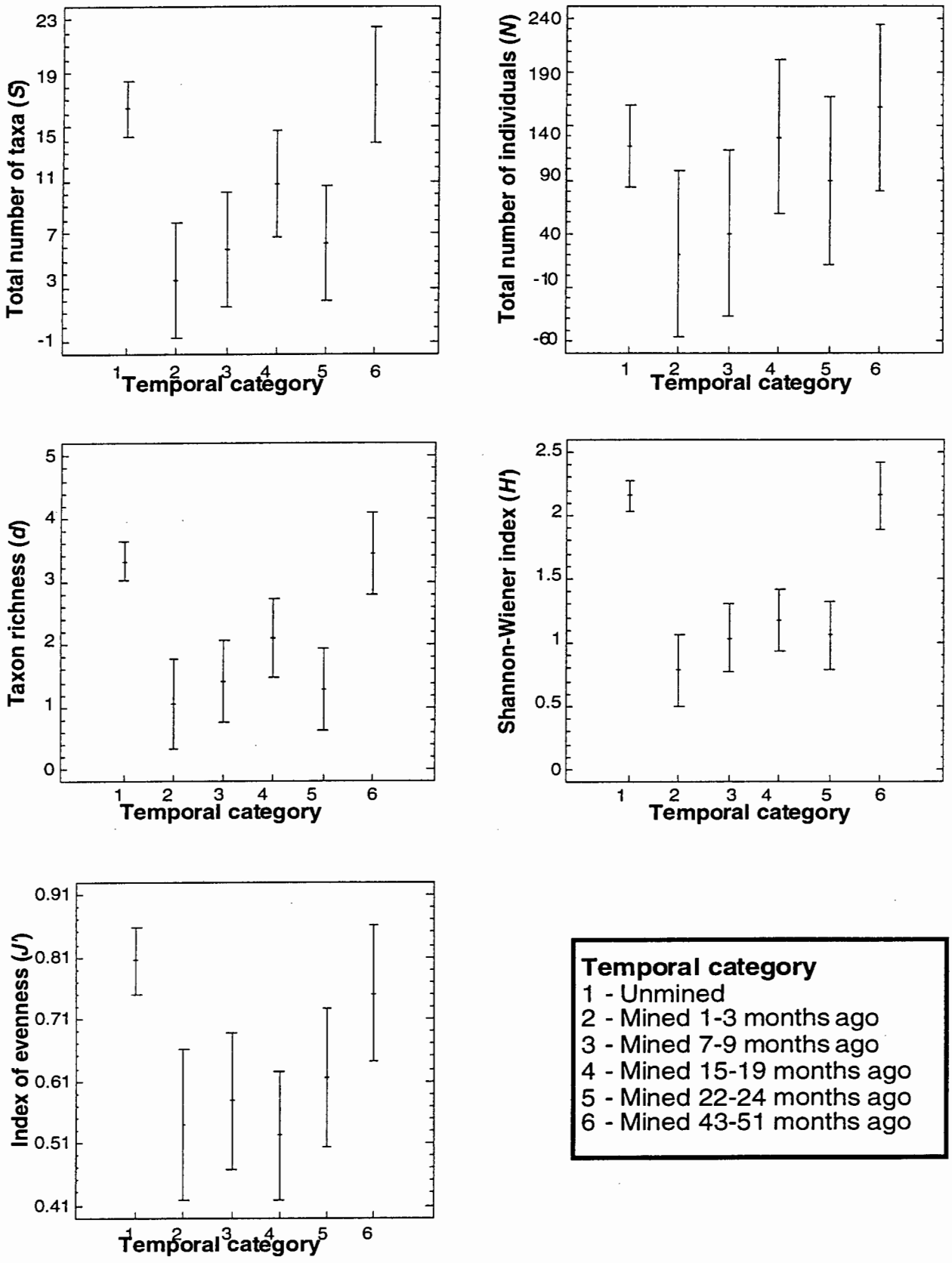

Figure 3.2: Southern research area: Means and confidence intervals of diversity indices.

Table 3.2: Southern research area: Results of ANOVA for diversity indices where * denotes a significant difference at the 5% significance level.

DIVERSITY INDEX	D.F.	*F*-RATIO	SIGNIFICANCE LEVEL
TOTAL NUMBER OF TAXA	5, 50	11.378	0.000*
TOTAL NUMBER OF INDIVIDUALS	5, 50	2.155	0.074
TAXON RICHNESS	5, 49	15.384	0.000*
SHANNON-WIENER INDEX	5, 49	34.361	0.000*
INDEX OF EVENNESS	5, 49	8.486	0.000*

Table 3.3: Southern research area: Results of Tukey tests indicating significant differences detected between temporal categories for all indices. **X** denotes a significant difference.

DIVERSITY INDEX	1 - 2	1 - 3	1 - 4	1 - 5	2 - 6	3 - 6	4 - 6	5 - 6
TOTAL NUMBER OF TAXA	X	X	--	X	X	X	--	X
TAXON RICHNESS	X	X	X	X	X	X	X	X
SHANNON-WIENER INDEX	X	X	X	X	X	X	X	X
INDEX OF EVENNESS	X	X	X	X	--	--	X	--

1 - Unmined
2 - Mined 1-3 months ago
3 - Mined 7-9 months ago
4 - Mined 15-19 months ago
5 - Mined 22-24 months ago
6 - Mined 43-51 months ago

3.3 Discussion

It appears that the northern research area is not severely affected by mining activity in terms of diversity. Mined replicates from the southern research area, on the other hand, show a marked decrease in all diversity indices taken into account in the present study, with the exception of the total number of individuals. However, although the effect of mining appears to be severe and immediate in this area, the communities appear to have recovered to a relatively undisturbed state 43-51 months subsequent to mining.

Although some tentative suggestions have been made in this chapter regarding the rate of recovery of benthic communities after mining activity, these suggestions have been based purely on the results of species-independent univariate techniques. For more conclusive deductions, it is necessary to conduct distributional and multivariate analyses on the data.

CHAPTER FOUR:

DISTRIBUTIONAL TECHNIQUES

4.1 Introduction

It is generally accepted that under "stable" conditions, competitive displacement will eventually bring about a relatively low diversity steady state as a result of interspecific competition (Warwick 1986). The species that assume the dominant role in this situation are regarded as *K*-selected species. These species, which are generally large and have a relatively long lifespan, also have a population size that is fairly constant in time and is close to the carrying capacity of the environment (Pianka 1970). These species are dominant with regard to biomass rather than abundance. In a moderately disturbed environment, the rate of recovery is generally slower than the frequency of disturbance. As a result, competitive equilibrium is not reached and diversity increases (Warwick 1986). Opportunistic species, which are favoured under these conditions, dominate with regard to both biomass and abundance. An increase in disturbance has a detrimental effect on the less resilient opportunistic species which decrease in abundance. This results in a decrease in diversity.

Warwick (1986) proposed a method of assessing the effect of disturbance on macrobenthic communities based on the assumption that the distribution of abundance of individuals among species should behave differently from the distribution of biomass. This is assessed with the use of dominance curves which include *k*-dominance, abundance-biomass comparison (ABC), and partial dominance curves.

A *k*-dominance curve is produced by plotting the cumulative ranked abundances or biomass against log species rank. By superimposing the abundance and biomass curves, abundance-biomass comparison (ABC) curves are produced (Warwick 1986). These curves, which do not reduce the information to a single summary statistic as univariate techniques do, are used to extract information regarding the dominance pattern within a sample. This technique is considered as intermediate between univariate and multivariate analysis. As in the univariate technique, the distributional technique is species-independent and extracts universal features which are not a function of the specific taxa.

Warwick (1986) proposes that under "undisturbed" conditions, the biomass will become increasingly dominated by a few individuals of a few large species. Abundance will be dominated by smaller species with a distinctly random element determining their abundance. The distribution of abundance among species will be more even than that of biomass which will show a definite dominance. Under "moderately" disturbed conditions, large competitive dominant species will be eliminated and the differences in size between abundance and biomass dominants will be reduced. Under "grossly disturbed" conditions, communities will become dominated with regard to abundance by a few small species. Although a few larger species will still be present, the greater proportion of their contribution will be with respect to biomass rather than abundance.

These scenarios are depicted graphically in the hypothetical ABC plots in Figure 4.1. An "undisturbed" condition is characterised by the biomass curve lying above the abundance curve for the duration of its length. The abundance and biomass curves for a "moderately disturbed" condition lie close together and may cross a number of times. A "grossly disturbed" condition is characterised by the abundance curve lying above the abundance curve throughout its length.

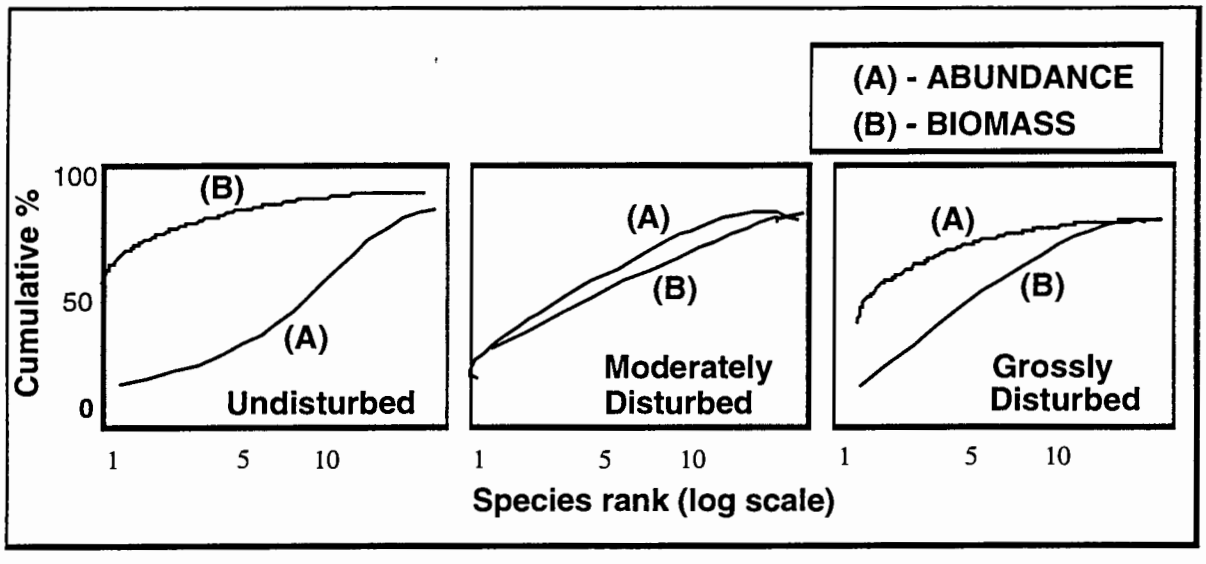

Figure 4.1: Hypothetical ABC curves for species biomass and abundance, showing "undisturbed", "moderately disturbed" and "grossly disturbed" conditions (after Warwick 1986).

A summary statistic (the *W*-statistic) can also be calculated for each plot in addition to the curves which are produced. The *W*-statistic, which summarises the difference in area under the biomass and abundance curves, ranges from -1 to +1. $W \longrightarrow +1$ characterises an "undisturbed" community with equal abundances across species but biomass dominated by a single species, while $W \longrightarrow -1$ represents a "disturbed"

community where abundance is dominated by a few small species (Clarke 1990). These limits are not likely to be attained in practice.

In order to test for statistical differences between samples or treatments, it is necessary to have replicate samples at each site (Clarke 1990). A one-way ANOVA followed by multiple comparison tests can be used to establish if there are overall differences among sites if the *W*-statistic is calculated for each replicate (Clarke 1990).

Although ABC curves may provide extensive information regarding the condition of an area, it becomes difficult to distinguish differences between curves as the cumulative frequencies approach 100%, which they do very rapidly. Furthermore, these curves are overdependent on the single most dominant species which may result in a misrepresentation of information (Clarke 1990). In a study by Beukema (1988), data was presented on intertidal benthic communities where the presence of large numbers of a small species generated ABC curves in which the abundance curve was situated above the biomass curve throughout its length. This incorrectly implied that the community was disturbed when this was not the case.

To overcome these problems, partial dominance curves are produced whereby the effect of the single most dominant species is suppressed (Clarke 1990). Under Warwick's (1986) hypothesis, in a "disturbed" environment the abundance curve will still lie above the biomass curve, but only in the initial stages. The biomass curve will reassert itself above the abundance curve in the later stages as a result of the greater

variability for biomass. One drawback of partial dominance curves is that *W*-statistics are not computed and it is therefore not possible to test for statistical differences between samples or treatments. Furthermore, this technique only recognises three levels of disturbance, namely "undisturbed", "moderately disturbed" and "grossly disturbed".

Distributional techniques are not necessarily more sensitive than diversity indices at detecting disturbance, and are definitely less sensitive than multivariate methods in discerning differences in community structure (Warwick and Clarke 1991). However, this technique does have an advantage in that it provides a better absolute measure of disturbance rather than a comparative one (Warwick 1993). It incorporates an internal comparison of the distribution of both the abundance among taxa as well as the distribution of biomass among taxa in the same sample (Warwick 1986).

4.2 Methods

ABC curves were plotted for each temporal category in both the northern and southern research areas using the computer package PRIMER (Plymouth Routines In Multivariate Ecological Research). A *W*-statistic was calculated for each of these plots using the formula:

$$W = \sum_{i=1}^{S} (B_i - A_i)/[50(S - 1)],$$

where B, A and S refer to biomass, abundance and the number of species, respectively (Clarke 1990).

A *W*-statistic was also calculated for each replicate in order to conduct statistical analyses on the data. One-way ANOVA was used to establish overall significant differences among temporal categories for the northern and southern research areas. Multiple comparison tests (specifically Tukey tests) were then conducted in order to determine which pairs of temporal categories were significantly different.

Partial dominance curves were also plotted for each temporal category for the two research areas. In order to emphasise dominance of the second most common species over the remainder, the third most common species over the remainder, etc., the following sequence was calculated (Clarke 1990):

$$p_1=100a_1/(\sum_{j=1}^{s} a_j),\ p_2=100a_2/(\sum_{j=2}^{s} a_j),\ ....,p_{s-1}=100a_{s-1}/(a_{s-1}+a_s),\ p_s=100a_s/a_s=100,$$

where a_j is the absolute abundance of the jth species when ranked in decreasing order of abundance.

4.3 Results

4.3.1 Northern Research Area

ABC curves suggest that replicates from the unmined stations, as well as those from stations mined 1-3 months ago and 7-9 months ago, are "moderately disturbed" with the abundance and biomass curves closely coincident in all three plots (Figure 4.2 A-C). Furthermore, the W-statistics are only marginally positive for these three temporal categories. Replicates from stations mined 15-19 months ago appear to less disturbed

as the biomass curve lies above the abundance curve for almost its entire length (Figure 4.2 D).

The majority of the partial dominance curves (Figure 4.3) for the northern research area do not depict the situation more clearly than the ABC curves. Figure 4.3D, however, indicates that the biomass curve remains above the abundance curve for almost its entire length, dropping below for only small portions of the plot and then reasserting itself above the abundance curve. This reiterates the idea that the area mined 15-19 months ago is relatively undisturbed.

However, one-way ANOVA results (F=0.604; d.f=3, 62; p=0.6147) and multiple comparison tests indicate that there are no significant differences between the W-statistics for these plots.

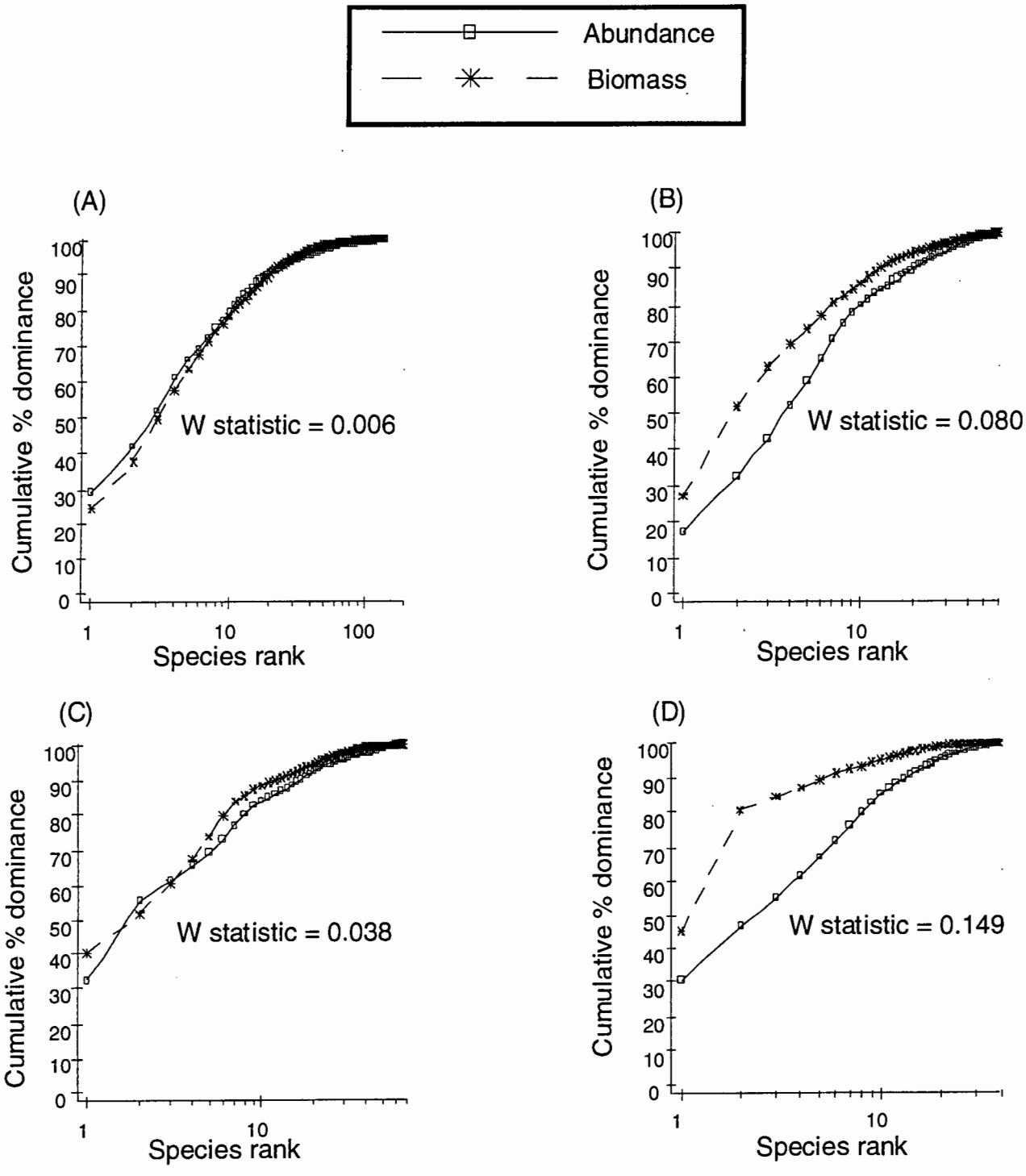

Figure 4.2: Northern research area: ABC curves for each of the temporal categories. The categories represented are (A) unmined, (B) mined 1-3 months ago, (C) mined 7-9 months ago, (D) mined 15-19 months ago.

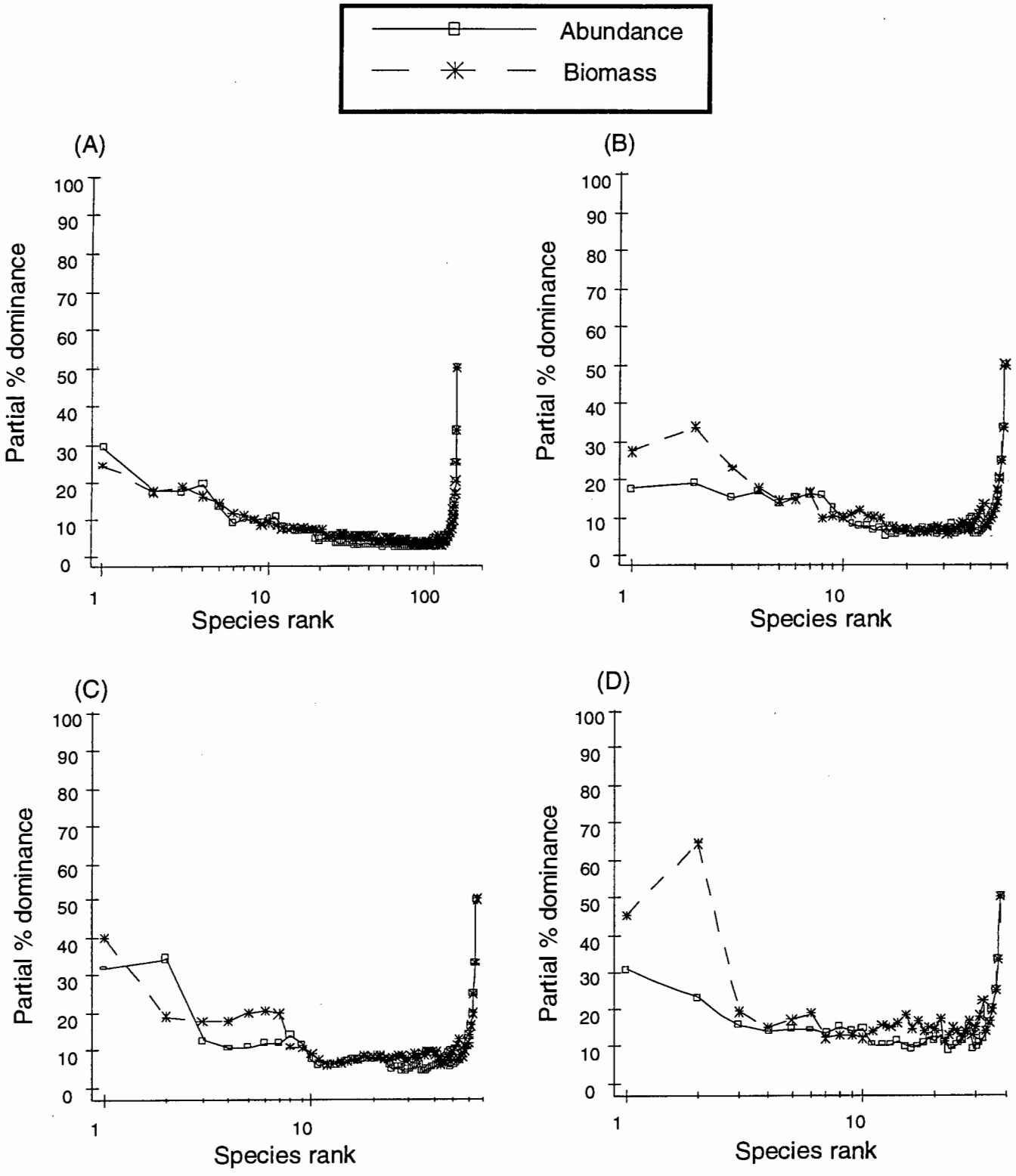

Figure 4.3: Northern research area: Partial dominance curves for each of the temporal categories. The categories represented are (A) unmined, (B) mined 1-3 months ago, (C) mined 7-9 months ago, (D) mined 15-19 months ago.

4.3.2 Southern Research Area

ABC curves for the southern research area suggest that replicates from the unmined category are "moderately disturbed" (Figure 4.4A), with abundance and biomass curves lying very close together and a *W*-statistic of 0.052. The corresponding partial dominance curve (Figure 4.5A) does not provide any further information. The ABC curve for replicates from sites mined 1-3 months ago (Figure 4.4B) also suggests a "moderately disturbed" area. The corresponding partial dominance curve (Figure 4.5B) depicts the plot more clearly from species 2 onwards. The biomass curves lies slightly above the abundance curve for most of its length, dropping below only at the very end. After 7-9 months, a "grossly disturbed" state is depicted with *W*=-0.152. The abundance curve lies above the biomass curve in the initial stages of the plot (Figure 4.4C), however the partial dominance curve (Figure 4.5C) shows that the two curves cross over a number of times after species 2. Between 15 to 24 months, the sites fluctuate between the "moderately disturbed" and "grossly disturbed" states (Figure 4.4D and E), with *W*-statistic values of 0.038 and -0.061 respectively. Although the latter may have a negative *W*-statistic value (which depicts a disturbed scenario), the partial dominance curve (Figure 4.5E) shows the biomass curve reasserting itself above the abundance curve between species 2 and 3. After 43-51 months (Figure 4.4F and 4.5F), the sites return to a relatively "undisturbed" state with the biomass curve above the abundance curve for almost its entire length (*W*=0.062).

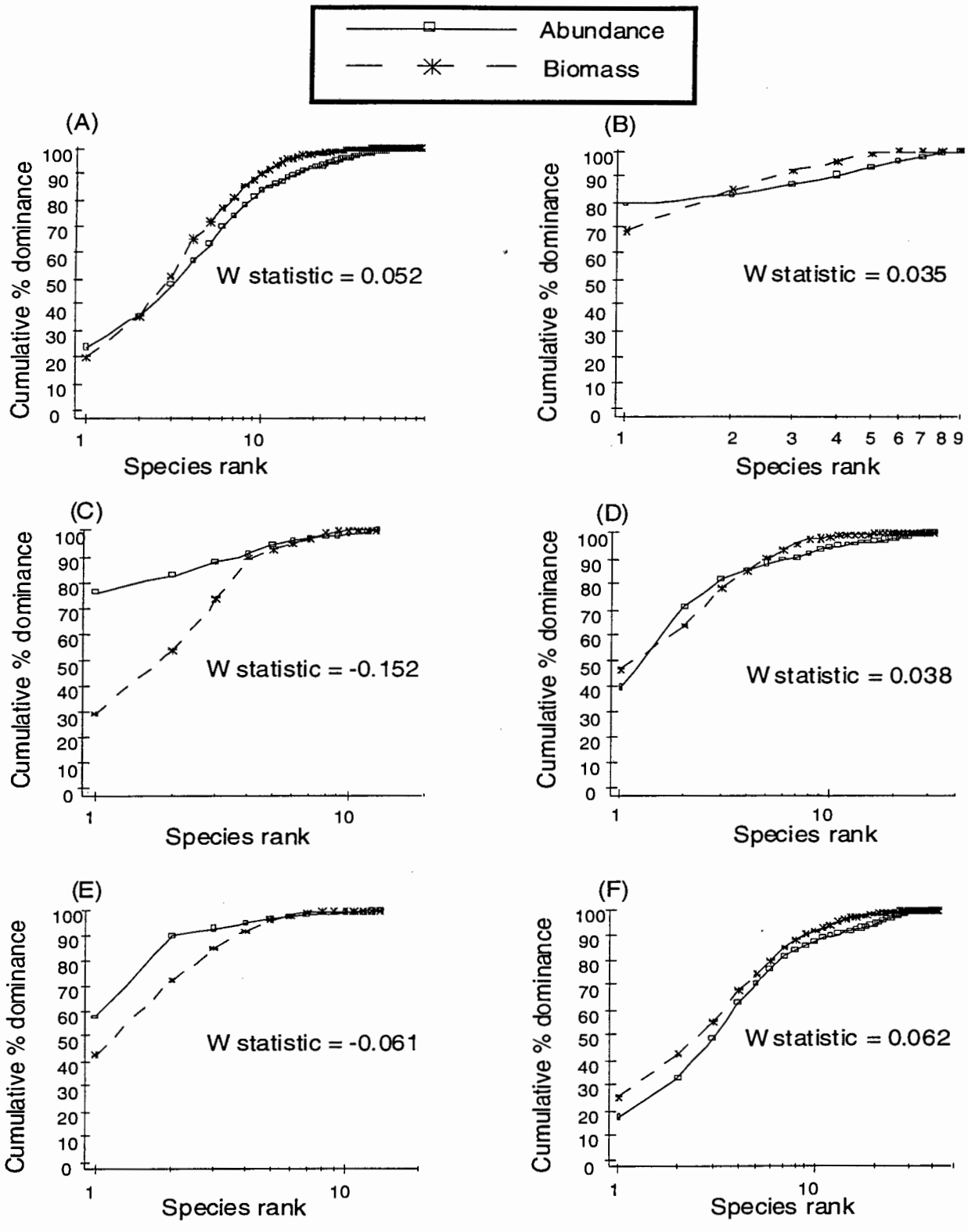

Figure 4.4: Southern research area: ABC curves for each of the temporal categories. The categories represented are (A) unmined, (B) mined 1-3 months ago, (C) mined 7-9 months ago, (D) mined 15-19 months ago, (E) mined 22-24 months ago, (F) mined 43-51 months ago.

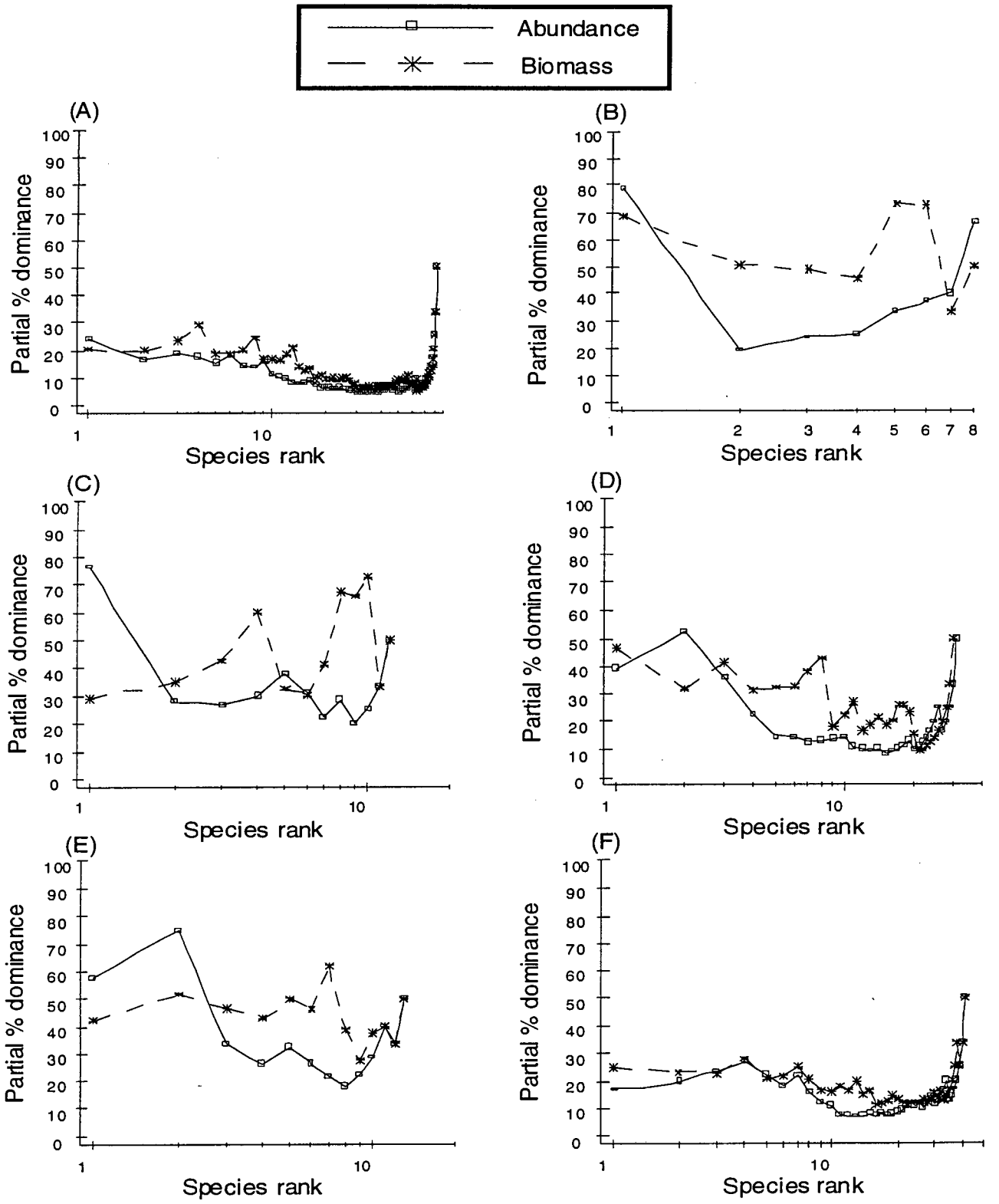

Figure 4.5: Southern research area: Partial dominance curves for each of the temporal categories. The categories represented are (A) unmined, (B) mined 1-3 months ago, (C) mined 7-9 months ago, (D) mined 15-19 months ago, (E) mined 22-24 months ago, (F) mined 43-51 months ago.

Table 4.1: Southern research area: Results of multiple comparison tests conducted on *W*-statistics calculated for temporal categories (where **SD** represents a significant difference at the 5% significance level).

	2	3	4	5	6
1	-	**S D**	-	**S D**	-
2		-	-	-	-
3			-	-	-
4				-	-
5					-

Temporal categories: **1** - Unmined
2 - Mined 1-3 months ago
3 - Mined 7-9 months ago
4 - Mined 15-19 months ago
5 - Mined 22-24 months ago
6 - Mined 43-51 months ago

Results of ANOVA indicate a significant difference between *W*-statistics for temporal categories in the southern research area (F=4.791; d.f=5, 49; p=0.0012). Results of multiple comparison tests (Table 4.1) detect a significant difference between unmined replicates and those mined 7-9 months ago, as well as between unmined replicates and those mined 22-24 months ago. These statistical results substantiate the graphical representation of the data in Figure 4.4.

4.4 Discussion

Although results for the northern research area indicate that the unmined category represents a "moderately disturbed" community, there does appear to be a recovery to a relatively "undisturbed" state 15-19 months subsequent to mining activity. Given the results, it is possible that the northern area is experiencing disturbance from factors other than mining, thus depicting a state of "moderate disturbance" in an unmined area.

Results for the southern research area provide a more lucid picture of the rate of recovery after mining. The unmined area is again depicted as being "moderately disturbed", which may be as a result of stress-inducing factors other than mining. However, 7-9 months after mining the area is depicted as "grossly disturbed". The community then appears to recovery at a slow, steady rate, reaching a point at 43-51 months ago where the area is considered to be "undisturbed". This suggests that the southern research area has recovered to a relatively stable state, with a community dominated primarily by large *K*-selected species. Once more, it is not possible to speculate on the species composition of these communities without first conducting multivariate analyses on the data.

CHAPTER FIVE:

MULTIVARIATE TECHNIQUES

5.1 Background

Biological surveys generally produce complex sets of data from which patterns and community relationships need to be extracted. A multivariate strategy for analysing such multispecies data has been proposed (Field *et al.* 1982). Multivariate techniques, which are based on community species compositions, are considerably more sensitive to community change than univariate or distributional techniques as more information is retained in the analysis (Gray *et al.* 1990; Warwick and Clarke 1991). Furthermore, multivariate techniques utilise information pertaining to the varying sensitivities to disturbance displayed by different marine taxa (Warwick and Clarke 1993).

Although multivariate techniques are useful in that they have generality and consistency of behaviour, they also have two drawbacks as measures of disturbance. The technique is sensitive to natural variability in species composition and may therefore present problems when attempting to interpret patterns and relationships. The species composition of communities varies spatially and this variability is dependent on local environmental conditions. As a result, it is expected that any species-dependent response to disturbance could be obscured by this natural variability. Secondly, it is difficult to allocate a value judgement on observed change as this technique only indicates if there is a change in species composition, and not whether that change is detrimental or not (Warwick and Clarke 1993).

The first problem may be overcome by working at a higher taxonomic level, as taxonomic composition becomes more similar at higher levels. For soft-bottom marine macrobenthos in particular, disturbance effects are noticeable with multivariate techniques at the highest taxonomic level (Heip *et al.* 1988; Warwick 1988a; Warwick 1988b). The second problem may be overcome by using multivariate techniques in conjunction with univariate and distributional techniques which provide an indication of whether a change in species composition in a community is detrimental or not.

Multivariate analysis is based on the concept of similarity between any pair of samples regarding the biological specimens they contain. In this respect, it is a biologically-motivated definition of what constitutes similarity between two communities (Clarke and Warwick 1994). The biological data consists of an arrangement with p rows (species) and n columns (sample replicates); entries are counts of the abundance of each species for each replicate. The starting point for multivariate analysis is the generation of a similarity matrix which is the basis for clustering and ordination analyses (Figure 5.1). Similarities with regard to shared species are calculated between every pair of samples and these values are entered into the similarity matrix.

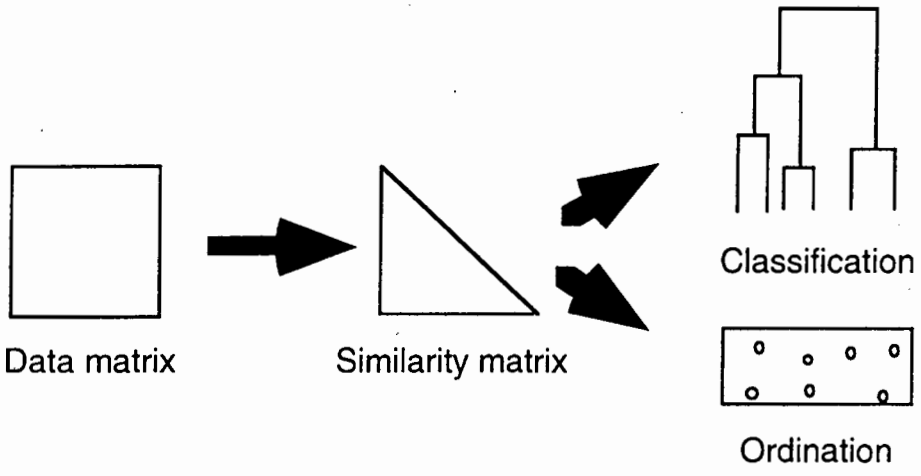

Figure 5.1: Schematic summary of stages leading to classification and ordination of samples in the multivariate analysis of benthic community data (after Field *et al.* 1982).

The computer package PRIMER (Plymouth Routines In Multivariate Ecological Research) was used to analyse the community data. The complexity of the data is reduced by generating a graphical representation of the biotic relationships between the samples. The program is valuable in the sense that it detects patterns in the community structure that are otherwise difficult to discern from the raw data. Furthermore, a range of options is available for the treatment of data prior to analysis, making this technique inherently flexible.

5.2 Data Transformation

Various definitions of similarity between samples have been used, each giving different weight to different aspects of the community. Some may focus on similarity in abundance of the most common species while others concentrate on the abundance of rare species. Such definitions do not take into account the similarity of the overall

community composition, and it is therefore preferable to transform the data before generating the similarity matrix.

A number of transformations can be used (Clarke and Green 1988), including root-root transformations, logarithmic transformations, and in the extreme, the reduction of data to presence-absence values for each species. Root-root transformation reduces the dominance of species that are numerically dominant, while the reduction of data to presence-absence values places more emphasis on rarer species. Root-root transformation is preferred to logarithmic transformation as it is not affected by the units in which abundance is expressed, or by the presence of zeros in the data set.

In root-root transformation, which is used in the current study, the less dominant and rare species play a role in determining similarity as the weighting of the very abundant species is reduced. The equation used in this transformation is:

$$Y_{ij} = \sqrt{\sqrt{X_{ij}}} = X_{ij}^{\frac{1}{4}}$$ (Field *et al.* 1982).

5.3 Coefficient of Similarity

A similarity coefficient (*S*) ranges in value from 0-100% (or 0 to 1). S takes a value of 100% (or 1) if two samples are identical, and a value of 0% if two samples are totally dissimilar. The overall similarity between two samples can be summarized using a variety of measures of distance, information, correlation, similarity and dissimilarity,

taking all or most species into account (Field *et al.* 1982). In marine data, numerous species are often absent from most of the samples, and as a result, many entries in the data matrix are zeros. This should not change when the data are transformed and consequently, measures which take joint absences into account are not robust enough for general application. If joint absences are taken into account, then two samples that lack the same species are effectively similar.

The Bray-Curtis (Czekanowski) coefficient of similarity, which has become particularly common in ecological work, is applied to data in the current study because it is not affected by joint absences (Field and McFarlane 1968). It is therefore particularly robust for marine survey data. Furthermore, it gives more weight to abundant species than to rare ones (Field *et al.* 1982).The Bray-Curtis measure takes the form:

$$\delta_{ij} = \frac{\sum_{i=1}^{s} | Y_{ij} - Y_{ik} |}{\sum_{i=1}^{s} (Y_{ij} + Y_{ik})}$$ (Clarke and Warwick 1994).

where Yij is the score for the ith species in the jth sample, Yik is the score for the ith species in the kth sample, and δ_{jk} is the dissimilarity between the jth and kth samples summed over all species (s). δ_{jk} has a range of zero to one, where zero represents identical scores for all species, and one represents samples with no common species.

The measure of similarity (S_{jk}) is complemented by δ_{jk} in the form:

$$S_{jk} = 1 - \delta_{jk}$$ (Field *et al.* 1982).

5.4 Classification (Cluster Analysis)

This technique simplifies data by clustering samples into distinct "natural groups" based on the similarity of species composition between samples. Hierarchical cluster analysis produces a dendrogram which successively fuses the samples into groups, and those groups into larger clusters, starting with the highest mutual similarities. The similarity level at which groups are formed is gradually lowered. Classification has four disadvantages (Field *et al.* 1982):

- The hierarchy is irreversible and a sample loses its identity once it has been placed in a group.
- The level of similarity indicated is only an average inter-group value and does not reveal inter-group relationships.
- The sequencing of samples is purely arbitrary and adjacent samples are not necessarily the most similar.
- Discontinuities are over-emphasized and graded series may be forced into discrete classes.

Given these disadvantages, it is necessary to use an additional and complementary method of presentation, such as ordination, to show relationships. If the two methods show congruency, then discontinuities can be accepted as real.

5.5 Ordination

The preferred method of ordination used in the PRIMER package is non-metric multi-dimensional scaling (MDS). MDS produces an ordination of the samples in 2 or 3 dimensions, representing the best possible reconciliation between all inter-sample distances. Distances between points (samples) on a plot represent the relative degree of similarity between those points. Points which are close together are more similar with regard to species composition than those which are far apart. Because ordination compresses multi-dimensional data into a plot of few dimensions, there is some degree of distortion (i.e. "stress") involved.

A stress function is calculated to assess how well the sample relationships are represented in the plot (Field *et al.* 1982). A low stress value indicates that the relationships between samples are well represented in the MDS plot. For a 2-dimensional ordination, a stress value of less than 0.05 gives an excellent representation with little or no chance of misinterpretation of the results (Clarke and Warwick 1994).

One of the main strengths of MDS ordination is its conceptual simplicity in the construction of a sample map where inter-point distances are a direct representation of the level of similarity between samples. In addition, the MDS is generally applicable to a wide variety of situations. Fewer assumptions regarding the nature and quality of the data are made than for any other ordination technique (Clarke and Warwick 1994).

5.6 Indicator Species

SIMPER (Similarity Percentage) is used to assess the contributions from individual taxa to the average Bray-Curtis similarity between two groups of samples, as well as to the average similarity within a group. Taxa having the greatest contribution to similarities between and within groups can be extracted using this technique. In effect, SIMPER determines which taxa are primarily responsible for sample groupings in the cluster and MDS analyses. The program can also be used to establish lists of taxa which may be characteristic of disturbed and undisturbed communities.

In the present study, SIMPER calculates the average dissimilarity, $\overline{\delta}$, between every sample in one temporal category versus every sample in another temporal category. This average is then broken down into the component contributions of each species/taxon. The Bray-Curtis dissimilarity, δjk, between any two samples j and k is defined as:

$$\delta_{jk}(i) = 100|y_{ij} - y_{ik}| \,/\, \sum_{i=1}^{p}(y_{ij} + y_{ik}) \quad \text{(Clarke 1993)},$$

where Y_{ij} is the abundance of the i^{th} species in the j^{th} sample, and p is the number of species (Clarke 1993). $\delta_{jk}(i)$ can be seen as the contribution of the i^{th} species to δ_{jk}. The average dissimilarity, $\overline{\delta}$, between temporal categories 1 and 2 is computed by averaging δjk over all sample pairs (j,k) with j in the first temporal category and k in the second (Clarke 1993).

CHAPTER SIX:

FORMAL STATISTICAL

TESTING

6.1 Background

Descriptive multivariate analyses, such as clustering and ordination, display the relationships among treatments or samples in a graphical way, highlighting the patterns in the community data. It is also necessary to assess if there are genuine significant differences between samples. ANOSIM (analysis of similarities), which is analogous to ANOVA (analysis of variance), is used as a formal statistical test for multivariate analyses. It is a non-parametric statistical test based on the principles of permutation and randomisation. In order to avoid circular argument, groups to be tested should be chosen *a priori* based on knowledge regarding temporal and spatial variability and not on the results obtained in cluster and ordination analyses.

A test-statistic (R), which reflects the average differences in rank similarities between and within temporal categories, is calculated as follows:

$$R = (\overline{rB} - \overline{rw}) / (M/2),$$

where $\overline{rB}$ is the average of all rank similarities between pairs of replicates between temporal categories, and $\overline{rw}$ is the average of all rank similarities between replicates within temporal categories. M = n(n-1)/2 where n is the total number of samples (Clarke 1993). The R statistic ranges from 0 to 1; a value approaching 0 validates the null hypothesis, while a value that approaches 1 rejects the null hypothesis. The null hypothesis (Ho) states that there are no significant differences between two or more temporal categories. Effectively, ANOSIM tests whether differences among group are

greater than differences within groups. If differences among groups are greater than difference within groups, the null hypothesis is rejected.

Under the null hypothesis, an arbitrary reshuffling of the labels identifying which samples belong to which temporal categories will have a negligible effect on average to the R statistic (Clarke 1993). This concept forms the basis of the permutation tests. The test statistic is compared with its value under a large number of random permutations such that all possible distributions of the sample labels are examined (Clarke and Warwick 1994). The R statistic is recalculated each time. The significance level is computed by referring the observed value of R to its permutation distribution (Clarke 1993). If >5% of the relabellings occur outside of the expected labels for the original data, then the null hypothesis is rejected at the $p<0.05$ significance level. In effect, the R statistic detects the presence of significant differences among groups when the percentage probability (P) is less than, say, five percent. Pairwise permutation tests are performed between every pair of groups to judge where these differences lie (Clarke and Green 1988).

6.2 One-way Layout

The one-way ANOSIM layout is the simplest statistical design which is used to test for differences between mined and unmined temporal categories. As mentioned above, cruise data were combined to produce a time series after mining, and the combined data were used in all numerical techniques. Using the one-way layout, the null hypothesis, Ho, stating that there are no differences between unmined and mined

categories was tested for the northern and southern research areas separately (refer to Table 2.1 in Chapter 2). The abundance data were root-root transformed and the Bray-Curtis coefficient of similarity was used to calculate the degree of similarity between the samples. The R statistic was computed and its value was compared under 5000 permutations using the ANOSIM program in PRIMER.

6.2.1 Northern Research Area

A Global R value of 0.401 was calculated, thus rejecting the null hypothesis at a significance level of P<0.001%. This indicates that there is a very significant difference in community structure between temporal categories in the northern research area.

Due to the inherent variability in benthic communities, it is necessary to determine the level of intrinsic site-to-site variability between replicates which were collected from 6 spatially different sites. The null hypothesis, Ho, states that there is no difference in community structure among temporal categories (which consist of replicates from a number of different sites). The test statistic calculates the observed differences between temporal categories and compares these with differences among replicates within temporal categories (Clarke 1993). The global R statistic indicates that there is a significant difference in community structure between temporal categories. Pairwise tests are performed between every pair of temporal categories in order to assess where these differences lie (Clarke and Green 1988). Results of these pairwise tests are presented in Table 6.1. A significant difference was detected between the unmined category and all other temporal categories. No significant differences were

detected between any of the mined temporal categories. This may suggest that the community has not yet recovered 15-19 months after mining.

Table 6.1: Northern Research Area: Results of one-way ANOSIM pairwise tests for variability between temporal categories, showing the R-statistic. Significant differences ($p<0.05$) are indicated by *. (m.a refers to "months ago"). Probabilities are not corrected for multiple testing.

SITE COMPARISON	R-VALUE	SIGNIFICANCE LEVEL (%)
Unmined vs Mined (1-3 m.a)	0.481	0.0*
Unmined vs Mined (7-9 m.a)	0.371	0.1*
Unmined vs Mined (15-19 m.a)	0.506	0.1*
Mined (1-3 m.a) vs Mined (7-9 m.a)	0.053	22.4
Mined (1-3 m.a) vs Mined (15-19 m.a)	0.012	38
Mined (7-9 m.a) vs Mined (15-19 m.a)	0.043	27.6

6.2.2 Southern Research Area

A global R statistic of 0.553 was calculated for the southern research area, rejecting the null hypothesis, Ho, of "no differences between temporal categories" at a significance level of $P<0.001\%$ (i.e. there is a very significant difference in community structure between temporal categories). It was again necessary to determine the level of intrinsic site-to-site variability between replicates collected from spatially different sites. Results of pairwise tests performed between every pair of temporal categories to assess where the differences lie are presented in Table 6.2. Significant differences

were detected between all temporal categories except the following:

* Mined 1-3 months ago and Mined 7-9 months ago

* Mined 7-9 months ago and Mined 15-19 months ago.

Table 6.2: Southern Research Area: Results of one-way ANOSIM pairwise tests for variability between temporal categories, showing the R-statistic. Significant differences ($p<0.05$) are indicated by *. (m.a refers to "months ago"). Probabilities are not corrected for multiple testing.

SITE COMPARISON	R-VALUE	SIGNIFICANCE LEVEL (%)
Unmined vs Mined (1-3 m.a)	0.233	2.6*
Unmined vs Mined (7-9 m.a)	0.567	0.0*
Unmined vs Mined (15-19 m.a)	0.671	0.0*
Unmined vs Mined (22-24 m.a)	0.776	0.0*
Unmined vs Mined (43-51 m.a)	0.757	0.0*
Mined (1-3 m.a) vs Mined (7-9 m.a)	0.205	7.6
Mined (1-3 m.a) vs Mined (15-19 m.a)	0.406	0.1*
Mined (1-3 m.a) vs Mined (22-24 m.a)	0.939	0.2*
Mined (1-3 m.a) vs Mined (43-51 m.a)	0.912	0.2*
Mined (7-9 m.a) vs Mined (15-19 m.a)	0.115	8.5
Mined (7-9 m.a) vs Mined (22-24 m.a)	0.822	0.2*
Mined (7-9 m.a) vs Mined (43-51 m.a)	0.83	0.2*
Mined (15-19 m.a) vs Mined (22-24 m.a)	0.304	2.0*
Mined (15-19 m.a) vs Mined (43-51 m.a)	0.634	0.1*
Mined (22-24 m.a) vs Mined (43-51 m.a)	0.38	0.9*

6.3 Discussion

One-way ANOSIM results indicate that there is site-to-site variability in both the northern and southern research areas, and the pairwise tests show which sites are responsible for this variability. The communities in the northern research area do not appear to have recovered 15-19 months subsequent to mining. This is suggested by the fact that the unmined category is significantly different from all mined categories, but there are no significant differences amongst any of the mined categories (Table 6.1).

In the southern research area, the unmined category is again significantly different from all mined categories, but there are also a number of differences amongst the mined categories (Table 6.2). The area mined 1-3 months ago is significantly different from all other mined areas except that mined 7-9 months ago, which in turn is different from all other mined areas except that mined 15-19 months ago. The pattern suggests that the community in the southern research area shows signs of gradual recovery after mining. Nevertheless, the mined (43-51 months ago) sites remain significantly different from the mined ones.

CHAPTER SEVEN:

MULTIVARIATE RESULTS

7.1 Cluster and Ordination

These techniques group samples together based purely on the biotic data, regardless of any other analyses , and without making any assumptions about the nature of the data. Methods are described in Chapter 5.

7.1.1 Northern Research Area

A level of 38% similarity in the cluster analysis (Figure 7.1) distinguishes a group of outliers from the remainder of the samples. At the 40% similarity level there appears to be a split into three groups (A, B and C). Group A consists almost entirely of unmined replicates, while groups B and C consist of a combination of mined replicates from a variety of temporal categories. At the 45% similarity level, there is a further split in group A, forming groups A', A" and A"'. Groups A' and A" consist entirely of unmined replicates, while group A"' consists of unmined replicates as well as replicates from areas mined 7-9 and 15-19 months ago.

In the MDS ordination plot (Figure 7.2), a solid line indicates an approximate split between unmined and mined replicates. Replicates below the line are primarily from unmined areas, while those above the line are from mined areas. This suggests that there is a slight difference in species composition between these two categories, indicating that mining has an impact on the community. Some further distinctions may be detected by examining the dominant species identified in replicates from each temporal category. This is investigated in section 7.3.1.

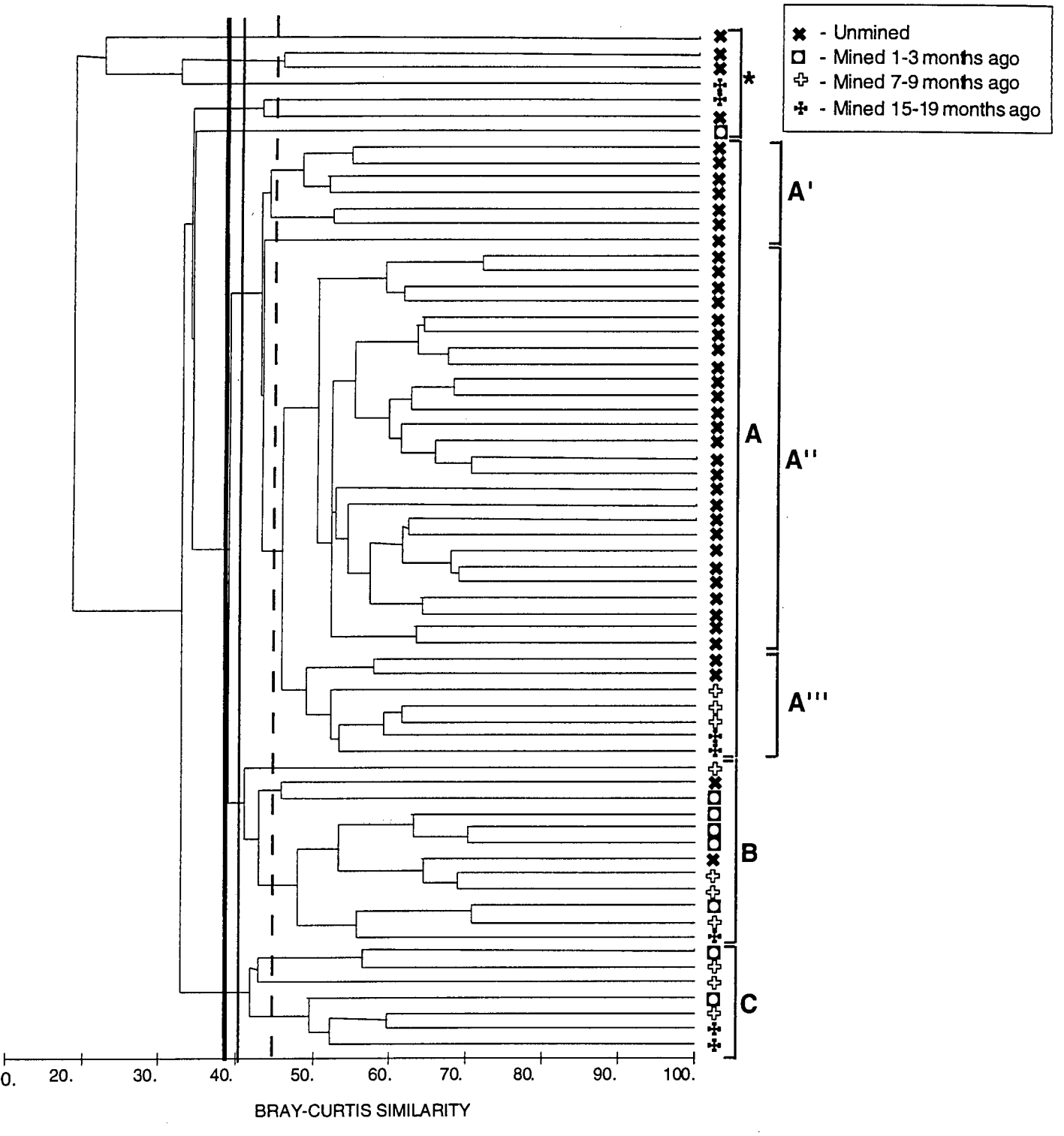

Figure 7.1: Northern research area: Dendrogram of abundance data. A bold solid line through 38% similarity level distinguishes a group of outliers (*) from the remainder of the samples. A solid line through 40% similarity level distinguishes between three groups (A, B and C). A dotted line through 45% similarity level distinguishes between five groups (A', A'', A''', B and C).

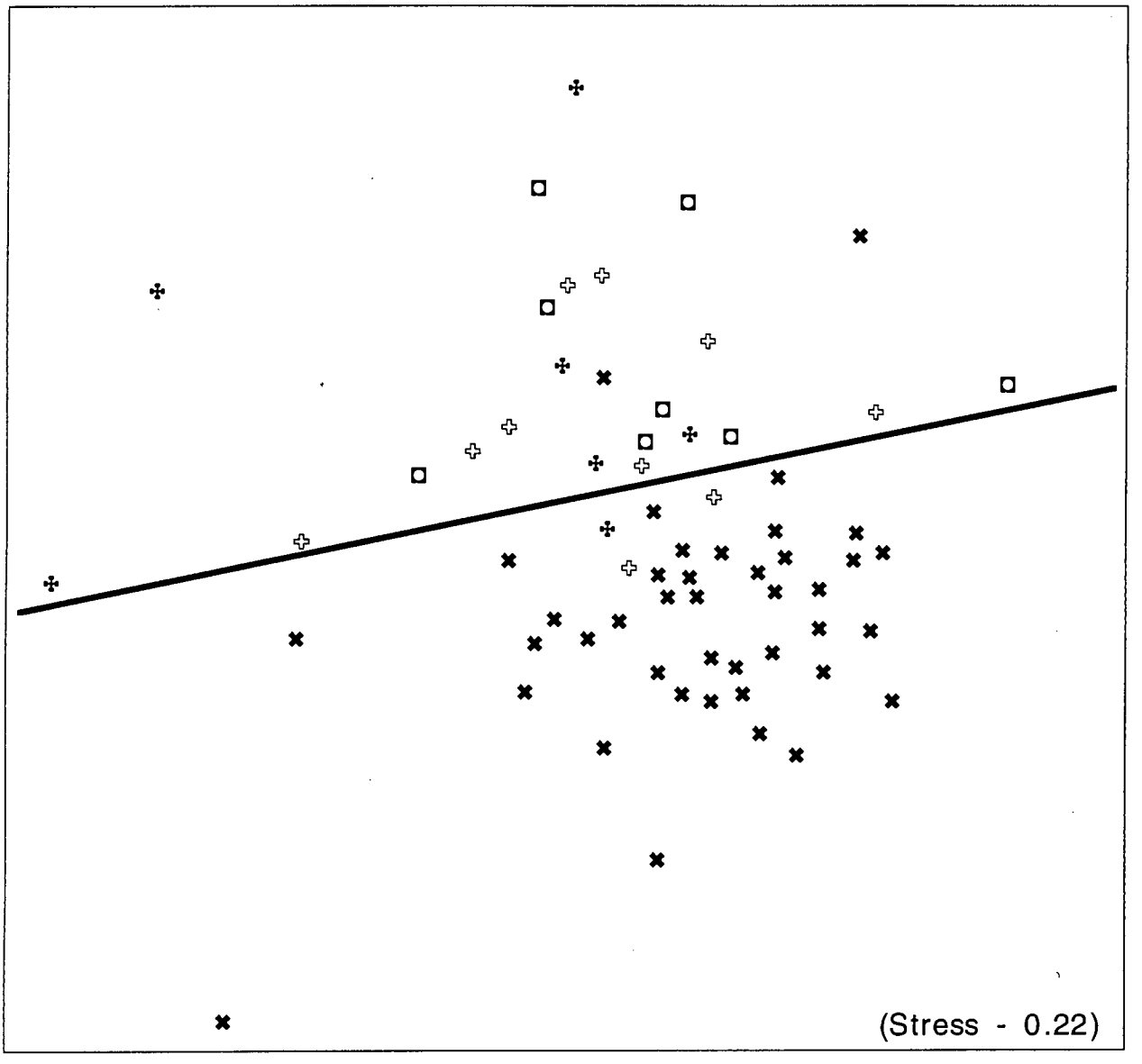

Figure 7.2: Northern research area: MDS ordination of abundance data (stress=0.22). The solid line indicates the approximate split between unmined and mined replicates.

7.1.2 Southern Research Area

In the cluster analysis (Figure 7.3) at the 20% similarity level, it is possible to distinguish between the group of unmined replicates (group A) and mainly mined replicates (groups B and C), with the exception of unmined replicates taken during the second "*Pentow Salvor*" cruise (group S). At the 30% similarity level, three groups (A-C) can be distinguished. The first group (A) consists entirely of unmined replicates, the second group (B) of replicates from areas mined 1-3 months ago, 7-9 months ago and 15-19 months ago (and the anomalous unmined replicates labelled S). The third group (C) consists almost entirely of replicates taken from areas mined 22-24 and 43-51 months ago.

The unmined replicates from the second "*Pentow Salvor*" cruise may be grouping with the mined replicates in group B due to the position of the sampling site. This site was situated south of the mining area and may therefore be in the path of the sediment stirred up by mining activity and carried southwards by the prevailing southerly current (Field *et al.* 1996).

The unmined replicates (A) which cluster together at the 35% similarity level form a (heterogenous) group which are similar in terms of their taxonomic composition, and this cluster appears to be distinct from the mined samples in this regard.

Although the MDS ordination (Figure 7.4) shows a similar pattern to that of the cluster analysis, the unmined replicates from the "Pentow Salvor" cruise (group S) are not as

far removed from the remaining unmined replicates (group A) as they appear in the cluster analysis. They nevertheless appear to form a distinct group. In concordance with the cluster analysis, replicates from areas mined 7-9 and 15-19 months group together (group B), as do replicates from areas mined 22-24 and 43-51 months ago

Both cluster analysis and MDS ordination results appear to suggest that mining has an immediate impact on species composition, lasting up to approximately 19 months subsequent to mining activity. Replicates from areas mined more than 22 months ago are different to replicates from areas mined between 7 to 19 months ago with regard to species composition. Furthermore, replicates from areas mined 43-51 months ago are relatively similar in species composition to replicates from unmined areas (Figure 7.4), suggesting that this area has recovered to a state of species composition that approximates that of the unmined state. This is supported by the approximate anticlockwise cycle of A to S to B to lower C to upper C, as depicted in the MDS ordination in figure 7.4. The species composition of temporal categories is discussed in greater depth in section 7.3.2.

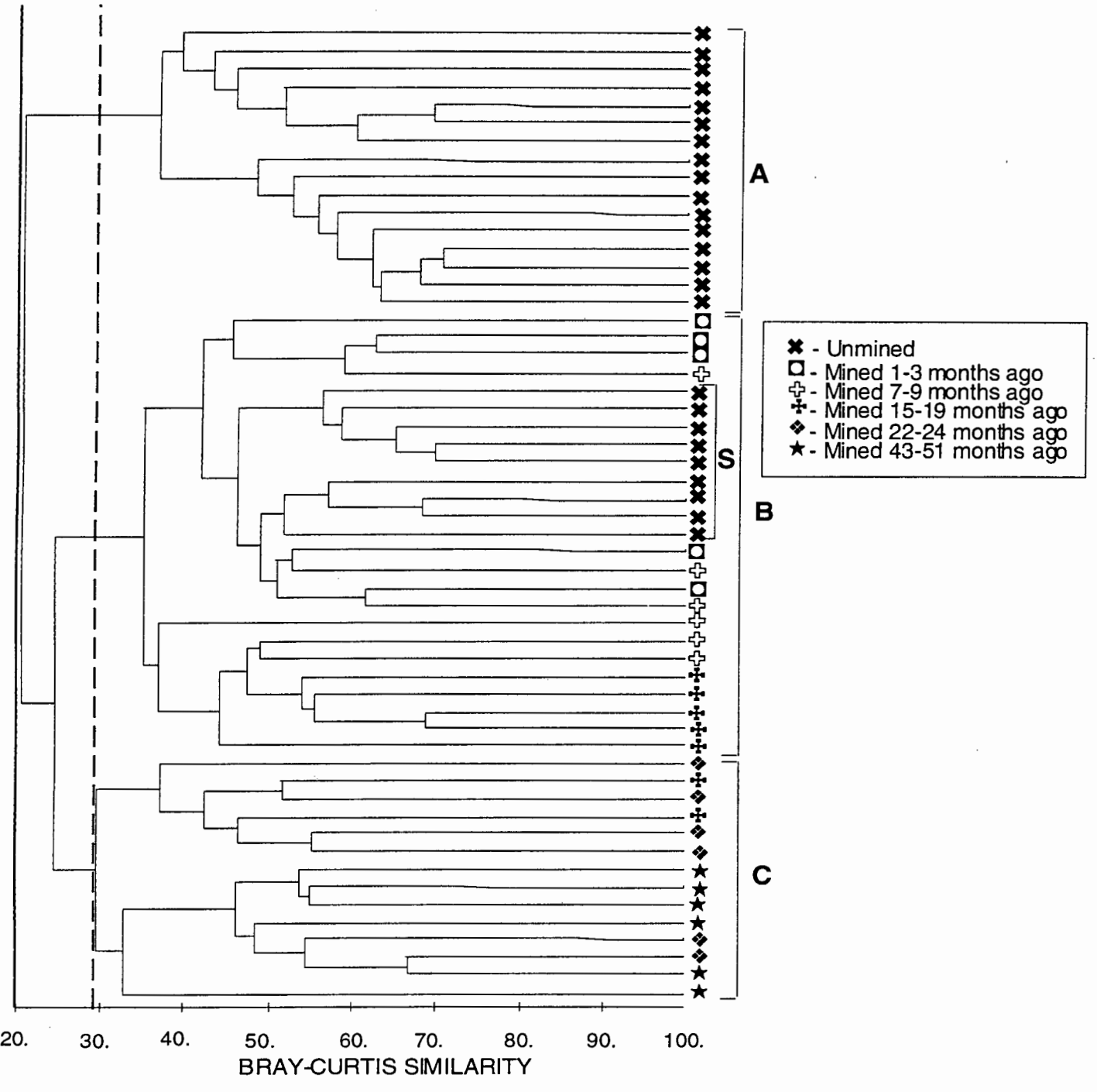

Figure 7.3: Southern research area: Dendrogram of abundance data. A solid line through 20% distinguishes between unmined replicates (group A) and mined replicates (groups B and C), with an anomalous group S. Three groups of replicates at the 30% similarity level (represented by a dotted line) are identified as groups A to C.

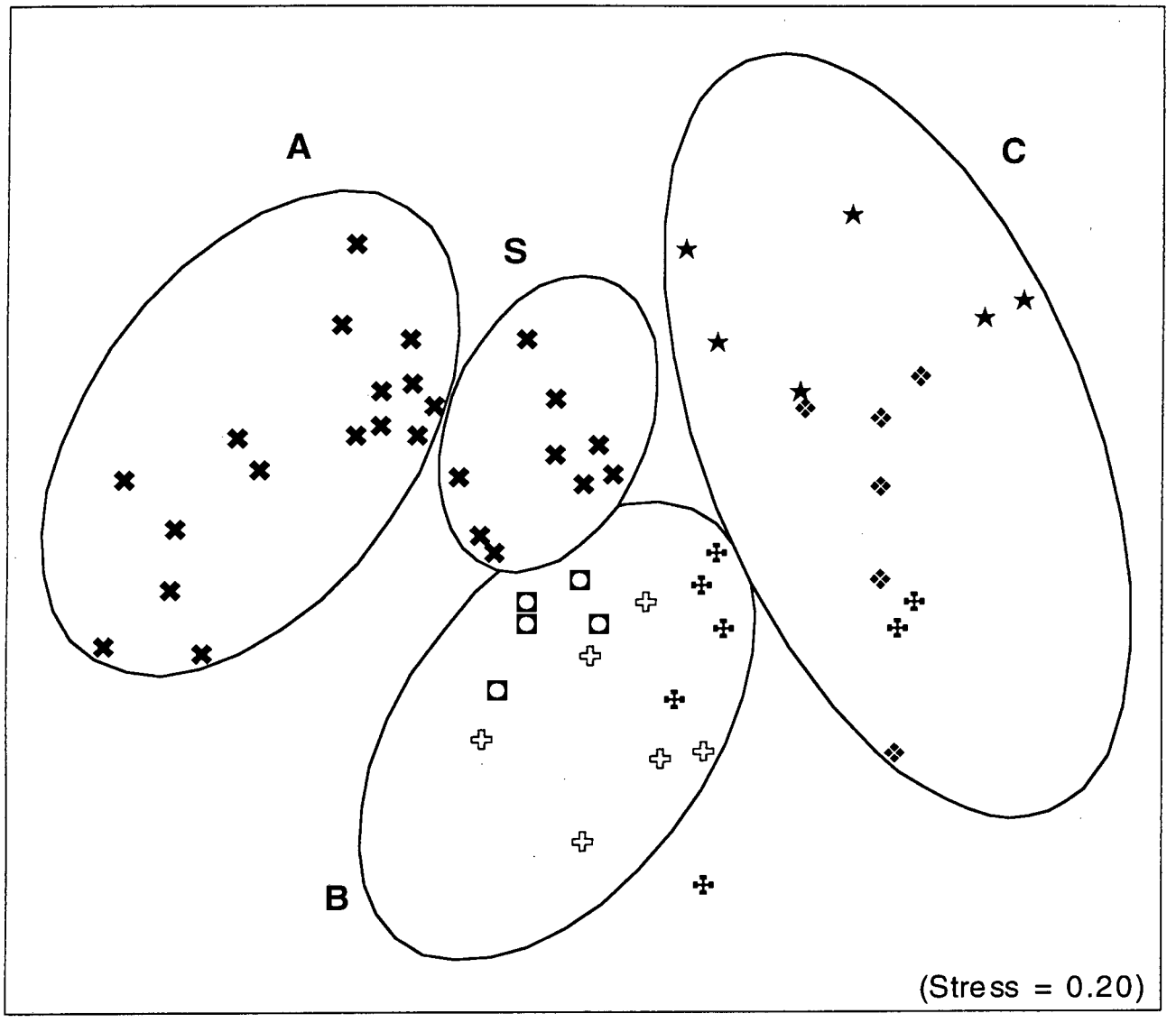

Figure 7.4: Southern research area: MDS ordination of abundance data (stress=0.20). The groups of samples identified in the cluster analysis are encircled and represented by groups A-C and S.

7.2 Indicator Species

SIMPER (Similarity Percentages) were conducted separately on untransformed abundance data from the northern and southern research areas. In order to limit the taxon list to a manageable size, an arbitrarily selected cut-off percentage of 50% (cumulative percentage) was implemented. Beyond this cut-off value, taxa were contributing negligible amounts to the sample groupings.

7.2.1 Northern Research Area

Average percentage similarities for the northern research area presented in Table 7.1 indicate that none of the temporal categories have a similar species composition. This is substantiated by the graphical results presented in Figure 7.5. The unmined replicates in the northern research area are characterised by the presence of a large number of polychaetes. *Prionospio pinnata* is particularly abundant in the unmined area, but has reduced numbers in all mined areas. Bivalves (i.e. *Macoma spp.*) and gastropods (i.e. *Nassarius spp.*), on the other hand, are prevalent in large numbers in replicates taken from areas mined 7-9 and 15-19 months ago. Replicates from areas mined 1-3 months ago have relatively few of all five taxa taken into account. This pattern indicates that there is a change in species composition directly after mining. Furthermore, results suggest that the community has not fully recovered 15-19 months subsequent to mining activity as the average abundance of *P. pinnata* is still reduced at this stage. This is further supported by the results of ANOSIM which are discussed in section 6.2.1.

Table 7.1: Northern research area: Average percentage similarity ($\overline{S}$) between temporal categories.

	MINED 1-3M.A	MINED 7-9M.A	MINED 15-19M.A
UNMINED	34.77%	37.45%	31.07%
MINED 1-3M.A		39.35%	34.81%
MINED 7-9M.A			37.38%

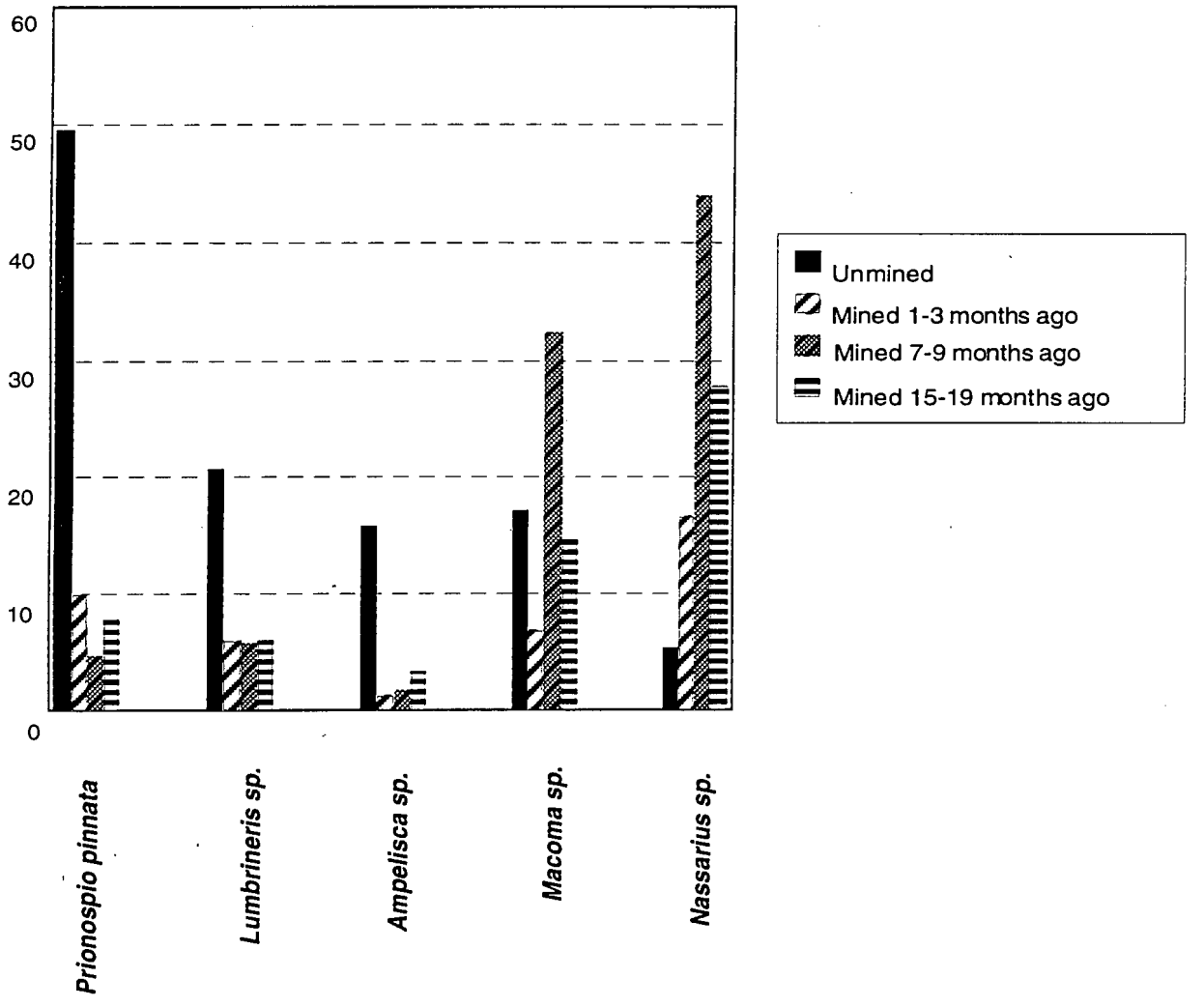

Figure 7.5: Northern research area: Average abundance (numbers per 0.2m²) of the top 5 taxa contributing to percentage differences between temporal categories.

7.2.2 Southern Research Area

Average percentage similarity results for the southern research area (Table 7.2) suggest that there is a relatively slow, steady rate of recovery of the community after mining. Unmined replicates are not similar to those taken from areas mined 1-3 months ago ($\overline{S}$ =20.97%), which indicates that the impact of mining on community structure is immediate and drastic. The level of similarity between the unmined category and the remaining temporal categories increases with time after mining, with an average percentage similarity of 47.52% between the unmined category and that mined 43-51 months ago. Furthermore, the average percentage similarity between areas mined 1-3 months ago and those mined 43-51 months ago is 19.39%. The community in the southern research area appears to have recovered considerably 43-51 months subsequent to mining activity.

This is also displayed in Figure 7.6 where replicates from unmined areas and areas mined 43-51 months ago have a similar dominant species (i.e. large numbers of *Prionospio pinnata* and *Lumbrineris spp.*). Species composition for replicates taken from areas mined 1-3 months ago is very different to those taken from unmined areas and areas mined 43-51 months ago.

By generating plots of changes in the average abundances of top taxa with time after mining, it is possible to extract patterns of species composition that may exist in the time series. This is done for both the northern and southern research areas and is presented in figure 7.7.

Table 7.2: Southern research area: Average percentage similarity ($\overline{S}$) between temporal categories.

	MNED 1-3M.A	MNED 7-9M.A	MNED 15-19M.A	MINED 22-24M.A	MINED 43-51M.A
UNMINED	20.97%	34.64%	42.24%	34.79%	47.52%
MINED 1-3M.A		41.8%	34.57%	32.36%	19.39%
MINED 7-9M.A			53.03%	47.94%	32.35%
MINED 15-19M.A				52.95%	40.87%
MINED 22-24M.A					37.31%

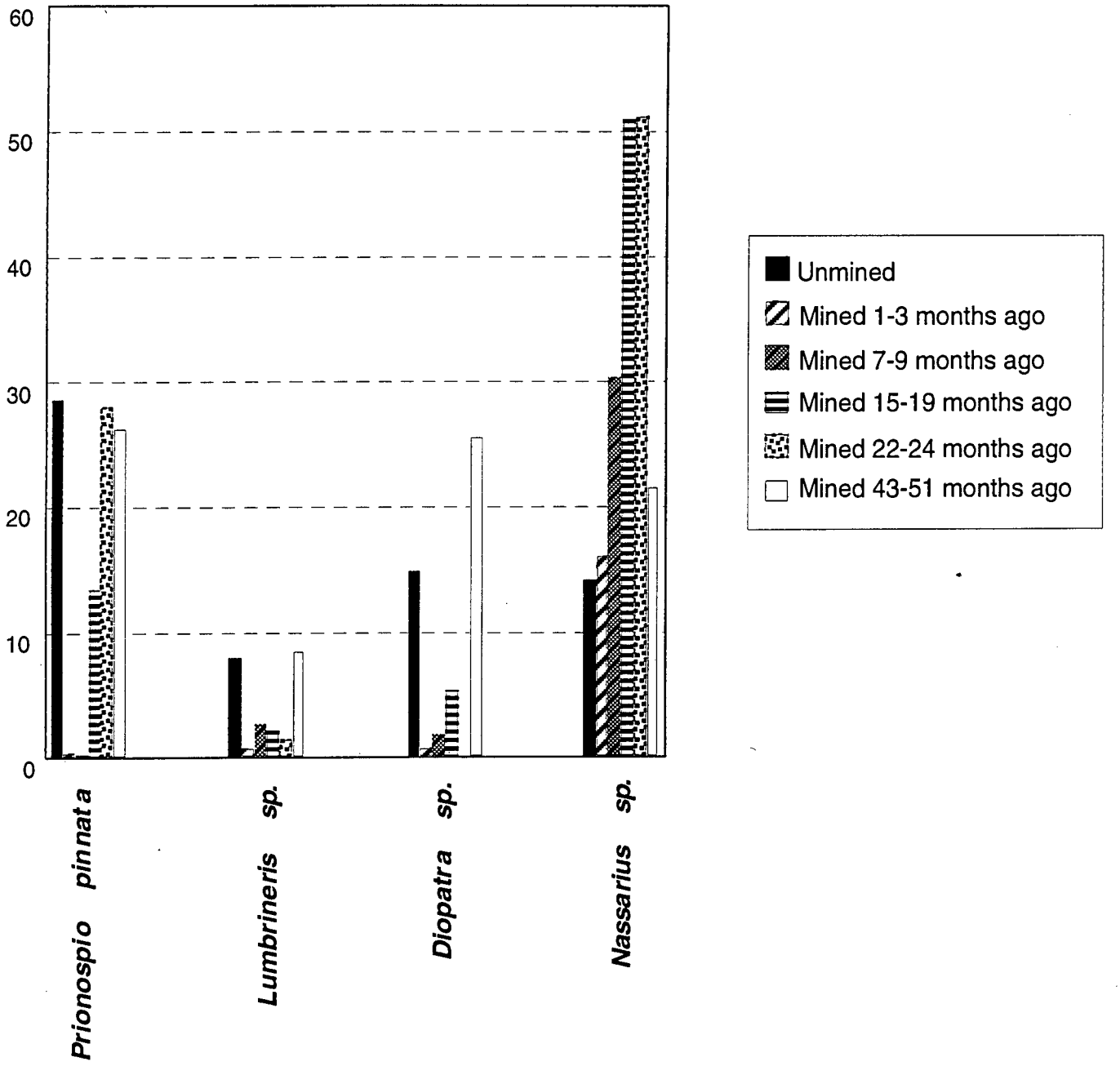

Figure 7.6: Southern research area: Average abundance (numbers per 0.2m^2) of the top 4 taxa contributing to percentage differences between temporal categories.

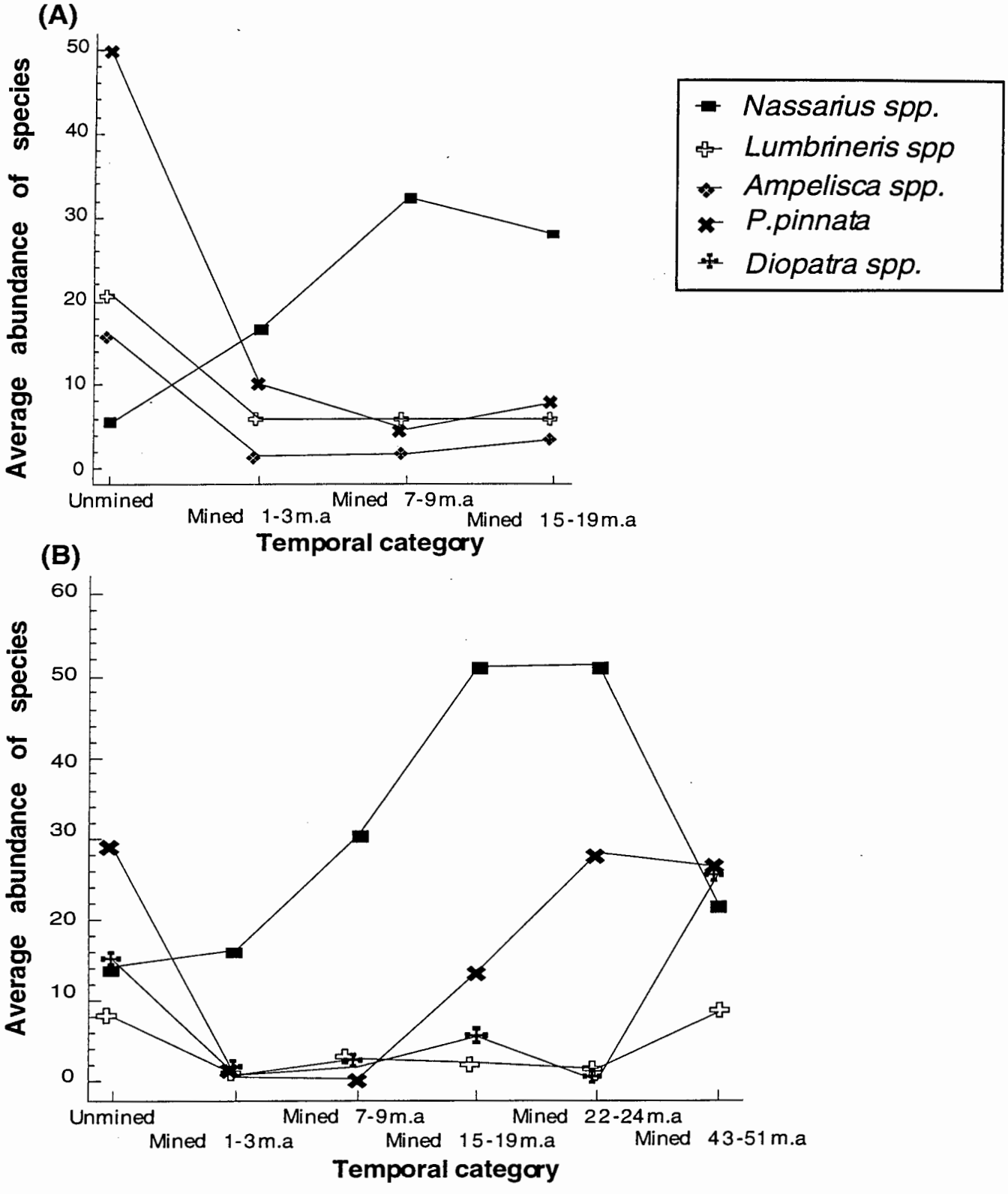

Figure 7.7: Changes in the average abundances (numbers per 0.2m^2) of top taxa with time after mining for the (A) northern and (B) southern research areas.

It is interesting to note that there are three taxa common to the northern and southern research areas which are responsible for average percentage similarities between temporal categories (i.e. *Prionospio pinnata*, *Lumbrineris spp.* and *Nassarius spp.*). *P. pinnata* and individuals of the *Lumbrineris* genus are abundant in the unmined category for both the northern and southern research areas, and show a marked decrease in abundance in areas mined 1-3 and 7-9 months ago. *Nassarius spp.*, on the other hand, are abundant in areas mined 1-3, 7-9 and 15-19 months ago for both research areas (as well as in areas mined 22-24 months ago in the southern research area), and have relatively low numbers in unmined areas. It is possible that *P. pinnata* and *Lumbrineris spp.* are characteristic of unmined or undisturbed areas, while *Nassarius spp.* are characteristic of relatively recently mined or disturbed areas. In this regard, it is important to take the life histories of these organisms into account. Both the polychaetes and the gastropod *Nassarius* show mass spawning events, suggesting that there is a stochastic factor involved in the larval resettlement of these organisms. In the adult phase, however, *Nassarius spp.* are capable of travelling relatively long distances along the substrate. This allows for the resettlement of adult individuals in recently disturbed areas. This may explain the large numbers of *Nassarius spp.* in sites mined 1-3 months ago. Polychaetes require a much longer period in order for resettlement to occur.

It is important to consider that large numbers of *P. pinnata* and individuals of the genus *Lumbrineris* in unmined areas, and large numbers of *Nassarius* in recently mined areas may merely be as a result of random spontaneous resettlement events.

However, SIMPER conducted only on unmined samples from each cruise, (i.e. samples taken at different times) suggests that the average abundance of these possible "indicator species" are similar for all three cruises (i.e. large numbers of *P. pinnata* and *Lumbrineris*, and low numbers of *Nassarius* in unmined areas). If there had been a random spontaneous settlement, average abundance for a particular species would not have been consistent for different sampling events conducted at different times of the year. This lends support to the idea that the species in question could be considered as indicator species.

In the northern research area (Figure 7.7), *Ampelisca spp.* appear to show a similar pattern to that of the polychaetes, with large numbers in unmined areas and decreased abundance in mined areas. In the southern research area (Figure 7.8), polychaetes of the genus *Diopatra* show the same pattern after mining as the polychaetes *P. pinnata* and *Lumbrineris spp.,* with a decrease in average abundance in recently mined areas. These patterns suggest that polychaetes are most sensitive to the effects of mining. Gastropods of the genus *Nassarius*, which are classified as scavengers, appear to be opportunistic as defined by Grizzle (1984) in that they rapidly inhabit recently mined areas. Mining activity may result in the release of a large amount of potential food for these species, as the mining process causes extensive damage to macrobenthos such as bivalves and polychaetes, often leaving behind fragments of these organisms. The patterns in average abundance again suggest the possibility that these species may function as indicator species, providing a means of assessing the level of disturbance in an area subsequent to mining based on species composition.

CHAPTER EIGHT:

GEOLOGICAL ANALYSIS

8.1 Introduction

The majority of the potential food for detritus-feeding invertebrates is found in the upper 2cm of seabed in subtidal sediments (Hall 1994). Mining operations frequently result in the disturbance of sediment composition and sedimentary processes, thus having a possible detrimental effect on marine organisms. Mining has effects at two locations, the site of removal and the site where the material is dumped.

The overboard dumping of 'tailings' affects water quality, and redistributes sediments, creating an artificial sedimentary process (Charlier and Charlier 1992). Marine tin-mining in Southeast Asia provides an example of the detrimental effect of mining operations on marine organisms. Such operations, which smother sessile organisms, could pose serious environmental and ecological problems. Organisms which are most susceptible to sediment overburden are mucous tube feeders and labial palp deposit feeders, followed by suspension feeders, boring species and deep burrowing siphonate suspension feeders. The most resistant species are deep burrowing siphonate suspension feeders (Hall 1994).

Sand and gravel mining operations affect bivalves present in silts, molluscs in fine sands, annelids in medium-grain-sized sands, and bivalves and echinoderms in gravel mixed with sand. Mining operations may also release nutrients and pollutants in the sediment resulting in the disruption of benthic fauna (Charlier and Charlier 1992). Furthermore, a sediment plume may alter the depth of light penetration.

In an experiment conducted by Thiel and Schreiver (cited in Hall 1994), the immediate effects of disturbance of deep sea mining were to kill epifauna taxa in the path of the disturbance, and to cover individuals in close proximity in a thick layer of sediment. The experimental site was revisited six months later and it was noted that epifauna persisted in the areas subject to sedimentation.

Disturbances due to mining activity may only have a temporary effect on sediment and species composition, and recolonization of disturbed areas may be rapid. It has been suggested that the removal or addition of sand and/or gravel will have no long-term effects in the marine benthos (Charlier and Charlier 1992). However, it has also been reported that macrofauna, which are relatively unselective in their food requirements and are dependent on spatial partitioning of the habitat to maintain diversity, may be heavily impacted by sediment instability (Warwick *et al.* 1990).

Changes in community structure following disturbance by mining have been characterised with the use of univariate, distributional and multivariate techniques in the preceding chapters. It is now important to attempt to explain the patterns of species composition with respect to environmental factors. The current chapter attempts to estimate the relative importance of the few sedimentary variables it was possible to measure, in influencing community structure.

8.2 Environmental variables

Analyses of texture and particle-size were conducted at the Marine Geoscience Unit at the University of Cape Town by Drs. David Li and John Rogers, as part of the environmental impact assessment for de Beers Marine.

8.2.1 Textural analysis

Surficial sediment was examined and the percentage composition of gravel, sand and mud measured. Interstitial salt was removed from the sediment by means of osmosis, and dialysis was conducted on the samples which were placed in cellophane tubing and suspended in a bucket of running water. The sediment was then wet-sieved through a 63-micron sieve to separate the silt+clay fractions, which have a particle-size of less than 63 microns, from the sand+gravel fractions, which have a particle-size of more than 63 microns. The sand+gravel fractions were dried overnight at 105°C and weighed. The gravel component, which was further separated from the sand by dry-sieving through a 2mm sieve, was weighed. The sand fraction was then derived by subtraction.

The silt+clay fraction was placed in a 1-litre perspex cylinder and stirred vigorously. A 25ml aliquot was removed, dried overnight and weighed. The aliquot weight was multiplied by a pipetting factor of 40 in order to determine the weight of silt+clay. This weight was added to that of the sand and gravel to calculate the total weight and percentages of the individual fractions. A triangular Gravel-Sand-Mud diagram (Folk 1954) was used to classify each sample texturally.

8.2.2 Particle-size analysis

Each sand fraction was split to a weight of 2-3g, weighed and settled in a settling tube. The weight which accumulated on a pan suspended from an electronic balance was recorded at 1.5 second intervals; the results produced an arithmetic cumulative curve, a probability plot and a frequency curve. Cumulative percentages at $^1/_{10}$ phi intervals were used to calculate the percentages of individual phi-fractions. Phi values were calculated using the equation:

$$\text{phi} = -\log_2 (\text{particle diameter(mm)}) \quad \text{(Rogers 1995).}$$

A computer-linked Sedigraph 5000D was used to conduct the particle-size analysis of the silt+clay fraction. This device sends a beam of x-rays through a glass-sided cell through which the silt+clay fraction is pumped. Relatively more x-rays are detected as the silt and clay particles settle out. Organic matter was removed using hydrogen peroxide in a water bath, as a relatively high organic content could cause samples to flocculate within the cell thus producing erroneous results.

8.3 Results

The analyses described above were used to characterise the sediment samples into %gravel, %sand and %mud, and provide calculated data of average particle size for each sample. These results are presented in Appendix B. Particle size was recorded in phi units with large particles having small phi values and vice versa. Samples are

classified as gravel, sand or mud on the Wentworth scale (Table 8.1) according to particle size (phi).

Table 8.1: Phi-scale used for defining Wentworth grades.

PARTICLE SIZE	WENTWORTH GRADE
< -1 phi (> 2mm)	gravel
-1 to 0 phi (2 to 1mm)	very coarse sand
0 to 1 phi (1000 to 500 microns)	coarse sand
1 to 2 phi (500 to 250 microns)	medium sand
2 to 3 phi (250 to 125 microns)	fine sand
3 to 4 phi (125 to 63 microns)	very fine sand
> 4 phi (< 63 microns)	silt + clay (mud)

Mean particle-size for each sample was plotted against each temporal category, with a view towards providing insight into the changes in particle-size as a result of the disturbance caused by mining. In the northern research area (Figure 8.1A), replicates from unmined areas showed a predominance of high phi values (i.e. small particle-size). Mined areas had a higher occurrence of low phi values (i.e. large particle-size). The southern research area (Figure 8.1B) shows a similar trend with high phi values in unmined areas, and a decrease in these values in recently mined areas. However, 22-24 months subsequent to mining there appears to be a slight increase in phi values, suggesting that the area has regained some sediment of smaller particle-size.

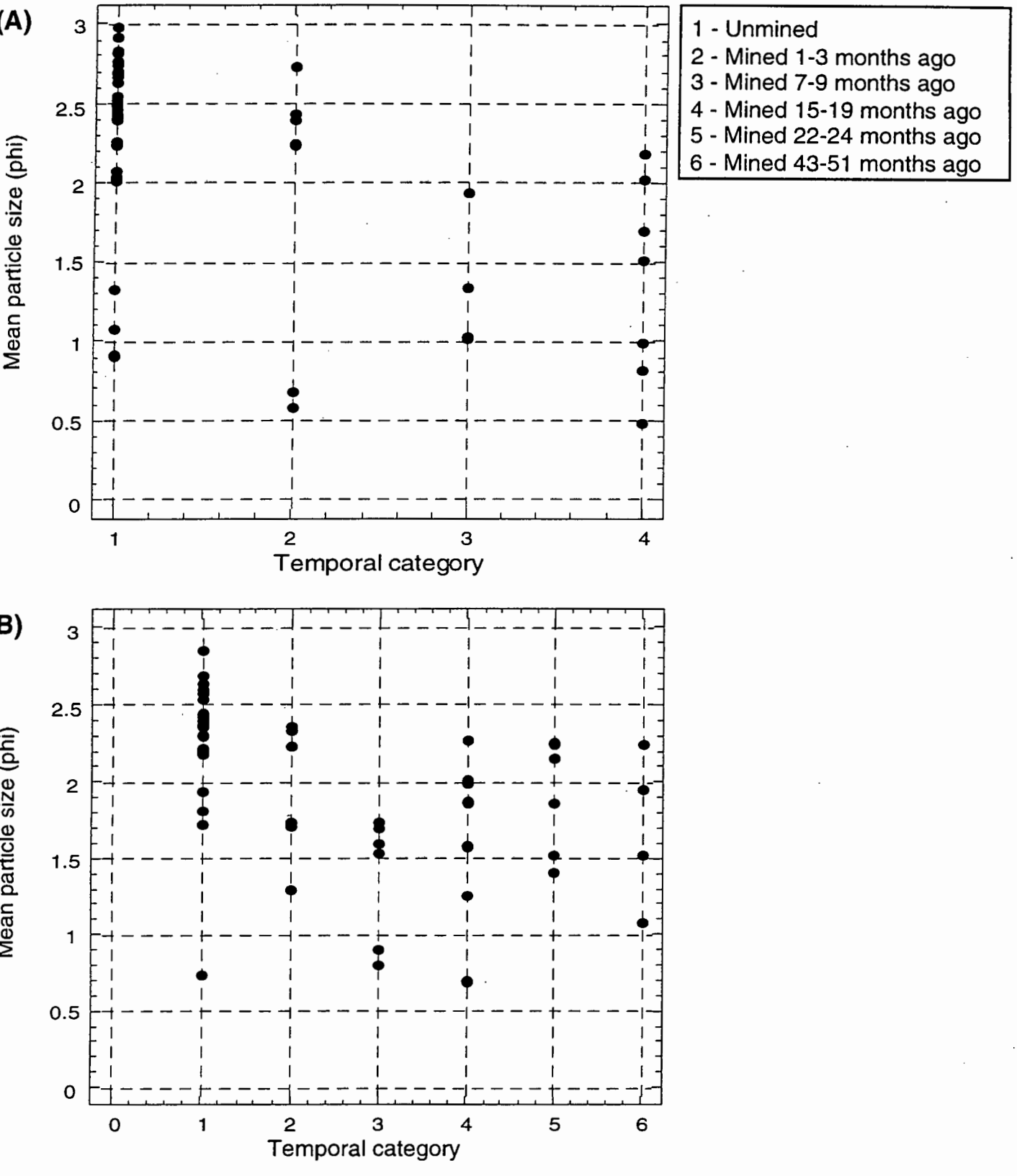

Figure 8.1: Changes in mean particle size (phi) with time after mining for the (A) northern and (B) southern research areas.

The results obtained are as expected. During the mining operation, processed sediment is released overboard in the form of tailings. The fine sand component remains suspended in the water column and gradually disperses over a wide area by the prevailing currents, while the larger, heavier particles (i.e. gravel) sink to the sea-floor more rapidly. This results in a net increase in the relative percentage of gravel component in a recently mined area (Rogers 1995). Over time, finer sediment components may be carried into the area as a result of currents and sedimentation processes. This may explain the patterns in mean particle size over time noted in the northern and southern research areas.

Additional plots in the form of frequency distributions were generated for each temporal category in the two research areas. These frequency distributions further examine the relationship between particle size and time after mining by taking into account the average percentage of each sediment sample in a particular particle size category. For each research area (i.e. northern and southern), the frequency distributions of each temporal category are compared in order to detect any shifts in pattern with time after mining.

In the northern research area (Figure 8.2A), the peak of the distribution shifts from left slightly to the centre. This indicates that in the unmined area, the sediment is composed primarily of small-sized particles, while sediment in the recently mined area is constituted primarily of medium-sized particles. Both show a bimodal distribution. This lends support to the concept that small sediment particles do not sink to the sea-

floor when they are released overboard, but may be returned to the area some time later as a result of the prevailing currents.

This pattern is not as clear in the southern research area (Figure 8.2B) which shows a high percentage composition of very fine particles (>4phi) in all temporal categories. This may be as a result of the geological data collected during the third "*De Beers*" cruise. Most of the replicate samples taken during this cruise were located in an area aligned with the Orange River delta. The area in question had an exceptionally high clay component (i.e. very fine sediment particles) as a result of its location. All temporal categories in the southern area (with the exception of that of 43-51 months ago) contain replicate samples taken during this cruise. This has resulted in the generation of frequency distributions showing high average percentages of small particles (phi>4) for all temporal categories. Taking this into account, however, it is still possible to detect a pattern of changes in particle size with time after mining. Although there is no distinct shift in the peak of the distribution from the unmined category to that of 1-3 months ago, there is a detectable shift to the left 7-9 months after mining, indicating a slight increase in the prevalence of larger particles. The peak then shifts back to the right (i.e. more fine particles) 15-19 months after mining. It remains in this position for the last two distributions (i.e. 22-24 and 43-51 months after mining).

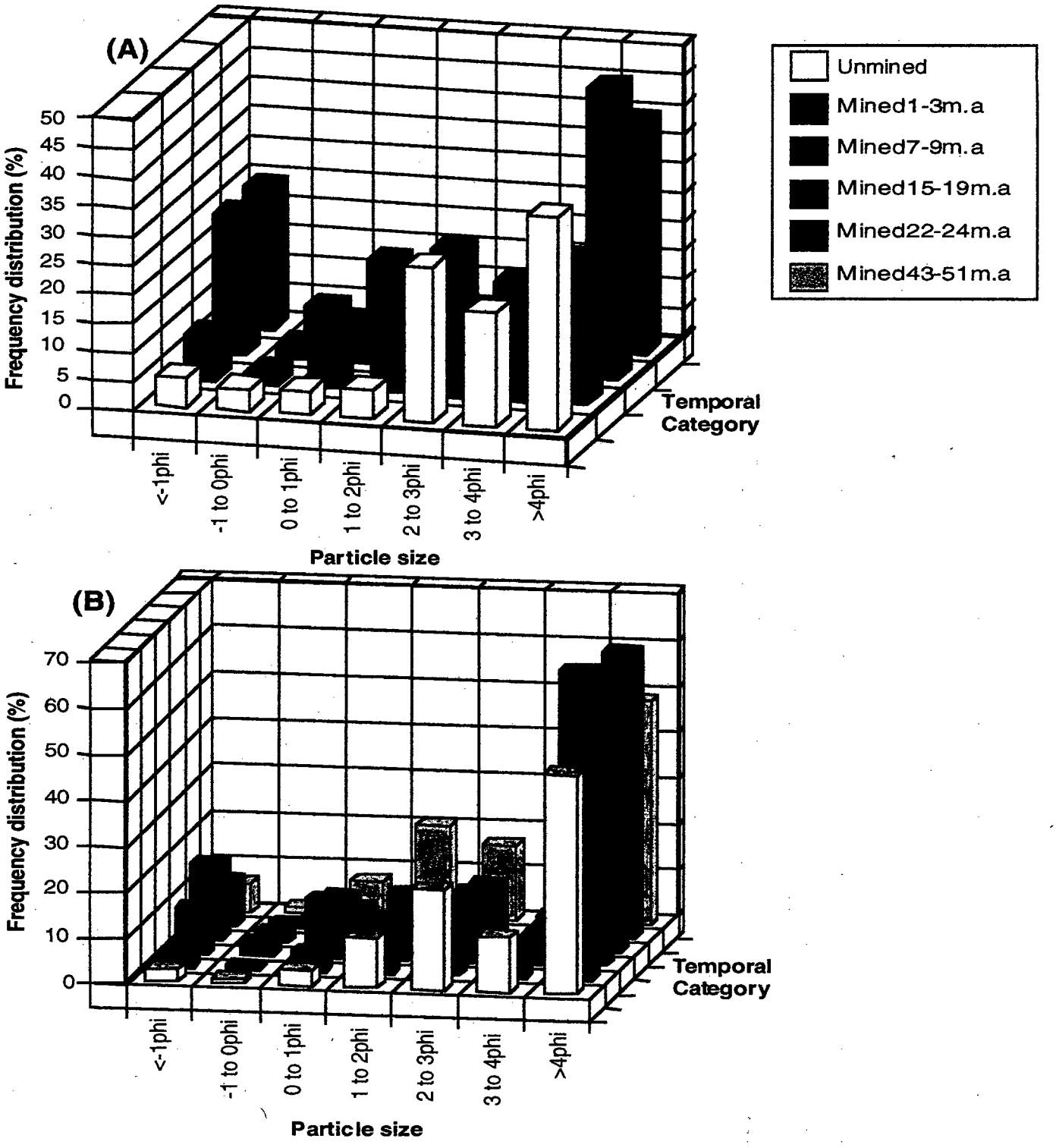

Figure 8.2: Frequency distributions of the average percentage of each sediment sample in a particular particle size category for the (A) northern and (B) southern research areas.

Results for the southern research area appears to suggest that the sediment composition has returned to a state where it is composed primarily of fine-grained particles 15-19 months after mining. This does not necessarily infer that the species composition in areas mined 15-19 months previously will approximate that of unmined areas. It may take significantly longer for the relevant species to re-inhabit an area that was formally considered disturbed as a result of mining activity.

8.4 Relating environmental variables to multivariate analysis

There are two approaches to this type of investigation. The first was proposed by Field *et al.* (1982) and involves the analysis of each variable separately. Biological data are analysed first and the environmental data are then tested for concordance. Environmental parameters (%gravel, %sand and %mud) are superimposed on the biological MDS plots to illustrate the extent of correlation of the variables with the group differences. According to Clarke and Ainsworth (1993), the basis of this concept is that samples which are similar with respect to environmental factors will also exhibit a similar species composition. The two analyses are conducted separately in order to avoid compounding assumptions.

The second approach which was put forward by Clarke and Ainsworth (1993) forms the theoretical basis of the BIO-ENV program in PRIMER. The biological and environmental similarity matrices are again calculated separately, but the matrix of environmental data is computed repeatedly using all possible combinations of the environmental variables. For each combination of variables, a rank correlation is

computed and the degree of improvement or deterioration in each match is recorded. The rank correlation is used to assess which set of variables best explains the biological pattern (Clarke and Ainsworth 1993).

Although the latter method is sound in that it considers all variables and combinations of variables simultaneously, its major drawback is that it is more suited to macrobenthic studies where there is a gradient of pollution and the measurement of several related contaminant chemicals. Consequently, use is made of the former approach with environmental data superimposed on biological data one variable at a time. The result is a MDS plot where samples are categorised according to the primary constituent of the sediment. Geological results were not available for all faunal samples, and several samples were thus excluded from the biological MDS and geographical overlays.

The biological MDS plot for the northern research area (Figure 8.3A) shows the split between unmined and mined replicates previously discussed in Chapter 7. Figure 8.3B illustrates which sediments were prevalent in each sample. There does not appear to be any clear distinction in sediment types between these groups, although more unmined samples have a prevalence of sand. Taking into account the fact that mined areas generally have a higher percentage composition of gravel than unmined areas, a plot is generated indicating which samples contain an arbitrary value of more than 10% gravel (Figure 8.3C). Interpretation of this plot indicates that there is an increase in percentage gravel in mined areas. Only a few samples in the unmined area, one of which is an outlier, have more than 10% gravel.

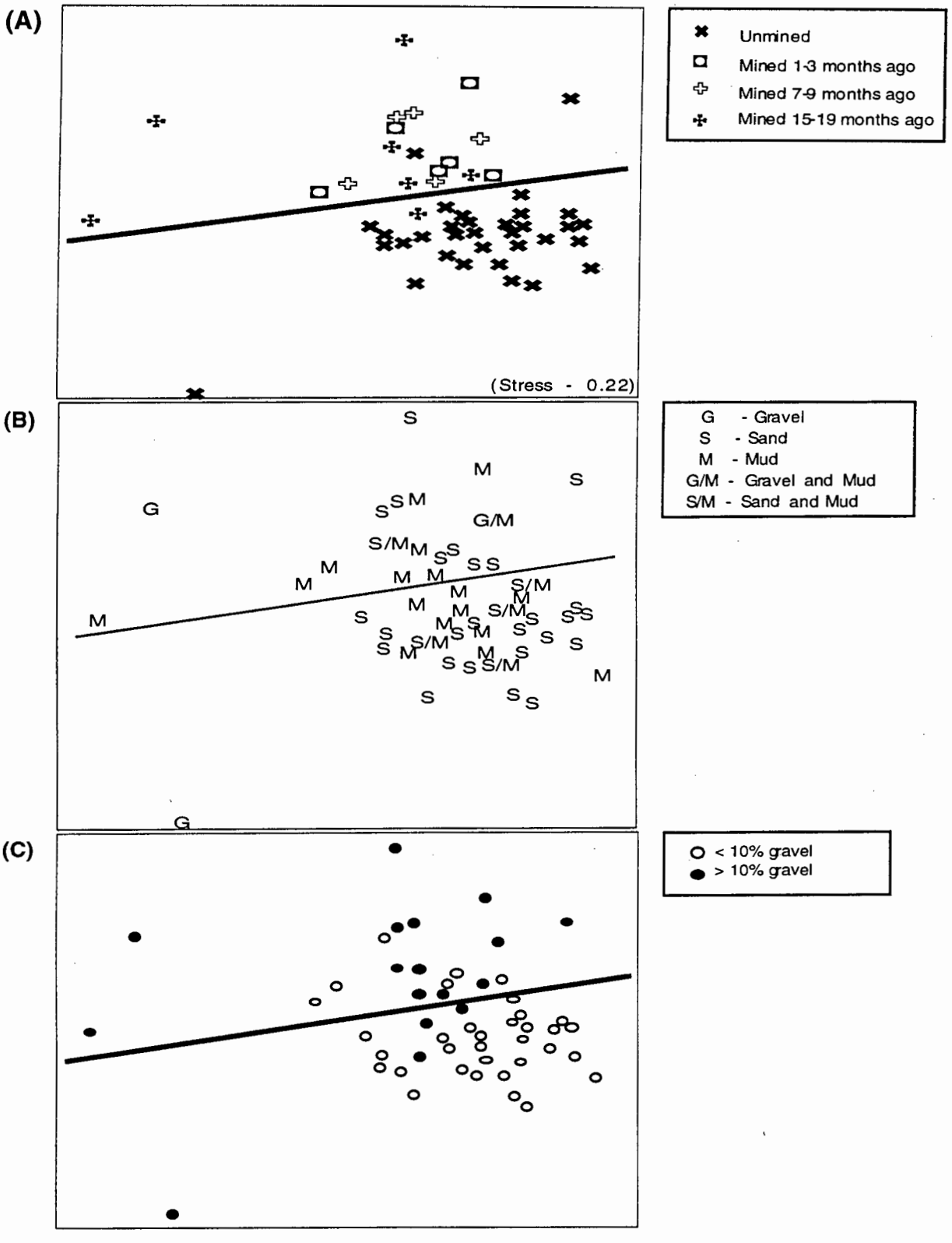

Figure 8.3: Northern research area: (A) MDS ordination for the biological data (stress=0.22). (B) The dominant partice size-class superimposed on the biological MDS. (C) Percentage gravel superimposed on the biological MDS.

The biological MDS ordination for the southern research area is presented in Figure 8.4A, showing the original four groups of samples (A, S, B and C) discussed in Chapter 7. Group A represents the majority of the unmined samples, S consists of the anomalous unmined samples taken during the second "*Pentow Salvor*" cruise, B is a group of samples taken from areas mined 7-9 and 15-19 months ago, and C is comprised of samples from areas mined 22-24 and 43-51 months ago. The geological data were superimposed on this ordination, producing the plot shown in Figure 8.4B. A number of samples in all groups have a large percentage of silt+clay (phi>4). This anomaly is attributed to the replicates taken during the third "*De Beers*" cruise, and is explained in section 8.3 above. Disregarding this, however, there is a greater prevalence of sand in the unmined areas than in the mined areas. The latter consist primarily of sediment samples which have abundant mud and/or gravel components.

Figure 8.4C reveals which samples have a sedimentary composition with more than 10% gravel. All replicates from unmined areas (Groups A and S) have less than 10% gravel, with the exception of one sample in Group S, while a number of samples in Group B have more than 10% gravel, a situation which is typical of recently mined areas. Although there are four samples in Group C with more than 10% gravel, reference to Figure 8.4A indicates that two of these samples are from areas mined 15-19 months ago, and two are from areas mined 22-24 months ago. None of the samples from areas mined 43-51 months ago have more than 10% gravel.

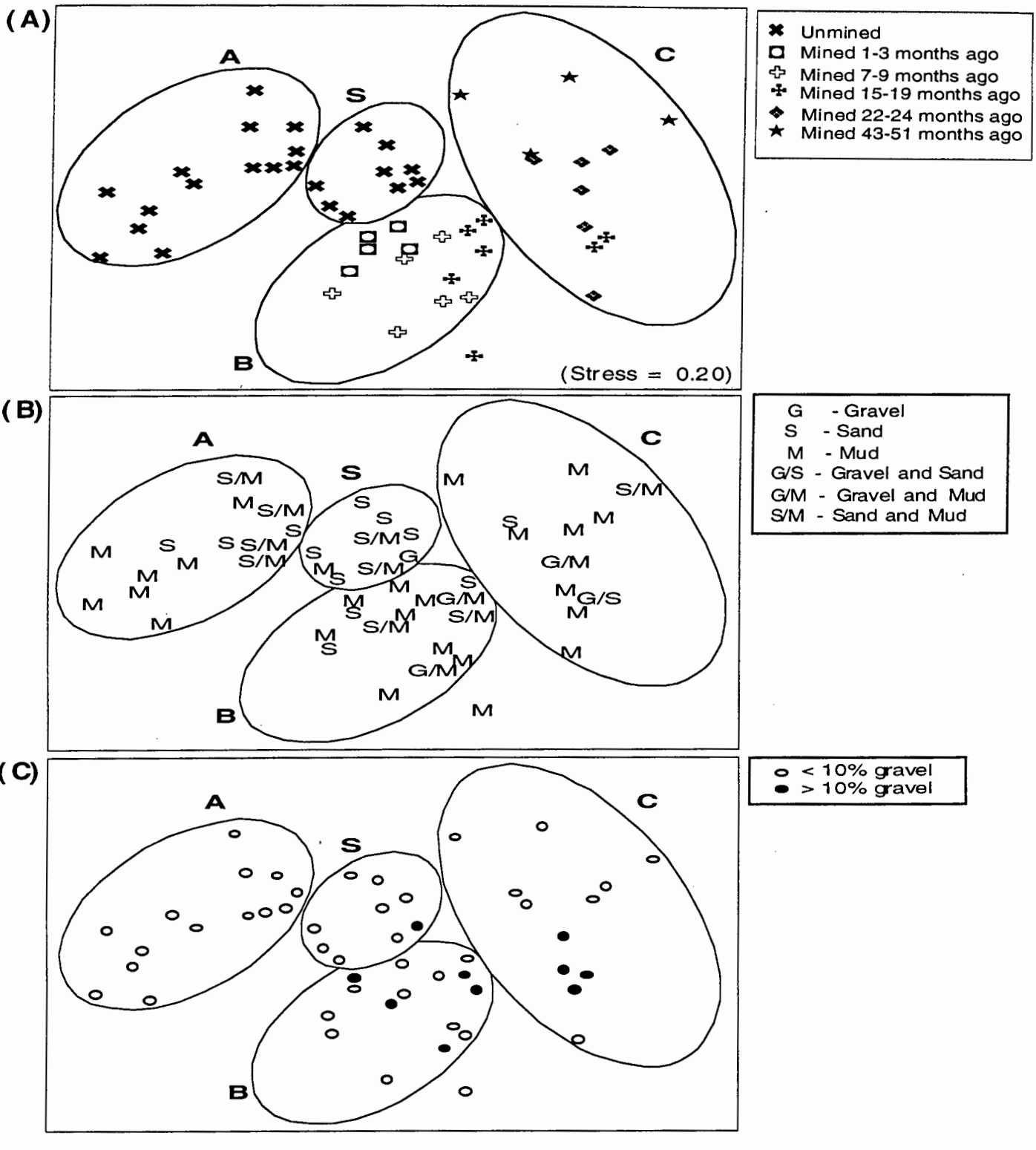

Figure 8.4: Southern research area: (A) MDS ordination for the biological data (stress=0.20). (B) The dominant partice size-class superimposed on the biological MDS. (C) Percentage gravel superimposed on the biological MDS.

Although the selected 10% cut-off value was an arbitrary one, it did provide insight into the changes in sedimentary composition as a result of mining activity. It appears that the environmental parameter of percentage gravel can be used as a tentative indication of the state of an area subsequent to mining. Areas which have not been previously mined would be expected to have very little gravel relative to mud and sand since the gravel is overlain by fine sediment which sampled by the grabs, while those which have been recently mined would have significantly more than their unmined counterparts. As an area begins to recover to its natural state subsequent to mining, the amount of gravel in the surface sediment would decrease, and there would be a substantial influx of fine sand particles as a result of the sediment processes.

The relative abundances of gravel, sand and mud are important in the distribution of a number of organisms as porosity and interstitial space are directly controlled by the proportions of different sized particles (Gray 1981). It has been noted that there is a predominance of deposit feeders in clay-silt sediments, and filter feeders in sandy sediments (Mann 1982). It is therefore postulated that mining activity would result in a shift in community composition towards more filter-feeding organisms, as the physical disturbance caused by mining includes removing the silt-mud component and returning the sediment as a mixture of gravel and, later, mud.

Although sediment particle size may be important in determining community structure, it does not demonstrate a cause-and-effect relationship between environmental parameters and species composition. However, it is assumed that particle size is a

contributing factor in the establishment of niches, and would thus indirectly influence community patterns.

It is also important to assess whether the relationship between biotic and abiotic data is a result of anthropogenic disturbance, or a consequence of differences in natural environmental variables. It is difficult to separate these two sources of variability as a result of the impact of mining on the stratigraphy of the sediment. However, results of the ANOSIM statistical tests (Chapter 6) indicate that there are significant differences between unmined and mined areas for both the northern and southern areas. It is thus certain that the natural stratigraphy and particle size distribution of an area are disturbed during mining, and that the resultant changes, in turn, are likely to have an impact on the species composition of the benthic community in that area.

CHAPTER NINE:

CONCLUSION

Results presented in the preceding chapters suggest that the northern research area is affected by mining activity in terms of species composition, but not in terms of species diversity. The various techniques used to detect changes in community structure all give the impression that the northern research area had not recovered fully, if at all, 15-19 months subsequent to mining. The species-independent distributional analysis did not detect any significant differences between the levels of disturbance in the four temporal categories. Furthermore, replicates from unmined areas were considered to be "moderately disturbed", and this may suggest that the impact of mining is confounded by additional stress-inducing factors in the northern research area.

The species-dependent multivariate analysis proved to be valuable in detecting and assessing the changes exhibited in mined areas. Temporal categories in the northern research area were found to show some disparity in community structure as differences were detected between unmined replicates and all other temporal categories, although there were no significant differences between any of the categories of mined replicates. Furthermore, cluster analysis and ordination plots showed a distinction only between unmined and mined replicates, supporting the statistical results obtained by ANOSIM (refer to Figure 6.1).

The overall picture generated gives reason to suggest that the northern area is affected by mining activity in terms of species composition. This impact appears to be immediate, resulting in rapid changes in the species comprising the community. There

is no indication that the community recovers to any steady state, let alone its original state, within the given time period of 15-19 months subsequent to mining.

The southern research area, on the other hand, presents a slightly different scenario. Mining activity in this area clearly has an immediate and severe impact on community structure. Areas which have been recently mined (i.e. 1-3 months ago) are distinctly different from unmined areas in terms of species diversity, as well as species composition. The implication of this is that recently mined areas not only have a lower species diversity, but also that a number of the organisms which were originally found in those areas can no longer tolerate the conditions imposed on the community by the disturbance of mining. However, given time, conditions become more favourable, making the area suitable for recolonisation by the original species.

The road to recovery in the southern research area is a slow, but steady one in terms of species composition. This is particularly apparent in the results of the "SIMPER" analysis, where the level of similarity between temporal categories increases steadily with time (refer to Table 7.2). The majority of the biological analyses conducted suggest that samples from sites mined 43-51 months ago are very similar to those from unmined sites. This is an indication that the area had not only recovered substantially after 43-51 months, but also that its community approximates that of the unmined area with regard to species composition.

An important finding in this study relates to the topic of indicator species. In both the northern and southern research areas, there appears to be a trend in the abundance of certain species with changes in the community as a result of mining activity. Polychaetes (in particular *Prionospio pinnata* and individuals of the genus *Lumbrineris*) were abundant in unmined sites, as well as in sites mined 43-51 months ago in the southern research area. Conversely, individuals of the genus *Nassarius* were scarce in unmined sites, but appeared to be favoured by the conditions resulting from mining activity as their numbers showed a marked increase in mined sites. Their numbers decreased again in sites mined 43-51 months subsequent to mining in the southern research area (refer to Figure 7.7). These taxa appear to be reliable indicators of the level of recovery attained in previously mined areas.

This study also highlights the effect of mining activity on the geology of an area, and the manner in which this relates to the changes in species composition. Unmined sites are characterised primarily by the prevalence of fine sediment particles at the surface (i.e. having a high phi value). Mined sites, on the other hand, consist mostly of coarse sediment particles with a low phi value. Percentage gravel, in particular, was found to be a reliable indicator of the condition of a site. Using an arbitrary cut-off value, a number of replicates from mined sites were found to have more than 10% gravel, while those from unmined sites generally had less than 10% with only a few exceptions (refer to Figures 8.3C and 8.4C).

It is interesting to note that the sediment composition of replicates taken from areas mined 15-19 months ago approximates that of replicates from unmined areas, suggesting that the sediment composition has returned to a condition consisting primarily of fine-grained particles by this time. However, it clearly takes slightly longer for the original species to re-inhabit the area in question.

Sediment particle-size appears to play an important role in influencing patterns in a benthic community. However, this does not necessarily imply a cause-and-effect relationship between environmental parameters and species composition. Rather, it is more feasible to infer an indirect effect whereby particle size contributes to the establishment of a range of niches, which in turn influence community patterns. The results of this study suggest that mining activity is responsible for the disturbance of the natural stratigraphy and particle size distribution of an area. This altered stratigraphy, in turn, influences the structure of benthic communities in that area.

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APPENDIX A:

ABUNDANCE/BIOMASS

DATA

MACROFAUNA ABUNDANCE DATA FOR ALL SAMPLES FROM THE NORTHERN RESEARCH AREA.

Species	R1.1	R1.2	R1.3	R1.4	R1.5	R1.6	R1.7	R1.8	R1.9
PHYLUM PORIFERA									
Porifera A					1				
PHYLUM CNIDARIA									
Scyphozoa A									
Anthozoa A									
Anthozoa B									
Anthozoa D									
PHYLUM NEMERTEA									
Cerebratulus spp.		2	8				5	1	
Lineus spp.		2							
Nemertea B									
Nemertea C					1		1		
Nemertea D									
Siphunculid A									
Siphunculid B									
PHYLUM ANNELIDA									
Lumbrineris spp.	15	2	35	6	27	36	48	34	33
Arabella spp.	1	1		2			1		
Diopatra spp.			2	2	1			1	
Glyceridae							1		
Nereidae									
Nereis spp.	2					1			
Perinereis/Pseudonereis spp.									
Nephtys spp.	2	1	1		1			9	
Spionidae									
Prionospio pinnata	68	35	39	29	47	47	116	19	39
Spio spp.									
Spiophanes spp.			4						
Laonice cirrata			2		2	3	8		8
Spionid O								3	
Spionid P									
Polydora spp.				1					
Orbiniidae		4	11		15			4	
Haploscoloplos spp.						19	2		11
Scoloplos spp.									
Phylo spp.		1	4	2			1		
Naineris spp.									
Orbiniidae B									
Orbinia angrapaquensis						1			
Poly BB									
Poly WW									
Paraonidae			2						
Cirrophorus branchiatus				3					
Ophelia spp.	5								
Capitellidae									
Notomastus spp.	1								
Maldanidae		5	48				6	62	
Maldaninae A					14				
Maldaninae B				2					
Euclymene luderitziana				5			19		19

Species	R1.1	R1.2	R1.3	R1.4	R1.5	R1.6	R1.7	R1.8	R1.9
Petaloproctus spp.				1					
Rhodine gracilior									
Sabellides spp.	2								
Ampharetidae		4							
Amphicteis gunneri			5			6	1		1
Ampharete spp.A									
Terebellidae			1						
Trichobranchus glacialis									
Terebellides spp.	3				2				
Amaeana trilobata/Polycirrus									
Flabelligera spp.									
Pectinariidae								19	
Poly UU									
PHYLUM ARTHROPODA									
Copepoda A									
Myodocopa									
Isopod A									
Arcturidae									
Arcturidae A			1						
Arcturid B						1			
Arcturid C									
Arcturid D							1		
Cirolana spp.									
Microarcturus quadriconus									
New amphipod									
Ampelisca spp.	3	7	7	1	7	1	5	15	3
Aoro kergeuleni									
Aorcho delgadus		2				1			
Corophiid A (Gammaropsis)				1			1		
Corophiid Q									
Atylus swammerdamei									
Guernea rhomba									
Paramoera capensis									
Maera spp.									
Urothoe spp.	1	1					1		1
Leucothoe spp.			1						
Acidostoma obesum					2				
Hippomedon longimanus	23	17	21	22	24	23	28	3	8
Euonyx biscayensis									
Socarnopsis crenulata									
Monoculodopsis longimana									
Oediceroides cinderella									
Perioculodes spp.								1	
Westwoodilla manta									1
Paraphoxus oculatus							1		1
Platyischnopus herdmani									
Podocerus brasiliensis									
Podoceropsis sophiae									
Eupariambus fallax		1	2				1		
Phtisca marina					1				
Hyperiidae					2				1
Hyperiid B									
Ingolfiellid A			1						
Ingolfiellid B									
Ingolfiellid C						1			
Cumacea A					1				
Cumacea C									

Species	R1.1	R1.2	R1.3	R1.4	R1.5	R1.6	R1.7	R1.8	R1.9
Leptostraca A									
Pterygosquilla armata									
Stomatopoda B									
Stomatopod juvenile									
Misidacea spp.									
Gastrosaccus psammodytes					1				
Euphausiacea	5	1	2		2	3	1	6	2
Penaeid A									
Penaeid B									
Penaeid C									
Carida B									
Carida C (Mysidaea)		1							
Carida F			1						
Anomura									
Calocaris barnardi			1						
Callianassa spp.	2		6		2	1		5	
Anomura A									
Goneplax angulata	1	2	1	4	5		1	3	2
Mursia cristimanus		1							
Brachyura A									
Brachyura B									
Brachyura C					1				
PHYLUM BRACHIOPODA									
Terebratulina meridionalis									
PHYLUM MOLLUSCA									
Ischnochiton bergoti				2					
Macoma spp.	2	8	18	4	29		11	8	1
Tellina spp.	1								
Dosinia spp.	2	3	2		8	5	4	3	4
Nucula nucleus				1					
Bivalve F									
Bivalve M									
Alvania fenestrata									
Bullia digitalis									
Charitodoron euphrosyne									
Epitonium kraussi			1						
Gibbula spp.									
Heliacus variegata									
Marginella spp.		7	2		1	2		1	
Melanella spp.									
Nassarius spp.		6	3		5	1	1	1	
Natica tecta									
Ocenebra spp.									
Protomella capensis									
Pyramidella spp.									
Solariella agulhasensis									
Tricolia capensis			1		2		3		
Triphora africana									
Turris spp.									
Turritella spp.									
Volutocorbis abyssicola									
Volvarina capensis									
Sepia spp.									
Cucumaria spp.									
Amphipholis squamata									
PHYLUM ECHINODERMATA									
Ophionereis porrecta					1				
Henricia spp.									

Species	R1.10	R1.11	R2.1	R2.2	R2.3	R2.4	R2.5	R2.6	R2.7
PHYLUM PORIFERA									
Porifera A									
PHYLUM CNIDARIA									
Scyphozoa A									
Anthozoa A					1				
Anthozoa B									
Anthozoa D									
PHYLUM NEMERTEA									
Cerebratulus spp.			1	2			1		
Lineus spp.	5						1		
Nemertea B									
Nemertea C				3					
Nemertea D									
Siphunculid A									
Siphunculid B									
PHYLUM ANNELIDA									
Lumbrineris spp.	25	31	57	24	8	33	61	24	28
Arabella spp.									1
Diopatra spp.			1		1			1	1
Glyceridae									
Nereidae			1	1					
Nereis spp.									
Perinereis/Pseudonereis spp.									
Nephtys spp.	2		1	2	1			1	1
Spionidae									
Prionospio pinnata	9	77	123	98	38	112	83	148	125
Spio spp.									
Spiophanes spp.									13
Laonice cirrata		1	14					7	11
Spionid O					1		7		
Spionid P									1
Polydora spp.									
Orbiniidae	13		19	14		17			3
Haploscoloplos spp.		6			11			2	21
Scoloplos spp.						1			1
Phylo spp.	1							1	
Naineris spp.									
Orbiniidae B							14		
Orbinia angrapaquensis									
Poly BB					1				
Poly WW									
Paraonidae									1
Cirrophorus branchiatus									
Ophelia spp.									
Capitellidae									
Notomastus spp.				1					7
Maldanidae	51	8	1	2		2			
Maldaninae A									
Maldaninae B									
Euclymene luderitziana									4
Petaloproctus spp.									
Rhodine gracilior									
Sabellides spp.									
Ampharetidae									
Amphicteis gunneri	11	1							
Ampharete spp.A									
Terebellidae				1		1			
Trichobranchus glacialis									

Species	R1.10	R1.11	R2.1	R2.2	R2.3	R2.4	R2.5	R2.6	R2.7
Terebellides spp.			2		3	2			2
Amaeana trilobata/Polycirrus								2	
Flabelligera spp.							1		
Pectinariidae									
Poly UU									2
PHYLUM ARTHROPODA									
Copepoda A									
Myodocopa									
Isopod A									
Arcturidae									
Arcturidae A		2							2
Arcturid B									
Arcturid C									
Arcturid D									
Cirolana spp.									
Microarcturus quadriconus									
New amphipod									
Ampelisca spp.	6	4	51	12	7	27	43	24	45
Aoro kergeuleni									1
Aorcho delgadus									
Corophiid A (Gammaropsis)				1			2		
Corophiid Q									1
Atylus swammerdamei									
Guernea rhomba									
Paramoera capensis							4		
Maera spp.			1	1					
Urothoe spp.	3	1		1				1	
Leucothoe spp.		1					3	1	
Acidostoma obesum				1					
Hippomedon longimanus	15	19	6	17	2	11		4	16
Euonyx biscayensis									
Socarnopsis crenulata									
Monoculodopsis longimana									
Oediceroides cinderella		1							
Perioculodes spp.									
Westwoodilla manta			1			3			
Paraphoxus oculatus									3
Platyischnopus herdmani									
Podocerus brasiliensis									
Podoceropsis sophiae									
Eupariambus fallax									
Phtisca marina									
Hyperiidae					1		1		
Hyperiid B									
Ingolfiellid A	1		1	1					
Ingolfiellid B					1				
Ingolfiellid C									
Cumacea A		1				1	2		
Cumacea C									
Leptostraca A							1		
Pterygosquilla armata									
Stomatopoda B									
Stomatopod juvenile						1			
Misidacea spp.									
Gastrosaccus psammodytes									
Euphausiacea	2		1			2	1	3	9
Penaeid A									

Species	R1.10	R1.11	R2.1	R2.2	R2.3	R2.4	R2.5	R2.6	R2.7
Penaeid B									
Penaeid C									
Carida B				1					
Carida C (Mysidaea)									
Carida F									
Anomura									
Calocaris barnardi	8								
Callianassa spp.		6	2	3	2	1		4	4
Anomura A				1	3	1	2		1
Goneplax angulata	3		1	2	5	5	6	7	8
Mursia cristimanus		1							
Brachyura A									
Brachyura B									
Brachyura C								1	
PHYLUM BRACHIOPODA									
Terebratulina meridionalis									
PHYLUM MOLLUSCA									
Ischnochiton bergoti									
Macoma spp.	9	4	2	16	37	12	3	22	1
Tellina spp.	1		1			1			
Dosinia spp.	2	5	6	2	2		2	1	2
Nucula nucleus									
Bivalve F						1		1	
Bivalve M									
Alvania fenestrata									
Bullia digitalis									
Charitodoron euphrosyne									
Epitonium kraussi									
Gibbula spp.									
Heliacus variegata				1					
Marginella spp.			5	6			12		
Melanella spp.									
Nassarius spp.	3	1	9	8		1			
Natica tecta									
Ocenebra spp.									
Protomella capensis									
Pyramidella spp.									
Solariella agulhasensis									
Tricolia capensis									
Triphora africana									
Turris spp.				1					
Turritella spp.									
Volutocorbis abyssicola									
Volvarina capensis									
Sepia spp.									
Cucumaria spp.									
Amphipholis squamata									
PHYLUM ECHINODERMATA									
Ophionereis porrecta	1								
Henricia spp.									

Species	R2.8	R2.9	R2.10	R3.1	R3.2	R3.3	R3.4	R3.5	R3.6
PHYLUM PORIFERA									
Porifera A									
PHYLUM CNIDARIA									
Scyphozoa A		1							
Anthozoa A								4	
Anthozoa B						1			
Anthozoa D				1					
PHYLUM NEMERTEA									
Cerebratulus spp.	4			1					4
Lineus spp.									
Nemertea B									
Nemertea C	2								
Nemertea D				1					
Siphunculid A				3					
Siphunculid B				1					
PHYLUM ANNELIDA									
Lumbrineris spp.	18	8	37	25	1	11			41
Arabella spp.	6							1	
Diopatra spp.	1								
Glyceridae									
Nereidae									
Nereis spp.									
Perinereis/Pseudonereis spp.									
Nephtys spp.	3			8					
Spionidae									
Prionospio pinnata	15	5	7	2		32	1	1	17
Spio spp.	1					1			
Spiophanes spp.						1			
Laonice cirrata			2	1		2			16
Spionid O									
Spionid P									
Polydora spp.									
Orbiniidae			15	3					11
Haploscoloplos spp.	12	4							
Scoloplos spp.									
Phylo spp.								1	
Naineris spp.									
Orbiniidae B				1					
Orbinia angrapaquensis									
Poly BB									
Poly WW									
Paraonidae									
Cirrophorus branchiatus									
Ophelia spp.						3			
Capitellidae									
Notomastus spp.	3				1				
Maldanidae									
Maldaninae A									
Maldaninae B									
Euclymene luderitziana									
Petaloproctus spp.									1
Rhodine gracilior									
Sabellides spp.									
Ampharetidae							1		
Amphicteis gunneri									2
Ampharete spp.A									
Terebellidae									
Trichobranchus glacialis									

Species	R2.8	R2.9	R2.10	R3.1	R3.2	R3.3	R3.4	R3.5	R3.6
Terebellides spp.	1		16	3		6		2	5
Amaeana trilobata/Polycirrus	4								
Flabelligera spp.									
Pectinariidae									
Poly UU									
PHYLUM ARTHROPODA									
Copepoda A									
Myodocopa		1							
Isopod A									
Arcturidae									2
Arcturidae A	1								
Arcturid B									
Arcturid C	1								
Arcturid D									
Cirolana spp.	2					2	3		
Microarcturus quadriconus									
New amphipod				1					
Ampelisca spp.	36	3	48	5		9	5		77
Aoro kergeuleni									
Aorcho delgadus	1	15				1			8
Corophiid A (Gammaropsis)									
Corophiid Q									
Atylus swammerdamei									
Guernea rhomba									
Paramoera capensis									
Maera spp.									
Urothoe spp.	1								
Leucothoe spp.	1		1	2					8
Acidostoma obesum	1	4					146		
Hippomedon longimanus	15	1		19					1
Euonyx biscayensis									
Socarnopsis crenulata									
Monoculodopsis longimana									
Oediceroides cinderella		1							
Perioculodes spp.			1						
Westwoodilla manta									
Paraphoxus oculatus	2								
Platyischnopus herdmani	1								
Podocerus brasiliensis			1						
Podoceropsis sophiae		1							
Eupariambus fallax									
Phtisca marina	1								1
Hyperiidae	3		1				1		1
Hyperiid B									
Ingolfiellid A	1								
Ingolfiellid B									
Ingolfiellid C									
Cumacea A	1								
Cumacea C									
Leptostraca A									
Pterygosquilla armata									
Stomatopoda B									
Stomatopod juvenile									
Misidacea spp.									
Gastrosaccus psammodytes									
Euphausiacea	6	9	1	2		1	4		5
Penaeid A									

Species	R2.8	R2.9	R2.10	R3.1	R3.2	R3.3	R3.4	R3.5	R3.6
Penaeid B									1
Penaeid C									
Carida B	4		1			1	1		
Carida C (Mysidaea)	1								
Carida F									
Anomura									
Calocaris barnardi									
Callianassa spp.	3		1						
Anomura A			1	2	1	9	1	2	2
Goneplax angulata	4	1	1	11	2	1	12		3
Mursia cristimanus									
Brachyura A								1	
Brachyura B									
Brachyura C									
PHYLUM BRACHIOPODA									
Terebratulina meridionalis		2							
PHYLUM MOLLUSCA									
Ischnochiton bergoti									
Macoma spp.	13		22	137	1	2			24
Tellina spp.									
Dosinia spp.	3		1	5		1			
Nucula nucleus									
Bivalve F	1	1	1	3					3
Bivalve M									
Alvania fenestrata									
Bullia digitalis									
Charitodoron euphrosyne									
Epitonium kraussi									
Gibbula spp.									
Heliacus variegata			1						
Marginella spp.	17	2	3	5	4	1	2		2
Melanella spp.									
Nassarius spp.	22	1	5	21	5	1	1		3
Natica tecta	1								
Ocenebra spp.									
Protomella capensis									
Pyramidella spp.				1					
Solariella agulhasensis				1					
Tricolia capensis				4	1				
Triphora africana				1					
Turris spp.									
Turritella spp.	1								
Volutocorbis abyssicola									
Volvarina capensis									
Sepia spp.									
Cucumaria spp.									
Amphipholis squamata									
PHYLUM ECHINODERMATA									
Ophionereis porrecta						1			3
Henricia spp.									

Species	R2.8	R2.9	R2.10	R3.1	R3.2	R3.3	R3.4	R3.5	R3.6
Penaeid B									1
Penaeid C									
Carida B	4		1			1	1		
Carida C (Mysidaea)	1								
Carida F									
Anomura									
Calocaris barnardi									
Callianassa spp.	3		1						
Anomura A			1	2	1	9	1	2	2
Goneplax angulata	4	1	1	11	2	1	12		3
Mursia cristimanus									
Brachyura A								1	
Brachyura B									
Brachyura C									
PHYLUM BRACHIOPODA									
Terebratulina meridionalis		2							
PHYLUM MOLLUSCA									
Ischnochiton bergoti									
Macoma spp.	13		22	137	1	2			24
Tellina spp.									
Dosinia spp.	3		1	5		1			
Nucula nucleus									
Bivalve F	1	1	1	3					3
Bivalve M									
Alvania fenestrata									
Bullia digitalis									
Charitodoron euphrosyne									
Epitonium kraussi									
Gibbula spp.									
Heliacus variegata			1						
Marginella spp.	17	2	3	5	4	1	2		2
Melanella spp.									
Nassarius spp.	22	1	5	21	5	1	1		3
Natica tecta	1								
Ocenebra spp.									
Protomella capensis									
Pyramidella spp.				1					
Solariella agulhasensis				1					
Tricolia capensis				4	1				
Triphora africana				1					
Turris spp.									
Turritella spp.	1								
Volutocorbis abyssicola									
Volvarina capensis									
Sepia spp.									
Cucumaria spp.									
Amphipholis squamata									
PHYLUM ECHINODERMATA									
Ophionereis porrecta						1			3
Henricia spp.									

Species	R3.7	R3.8	R3.9	R3.10	R4.1	R4.2	R4.3	R4.4	R4.5
PHYLUM PORIFERA									
Porifera A									
PHYLUM CNIDARIA									
Scyphozoa A									
Anthozoa A		4							
Anthozoa B		1							
Anthozoa D									
PHYLUM NEMERTEA									
Cerebratulus spp.		1		1					1
Lineus spp.									
Nemertea B							1		
Nemertea C		1							
Nemertea D									
Siphunculid A									3
Siphunculid B									1
PHYLUM ANNELIDA									
Lumbrineris spp.	5	27	12	13	6	1	19	7	12
Arabella spp.								1	
Diopatra spp.									
Glyceridae									
Nereidae									
Nereis spp.			1	1					1
Perinereis/Pseudonereis spp.									
Nephtys spp.		5	7	4		1	5	9	1
Spionidae									
Prionospio pinnata	13	89	5	43	28	1	41	35	18
Spio spp.									
Spiophanes spp.									
Laonice cirrata		6	4		1		2		
Spionid O									
Spionid P									
Polydora spp.									
Orbiniidae		27							
Haploscoloplos spp.	2	1	8	7	1		6		5
Scoloplos spp.									
Phylo spp.									
Naineris spp.									
Orbiniidae B									
Orbinia angrapaquensis									
Poly BB									
Poly WW									2
Paraonidae									
Cirrophorus branchiatus									
Ophelia spp.									1
Capitellidae									
Notomastus spp.									
Maldanidae									
Maldaninae A									
Maldaninae B									
Euclymene luderitziana				14					
Petaloproctus spp.									
Rhodine gracilior									
Sabellides spp.									
Ampharetidae									
Amphicteis gunneri		4							
Ampharete spp.A									
Terebellidae									
Trichobranchus glacialis									

Species	R3.7	R3.8	R3.9	R3.10	R4.1	R4.2	R4.3	R4.4	R4.5
Terebellides spp.	2	2	1	4	1	1	4		2
Amaeana trilobata/Polycirrus									
Flabelligera spp.									
Pectinariidae									
Poly UU									
PHYLUM ARTHROPODA									
Copepoda A			1						
Myodocopa									
Isopod A							1		
Arcturidae									
Arcturidae A									
Arcturid B									
Arcturid C									
Arcturid D									
Cirolana spp.									
Microarcturus quadriconus					2				
New amphipod									
Ampelisca spp.		22	26	27	28		34	3	1
Aoro kergeuleni									
Aorcho delgadus									
Corophiid A (Gammaropsis)									
Corophiid Q									
Atylus swammerdamei					1			3	
Guernea rhomba					1				
Paramoera capensis									
Maera spp.									
Urothoe spp.									
Leucothoe spp.		1		1					3
Acidostoma obesum		1	1			3			
Hippomedon longimanus		14	7	18				4	
Euonyx biscayensis									
Socarnopsis crenulata									
Monoculodopsis longimana					1				
Oediceroides cinderella									
Perioculodes spp.		1							
Westwoodilla manta		1					2		
Paraphoxus oculatus			1	1					
Platyischnopus herdmani									
Podocerus brasiliensis									
Podoceropsis sophiae									
Eupariambus fallax									
Phtisca marina									
Hyperiidae		4	1		1		1		1
Hyperiid B									
Ingolfiellid A									
Ingolfiellid B									
Ingolfiellid C									
Cumacea A									
Cumacea C									
Leptostraca A									
Pterygosquilla armata									
Stomatopoda B				1					
Stomatopod juvenile									
Misidacea spp.									
Gastrosaccus psammodytes									
Euphausiacea		1		4	2		4	1	
Penaeid A									

Species	R3.7	R3.8	R3.9	R3.10	R4.1	R4.2	R4.3	R4.4	R4.5
Penaeid B									1
Penaeid C									
Carida B			1						
Carida C (Mysidaea)									
Carida F									
Anomura									
Calocaris barnardi									1
Callianassa spp.		3	1	1			4	2	
Anomura A		3	1						1
Goneplax angulata		15	7	7	1	6	15	6	5
Mursia cristimanus								1	
Brachyura A									
Brachyura B									
Brachyura C									
PHYLUM BRACHIOPODA									
Terebratulina meridionalis									
PHYLUM MOLLUSCA									
Ischnochiton bergoti			5						
Macoma spp.		63	39	31	27	57	38	71	18
Tellina spp.									
Dosinia spp.		6		2			2	2	1
Nucula nucleus			3		7		3		5
Bivalve F		1	7						1
Bivalve M									
Alvania fenestrata									
Bullia digitalis									
Charitodoron euphrosyne									
Epitonium kraussi									
Gibbula spp.									
Heliacus variegata									
Marginella spp.		18	3	4	7		1	1	14
Melanella spp.									
Nassarius spp.		13	1	2		14	41		4
Natica tecta									
Ocenebra spp.									
Protomella capensis									
Pyramidella spp.									
Solariella agulhasensis									
Tricolia capensis									
Triphora africana									
Turris spp.		1							
Turritella spp.									
Volutocorbis abyssicola									
Volvarina capensis									
Sepia spp.									
Cucumaria spp.									
Amphipholis squamata									
PHYLUM ECHINODERMATA									
Ophionereis porrecta									
Henricia spp.									

Species	R4.6	R4.7	R4.8	R4.9	R4.10	S1.1	S1.5	S1.11	S1.14
PHYLUM PORIFERA									
Porifera A									
PHYLUM CNIDARIA									
Scyphozoa A									
Anthozoa A									
Anthozoa B									
Anthozoa D									
PHYLUM NEMERTEA									
Cerebratulus spp.			1						
Lineus spp.									
Nemertea B									
Nemertea C			1						
Nemertea D									
Siphunculid A									
Siphunculid B						1			
PHYLUM ANNELIDA									
Lumbrineris spp.	2	9	6	2	2	3	6	1	13
Arabella spp.	2								
Diopatra spp.	1		2						
Glyceridae									
Nereidae									
Nereis spp.	1		2						
Perinereis/Pseudonereis spp.							3		
Nephtys spp.	2	1	8					1	2
Spionidae									
Prionospio pinnata	5	7	2	1	1	2	12	7	21
Spio spp.									
Spiophanes spp.			1						12
Laonice cirrata	1	2			2			1	
Spionid O			2						
Spionid P									
Polydora spp.									
Orbiniidae			11		1				
Haploscoloplos spp.						2	2	8	12
Scoloplos spp.									
Phylo spp.									
Naineris spp.									
Orbiniidae B									
Orbinia angrapaquensis									2
Poly BB									
Poly WW									
Paraonidae									
Cirrophorus branchiatus									1
Ophelia spp.	1								
Capitellidae									
Notomastus spp.					1			2	1
Maldanidae			1					1	4
Maldaninae A									
Maldaninae B									
Euclymene luderitziana									
Petaloproctus spp.									
Rhodine gracilior								1	
Sabellides spp.			3						
Ampharetidae			2						
Amphicteis gunneri	6	1							
Ampharete spp.A									
Terebellidae									
Trichobranchus glacialis									

Species	R4.6	R4.7	R4.8	R4.9	R4.10	S1.1	S1.5	S1.11	S1.14
Terebellides spp.	7	3	18	2	1			5	
Amaeana trilobata/Polycirrus									
Flabelligera spp.									
Pectinariidae									
Poly UU									
PHYLUM ARTHROPODA									
Copepoda A						1			
Myodocopa									
Isopod A									
Arcturidae									1
Arcturidae A									
Arcturid B									
Arcturid C									
Arcturid D									
Cirolana spp.			1						
Microarcturus quadriconus			2						
New amphipod									
Ampelisca spp.	2	4	8					1	4
Aoro kergeuleni									
Aorcho delgadus	1		1						
Corophiid A (Gammaropsis)									
Corophiid Q									
Atylus swammerdamei									
Guernea rhomba									
Paramoera capensis									
Maera spp.									
Urothoe spp.									
Leucothoe spp.		1	3					1	2
Acidostoma obesum	1		1						1
Hippomedon longimanus	1	28	41	3		1	5	11	27
Euonyx biscayensis									
Socarnopsis crenulata									
Monoculodopsis longimana									
Oediceroides cinderella									
Perioculodes spp.									
Westwoodilla manta									
Paraphoxus oculatus								1	
Platyischnopus herdmani									
Podocerus brasiliensis									
Podoceropsis sophiae									
Eupariambus fallax			2						
Phtisca marina									
Hyperiidae									1
Hyperiid B									
Ingolfiellid A									
Ingolfiellid B									
Ingolfiellid C									
Cumacea A							1		2
Cumacea C									
Leptostraca A									
Pterygosquilla armata	1								
Stomatopoda B									
Stomatopod juvenile									
Misidacea spp.									
Gastrosaccus psammodytes									
Euphausiacea									
Penaeid A									

Species	R4.6	R4.7	R4.8	R4.9	R4.10	S1.1	S1.5	S1.11	S1.14
Penaeid B									
Penaeid C									1
Carida B									
Carida C (Mysidaea)			1				1		
Carida F									
Anomura									
Calocaris barnardi									
Callianassa spp.									
Anomura A		2	2						
Goneplax angulata	6	5	18	2					
Mursia cristimanus			2						
Brachyura A									
Brachyura B									
Brachyura C									
PHYLUM BRACHIOPODA									
Terebratulina meridionalis									
PHYLUM MOLLUSCA									
Ischnochiton bergoti					1				
Macoma spp.	123	32	153	8	11	4	1	12	21
Tellina spp.			1					3	
Dosinia spp.	2		8			1	1		
Nucula nucleus				2	1				
Bivalve F								1	1
Bivalve M									
Alvania fenestrata			3	1				1	1
Bullia digitalis						9	2		
Charitodoron euphrosyne								1	1
Epitonium kraussi			6				1	2	
Gibbula spp.						1			
Heliacus variegata						1			
Marginella spp.	2		4	3		15	3	1	2
Melanella spp.						2			
Nassarius spp.	11	2	12	1		28	99	22	6
Natica tecta									
Ocenebra spp.			5			2	4	1	
Protomella capensis						6	1		
Pyramidella spp.			2						
Solariella agulhasensis			42			1	9	2	
Tricolia capensis	1		31	4		19	9	14	2
Triphora africana									
Turris spp.									
Turritella spp.									
Volutocorbis abyssicola									
Volvarina capensis									
Sepia spp.									
Cucumaria spp.									
Amphipholis squamata									
PHYLUM ECHINODERMATA									
Ophionereis porrecta			3						
Henricia spp.			1						

Species	S1.15	S1.17	S2.2	S2.3	S2.4	S2.5	S2.6	S2.7	S3.1
PHYLUM PORIFERA									
Porifera A									
PHYLUM CNIDARIA									
Scyphozoa A									
Anthozoa A									
Anthozoa B									
Anthozoa D									
PHYLUM NEMERTEA									
Cerebratulus spp.	1								
Lineus spp.	1								
Nemertea B									
Nemertea C								1	
Nemertea D									
Siphunculid A									
Siphunculid B									
PHYLUM ANNELIDA									
Lumbrineris spp.	21	12	9	1	4	12	3	7	1
Arabella spp.	1								
Diopatra spp.								1	
Glyceridae									
Nereidae									
Nereis spp.	1								
Perinereis/Pseudonereis spp.									
Nephtys spp.	1			1	2	3			
Spionidae	1					9			
Prionospio pinnata	1	24	3	36	52	47	3	36	6
Spio spp.									
Spiophanes spp.		6							
Laonice cirrata	1	1	4			1	2		1
Spionid O									
Spionid P									
Polydora spp.									
Orbiniidae						3			
Haploscoloplos spp.	41	13	7	3		1	3		1
Scoloplos spp.									
Phylo spp.	1								
Naineris spp.									
Orbiniidae B	1								
Orbinia angrapaquensis								2	
Poly BB									
Poly WW									
Paraonidae									
Cirrophorus branchiatus									
Ophelia spp.									
Capitellidae								1	
Notomastus spp.									
Maldanidae	1	1							
Maldaninae A									
Maldaninae B									
Euclymene luderitziana									
Petaloproctus spp.									
Rhodine gracilior	2								
Sabellides spp.									
Ampharetidae									
Amphicteis gunneri	1							1	
Ampharete spp.A									
Terebellidae									
Trichobranchus glacialis									

Species	S1.15	S1.17	S2.2	S2.3	S2.4	S2.5	S2.6	S2.7	S3.1
Terebellides spp.			5		2				
Amaeana trilobata/Polycirrus						1			
Flabelligera spp.									
Pectinariidae									
Poly UU									
PHYLUM ARTHROPODA									
Copepoda A					1		1		
Myodocopa									
Isopod A									
Arcturidae	1								
Arcturidae A									
Arcturid B								1	
Arcturid C									
Arcturid D									
Cirolana spp.									
Microarcturus quadriconus									
New amphipod									
Ampelisca spp.		1	5	4	19	4	11	9	
Aoro kergeuleni									
Aorcho delgadus	1						1		
Corophiid A (Gammaropsis)									
Corophiid Q									
Atylus swammerdamei									
Guernea rhomba									
Paramoera capensis									
Maera spp.									
Urothoe spp.									
Leucothoe spp.	2	1			3	1	4	2	
Acidostoma obesum	6								
Hippomedon longimanus		39	1		14			6	
Euonyx biscayensis						3			
Socarnopsis crenulata									
Monoculodopsis longimana									
Oediceroides cinderella									
Perioculodes spp.		1							
Westwoodilla manta				1		4			
Paraphoxus oculatus									
Platyischnopus herdmani			1						
Podocerus brasiliensis									
Podoceropsis sophiae									
Eupariambus fallax									
Phtisca marina	1								
Hyperiidae	2		1			1			
Hyperiid B	1						2		
Ingolfiellid A	2								
Ingolfiellid B									
Ingolfiellid C									
Cumacea A			1						
Cumacea C									
Leptostraca A					1				
Pterygosquilla armata									
Stomatopoda B									
Stomatopod juvenile	1								
Misidacea spp.									
Gastrosaccus psammodytes									
Euphausiacea		1			2			1	
Penaeid A				1	1				

Species	S1.15	S1.17	S2.2	S2.3	S2.4	S2.5	S2.6	S2.7	S3.1
Penaeid B									
Penaeid C			4						
Carida B							1		
Carida C (Mysidaea)			1			4			
Carida F									
Anomura						1			
Calocaris barnardi									
Callianassa spp.					3				
Anomura A									
Goneplax angulata				1	4	3		1	
Mursia cristimanus									
Brachyura A									
Brachyura B					1				
Brachyura C									
PHYLUM BRACHIOPODA									
Terebratulina meridionalis					1		1	1	
PHYLUM MOLLUSCA									
Ischnochiton bergoti									
Macoma spp.	1	9	2		2	2	2	4	4
Tellina spp.									
Dosinia spp.	1						1	1	
Nucula nucleus									1
Bivalve F		1	6			2			
Bivalve M									
Alvania fenestrata	2								
Bullia digitalis									
Charitodoron euphrosyne									
Epitonium kraussi		1							
Gibbula spp.									
Heliacus variegata									
Marginella spp.	1		1	1	1			6	1
Melanella spp.									
Nassarius spp.	2	14		1	8		3	12	1
Natica tecta									
Ocenebra spp.		1							
Protomella capensis									
Pyramidella spp.									
Solariella agulhasensis		1							
Tricolia capensis	3	6							
Triphora africana									
Turris spp.									
Turritella spp.		1							
Volutocorbis abyssicola									
Volvarina capensis	1								
Sepia spp.									
Cucumaria spp.						1			
Amphipholis squamata							1		
PHYLUM ECHINODERMATA									
Ophionereis porrecta									
Henricia spp.									

Species	S3.2	S3.3	S3.4	S3.5	S3.7	S4.2	S4.6	S4.8	S4.9
PHYLUM PORIFERA									
Porifera A									
PHYLUM CNIDARIA									
Scyphozoa A									
Anthozoa A									
Anthozoa B									
Anthozoa D									
PHYLUM NEMERTEA									
Cerebratulus spp.						1			
Lineus spp.									
Nemertea B									
Nemertea C									
Nemertea D									
Siphunculid A									
Siphunculid B	3								
PHYLUM ANNELIDA									
Lumbrineris spp.	8	11	15	3	4	1	1	7	
Arabella spp.									
Diopatra spp.	1								
Glyceridae									
Nereidae									
Nereis spp.									
Perinereis/Pseudonereis spp.									
Nephtys spp.									
Spionidae									
Prionospio pinnata	2		16	1	1	5	1	6	12
Spio spp.									
Spiophanes spp.									
Laonice cirrata	2	2	3	2	1	5		3	
Spionid O									
Spionid P									
Polydora spp.									
Orbiniidae									
Haploscoloplos spp.	3	8	2	1					
Scoloplos spp.								2	
Phylo spp.									
Naineris spp.	6								
Orbiniidae B									
Orbinia angrapaquensis									
Poly BB									
Poly WW									
Paraonidae									
Cirrophorus branchiatus									
Ophelia spp.									
Capitellidae									
Notomastus spp.	1	1							
Maldanidae									
Maldaninae A									
Maldaninae B									
Euclymene luderitziana									
Petaloproctus spp.									
Rhodine gracilior									
Sabellides spp.									
Ampharetidae									
Amphicteis gunneri						1			
Ampharete spp.A	1								
Terebellidae									
Trichobranchus glacialis					1				

Species	S3.2	S3.3	S3.4	S3.5	S3.7	S4.2	S4.6	S4.8	S4.9
Terebellides spp.		1		1		15		9	
Amaeana trilobata/Polycirrus									
Flabelligera spp.						1			
Pectinariidae									
Poly UU									
PHYLUM ARTHROPODA									
Copepoda A	1			2					
Myodocopa									
Isopod A					1				
Arcturidae									
Arcturidae A									
Arcturid B									
Arcturid C									
Arcturid D									
Cirolana spp.									
Microarcturus quadriconus									
New amphipod									
Ampelisca spp.		1	3	2		1			
Aoro kergeuleni		1	1						
Aorcho delgadus	1			3				1	
Corophiid A (Gammaropsis)									
Corophiid Q									
Atylus swammerdamei									
Guernea rhomba									
Paramoera capensis									
Maera spp.	6	2			1				
Urothoe spp.									
Leucothoe spp.	8	2	1	2	1		1	1	
Acidostoma obesum	1	2	1	3	1				
Hippomedon longimanus			2	1		1			
Euonyx biscayensis									
Socarnopsis crenulata		1							
Monoculodopsis longimana									
Oediceroides cinderella									
Perioculodes spp.									
Westwoodilla manta						1			
Paraphoxus oculatus									
Platyischnopus herdmani									
Podocerus brasiliensis									
Podoceropsis sophiae									
Eupariambus fallax									
Phtisca marina									
Hyperiidae		1	1	1					
Hyperiid B	1				1				
Ingolfiellid A									
Ingolfiellid B									
Ingolfiellid C									
Cumacea A									
Cumacea C	1					1			
Leptostraca A									
Pterygosquilla armata									
Stomatopoda B									
Stomatopod juvenile				1					
Misidacea spp.								1	
Gastrosaccus psammodytes									
Euphausiacea		1							
Penaeid A									

Species	S3.2	S3.3	S3.4	S3.5	S3.7	S4.2	S4.6	S4.8	S4.9
Penaeid B									
Penaeid C		1	2		1	2		3	
Carida B				2					
Carida C (Mysidaea)									
Carida F									
Anomura	1	2	2	1					
Calocaris barnardi									
Callianassa spp.			1						
Anomura A					1				
Goneplax angulata		3	2		4			2	
Mursia cristimanus									
Brachyura A									
Brachyura B									
Brachyura C									
PHYLUM BRACHIOPODA									
Terebratulina meridionalis									
PHYLUM MOLLUSCA									
Ischnochiton bergoti	4								
Macoma spp.	5	17	35	8	4	49		12	
Tellina spp.	6	2		3					
Dosinia spp.	1								
Nucula nucleus					1			2	
Bivalve F					2				
Bivalve M	1								
Alvania fenestrata	1								
Bullia digitalis									
Charitodoron euphrosyne									
Epitonium kraussi		1							
Gibbula spp.	2								
Heliacus variegata									
Marginella spp.	1				1	1		5	
Melanella spp.									
Nassarius spp.	47	5	4	21	5	31		54	4
Natica tecta									
Ocenebra spp.	2	1						1	
Protomella capensis									
Pyramidella spp.			1					1	
Solariella agulhasensis		1	2	3					1
Tricolia capensis	11	2	5	1		2		1	
Triphora africana									
Turris spp.					2				
Turritella spp.									
Volutocorbis abyssicola						1			
Volvarina capensis									
Sepia spp.			1						
Cucumaria spp.									
Amphipholis squamata									
PHYLUM ECHINODERMATA									
Ophionereis porrecta									
Henricia spp.									

Species	S4.13	S4.14	S4.15
PHYLUM PORIFERA			
Porifera A			
PHYLUM CNIDARIA			
Scyphozoa A			
Anthozoa A			
Anthozoa B			
Anthozoa D			
PHYLUM NEMERTEA			
Cerebratulus spp.	2	1	
Lineus spp.			
Nemertea B			
Nemertea C			
Nemertea D			
Siphunculid A			
Siphunculid B			
PHYLUM ANNELIDA			
Lumbrineris spp.	11	1	3
Arabella spp.		2	
Diopatra spp.			
Glyceridae			
Nereidae			
Nereis spp.			
Perinereis/Pseudonereis spp.		1	
Nephtys spp.	3	7	
Spionidae			
Prionospio pinnata	1	21	
Spio spp.			
Spiophanes spp.			
Laonice cirrata		1	
Spionid O			
Spionid P			
Polydora spp.			
Orbiniidae			1
Haploscoloplos spp.	4	1	
Scoloplos spp.		1	1
Phylo spp.			
Naineris spp.			
Orbiniidae B			
Orbinia angrapaquensis			
Poly BB			
Poly WW			
Paraonidae			
Cirrophorus branchiatus			
Ophelia spp.			
Capitellidae			
Notomastus spp.			
Maldanidae			
Maldaninae A			
Maldaninae B			
Euclymene luderitziana			
Petaloproctus spp.			
Rhodine gracilior			
Sabellides spp.			
Ampharetidae			
Amphicteis gunneri			
Ampharete spp.A			
Terebellidae			
Trichobranchus glacialis			

Species	S4.13	S4.14	S4.15
Terebellides spp.	1		
Amaeana trilobata/Polycirrus			
Flabelligera spp.	1		
Pectinariidae			
Poly UU			
PHYLUM ARTHROPODA			
Copepoda A			
Myodocopa			
Isopod A			
Arcturidae			
Arcturidae A			
Arcturid B			
Arcturid C			
Arcturid D			
Cirolana spp.	1		
Microarcturus quadriconus			
New amphipod			
Ampelisca spp.	13	1	
Aoro kergeuleni			
Aorcho delgadus	1		
Corophiid A (Gammaropsis)			
Corophiid Q			
Atylus swammerdamei			
Guernea rhomba			
Paramoera capensis			
Maera spp.	17		
Urothoe spp.			
Leucothoe spp.	3		
Acidostoma obesum	19		
Hippomedon longimanus	5	2	
Euonyx biscayensis			
Socarnopsis crenulata			
Monoculodopsis longimana			
Oediceroides cinderella			
Perioculodes spp.			
Westwoodilla manta			
Paraphoxus oculatus			
Platyischnopus herdmani			
Podocerus brasiliensis			
Podoceropsis sophiae			
Eupariambus fallax			
Phtisca marina			
Hyperiidae			
Hyperiid B			
Ingolfiellid A			
Ingolfiellid B			
Ingolfiellid C			
Cumacea A			
Cumacea C			
Leptostraca A			
Pterygosquilla armata			
Stomatopoda B			
Stomatopod juvenile			
Misidacea spp.			
Gastrosaccus psammodytes			
Euphausiacea			
Penaeid A			

Species	S4.13	S4.14	S4.15
Penaeid B			
Penaeid C			
Carida B			
Carida C (Mysidaea)			
Carida F			
Anomura			
Calocaris barnardi			
Callianassa spp.			
Anomura A			
Goneplax angulata		4	
Mursia cristimanus			
Brachyura A			
Brachyura B			
Brachyura C			
PHYLUM BRACHIOPODA			
Terebratulina meridionalis			
PHYLUM MOLLUSCA			
Ischnochiton bergoti			
Macoma spp.	4	2	1
Tellina spp.		5	
Dosinia spp.		3	
Nucula nucleus			
Bivalve F	1		
Bivalve M			
Alvania fenestrata			1
Bullia digitalis			
Charitodoron euphrosyne			
Epitonium kraussi		1	
Gibbula spp.			
Heliacus variegata			
Marginella spp.			2
Melanella spp.			
Nassarius spp.	4	55	48
Natica tecta			
Ocenebra spp.			1
Protomella capensis			
Pyramidella spp.			1
Solariella agulhasensis		2	1
Tricolia capensis		16	9
Triphora africana			
Turris spp.			
Turritella spp.			
Volutocorbis abyssicola			
Volvarina capensis			
Sepia spp.			
Cucumaria spp.			
Amphipholis squamata			
PHYLUM ECHINODERMATA			
Ophionereis porrecta			
Henricia spp.			

MACROFAUNA ABUNDANCE DATA FOR ALL SAMPLES FROM THE SOUTHERN RESEARCH AREA.

Species	R5.1	R5.3	R5.4	R5.5	R5.6	R5.7	R5.8	R5.9	R5.10
PHYLUM CNIDARIA									
Anthozoa A									
PHYLUM NEMERTEA									
Cerebratulus spp.	2		1	1			1	1	1
Lineus spp.	3			2					
Nemertea B									
PHYLUM ANNELIDA									
Eunicidae									
Lumbrineris spp.	17	4	6	13	12	6	8	19	4
Arabella spp.				1		2		1	
Diopatra spp.	71	26	7	3	25	2		9	26
Epidiopatra spp.									
Nereidae									
Nereis spp.		5		1					
Perinereis/Pseudonereis spp.									
Micronereides capensis				1					
Nephtyidae	4		2				9		
Nephtys spp.				3	2	7		2	
Spionidae									
Prionospio pinnata	43	2	2	61	43	58	16	91	12
Spio spp.									
Laonice cirrata		1						1	
Haploscoloplos spp.					2			3	
Phylo spp.								4	
Capitellidae									
Notomastus spp.		3							
Maldanidae	4				1				
Euclymene luderitziana		2							
Maldanella capensis									
Petaloproctus spp.									
Sabellides spp.		2							
Ampharetidae			4	1					
Amphicteis gunneri		6							
Terebellides spp.	21	287	4	3	2			17	8
Amaeana trilobata/Polycirrus						1	1		1
Ancistrosyllis parva									
Flabelligeridae			2						
Flabelligera spp.									
Pectinaria capensis									
Cossura coasta									
PHYLUM ARTHROPODA									
Tanaid A									
Copepoda A						1	7		
Isopod A									
Ampelisca spp.			1	1	14	17	24	41	3
Aoro kergeuleni									
Aorcho delgadus		1							
Corophiid Q								1	
Guernea rhomba									
Rhachotropis spp.						1			

Species	R5.1	R5.3	R5.4	R5.5	R5.6	R5.7	R5.8	R5.9	R5.10
Elasmopus affinis			2						
Ceradocus natalensis									
Maera spp.					1				
Urothoe spp.									
Leucothoe spp.				5					
Listriella lindae		2			3		1		
Acidostoma obesum		1		2					
Hippomedon longimanus				1	1		2		
Westwoodilla manta				2	1	1	21		
Paraphoxus oculatus			2					1	
Platyischnopus herdmani					1				
Podocerus brasiliensis									
Eupariambus fallax									
Hyperiidae					3	1	4	1	
Hyperiid B									
Cumacea B									
Pterygosquilla armata	4	1		1	4	1			
Stomatopod juvenile							1	2	
Meiosquilla desmarestii									
Euphausiacea			1	12	15		4	3	1
Carida A							2		
Carida B		2							
Carida C (Mysidaea)		1			1	1	4		
Carida D		1				7			
Carida F				2	1		1		
Calocaris barnardi	4	9		3	11	2		1	3
Callianassa spp.	7	1	1	1	12	5	6	4	
Anomura A		3							
Goneplax angulata	3			3	2	6	4	3	1
Mursia cristimanus									
PHYLUM MOLLUSCA									
Macoma spp.	1	11		1	14	5	1	27	
Tellina spp.									
Dosinia spp.									
Nucula nucleus			4			1		1	
Bivalve F			1						
Bivalve I									
Alvania fenestrata									
Clanculus spp.									
Epitonium kraussi									
Marginella spp.				1		1			
Nassarius spp.	1	48	9	6		7		3	1
Ocenebra spp.									
Pyramidella spp.									
Solariella agulhasensis									
Tricolia capensis									
Turris spp.						1			
Volutocorbis abyssicola				1					1
Amphipholis squamata									
PHYLUM ECHINODERMATA									
Ophionereis porrecta		2							

Species	R6.6	R6.7	R6.8	R6.9	R6.10	S5.2	S5.3	S5.5	S5.6
PHYLUM CNIDARIA									
Anthozoa A									
PHYLUM NEMERTEA									
Cerebratulus spp.					1				
Lineus spp.									
Nemertea B									
PHYLUM ANNELIDA									
Eunicidae									
Lumbrineris spp.	3	15	6	7	14	8	8	13	2
Arabella spp.		1					1		
Diopatra spp.	3	34	37	8	57	1	48	1	12
Epidiopatra spp.									
Nereidae									
Nereis spp.							4		
Perinereis/Pseudonereis spp.						2	6	4	1
Micronereides capensis									
Nephtyidae									
Nephtys spp.		4	2	2	5	3	6	5	4
Spionidae									
Prionospio pinnata	2	59	23	21	43	31	25	37	46
Spio spp.									
Laonice cirrata									
Haploscoloplos spp.			1				1	3	
Phylo spp.									
Capitellidae									
Notomastus spp.		2							
Maldanidae						9	6		
Euclymene luderitziana									
Maldanella capensis								4	
Petaloproctus spp.								4	
Sabellides spp.									
Ampharetidae					1				
Amphicteis gunneri			1						
Terebellides spp.		1	1		47	1	4	7	9
Amaeana trilobata/Polycirrus	1								
Ancistrosyllis parva		1							
Flabelligeridae									
Flabelligera spp.			1						
Pectinaria capensis									
Cossura coasta									
PHYLUM ARTHROPODA									
Tanaid A									
Copepoda A									1
Isopod A				1					
Ampelisca spp.	1	14	11		33	3	2	3	17
Aoro kergeuleni									
Aorcho delgadus			1		1				
Corophiid Q									
Guernea rhomba									
Rhachotropis spp.									
Elasmopus affinis									
Ceradocus natalensis									
Maera spp.									
Urothoe spp.			1		1				
Leucothoe spp.							2	1	
Listriella lindae		1							
Acidostoma obesum									
Hippomedon longimanus		1							

Species	R6.6	R6.7	R6.8	R6.9	R6.10	S5.2	S5.3	S5.5	S5.6
Westwoodilla manta		1			6	1		1	1
Paraphoxus oculatus	1	1							
Platyischnopus herdmani									
Podocerus brasiliensis									
Eupariambus fallax								1	
Hyperiidae		4	1		1		1		
Hyperiid B									
Cumacea B									
Pterygosquilla armata		3			2	2	1	1	
Stomatopod juvenile		1					1		
Meiosquilla desmarestii		1							
Euphausiacea		8	3	1	2	1	1		
Carida A		1							
Carida B					3	1			
Carida C (Mysidaea)									
Carida D									
Carida F									
Calocaris barnardi		4	2		7	16	15	3	16
Callianassa spp.		5		1		6	7		4
Anomura A									
Goneplax angulata		1	4		1			2	1
Mursia cristimanus									
PHYLUM MOLLUSCA									
Macoma spp.	6	6	32		44	17	87	23	24
Tellina spp.					2		1		
Dosinia spp.			4		3			1	
Nucula nucleus				3			1		
Bivalve F					1		2	1	
Bivalve I							1		
Alvania fenestrata							4		
Clanculus spp.							1		
Epitonium kraussi							2		
Marginella spp.									
Nassarius spp.	1	5		34	37	11	27	27	5
Ocenebra spp.				1			2		
Pyramidella spp.									
Solariella agulhasensis						1			
Tricolia capensis							2		
Turris spp.				1					
Volutocorbis abyssicola									
Amphipholis squamata									
PHYLUM ECHINODERMATA									
Ophionereis porrecta									

Species	S5.9	S5.11	S6.1	S6.2	S6.3	S6.4	S6.5	S6.6
PHYLUM CNIDARIA								
Anthozoa A	1							
PHYLUM NEMERTEA								
Cerebratulus spp.								
Lineus spp.			2			1		
Nemertea B								1
PHYLUM ANNELIDA								
Eunicidae								1
Lumbrineris spp.	9	8	7	9	11	9	6	6
Arabella spp.					1			1
Diopatra spp.	19			33	4	28	12	2
Epidiopatra spp.	2					2		
Nereidae	3							1
Nereis spp.			5					
Perinereis/Pseudonereis spp.					7			2
Micronereides capensis								
Nephtyidae								
Nephtys spp.		1	3	1	2	2		
Spionidae	1	2						
Prionospio pinnata	13	9	52	34	7	2	12	9
Spio spp.								
Laonice cirrata								1
Haploscoloplos spp.		4						
Phylo spp.								
Capitellidae								1
Notomastus spp.								
Maldanidae	3							
Euclymene luderitziana								
Maldanella capensis								
Petaloproctus spp.								
Sabellides spp.								
Ampharetidae								
Amphicteis gunneri					4			
Terebellides spp.	3	6	3	1	1	12	7	
Amaeana trilobata/Polycirrus								
Ancistrosyllis parva								
Flabelligeridae								
Flabelligera spp.							2	
Pectinaria capensis								
Cossura coasta								
PHYLUM ARTHROPODA								
Tanaid A		1						
Copepoda A		3	1	2	1	14		
Isopod A								
Ampelisca spp.	1	13		4	2	38	2	
Aoro kergeuleni					3		2	
Aorcho delgadus					3	2		1
Corophiid Q						2		
Guernea rhomba		1						
Rhachotropis spp.								
Elasmopus affinis								
Ceradocus natalensis								1
Maera spp.					7		1	4
Urothoe spp.								
Leucothoe spp.								
Listriella lindae								
Acidostoma obesum								
Hippomedon longimanus								

Species	S5.9	S5.11	S6.1	S6.2	S6.3	S6.4	S6.5	S6.6
Westwoodilla manta		4				1		
Paraphoxus oculatus			1		2	1	1	
Platyischnopus herdmani								
Podocerus brasiliensis						1		
Eupariambus fallax								
Hyperiidae	1					3		1
Hyperiid B		2	1					
Cumacea B						1		
Pterygosquilla armata	3		2	1	3			
Stomatopod juvenile				1		1		
Meiosquilla desmarestii								
Euphausiacea		3				2	1	
Carida A		1						
Carida B								
Carida C (Mysidaea)						23		
Carida D								
Carida F								
Calocaris barnardi	5		8	25	6	3	5	3
Callianassa spp.	6	5		5			1	
Anomura A								
Goneplax angulata		5	3				1	2
Mursia cristimanus								1
PHYLUM MOLLUSCA								
Macoma spp.	12	6	11	11	5	6	1	1
Tellina spp.			1					
Dosinia spp.					2			
Nucula nucleus		3	1	1	1			
Bivalve F			1		1			1
Bivalve I								
Alvania fenestrata								
Clanculus spp.								
Epitonium kraussi					1			
Marginella spp.								
Nassarius spp.	6	38	4	13	44		11	5
Ocenebra spp.					3			1
Pyramidella spp.					1			
Solariella agulhasensis								
Tricolia capensis					6			
Turris spp.		1			3		1	
Volutocorbis abyssicola								
Amphipholis squamata								2
PHYLUM ECHINODERMATA								
Ophionereis porrecta								

Species	DB1.1	DB1.2	DB1.3	DB1.4	DB1.5	DB1.6	DB2.1	DB2.2	DB2.3
PHYLUM CNIDARIA									
Anthozoa A									
PHYLUM NEMERTEA									
Cerebratulus spp.				1					
Lineus spp.									
Nemertea B									
PHYLUM ANNELIDA									
Eunicidae									
Lumbrineris spp.	2	5	2	2		5	3		3
Arabella spp.					2				
Diopatra spp.	3	3	1		2	2	2	4	1
Epidiopatra spp.									
Nereidae									
Nereis spp.									
Perinereis/Pseudonereis spp.									
Micronereides capensis									
Nephtyidae									
Nephtys spp.	1	1	1	3		3	1	3	1
Spionidae									
Prionospio pinnata		1					2	25	4
Spio spp.									
Laonice cirrata									
Haploscoloplos spp.									
Phylo spp.									
Capitellidae									
Notomastus spp.									
Maldanidae									
Euclymene luderitziana									
Maldanella capensis									
Petaloproctus spp.									
Sabellides spp.									
Ampharetidae									
Amphicteis gunneri									
Terebellides spp.									
Amaeana trilobata/Polycirrus									
Ancistrosyllis parva									
Flabelligeridae									
Flabelligera spp.									
Pectinaria capensis									
Cossura coasta			1					3	
PHYLUM ARTHROPODA									
Tanaid A									
Copepoda A									
Isopod A									
Ampelisca spp.									
Aoro kergeuleni									
Aorcho delgadus	1								1
Corophiid Q									
Guernea rhomba									
Rhachotropis spp.									
Elasmopus affinis									
Ceradocus natalensis									
Maera spp.									
Urothoe spp.									
Leucothoe spp.									
Listriella lindae									
Acidostoma obesum									
Hippomedon longimanus									

Species	DB1.1	DB1.2	DB1.3	DB1.4	DB1.5	DB1.6	DB2.1	DB2.2	DB2.3
Westwoodilla manta									
Paraphoxus oculatus								1	
Platyischnopus herdmani									
Podocerus brasiliensis									
Eupariambus fallax									
Hyperiidae									
Hyperiid B									
Cumacea B									
Pterygosquilla armata		1		2		1	3	2	1
Stomatopod juvenile									
Meiosquilla desmarestii									
Euphausiacea									
Carida A									1
Carida B									
Carida C (Mysidaea)									
Carida D									
Carida F									
Calocaris barnardi		2			2	4		4	
Callianassa spp.		1						1	1
Anomura A									
Goneplax angulata									
Mursia cristimanus									
PHYLUM MOLLUSCA									
Macoma spp.									
Tellina spp.									
Dosinia spp.									
Nucula nucleus									
Bivalve F									
Bivalve I									
Alvania fenestrata									
Clanculus spp.									
Epitonium kraussi									
Marginella spp.									
Nassarius spp.	34	6	22	11	89	21	23	66	36
Ocenebra spp.									
Pyramidella spp.									
Solariella agulhasensis									
Tricolia capensis									
Turris spp.									
Volutocorbis abyssicola		1			1				
Amphipholis squamata									
PHYLUM ECHINODERMATA									
Ophionereis porrecta									

Species	DB2.4	DB2.5	DB2.6	DB3.1	DB3.2	DB3.3	DB3.4	DB3.5	DB3.6
PHYLUM CNIDARIA									
Anthozoa A									
PHYLUM NEMERTEA									
Cerebratulus spp.	3						2		
Lineus spp.									
Nemertea B									
PHYLUM ANNELIDA									
Eunicidae									
Lumbrineris spp.	2	3	1	1	2	1		4	1
Arabella spp.			1						
Diopatra spp.	2	3							
Epidiopatra spp.									
Nereidae									
Nereis spp.									
Perinereis/Pseudonereis spp.									
Micronereides capensis									
Nephtyidae									
Nephtys spp.	1	3			8		3	6	2
Spionidae									
Prionospio pinnata	8	52	1	8	55	39	3	26	38
Spio spp.									
Laonice cirrata									
Haploscoloplos spp.									
Phylo spp.									
Capitellidae									
Notomastus spp.									
Maldanidae									
Euclymene luderitziana									
Maldanella capensis									
Petaloproctus spp.									
Sabellides spp.									
Ampharetidae									
Amphicteis gunneri									
Terebellides spp.									
Amaeana trilobata/Polycirrus									
Ancistrosyllis parva									
Flabelligeridae									
Flabelligera spp.									
Pectinaria capensis		3	1					2	
Cossura coasta					1				
PHYLUM ARTHROPODA									
Tanaid A									
Copepoda A									
Isopod A									
Ampelisca spp.	1	1			3	1		1	
Aoro kergeuleni									
Aorcho delgadus	1		1		2				
Corophiid Q									
Guernea rhomba									
Rhachotropis spp.									
Elasmopus affinis									
Ceradocus natalensis									
Maera spp.									
Urothoe spp.									
Leucothoe spp.									
Listriella lindae									
Acidostoma obesum									
Hippomedon longimanus									

Species	DB2.4	DB2.5	DB2.6	DB3.1	DB3.2	DB3.3	DB3.4	DB3.5	DB3.6
Westwoodilla manta									
Paraphoxus oculatus					1				
Platyischnopus herdmani									
Podocerus brasiliensis									
Eupariambus fallax									
Hyperiidae									
Hyperiid B									
Cumacea B									
Pterygosquilla armata	2	3				2	1		
Stomatopod juvenile									
Meiosquilla desmarestii									
Euphausiacea									
Carida A		1							
Carida B									
Carida C (Mysidaea)									
Carida D									
Carida F									
Calocaris barnardi	1	4	1		2	4	1	3	
Callianassa spp.									
Anomura A									
Goneplax angulata									
Mursia cristimanus									
PHYLUM MOLLUSCA									
Macoma spp.									
Tellina spp.					1			1	
Dosinia spp.									
Nucula nucleus									
Bivalve F									
Bivalve I									
Alvania fenestrata									
Clanculus spp.									
Epitonium kraussi					1				
Marginella spp.		1							
Nassarius spp.	5	118	17	21	217	38	11	4	17
Ocenebra spp.									
Pyramidella spp.									
Solariella agulhasensis									
Tricolia capensis									
Turris spp.									
Volutocorbis abyssicola									
Amphipholis squamata									
PHYLUM ECHINODERMATA									
Ophionereis porrecta									

Species	DB4.1	DB4.2	DB4.3	DB4.4	DB4.5	DB4.6	DB5.1	DB5.2	DB5.3
PHYLUM CNIDARIA									
Anthozoa A									
PHYLUM NEMERTEA									
Cerebratulus spp.	2	1		1					
Lineus spp.									
Nemertea B									
PHYLUM ANNELIDA									
Eunicidae									
Lumbrineris spp.	5	3	5	5	4	4		3	
Arabella spp.						2	1		
Diopatra spp.	4	7	7	2	1	12	1	2	
Epidiopatra spp.									
Nereidae									
Nereis spp.									
Perinereis/Pseudonereis spp.									
Micronereides capensis									
Nephtyidae									
Nephtys spp.	1			2	1				
Spionidae									
Prionospio pinnata	4	2	4	8	2	5			
Spio spp.									
Laonice cirrata									
Haploscoloplos spp.									
Phylo spp.									
Capitellidae									
Notomastus spp.									
Maldanidae									
Euclymene luderitziana									
Maldanella capensis									
Petaloproctus spp.									
Sabellides spp.									
Ampharetidae									
Amphicteis gunneri									
Terebellides spp.									
Amaeana trilobata/Polycirrus									
Ancistrosyllis parva						1			
Flabelligeridae									
Flabelligera spp.									
Pectinaria capensis									
Cossura coasta									
PHYLUM ARTHROPODA									
Tanaid A									
Copepoda A									
Isopod A									
Ampelisca spp.									
Aoro kergeuleni									
Aorcho delgadus		2	4	1		2			
Corophiid Q									
Guernea rhomba									
Rhachotropis spp.									
Elasmopus affinis									
Ceradocus natalensis									
Maera spp.									
Urothoe spp.									
Leucothoe spp.									
Listriella lindae									
Acidostoma obesum									
Hippomedon longimanus									

Species	DB4.1	DB4.2	DB4.3	DB4.4	DB4.5	DB4.6	DB5.1	DB5.2	DB5.3
Westwoodilla manta									
Paraphoxus oculatus									
Platyischnopus herdmani									
Podocerus brasiliensis									
Eupariambus fallax									
Hyperiidae		1							
Hyperiid B									
Cumacea B									
Pterygosquilla armata	2	1	1		3			3	
Stomatopod juvenile									
Meiosquilla desmarestii									
Euphausiacea									
Carida A									
Carida B									
Carida C (Mysidaea)									
Carida D									
Carida F									
Calocaris barnardi	3	1	3	4	3	3			
Callianassa spp.	6	1	6	4	6	2			
Anomura A									
Goneplax angulata									
Mursia cristimanus									
PHYLUM MOLLUSCA									
Macoma spp.									
Tellina spp.								1	
Dosinia spp.									
Nucula nucleus									
Bivalve F									
Bivalve I									
Alvania fenestrata									
Clanculus spp.									
Epitonium kraussi									
Marginella spp.									
Nassarius spp.	4			3	1	1	35	24	
Ocenebra spp.									
Pyramidella spp.									
Solariella agulhasensis									
Tricolia capensis									
Turris spp.									
Volutocorbis abyssicola									
Amphipholis squamata									
PHYLUM ECHINODERMATA									
Ophionereis porrecta									

Species	DB5.4	DB5.5	DB5.6
PHYLUM CNIDARIA			
Anthozoa A			
PHYLUM NEMERTEA			
Cerebratulus spp.			
Lineus spp.			
Nemertea B			
PHYLUM ANNELIDA			
Eunicidae			
Lumbrineris spp.	2		
Arabella spp.	2		1
Diopatra spp.	1	1	
Epidiopatra spp.			
Nereidae			
Nereis spp.			
Perinereis/Pseudonereis spp.			
Micronereides capensis			
Nephtyidae			
Nephtys spp.			
Spionidae			
Prionospio pinnata	3		
Spio spp.			
Laonice cirrata			
Haploscoloplos spp.			
Phylo spp.			
Capitellidae			
Notomastus spp.			
Maldanidae			
Euclymene luderitziana			
Maldanella capensis			
Petaloproctus spp.			
Sabellides spp.			
Ampharetidae			
Amphicteis gunneri			
Terebellides spp.			
Amaeana trilobata/Polycirrus			
Ancistrosyllis parva			
Flabelligeridae			
Flabelligera spp.			
Pectinaria capensis			
Cossura coasta			
PHYLUM ARTHROPODA			
Tanaid A			
Copepoda A			
Isopod A			
Ampelisca spp.			2
Aoro kergeuleni			
Aorcho delgadus			
Corophiid Q			
Guernea rhomba			
Rhachotropis spp.			
Elasmopus affinis			
Ceradocus natalensis			
Maera spp.			
Urothoe spp.			
Leucothoe spp.			
Listriella lindae			
Acidostoma obesum			
Hippomedon longimanus			

Species	DB5.4	DB5.5	DB5.6
Westwoodilla manta			1
Paraphoxus oculatus			
Platyischnopus herdmani			
Podocerus brasiliensis			
Eupariambus fallax			
Hyperiidae			
Hyperiid B			
Cumacea B			
Pterygosquilla armata		1	
Stomatopod juvenile			
Meiosquilla desmarestii			
Euphausiacea			
Carida A			
Carida B			
Carida C (Mysidaea)			
Carida D			
Carida F			
Calocaris barnardi			
Callianassa spp.			
Anomura A			
Goneplax angulata			
Mursia cristimanus			
PHYLUM MOLLUSCA			
Macoma spp.			
Tellina spp.			1
Dosinia spp.			
Nucula nucleus			
Bivalve F			
Bivalve I			
Alvania fenestrata			
Clanculus spp.			
Epitonium kraussi			
Marginella spp.			
Nassarius spp.	9	7	22
Ocenebra spp.			
Pyramidella spp.			
Solariella agulhasensis			
Tricolia capensis			
Turris spp.			
Volutocorbis abyssicola			
Amphipholis squamata			
PHYLUM ECHINODERMATA			
Ophionereis porrecta			

MACROFAUNA BIOMASS DATA FOR ALL SAMPLES FROM THE NORTHERN RESEARCH AREA.

Species	R1.1	R1.2	R1.3	R1.4	R1.5	R1.6	R1.7	R1.8	R1.9
PHYLUM PORIFERA									
Porifera A					0.1				
PHYLUM CNIDARIA									
Scyphozoa A									
Anthozoa A									
Anthozoa B									
Anthozoa D									
PHYLUM NEMERTEA									
Cerebratulus spp.		0.31	0.31				0.8	0.4	
Lineus spp.		0.4							
Nemertea B									
Nemertea C					0.3		0.1		
Nemertea D									
Siphunculid A									
Siphunculid B									
PHYLUM ANNELIDA									
Lumbrineris spp.	1.18	0.93	0.27	0.3	2.1	0.82	0.62	0.28	2.67
Arabella spp.	0.9	0.7		0.1			0.9		
Diopatra spp.			0.29	1.8	0.1			0.4	
Glyceridae							0.2		
Nereidae									
Nereis spp.	0.2					0.1			
Perinereis/Pseudonereis spp.									
Nephtys spp.	0.5	0.2	0.3		0.3			0.3	
Spionidae									
Prionospio pinnata	0.43	0.14	0.23	0.13	0.25	0.25	0.8	0.19	0.4
Spio spp.									
Spiophanes spp.			0.2						
Laonice cirrata			0.1		0.1	0.2	0.4		0.6
Spionid O								0.2	
Spionid P									
Polydora spp.				0.1					
Orbiniidae		0.1	0.3		0.4			0.1	
Haploscoloplos spp.						0.2	0.5		0.3
Scoloplos spp.									
Phylo spp.		0.19	1.12	0.8			0.5		
Naineris spp.									
Orbiniidae B									
Orbinia angrapaquensis						0.1			
Poly BB									
Poly WW									
Paraonidae			0.1						
Cirrophorus branchiatus				0.1					
Ophelia spp.	0.1								
Capitellidae									
Notomastus spp.	0.13								
Maldanidae		0.2	0.16				0.2	0.2	
Maldaninae A					0.4				
Maldaninae B				0.1					
Euclymene luderitziana				0.5			0.3		0.4

Species	R1.1	R1.2	R1.3	R1.4	R1.5	R1.6	R1.7	R1.8	R1.9
Petaloproctus spp.				0.1					
Rhodine gracilior									
Sabellides spp.	0.2								
Ampharetidae		0.4							
Amphicteis gunneri			0.7			0.9	0.1		0.1
Ampharete spp.A									
Terebellidae			0.1						
Trichobranchus glacialis									
Terebellides spp.	0.39				0.5				
Amaeana trilobata/Polycirrus									
Flabelligera spp.									
Pectinariidae								0.2	
Poly UU									
PHYLUM ARTHROPODA									
Copepoda A									
Myodocopa									
Isopod A									
Arcturidae									
Arcturidae A			0.1						
Arcturid B						0.1			
Arcturid C									
Arcturid D							0.1		
Cirolana spp.									
Microarcturus quadriconus									
New amphipod									
Ampelisca spp.	0.1	0.3	0.2	0.1	0.1	0.5	0.3	0.3	0.1
Aoro kergeuleni									
Aorcho delgadus		0.1				0.1			
Corophiid A (Gammaropsis)				0.1			0.1		
Corophiid Q									
Atylus swammerdamei									
Guernea rhomba									
Paramoera capensis									
Maera spp.									
Urothoe spp.	0.1	0.1					0.1		0.1
Leucothoe spp.			0.1						
Acidostoma obesum					0.1				
Hippomedon longimanus	0.7	0.4	0.8	0.6	0.6	0.4	0.6	0.1	0.1
Euonyx biscayensis									
Socarnopsis crenulata									
Monoculodopsis longimana									
Oediceroides cinderella									
Perioculodes spp.								0.1	
Westwoodilla manta									0.1
Paraphoxus oculatus							0.1		0.1
Platyischnopus herdmani									
Podocerus brasiliensis									
Podoceropsis sophiae									
Eupariambus fallax		0.1	0.1				0.1		
Phtisca marina					0.1				
Hyperiidae					0.2				0.1
Hyperiid B									
Ingolfiellid A			0.1						
Ingolfiellid B									
Ingolfiellid C						0.1			
Cumacea A					0.1				
Cumacea C									

Species	R1.1	R1.2	R1.3	R1.4	R1.5	R1.6	R1.7	R1.8	R1.9
Leptostraca A									
Pterygosquilla armata									
Stomatopoda B									
Stomatopod juvenile									
Misidacea spp.									
Gastrosaccus psammodytes					0.1				
Euphausiacea	0.1	0.1	0.1		0.2	0.1	0.1	0.2	0.1
Penaeid A									
Penaeid B									
Penaeid C									
Carida B									
Carida C (Mysidaea)		0.1							
Carida F			0.1						
Anomura									
Calocaris barnardi			0.1						
Callianassa spp.	0.1		0.1		0.1	0.1		0.2	
Anomura A									
Goneplax angulata	0.1	0.34	0.1	0.8	0.83		0.12	0.99	0.2
Mursia cristimanus		7.55							
Brachyura A									
Brachyura B									
Brachyura C					0.1				
PHYLUM BRACHIOPODA									
Terebratulina meridionalis									
PHYLUM MOLLUSCA									
Ischnochiton bergoti				0.1					
Macoma spp.	0.1	0.1	0.8	0.1	0.8		0.4	0.1	0.3
Tellina spp.	0.8								
Dosinia spp.	0.1	0.3	0.4		0.19	0.6	0.4	0.1	0.6
Nucula nucleus				0.5					
Bivalve F									
Bivalve M									
Alvania fenestrata									
Bullia digitalis									
Charitodoron euphrosyne									
Epitonium kraussi			0.7						
Gibbula spp.									
Heliacus variegata									
Marginella spp.		1.37	0.2		0.1	0.3		0.8	
Melanella spp.									
Nassarius spp.		0.49	0.71		0.87	0.22	0.1	0.39	
Natica tecta									
Ocenebra spp.									
Protomella capensis									
Pyramidella spp.									
Solariella agulhasensis									
Tricolia capensis			0.1		0.1		0.4		
Triphora africana									
Turris spp.									
Turritella spp.									
Volutocorbis abyssicola									
Volvarina capensis									
Sepia spp.									
Cucumaria spp.									
Amphipholis squamata									
PHYLUM ECHINODERMATA									
Ophionereis porrecta					0.1				
Henricia spp.									

Species	R1.10	R1.11	R2.1	R2.2	R2.3	R2.4	R2.5	R2.6	R2.7
Terebellides spp.			0.26		0.39	0.44			0.5
Amaeana trilobata/Polycirrus								0.5	
Flabelligera spp.							0.18		
Pectinariidae									
Poly UU									0.1
PHYLUM ARTHROPODA									
Copepoda A									
Myodocopa									
Isopod A									
Arcturidae									
Arcturidae A		0.1							0.1
Arcturid B									
Arcturid C									
Arcturid D									
Cirolana spp.									
Microarcturus quadriconus									
New amphipod									
Ampelisca spp.	0.3	0.2	0.11	0.3	0.3	0.7	0.7	0.7	0.7
Aoro kergeuleni									0.1
Aorcho delgadus									
Corophiid A (Gammaropsis)				0.1			0.1		
Corophiid Q									0.1
Atylus swammerdamei									
Guernea rhomba									
Paramoera capensis							0.1		
Maera spp.			0.1	0.1					
Urothoe spp.	0.1	0.1		0.1				0.1	
Leucothoe spp.		0.1					0.1	0.1	
Acidostoma obesum				0.1					
Hippomedon longimanus	0.4	0.4	0.1	0.4	0.1	0.3		0.1	0.4
Euonyx biscayensis									
Socarnopsis crenulata									
Monoculodopsis longimana									
Oediceroides cinderella		0.1							
Perioculodes spp.									
Westwoodilla manta			0.1			0.1			
Paraphoxus oculatus									0.1
Platyischnopus herdmani									
Podocerus brasiliensis									
Podoceropsis sophiae									
Eupariambus fallax									
Phtisca marina									
Hyperiidae					0.1		0.1		
Hyperiid B									
Ingolfiellid A	0.1		0.1	0.1					
Ingolfiellid B					0.1				
Ingolfiellid C									
Cumacea A		0.1				0.1	0.1		
Cumacea C									
Leptostraca A							0.1		
Pterygosquilla armata									
Stomatopoda B									
Stomatopod juvenile						0.1			
Misidacea spp.									
Gastrosaccus psammodytes									
Euphausiacea	0.2		0.1			0.1	0.4	0.3	0.5
Penaeid A									

Species	R1.10	R1.11	R2.1	R2.2	R2.3	R2.4	R2.5	R2.6	R2.7
Penaeid B									
Penaeid C									
Carida B				0.7					
Carida C (Mysidaea)									
Carida F									
Anomura									
Calocaris barnardi	0.1								
Callianassa spp.		0.1	0.1	0.1	0.1	0.1		0.1	0.2
Anomura A				0.5	0.19	0.1	0.3		0.1
Goneplax angulata	0.31		0.5	1.12	1.19	0.23	0.5	0.5	0.9
Mursia cristimanus		5							
Brachyura A									
Brachyura B									
Brachyura C								0.1	
PHYLUM BRACHIOPODA									
Terebratulina meridionalis									
PHYLUM MOLLUSCA									
Ischnochiton bergoti									
Macoma spp.	0.15	0.1	0.1	0.5	0.11	0.2	0.1	0.4	0.1
Tellina spp.	0.14		0.1			0.1			
Dosinia spp.	0.1	0.8	0.8	0.28	0.1		0.1	0.1	0.14
Nucula nucleus									
Bivalve F						0.1		0.1	
Bivalve M									
Alvania fenestrata									
Bullia digitalis									
Charitodoron euphrosyne									
Epitonium kraussi									
Gibbula spp.									
Heliacus variegata				0.14					
Marginella spp.			0.4	0.6			0.23		
Melanella spp.									
Nassarius spp.	0.2	0.1	2.17	1.23		0.18			
Natica tecta									
Ocenebra spp.									
Protomella capensis									
Pyramidella spp.									
Solariella agulhasensis									
Tricolia capensis									
Triphora africana									
Turris spp.				0.45					
Turritella spp.									
Volutocorbis abyssicola									
Volvarina capensis									
Sepia spp.									
Cucumaria spp.									
Amphipholis squamata									
PHYLUM ECHINODERMATA									
Ophionereis porrecta	0.5								
Henricia spp.									

Species	R1.10	R1.11	R2.1	R2.2	R2.3	R2.4	R2.5	R2.6	R2.7
PHYLUM PORIFERA									
Porifera A									
PHYLUM CNIDARIA									
Scyphozoa A									
Anthozoa A					0.14				
Anthozoa B									
Anthozoa D									
PHYLUM NEMERTEA									
Cerebratulus spp.			0.3	0.15			0.5		
Lineus spp.	0.6						0.2		
Nemertea B									
Nemertea C				0.9					
Nemertea D									
Siphunculid A									
Siphunculid B									
PHYLUM ANNELIDA									
Lumbrineris spp.	0.26	0.52	2.18	0.76	2.63	1.22	1.39	1.27	0.43
Arabella spp.									0.3
Diopatra spp.			0.44		0.3			0.96	1.9
Glyceridae									
Nereidae			0.1	0.4					
Nereis spp.									
Perinereis/Pseudonereis spp.									
Nephtys spp.	0.12		0.6	0.4	0.8			0.2	0.8
Spionidae									
Prionospio pinnata	0.4	0.24	0.43	0.44	0.19	0.75	0.43	1.73	0.51
Spio spp.									
Spiophanes spp.									0.1
Laonice cirrata		0.1	0.9					0.8	0.6
Spionid O					0.1		0.5		
Spionid P									0.1
Polydora spp.									
Orbiniidae	0.12		0.13	0.22		0.5			0.1
Haploscoloplos spp.		0.1			0.3			0.9	0.7
Scoloplos spp.						0.1			0.1
Phylo spp.	0.2							0.39	
Naineris spp.									
Orbiniidae B							0.8		
Orbinia angrapaquensis									
Poly BB					0.21				
Poly WW									
Paraonidae									0.1
Cirrophorus branchiatus									
Ophelia spp.									
Capitellidae									
Notomastus spp.				0.12					0.2
Maldanidae	0.16	0.2	0.1	0.1		0.3			
Maldaninae A									
Maldaninae B									
Euclymene luderitziana									0.1
Petaloproctus spp.									
Rhodine gracilior									
Sabellides spp.									
Ampharetidae	0.9								
Amphicteis gunneri		0.1							
Ampharete spp.A									
Terebellidae				0.23		0.12			
Trichobranchus glacialis									

Species	R2.8	R2.9	R2.10	R3.1	R3.2	R3.3	R3.4	R3.5	R3.6
PHYLUM PORIFERA									
Porifera A									
PHYLUM CNIDARIA									
Scyphozoa A		0.1							
Anthozoa A								0.83	
Anthozoa B						0.8			
Anthozoa D				0.2					
PHYLUM NEMERTEA									
Cerebratulus spp.	0.6			0.9					0.8
Lineus spp.									
Nemertea B									
Nemertea C	0.2								
Nemertea D				0.1					
Siphunculid A				0.39					
Siphunculid B				0.73					
PHYLUM ANNELIDA									
Lumbrineris spp.	1.75	0.3	0.16	3.81	0.15	0.76			0.11
Arabella spp.	0.74							0.4	
Diopatra spp.	0.4								
Glyceridae									
Nereidae									
Nereis spp.									
Perinereis/Pseudonereis spp.									
Nephtys spp.	0.8			0.13					
Spionidae									
Prionospio pinnata	0.5	0.2	0.36	0.1		0.3	0.1	0.1	0.8
Spio spp.	0.1					0.1			
Spiophanes spp.						0.1			
Laonice cirrata			0.2	0.1		0.3			0.1
Spionid O									
Spionid P									
Polydora spp.									
Orbiniidae			0.7	0.1					0.5
Haploscoloplos spp.	0.3	0.2							
Scoloplos spp.									
Phylo spp.								0.35	
Naineris spp.									
Orbiniidae B				0.9					
Orbinia angrapaquensis									
Poly BB									
Poly WW									
Paraonidae									
Cirrophorus branchiatus									
Ophelia spp.						0.2			
Capitellidae									
Notomastus spp.	0.34				0.1				
Maldanidae									
Maldaninae A									
Maldaninae B									
Euclymene luderitziana									
Petaloproctus spp.									0.8
Rhodine gracilior									
Sabellides spp.									
Ampharetidae							0.1		
Amphicteis gunneri									0.6
Ampharete spp.A									
Terebellidae									
Trichobranchus glacialis									

Species	R2.8	R2.9	R2.10	R3.1	R3.2	R3.3	R3.4	R3.5	R3.6
Terebellides spp.	0.3		1.22	0.12		0.8		0.39	0.58
Amaeana trilobata/Polycirrus	1.57								
Flabelligera spp.									
Pectinariidae									
Poly UU									
PHYLUM ARTHROPODA									
Copepoda A									
Myodocopa		0.1							
Isopod A									
Arcturidae									0.1
Arcturidae A	0.1								
Arcturid B									
Arcturid C	0.1								
Arcturid D									
Cirolana spp.	0.2					0.3	0.3		
Microarcturus quadriconus									
New amphipod				0.1					
Ampelisca spp.	0.5	0.2	0.6	0.2		0.3	0.1		0.13
Aoro kergeuleni									
Aorcho delgadus	0.1	0.1				0.1			0.1
Corophiid A (Gammaropsis)									
Corophiid Q									
Atylus swammerdamei									
Guernea rhomba									
Paramoera capensis									
Maera spp.									
Urothoe spp.	0.1								
Leucothoe spp.	0.1		0.1	0.1					0.1
Acidostoma obesum	0.1	0.1					1.2		
Hippomedon longimanus	0.4	0.1		0.2					0.1
Euonyx biscayensis									
Socarnopsis crenulata									
Monoculodopsis longimana									
Oediceroides cinderella		0.1							
Perioculodes spp.			0.1						
Westwoodilla manta									
Paraphoxus oculatus	0.1								
Platyischnopus herdmani	0.1								
Podocerus brasiliensis			0.1						
Podoceropsis sophiae		0.1							
Eupariambus fallax									
Phtisca marina	0.1								0.1
Hyperiidae	0.1		0.1				0.1		0.1
Hyperiid B									
Ingolfiellid A	0.1								
Ingolfiellid B									
Ingolfiellid C									
Cumacea A	0.1								
Cumacea C									
Leptostraca A									
Pterygosquilla armata									
Stomatopoda B									
Stomatopod juvenile									
Misidacea spp.									
Gastrosaccus psammodytes									
Euphausiacea	0.2	0.5	0.1	0.1		0.1	0.1		0.2
Penaeid A									

Species	R2.8	R2.9	R2.10	R3.1	R3.2	R3.3	R3.4	R3.5	R3.6
Penaeid B									0.2
Penaeid C									
Carida B	0.3		0.1			0.1	0.1		
Carida C (Mysidaea)	0.1								
Carida F									
Anomura									
Calocaris barnardi									
Callianassa spp.	2.1		0.1						
Anomura A			0.1	0.1	0.5	0.1	0.1	0.1	0.1
Goneplax angulata	0.28	0.1	0.8	3.56	0.1	0.25	0.4		0.1
Mursia cristimanus									
Brachyura A								0.31	
Brachyura B									
Brachyura C									
PHYLUM BRACHIOPODA									
Terebratulina meridionalis		0.3							
PHYLUM MOLLUSCA									
Ischnochiton bergoti									
Macoma spp.	0.3		0.5	0.53	0.1	0.1			0.12
Tellina spp.									
Dosinia spp.	0.44		0.1	0.6		0.5			
Nucula nucleus									
Bivalve F	0.1	0.2	0.1	0.5					0.2
Bivalve M									
Alvania fenestrata									
Bullia digitalis									
Charitodoron euphrosyne									
Epitonium kraussi									
Gibbula spp.									
Heliacus variegata			0.15						
Marginella spp.	0.29	0.5	0.2	0.5	0.3	0.91	0.2		1.91
Melanella spp.									
Nassarius spp.	4.46	0.3	0.28	0.64	0.2	0.11	0.47		0.2
Natica tecta	0.17								
Ocenebra spp.									
Protomella capensis									
Pyramidella spp.				0.2					
Solariella agulhasensis				0.1					
Tricolia capensis				0.2	0.1				
Triphora africana				0.1					
Turris spp.									
Turritella spp.	0.9								
Volutocorbis abyssicola									
Volvarina capensis									
Sepia spp.									
Cucumaria spp.									
Amphipholis squamata									
PHYLUM ECHINODERMATA									
Ophionereis porrecta						0.1			0.1
Henricia spp.									

Species	R3.7	R3.8	R3.9	R3.10	R4.1	R4.2	R4.3	R4.4	R4.5
PHYLUM PORIFERA									
Porifera A									
PHYLUM CNIDARIA									
Scyphozoa A									
Anthozoa A		1.75							
Anthozoa B		0.11							
Anthozoa D									
PHYLUM NEMERTEA									
Cerebratulus spp.		0.7		0.5					0.2
Lineus spp.									
Nemertea B							0.86		
Nemertea C		0.1							
Nemertea D									
Siphunculid A									0.65
Siphunculid B									1
PHYLUM ANNELIDA									
Lumbrineris spp.	0.1	3.17	1.75	1.54	0.2	0.1	1.81	2.73	4.11
Arabella spp.								0.1	
Diopatra spp.									
Glyceridae									
Nereidae									
Nereis spp.			0.1	0.7					0.2
Perinereis/Pseudonereis spp.									
Nephtys spp.		0.41	0.15	0.42		0.1	0.7	0.9	0.2
Spionidae									
Prionospio pinnata	0.5	0.47	0.33	0.27	0.13	0.1	0.18	0.2	0.6
Spio spp.									
Spiophanes spp.									
Laonice cirrata		0.1	0.2		0.1		0.1		
Spionid O									
Spionid P									
Polydora spp.									
Orbiniidae		0.5							
Haploscoloplos spp.	0.1	0.1	0.3	0.1	0.1		0.1		0.3
Scoloplos spp.									
Phylo spp.									
Naineris spp.									
Orbiniidae B									
Orbinia angrapaquensis									
Poly BB									
Poly WW									0.1
Paraonidae									
Cirrophorus branchiatus									
Ophelia spp.									0.1
Capitellidae									
Notomastus spp.									
Maldanidae									
Maldaninae A									
Maldaninae B									
Euclymene luderitziana				0.5					
Petaloproctus spp.									
Rhodine gracilior									
Sabellides spp.									
Ampharetidae									
Amphicteis gunneri		0.5							
Ampharete spp.A									
Terebellidae									
Trichobranchus glacialis									

Species	R3.7	R3.8	R3.9	R3.10	R4.1	R4.2	R4.3	R4.4	R4.5
Terebellides spp.	0.1	0.34	0.14	0.5	0.9	0.1	0.33		0.2
Amaeana trilobata/Polycirrus									
Flabelligera spp.									
Pectinariidae									
Poly UU									
PHYLUM ARTHROPODA									
Copepoda A			0.1						
Myodocopa									
Isopod A							0.1		
Arcturidae									
Arcturidae A									
Arcturid B									
Arcturid C									
Arcturid D									
Cirolana spp.									
Microarcturus quadriconus					0.1				
New amphipod									
Ampelisca spp.		0.2	0.3	0.3	0.4		0.4	0.1	0.1
Aoro kergeuleni									
Aorcho delgadus									
Corophiid A (Gammaropsis)									
Corophiid Q									
Atylus swammerdamei					0.1			0.1	
Guernea rhomba					0.1				
Paramoera capensis									
Maera spp.									
Urothoe spp.									
Leucothoe spp.		0.1		0.1					0.1
Acidostoma obesum		0.1	0.1			0.1			
Hippomedon longimanus		0.1	0.1	0.3				0.1	
Euonyx biscayensis									
Socarnopsis crenulata									
Monoculodopsis longimana					0.1				
Oediceroides cinderella									
Perioculodes spp.		0.1							
Westwoodilla manta		0.1					0.1		
Paraphoxus oculatus			0.1	0.1					
Platyischnopus herdmani									
Podocerus brasiliensis									
Podoceropsis sophiae									
Eupariambus fallax									
Phtisca marina									
Hyperiidae		0.1	0.1		0.1		0.1		0.1
Hyperiid B									
Ingolfiellid A									
Ingolfiellid B									
Ingolfiellid C									
Cumacea A									
Cumacea C									
Leptostraca A									
Pterygosquilla armata									
Stomatopoda B				0.1					
Stomatopod juvenile									
Misidacea spp.									
Gastrosaccus psammodytes									
Euphausiacea		0.1		0.1	0.2		0.1	0.1	
Penaeid A									

Species	R3.7	R3.8	R3.9	R3.10	R4.1	R4.2	R4.3	R4.4	R4.5
Penaeid B									0.2
Penaeid C									
Carida B			0.1						
Carida C (Mysidaea)									
Carida F									
Anomura									
Calocaris barnardi									0.1
Callianassa spp.		0.5	0.1	0.1			0.1	0.1	
Anomura A		0.1	0.1						0.1
Goneplax angulata		1.6	0.9	1.14	0.1	0.5	1.63	0.7	0.62
Mursia cristimanus								1.83	
Brachyura A									
Brachyura B									
Brachyura C									
PHYLUM BRACHIOPODA									
Terebratulina meridionalis									
PHYLUM MOLLUSCA									
Ischnochiton bergoti			0.83						
Macoma spp.		0.24	0.6	0.4	0.1	0.53	0.8	0.49	0.7
Tellina spp.									
Dosinia spp.		0.13		0.3			0.2	0.1	0.1
Nucula nucleus			0.61		2.1		0.68		1.1
Bivalve F		0.2	0.11						0.1
Bivalve M									
Alvania fenestrata									
Bullia digitalis									
Charitodoron euphrosyne									
Epitonium kraussi									
Gibbula spp.									
Heliacus variegata									
Marginella spp.		0.2	0.3	0.4	0.6		0.1	0.1	0.11
Melanella spp.									
Nassarius spp.		0.64	0.1	0.13		3.8	6.3		0.42
Natica tecta									
Ocenebra spp.									
Protomella capensis									
Pyramidella spp.									
Solariella agulhasensis									
Tricolia capensis									
Triphora africana									
Turris spp.		0.4							
Turritella spp.									
Volutocorbis abyssicola									
Volvarina capensis									
Sepia spp.									
Cucumaria spp.									
Amphipholis squamata									
PHYLUM ECHINODERMATA									
Ophionereis porrecta									
Henricia spp.									

Species	R4.6	R4.7	R4.8	R4.9	R4.10	S1.1	S1.5	S1.11	S1.14
PHYLUM PORIFERA									
Porifera A									
PHYLUM CNIDARIA									
Scyphozoa A									
Anthozoa A									
Anthozoa B									
Anthozoa D									
PHYLUM NEMERTEA									
Cerebratulus spp.			0.1						
Lineus spp.									
Nemertea B									
Nemertea C			0.7						
Nemertea D									
Siphunculid A									
Siphunculid B						0.9			
PHYLUM ANNELIDA									
Lumbrineris spp.	0.1	1.59	0.14	0.1	0.1	0.1	0.2	0.12	0.3
Arabella spp.	0.41								
Diopatra spp.	0.5		0.18						
Glyceridae									
Nereidae									
Nereis spp.	0.1		0.21						
Perinereis/Pseudonereis spp.							0.4		
Nephtys spp.	0.15	0.4	0.9					0.8	0.3
Spionidae									
Prionospio pinnata	0.2	0.4	0.1	0.1	0.1	0.15	0.8	0.3	0.3
Spio spp.									
Spiophanes spp.			0.1						0.1
Laonice cirrata	0.1	0.2			0.4			0.1	
Spionid O			0.2						
Spionid P									
Polydora spp.									
Orbiniidae			0.3		0.1				
Haploscoloplos spp.						0.1	0.1	0.4	0.13
Scoloplos spp.									
Phylo spp.									
Naineris spp.									
Orbiniidae B									
Orbinia angrapaquensis									0.2
Poly BB									
Poly WW									
Paraonidae									
Cirrophorus branchiatus									0.1
Ophelia spp.	0.1								
Capitellidae									
Notomastus spp.					0.4			0.1	0.5
Maldanidae			0.1					0.1	0.1
Maldaninae A									
Maldaninae B									
Euclymene luderitziana									
Petaloproctus spp.									
Rhodine gracilior								0.1	
Sabellides spp.			0.13						
Ampharetidae			0.9						
Amphicteis gunneri	0.8	0.1							
Ampharete spp.A									
Terebellidae									
Trichobranchus glacialis									

Species	R4.6	R4.7	R4.8	R4.9	R4.10	S1.1	S1.5	S1.11	S1.14
Terebellides spp.	0.31	0.7	1.88	0.16	0.1			0.8	
Amaeana trilobata/Polycirrus									
Flabelligera spp.									
Pectinariidae									
Poly UU									
PHYLUM ARTHROPODA									
Copepoda A						0.1			
Myodocopa									
Isopod A									
Arcturidae									0.1
Arcturidae A									
Arcturid B									
Arcturid C									
Arcturid D									
Cirolana spp.			0.2						
Microarcturus quadriconus			0.1						
New amphipod									
Ampelisca spp.	0.1	0.3	0.3					0.1	0.2
Aoro kergeuleni									
Aorcho delgadus	0.1		0.1						
Corophiid A (Gammaropsis)									
Corophiid Q									
Atylus swammerdamei									
Guernea rhomba									
Paramoera capensis									
Maera spp.									
Urothoe spp.									
Leucothoe spp.		0.1	0.1					0.1	0.1
Acidostoma obesum	0.1		0.1						0.1
Hippomedon longimanus	0.1	0.9	0.13	0.1		0.3	0.2	0.3	0.1
Euonyx biscayensis									
Socarnopsis crenulata									
Monoculodopsis longimana									
Oediceroides cinderella									
Perioculodes spp.									
Westwoodilla manta									
Paraphoxus oculatus								0.1	
Platyischnopus herdmani									
Podocerus brasiliensis									
Podoceropsis sophiae									
Eupariambus fallax			0.1						
Phtisca marina									
Hyperiidae									0.1
Hyperiid B									
Ingolfiellid A									
Ingolfiellid B									
Ingolfiellid C									
Cumacea A							0.1		0.1
Cumacea C									
Leptostraca A									
Pterygosquilla armata	0.69								
Stomatopoda B									
Stomatopod juvenile									
Misidacea spp.									
Gastrosaccus psammodytes									
Euphausiacea									
Penaeid A									

Species	R4.6	R4.7	R4.8	R4.9	R4.10	S1.1	S1.5	S1.11	S1.14
Penaeid B									
Penaeid C									0.3
Carida B									
Carida C (Mysidaea)			0.1				0.1		
Carida F									
Anomura									
Calocaris barnardi									
Callianassa spp.									
Anomura A		0.1	0.1						
Goneplax angulata	0.17	0.56	0.34	0.1					
Mursia cristimanus			5.31						
Brachyura A									
Brachyura B									
Brachyura C									
PHYLUM BRACHIOPODA									
Terebratulina meridionalis									
PHYLUM MOLLUSCA									
Ischnochiton bergoti					0.27				
Macoma spp.	0.82	0.44	1.8	0.4	0.6	0.2	0.3	0.7	0.43
Tellina spp.			0.18					0.1	
Dosinia spp.	0.2		0.9			0.1	0.5		
Nucula nucleus				0.42	0.56				
Bivalve F								0.1	0.1
Bivalve M									
Alvania fenestrata			0.1	0.1				0.1	0.1
Bullia digitalis						0.1	0.29		
Charitodoron euphrosyne								0.1	0.2
Epitonium kraussi			0.2				0.5	0.3	
Gibbula spp.						0.1			
Heliacus variegata						0.1			
Marginella spp.	0.1		0.1	0.3		0.12	0.1	0.1	0.1
Melanella spp.						0.2			
Nassarius spp.	0.8	0.1	0.44			0.2	2.99	0.35	0.38
Natica tecta									
Ocenebra spp.			0.2			0.1	0.6	0.1	
Protomella capensis						0.6	0.1		
Pyramidella spp.			0.2						
Solariella agulhasensis			0.22			0.1	0.5	0.3	
Tricolia capensis	0.1		0.13	0.2		0.8	0.9	0.11	0.1
Triphora africana									
Turris spp.									
Turritella spp.									
Volutocorbis abyssicola									
Volvarina capensis									
Sepia spp.									
Cucumaria spp.									
Amphipholis squamata									
PHYLUM ECHINODERMATA									
Ophionereis porrecta			0.1						
Henricia spp.			0.53						

Species	S1.15	S1.17	S2.2	S2.3	S2.4	S2.5	S2.6	S2.7	S3.1
PHYLUM PORIFERA									
Porifera A									
PHYLUM CNIDARIA									
Scyphozoa A									
Anthozoa A									
Anthozoa B									
Anthozoa D									
PHYLUM NEMERTEA									
Cerebratulus spp.	0.3								
Lineus spp.	0.1								
Nemertea B									
Nemertea C								0.2	
Nemertea D									
Siphunculid A									
Siphunculid B									
PHYLUM ANNELIDA									
Lumbrineris spp.	0.57	0.7	0.4	3.26	0.44	1.55	0.3	1.38	0.1
Arabella spp.	0.1								
Diopatra spp.								1.5	
Glyceridae									
Nereidae									
Nereis spp.	0.1								
Perinereis/Pseudonereis spp.									
Nephtys spp.	0.1			0.1	0.94	0.57			
Spionidae	0.1					0.2			
Prionospio pinnata	0.1	0.19	0.31	0.4	0.25	0.39	0.35	0.17	0.5
Spio spp.									
Spiophanes spp.		0.1							
Laonice cirrata	0.1	0.1	0.5			0.1	0.2		0.1
Spionid O									
Spionid P									
Polydora spp.									
Orbiniidae						0.3			
Haploscoloplos spp.	0.19	0.7	0.5	0.2		0.4	0.1		0.1
Scoloplos spp.									
Phylo spp.	0.1								
Naineris spp.									
Orbiniidae B	0.31								
Orbinia angrapaquensis								0.6	
Poly BB									
Poly WW									
Paraonidae									
Cirrophorus branchiatus									
Ophelia spp.									
Capitellidae								0.33	
Notomastus spp.									
Maldanidae	0.1	0.1							
Maldaninae A									
Maldaninae B									
Euclymene luderitziana									
Petaloproctus spp.									
Rhodine gracilior	0.1								
Sabellides spp.									
Ampharetidae									
Amphicteis gunneri	0.2							0.2	
Ampharete spp.A									
Terebellidae									
Trichobranchus glacialis									

Species	S1.15	S1.17	S2.2	S2.3	S2.4	S2.5	S2.6	S2.7	S3.1
Terebellides spp.			0.6		0.39				
Amaeana trilobata/Polycirrus						0.12			
Flabelligera spp.									
Pectinariidae									
Poly UU									
PHYLUM ARTHROPODA									
Copepoda A					0.1		0.1		
Myodocopa									
Isopod A									
Arcturidae	0.1								
Arcturidae A									
Arcturid B								0.1	
Arcturid C									
Arcturid D									
Cirolana spp.									
Microarcturus quadriconus									
New amphipod									
Ampelisca spp.		0.1	0.1	0.2	0.6	0.1	0.4	0.4	
Aoro kergeuleni									
Aorcho delgadus	0.1						0.1		
Corophiid A (Gammaropsis)									
Corophiid Q									
Atylus swammerdamei									
Guernea rhomba									
Paramoera capensis									
Maera spp.									
Urothoe spp.									
Leucothoe spp.	0.1	0.1			0.1	0.1	0.1	0.1	
Acidostoma obesum	0.1								
Hippomedon longimanus		0.18	0.1		0.2			0.1	
Euonyx biscayensis						0.2			
Socarnopsis crenulata									
Monoculodopsis longimana									
Oediceroides cinderella									
Perioculodes spp.		0.1							
Westwoodilla manta				0.1		0.1			
Paraphoxus oculatus									
Platyischnopus herdmani			0.1						
Podocerus brasiliensis									
Podoceropsis sophiae									
Eupariambus fallax									
Phtisca marina	0.1								
Hyperiidae	0.1		0.1			0.1			
Hyperiid B	0.1						0.1		
Ingolfiellid A	0.1								
Ingolfiellid B									
Ingolfiellid C									
Cumacea A			0.1						
Cumacea C									
Leptostraca A					0.1				
Pterygosquilla armata									
Stomatopoda B									
Stomatopod juvenile	0.1								
Misidacea spp.									
Gastrosaccus psammodytes									
Euphausiacea		0.1			0.2			0.1	
Penaeid A				0.6	0.3				

Species	S1.15	S1.17	S2.2	S2.3	S2.4	S2.5	S2.6	S2.7	S3.1
Penaeid B									
Penaeid C			0.12						
Carida B							0.1		
Carida C (Mysidaea)			0.1			0.1			
Carida F									
Anomura						0.1			
Calocaris barnardi									
Callianassa spp.					1.29				
Anomura A									
Goneplax angulata				0.21	0.2	1.61		0.7	
Mursia cristimanus									
Brachyura A									
Brachyura B					0.1				
Brachyura C									
PHYLUM BRACHIOPODA									
Terebratulina meridionalis					0.9		0.1	0.1	
PHYLUM MOLLUSCA									
Ischnochiton bergoti									
Macoma spp.	0.1	0.21	0.1		0.2	0.1	0.1	0.2	0.3
Tellina spp.									
Dosinia spp.	0.4						0.1	0.1	
Nucula nucleus									0.28
Bivalve F		0.1	0.14			0.4			
Bivalve M									
Alvania fenestrata	0.1								
Bullia digitalis									
Charitodoron euphrosyne									
Epitonium kraussi		0.5							
Gibbula spp.									
Heliacus variegata									
Marginella spp.	0.1		0.1	1.14	0.96			0.5	0.1
Melanella spp.									
Nassarius spp.	0.56	0.26		0.14	1.34		0.53	2.21	0.1
Natica tecta									
Ocenebra spp.		0.2							
Protomella capensis									
Pyramidella spp.									
Solariella agulhasensis		0.1							
Tricolia capensis	0.1	0.5							
Triphora africana									
Turris spp.									
Turritella spp.		0.4							
Volutocorbis abyssicola									
Volvarina capensis	0.1								
Sepia spp.									
Cucumaria spp.						2.19			
Amphipholis squamata							0.1		
PHYLUM ECHINODERMATA									
Ophionereis porrecta									
Henricia spp.									

Species	S3.2	S3.3	S3.4	S3.5	S3.7	S4.2	S4.6	S4.8	S4.9
PHYLUM PORIFERA									
Porifera A									
PHYLUM CNIDARIA									
Scyphozoa A									
Anthozoa A									
Anthozoa B									
Anthozoa D									
PHYLUM NEMERTEA									
Cerebratulus spp.						0.23			
Lineus spp.									
Nemertea B									
Nemertea C									
Nemertea D									
Siphunculid A									
Siphunculid B	3.72								
PHYLUM ANNELIDA									
Lumbrineris spp.	1.42	1.5	0.7	0.2	0.7	0.4	0.1	0.15	
Arabella spp.									
Diopatra spp.	0.3								
Glyceridae									
Nereidae									
Nereis spp.									
Perinereis/Pseudonereis spp.									
Nephtys spp.									
Spionidae									
Prionospio pinnata	0.1		0.11	0.1	0.1	0.5	0.1	0.2	0.13
Spio spp.									
Spiophanes spp.									
Laonice cirrata	0.1	0.2	0.3	0.1	0.1	0.6		0.2	
Spionid O									
Spionid P									
Polydora spp.									
Orbiniidae									
Haploscoloplos spp.	0.2	0.4	0.2	0.1					
Scoloplos spp.								0.1	
Phylo spp.									
Naineris spp.	0.29								
Orbiniidae B									
Orbinia angrapaquensis									
Poly BB									
Poly WW									
Paraonidae									
Cirrophorus branchiatus									
Ophelia spp.									
Capitellidae									
Notomastus spp.	0.2	0.2							
Maldanidae									
Maldaninae A									
Maldaninae B									
Euclymene luderitziana									
Petaloproctus spp.									
Rhodine gracilior									
Sabellides spp.									
Ampharetidae									
Amphicteis gunneri						0.1			
Ampharete spp.A	0.1								
Terebellidae									
Trichobranchus glacialis					0.14				

Species	S3.2	S3.3	S3.4	S3.5	S3.7	S4.2	S4.6	S4.8	S4.9
Terebellides spp.		0.1		0.3		0.45		0.14	
Amaeana trilobata/Polycirrus									
Flabelligera spp.						0.16			
Pectinariidae									
Poly UU									
PHYLUM ARTHROPODA									
Copepoda A	0.1			0.1					
Myodocopa									
Isopod A					0.1				
Arcturidae									
Arcturidae A									
Arcturid B									
Arcturid C									
Arcturid D									
Cirolana spp.									
Microarcturus quadriconus									
New amphipod									
Ampelisca spp.		0.1	0.1	0.2		0.3			
Aoro kergeuleni		0.1	0.1						
Aorcho delgadus	0.1			0.1				0.1	
Corophiid A (Gammaropsis)									
Corophiid Q									
Atylus swammerdamei									
Guernea rhomba									
Paramoera capensis									
Maera spp.	0.5	0.1			0.1				
Urothoe spp.									
Leucothoe spp.	0.2	0.1	0.1	0.2	0.1		0.1	0.1	
Acidostoma obesum	0.1	0.1	0.1	0.2	0.1				
Hippomedon longimanus			0.1	0.1		0.1			
Euonyx biscayensis									
Socarnopsis crenulata		0.1							
Monoculodopsis longimana									
Oediceroides cinderella									
Perioculodes spp.									
Westwoodilla manta						0.1			
Paraphoxus oculatus									
Platyischnopus herdmani									
Podocerus brasiliensis									
Podoceropsis sophiae									
Eupariambus fallax									
Phtisca marina									
Hyperiidae		0.1	0.1	0.1					
Hyperiid B	0.1				0.1				
Ingolfiellid A									
Ingolfiellid B									
Ingolfiellid C									
Cumacea A									
Cumacea C	0.1					0.1			
Leptostraca A									
Pterygosquilla armata									
Stomatopoda B									
Stomatopod juvenile				0.1					
Misidacea spp.								0.1	
Gastrosaccus psammodytes									
Euphausiacea		0.2							
Penaeid A									

Species	S3.2	S3.3	S3.4	S3.5	S3.7	S4.2	S4.6	S4.8	S4.9
Penaeid B									
Penaeid C		0.7	0.5		0.8	0.11		0.18	
Carida B				0.2					
Carida C (Mysidaea)									
Carida F									
Anomura	0.2	0.3	0.3	0.1					
Calocaris barnardi									
Callianassa spp.			0.1						
Anomura A					0.1				
Goneplax angulata		0.29	0.6		0.38			0.23	
Mursia cristimanus									
Brachyura A									
Brachyura B									
Brachyura C									
PHYLUM BRACHIOPODA									
Terebratulina meridionalis									
PHYLUM MOLLUSCA									
Ischnochiton bergoti	0.69								
Macoma spp.	0.5	0.9	0.9	0.4	0.3	0.14		0.28	
Tellina spp.	0.5	0.1		0.1					
Dosinia spp.	0.1								
Nucula nucleus					3			0.18	
Bivalve F					0.2				
Bivalve M	0.2								
Alvania fenestrata	0.1								
Bullia digitalis									
Charitodoron euphrosyne									
Epitonium kraussi		0.7							
Gibbula spp.	0.15								
Heliacus variegata									
Marginella spp.	0.1				0.1	0.1		2.9	
Melanella spp.									
Nassarius spp.	3.48	9.82	0.34	2.11	0.78	6.12		1.4	0.4
Natica tecta									
Ocenebra spp.	0.5	0.1						0.2	
Protomella capensis									
Pyramidella spp.			0.1					0.1	
Solariella agulhasensis		0.1	0.1	0.1					0.1
Tricolia capensis	0.7	0.3	0.3	0.1		0.1		0.11	
Triphora africana									
Turris spp.					0.84				
Turritella spp.									
Volutocorbis abyssicola						19.92			
Volvarina capensis									
Sepia spp.			0.12						
Cucumaria spp.									
Amphipholis squamata									
PHYLUM ECHINODERMATA									
Ophionereis porrecta									
Henricia spp.									

Species	S4.13	S4.14	S4.15
PHYLUM PORIFERA			
Porifera A			
PHYLUM CNIDARIA			
Scyphozoa A			
Anthozoa A			
Anthozoa B			
Anthozoa D			
PHYLUM NEMERTEA			
Cerebratulus spp.	0.8	0.2	
Lineus spp.			
Nemertea B			
Nemertea C			
Nemertea D			
Siphunculid A			
Siphunculid B			
PHYLUM ANNELIDA			
Lumbrineris spp.	1.1	0.2	0.3
Arabella spp.		0.41	
Diopatra spp.			
Glyceridae			
Nereidae			
Nereis spp.			
Perinereis/Pseudonereis spp.		0.1	
Nephtys spp.	0.28	0.89	
Spionidae			
Prionospio pinnata	0.6	0.12	
Spio spp.			
Spiophanes spp.			
Laonice cirrata		0.1	
Spionid O			
Spionid P			
Polydora spp.			
Orbiniidae			0.12
Haploscoloplos spp.	0.3	0.1	
Scoloplos spp.		0.15	0.16
Phylo spp.			
Naineris spp.			
Orbiniidae B			
Orbinia angrapaquensis			
Poly BB			
Poly WW			
Paraonidae			
Cirrophorus branchiatus			
Ophelia spp.			
Capitellidae			
Notomastus spp.			
Maldanidae			
Maldaninae A			
Maldaninae B			
Euclymene luderitziana			
Petaloproctus spp.			
Rhodine gracilior			
Sabellides spp.			
Ampharetidae			
Amphicteis gunneri			
Ampharete spp.A			
Terebellidae			
Trichobranchus glacialis			

Species	S4.13	S4.14	S4.15
Terebellides spp.	0.3		
Amaeana trilobata/Polycirrus			
Flabelligera spp.	0.25		
Pectinariidae			
Poly UU			
PHYLUM ARTHROPODA			
Copepoda A			
Myodocopa			
Isopod A			
Arcturidae			
Arcturidae A			
Arcturid B			
Arcturid C			
Arcturid D			
Cirolana spp.	0.3		
Microarcturus quadriconus			
New amphipod			
Ampelisca spp.	0.1	0.1	
Aoro kergeuleni			
Aorcho delgadus	0.1		
Corophiid A (Gammaropsis)			
Corophiid Q			
Atylus swammerdamei			
Guernea rhomba			
Paramoera capensis			
Maera spp.	0.5		
Urothoe spp.			
Leucothoe spp.	0.1		
Acidostoma obesum	0.11		
Hippomedon longimanus	0.1	0.1	
Euonyx biscayensis			
Socarnopsis crenulata			
Monoculodopsis longimana			
Oediceroides cinderella			
Perioculodes spp.			
Westwoodilla manta			
Paraphoxus oculatus			
Platyischnopus herdmani			
Podocerus brasiliensis			
Podoceropsis sophiae			
Eupariambus fallax			
Phtisca marina			
Hyperiidae			
Hyperiid B			
Ingolfiellid A			
Ingolfiellid B			
Ingolfiellid C			
Cumacea A			
Cumacea C			
Leptostraca A			
Pterygosquilla armata			
Stomatopoda B			
Stomatopod juvenile			
Misidacea spp.			
Gastrosaccus psammodytes			
Euphausiacea			
Penaeid A			

Species	S4.13	S4.14	S4.15
Penaeid B			
Penaeid C			
Carida B			
Carida C (Mysidaea)			
Carida F			
Anomura			
Calocaris barnardi			
Callianassa spp.			
Anomura A			
Goneplax angulata		1.5	
Mursia cristimanus			
Brachyura A			
Brachyura B			
Brachyura C			
PHYLUM BRACHIOPODA			
Terebratulina meridionalis			
PHYLUM MOLLUSCA			
Ischnochiton bergoti			
Macoma spp.	0.13	0.1	0.1
Tellina spp.		0.2	
Dosinia spp.		0.9	
Nucula nucleus			
Bivalve F	0.1		
Bivalve M			
Alvania fenestrata			0.1
Bullia digitalis			
Charitodoron euphrosyne			
Epitonium kraussi		0.2	
Gibbula spp.			
Heliacus variegata			
Marginella spp.			0.2
Melanella spp.			
Nassarius spp.	1.1	6.3	1.42
Natica tecta			
Ocenebra spp.			0.3
Protomella capensis			
Pyramidella spp.			0.1
Solariella agulhasensis		0.12	0.4
Tricolia capensis		0.9	0.6
Triphora africana			
Turris spp.			
Turritella spp.			
Volutocorbis abyssicola			
Volvarina capensis			
Sepia spp.			
Cucumaria spp.			
Amphipholis squamata			
PHYLUM ECHINODERMATA			
Ophionereis porrecta			
Henricia spp.			

MACROFAUNA BIOMASS DATA FOR ALL SAMPLES FROM THE SOUTHERN RESEARCH AREA.

Species	R5.1	R5.3	R5.4	R5.5	R5.6	R5.7	R5.8	R5.9	R5.10
PHYLUM CNIDARIA									
Anthozoa A									
PHYLUM NEMERTEA									
Cerebratulus spp.	0.65		0.16	0.1			0.64	0.3	0.85
Lineus spp.	0.5			0.6					
Nemertea B									
PHYLUM ANNELIDA									
Eunicidae									
Lumbrineris spp.	3.69	0.58	1.7	3.96	1.93	1.24	2.1	0.85	0.54
Arabella spp.				1.1		0.69		0.34	
Diopatra spp.	6.23	2.9	0.2	0.19	2.74	1.65		0.8	1.8
Epidiopatra spp.									
Nereidae									
Nereis spp.		0.34		0.24					
Perinereis/Pseudonereis spp.									
Micronereides capensis				0.1					
Nephtyidae	0.4		0.1				0.48		
Nephtys spp.				0.61	0.2	0.21		0.1	
Spionidae									
Prionospio pinnata	0.2	0.2	0.1	0.53	0.37	0.54	0.17	0.86	0.17
Spio spp.									
Laonice cirrata		0.1						0.1	
Haploscoloplos spp.					0.2			0.4	
Phylo spp.								0.87	
Capitellidae									
Notomastus spp.		0.1							
Maldanidae	0.1				0.1				
Euclymene luderitziana		0.1							
Maldanella capensis									
Petaloproctus spp.									
Sabellides spp.		0.8							
Ampharetidae			0.39	0.3					
Amphicteis gunneri		0.36							
Terebellides spp.	1.44	12.27	0.49	0.49	0.61			2.6	1.34
Amaeana trilobata/Polycirrus						0.5	0.5		0.3
Ancistrosyllis parva									
Flabelligeridae			0.58						
Flabelligera spp.									
Pectinaria capensis									
Cossura coasta									
PHYLUM ARTHROPODA									
Tanaid A									
Copepoda A						0.1	0.1		
Isopod A									
Ampelisca spp.			0.1	0.1	0.3	0.2	0.3	0.7	0.1
Aoro kergeuleni									
Aorcho delgadus		0.1							
Corophiid Q								0.1	
Guernea rhomba									
Rhachotropis spp.						0.1			

Species	R5.1	R5.3	R5.4	R5.5	R5.6	R5.7	R5.8	R5.9	R5.10
Elasmopus affinis			0.1						
Ceradocus natalensis									
Maera spp.					0.1				
Urothoe spp.									
Leucothoe spp.				0.4					
Listriella lindae		0.1			0.3		0.1		
Acidostoma obesum		0.1		0.1					
Hippomedon longimanus				0.1	0.1		0.1		
Westwoodilla manta				0.1	0.1	0.1	0.3		
Paraphoxus oculatus			0.1					0.1	
Platyischnopus herdmani					0.1				
Podocerus brasiliensis									
Eupariambus fallax									
Hyperiidae					0.1	0.1	0.1	0.1	
Hyperiid B									
Cumacea B									
Pterygosquilla armata	6.7	2.15		1.46	24.7	0.5			
Stomatopod juvenile							0.1	0.1	
Meiosquilla desmarestii									
Euphausiacea			0.1	0.5	0.6		0.1	0.1	0.1
Carida A							0.14		
Carida B		0.1							
Carida C (Mysidaea)		0.1			0.1	0.1	0.1		
Carida D		0.1				0.2			
Carida F				0.3	0.1		0.5		
Calocaris barnardi	0.76	2.34		0.8	0.58	0.31		0.16	0.12
Callianassa spp.	3.14	0.2	0.1	3.67	2.35	1.9	1.26	0.1	
Anomura A		0.1							
Goneplax angulata	2.99			1.53	0.2	0.9	0.65	2.1	0.1
Mursia cristimanus									
PHYLUM MOLLUSCA									
Macoma spp.	0.4	0.6		0.3	0.3	0.1	0.2	0.6	
Tellina spp.									
Dosinia spp.									
Nucula nucleus			0.78			0.13		0.1	
Bivalve F			0.1						
Bivalve I									
Alvania fenestrata									
Clanculus spp.									
Epitonium kraussi									
Marginella spp.				0.1		0.3			
Nassarius spp.	0.1	0.8	0.26	0.23		0.25		0.2	0.2
Ocenebra spp.									
Pyramidella spp.									
Solariella agulhasensis									
Tricolia capensis									
Turris spp.						0.17			
Volutocorbis abyssicola				6.82					9.42
Amphipholis squamata									
PHYLUM ECHINODERMATA									
Ophionereis porrecta		0.1							

Species	R6.6	R6.7	R6.8	R6.9	R6.10	S5.2	S5.3	S5.5	S5.6
Westwoodilla manta		0.1			0.1	0.1		0.1	0.1
Paraphoxus oculatus	0.1	0.1							
Platyischnopus herdmani									
Podocerus brasiliensis									
Eupariambus fallax								0.1	
Hyperiidae		0.1	0.1		0.1		0.1		
Hyperiid B									
Cumacea B									
Pterygosquilla armata		5.2			0.36	0.77	0.19	1.41	
Stomatopod juvenile		0.1					0.1		
Meiosquilla desmarestii		0.4							
Euphausiacea		0.1	0.1	0.1	0.1	0.1	0.1		
Carida A		0.22							
Carida B					0.2	0.1			
Carida C (Mysidaea)									
Carida D									
Carida F									
Calocaris barnardi		0.2	0.1		0.3	0.97	1.7	0.4	0.52
Callianassa spp.		1.81		0.6		0.3	0.72		0.1
Anomura A									
Goneplax angulata		0.1	0.32		1.79			0.4	0.7
Mursia cristimanus									
PHYLUM MOLLUSCA									
Macoma spp.	0.1	0.2	0.12		0.17	0.11	0.9	0.17	0.14
Tellina spp.					0.3		0.1		
Dosinia spp.			0.1		0.3			0.1	
Nucula nucleus				0.33			0.1		
Bivalve F					0.2		0.1	0.1	
Bivalve I							0.12		
Alvania fenestrata							0.1		
Clanculus spp.							0.1		
Epitonium kraussi							0.4		
Marginella spp.									
Nassarius spp.	0.2	0.8		1	1.14	0.1	0.96	0.15	0.2
Ocenebra spp.				0.1			0.5		
Pyramidella spp.									
Solariella agulhasensis						0.1			
Tricolia capensis							0.1		
Turris spp.				0.76					
Volutocorbis abyssicola									
Amphipholis squamata									
PHYLUM ECHINODERMATA									
Ophionereis porrecta									

Species	S5.9	S5.11	S6.1	S6.2	S6.3	S6.4	S6.5	S6.6
PHYLUM CNIDARIA								
Anthozoa A	0.21							
PHYLUM NEMERTEA								
Cerebratulus spp.								
Lineus spp.			0.6			0.2		
Nemertea B								0.14
PHYLUM ANNELIDA								
Eunicidae								0.9
Lumbrineris spp.	1.68	0.5	0.94	1.65	1.13	0.15	0.18	0.2
Arabella spp.					0.18			0.15
Diopatra spp.	1.51			2.51	1.44	1.7	0.74	0.75
Epidiopatra spp.	0.5					0.1		
Nereidae	0.9							0.1
Nereis spp.			0.32					
Perinereis/Pseudonereis spp.					0.13			0.7
Micronereides capensis								
Nephtyidae								
Nephtys spp.		0.1	0.12	0.3	0.1	0.1		
Spionidae	0.1	0.2						
Prionospio pinnata	0.1	1.7	0.6	0.29	0.4	0.2	0.9	0.6
Spio spp.								
Laonice cirrata								0.1
Haploscoloplos spp.		0.3						
Phylo spp.								
Capitellidae								0.1
Notomastus spp.								
Maldanidae	0.1							
Euclymene luderitziana								
Maldanella capensis								
Petaloproctus spp.								
Sabellides spp.								
Ampharetidae								
Amphicteis gunneri					0.13			
Terebellides spp.	0.92	0.35	0.52	0.1	0.45	0.95	0.85	
Amaeana trilobata/Polycirrus								
Ancistrosyllis parva								
Flabelligeridae								
Flabelligera spp.							0.75	
Pectinaria capensis								
Cossura coasta								
PHYLUM ARTHROPODA								
Tanaid A		0.2						
Copepoda A		0.1	0.1	0.1	0.1	0.2		
Isopod A								
Ampelisca spp.	0.1	0.2		0.1	0.1	0.4	0.1	
Aoro kergeuleni					0.1		0.1	
Aorcho delgadus					0.1	0.1		0.1
Corophiid Q						0.1		
Guernea rhomba		0.1						
Rhachotropis spp.								
Elasmopus affinis								
Ceradocus natalensis								0.1
Maera spp.					0.6		0.2	0.6
Urothoe spp.								
Leucothoe spp.								
Listriella lindae								
Acidostoma obesum								
Hippomedon longimanus								

Species	S5.9	S5.11	S6.1	S6.2	S6.3	S6.4	S6.5	S6.6
Westwoodilla manta		0.1				0.1		
Paraphoxus oculatus			0.1		0.1	0.1	0.1	
Platyischnopus herdmani								
Podocerus brasiliensis						0.1		
Eupariambus fallax								
Hyperiidae	0.1					0.1		0.1
Hyperiid B		0.1	0.1					
Cumacea B						0.1		
Pterygosquilla armata	1.66		4.75	3.77	7.3			
Stomatopod juvenile				0.1		0.1		
Meiosquilla desmarestii								
Euphausiacea		0.2				0.1	0.2	
Carida A		0.18						
Carida B								
Carida C (Mysidaea)						0.3		
Carida D								
Carida F								
Calocaris barnardi	0.17		0.13	2.8	0.11	0.3	0.4	0.2
Callianassa spp.	3.41	0.28		0.38			0.1	
Anomura A								
Goneplax angulata		3.36	0.47				0.9	0.38
Mursia cristimanus								3.99
PHYLUM MOLLUSCA								
Macoma spp.	0.9	0.2	0.7	0.14	0.3	0.3	0.9	0.1
Tellina spp.			0.1					
Dosinia spp.					0.2			
Nucula nucleus		0.4	0.22	0.5	0.1			
Bivalve F			0.1		0.1			0.4
Bivalve I								
Alvania fenestrata								
Clanculus spp.								
Epitonium kraussi					0.4			
Marginella spp.								
Nassarius spp.	0.1	1.39	0.5	0.36	3.38		0.26	0.64
Ocenebra spp.					0.55			0.1
Pyramidella spp.					0.1			
Solariella agulhasensis								
Tricolia capensis					0.17			
Turris spp.		0.62			0.87		0.86	
Volutocorbis abyssicola								
Amphipholis squamata								0.1
PHYLUM ECHINODERMATA								
Ophionereis porrecta								

Species	DB1.1	DB1.2	DB1.3	DB1.4	DB1.5	DB1.6	DB2.1	DB2.2	DB2.3
PHYLUM CNIDARIA									
Anthozoa A									
PHYLUM NEMERTEA									
Cerebratulus spp.				0.21					
Lineus spp.									
Nemertea B									
PHYLUM ANNELIDA									
Eunicidae									
Lumbrineris spp.	0.5	0.88	0.88	0.41		2.58	1.8		0.85
Arabella spp.					0.8				
Diopatra spp.	0.15	0.25	0.2		0.7	0.22	0.32	2.31	0.1
Epidiopatra spp.									
Nereidae									
Nereis spp.									
Perinereis/Pseudonereis spp.									
Micronereides capensis									
Nephtyidae									
Nephtys spp.	0.3	0.1	0.7	0.53		0.4	0.5	0.2	0.1
Spionidae									
Prionospio pinnata		0.1					0.2	0.1	0.1
Spio spp.									
Laonice cirrata									
Haploscoloplos spp.									
Phylo spp.									
Capitellidae									
Notomastus spp.									
Maldanidae									
Euclymene luderitziana									
Maldanella capensis									
Petaloproctus spp.									
Sabellides spp.									
Ampharetidae									
Amphicteis gunneri									
Terebellides spp.									
Amaeana trilobata/Polycirrus									
Ancistrosyllis parva									
Flabelligeridae									
Flabelligera spp.									
Pectinaria capensis									
Cossura coasta			0.1						
PHYLUM ARTHROPODA									
Tanaid A									
Copepoda A									
Isopod A									
Ampelisca spp.									
Aoro kergeuleni									
Aorcho delgadus	0.1								0.1
Corophiid Q									
Guernea rhomba									
Rhachotropis spp.									
Elasmopus affinis									
Ceradocus natalensis									
Maera spp.									
Urothoe spp.									
Leucothoe spp.									
Listriella lindae									
Acidostoma obesum									
Hippomedon longimanus									

Species	DB1.1	DB1.2	DB1.3	DB1.4	DB1.5	DB1.6	DB2.1	DB2.2	DB2.3
Westwoodilla manta									
Paraphoxus oculatus								0.1	
Platyischnopus herdmani									
Podocerus brasiliensis									
Eupariambus fallax									
Hyperiidae									
Hyperiid B									
Cumacea B									
Pterygosquilla armata		1.7		0.64		4.74	18.2	0.74	0.36
Stomatopod juvenile									
Meiosquilla desmarestii									
Euphausiacea									
Carida A									0.1
Carida B									
Carida C (Mysidaea)									
Carida D									
Carida F									
Calocaris barnardi		0.2			0.26	0.19		0.14	
Callianassa spp.		1.14						0.8	0.3
Anomura A									
Goneplax angulata									
Mursia cristimanus									
PHYLUM MOLLUSCA									
Macoma spp.									
Tellina spp.									
Dosinia spp.									
Nucula nucleus									
Bivalve F									
Bivalve I									
Alvania fenestrata									
Clanculus spp.									
Epitonium kraussi									
Marginella spp.									
Nassarius spp.	1.8	1.1	0.96	0.36	2.54	1.31	1.44	2.87	1.52
Ocenebra spp.									
Pyramidella spp.									
Solariella agulhasensis									
Tricolia capensis									
Turris spp.									
Volutocorbis abyssicola		2.49			7.2				
Amphipholis squamata									
PHYLUM ECHINODERMATA									
Ophionereis porrecta									

Species	DB2.4	DB2.5	DB2.6	DB3.1	DB3.2	DB3.3	DB3.4	DB3.5	DB3.6
PHYLUM CNIDARIA									
Anthozoa A									
PHYLUM NEMERTEA									
Cerebratulus spp.	1.47						1.3		
Lineus spp.									
Nemertea B									
PHYLUM ANNELIDA									
Eunicidae									
Lumbrineris spp.	0.32	0.77	0.31	0.31	1.15	0.43		0.57	0.19
Arabella spp.			0.8						
Diopatra spp.	0.4	0.39							
Epidiopatra spp.									
Nereidae									
Nereis spp.									
Perinereis/Pseudonereis spp.									
Micronereides capensis									
Nephtyidae									
Nephtys spp.	0.1	0.6			0.16		0.3	0.7	0.3
Spionidae									
Prionospio pinnata	0.3	0.17	0.1	0.5	0.22	0.21	0.2	0.14	0.22
Spio spp.									
Laonice cirrata									
Haploscoloplos spp.									
Phylo spp.									
Capitellidae									
Notomastus spp.									
Maldanidae									
Euclymene luderitziana									
Maldanella capensis									
Petaloproctus spp.									
Sabellides spp.									
Ampharetidae									
Amphicteis gunneri									
Terebellides spp.									
Amaeana trilobata/Polycirrus									
Ancistrosyllis parva									
Flabelligeridae									
Flabelligera spp.									
Pectinaria capensis		0.8	0.1					0.7	
Cossura coasta					0.1				
PHYLUM ARTHROPODA									
Tanaid A									
Copepoda A									
Isopod A									
Ampelisca spp.	0.1	0.1			0.1	0.1		0.1	
Aoro kergeuleni									
Aorcho delgadus	0.1		0.1		0.3				
Corophiid Q									
Guernea rhomba									
Rhachotropis spp.									
Elasmopus affinis									
Ceradocus natalensis									
Maera spp.									
Urothoe spp.									
Leucothoe spp.									
Listriella lindae									
Acidostoma obesum									
Hippomedon longimanus									

Species	DB2.4	DB2.5	DB2.6	DB3.1	DB3.2	DB3.3	DB3.4	DB3.5	DB3.6
Westwoodilla manta									
Paraphoxus oculatus					0.1				
Platyischnopus herdmani									
Podocerus brasiliensis									
Eupariambus fallax									
Hyperiidae									
Hyperiid B									
Cumacea B									
Pterygosquilla armata	15.66	0.63				4.84	1.25		
Stomatopod juvenile									
Meiosquilla desmarestii									
Euphausiacea									
Carida A		0.13							
Carida B									
Carida C (Mysidaea)									
Carida D									
Carida F									
Calocaris barnardi	0.5	0.9	0.7		0.7	0.16	0.1	0.16	
Callianassa spp.									
Anomura A									
Goneplax angulata									
Mursia cristimanus									
PHYLUM MOLLUSCA									
Macoma spp.									
Tellina spp.					0.1			0.1	
Dosinia spp.									
Nucula nucleus									
Bivalve F									
Bivalve I									
Alvania fenestrata									
Clanculus spp.									
Epitonium kraussi					0.1				
Marginella spp.		2.13							
Nassarius spp.	2.41	4.22	0.88	0.86	4.77	1.24	0.67	0.46	0.59
Ocenebra spp.									
Pyramidella spp.									
Solariella agulhasensis									
Tricolia capensis									
Turris spp.									
Volutocorbis abyssicola									
Amphipholis squamata									
PHYLUM ECHINODERMATA									
Ophionereis porrecta									

Species	DB4.1	DB4.2	DB4.3	DB4.4	DB4.5	DB4.6	DB5.1	DB5.2	DB5.3
PHYLUM CNIDARIA									
Anthozoa A									
PHYLUM NEMERTEA									
Cerebratulus spp.	0.96	0.17		0.29					
Lineus spp.									
Nemertea B									
PHYLUM ANNELIDA									
Eunicidae									
Lumbrineris spp.	4.39	1.67	2.39	1.48	0.74	1.39		0.32	
Arabella spp.						0.2	0.5		
Diopatra spp.	2.59	3.96	1.6	0.14	1.12	1.65	0.1	0.9	
Epidiopatra spp.									
Nereidae									
Nereis spp.									
Perinereis/Pseudonereis spp.									
Micronereides capensis									
Nephtyidae									
Nephtys spp.	0.4			0.2	0.2				
Spionidae									
Prionospio pinnata	0.4	0.1	0.4	0.3	0.1	0.4			
Spio spp.									
Laonice cirrata									
Haploscoloplos spp.									
Phylo spp.									
Capitellidae									
Notomastus spp.									
Maldanidae									
Euclymene luderitziana									
Maldanella capensis									
Petaloproctus spp.									
Sabellides spp.									
Ampharetidae									
Amphicteis gunneri									
Terebellides spp.									
Amaeana trilobata/Polycirrus									
Ancistrosyllis parva						0.1			
Flabelligeridae									
Flabelligera spp.									
Pectinaria capensis									
Cossura coasta									
PHYLUM ARTHROPODA									
Tanaid A									
Copepoda A									
Isopod A									
Ampelisca spp.									
Aoro kergeuleni									
Aorcho delgadus		0.2	0.3	0.1		0.2			
Corophiid Q									
Guernea rhomba									
Rhachotropis spp.									
Elasmopus affinis									
Ceradocus natalensis									
Maera spp.									
Urothoe spp.									
Leucothoe spp.									
Listriella lindae									
Acidostoma obesum									
Hippomedon longimanus									

Species	DB4.1	DB4.2	DB4.3	DB4.4	DB4.5	DB4.6	DB5.1	DB5.2	DB5.3
Westwoodilla manta									
Paraphoxus oculatus									
Platyischnopus herdmani									
Podocerus brasiliensis									
Eupariambus fallax									
Hyperiidae		0.1							
Hyperiid B									
Cumacea B									
Pterygosquilla armata	0.5	0.56	0.48		3.28			1.12	
Stomatopod juvenile									
Meiosquilla desmarestii									
Euphausiacea									
Carida A									
Carida B									
Carida C (Mysidaea)									
Carida D									
Carida F									
Calocaris barnardi	0.45	0.8	0.48	0.24	0.74	0.89			
Callianassa spp.	3.88	1.34	5.39	5.47	3.19	1.72			
Anomura A									
Goneplax angulata									
Mursia cristimanus									
PHYLUM MOLLUSCA									
Macoma spp.									
Tellina spp.								0.7	
Dosinia spp.									
Nucula nucleus									
Bivalve F									
Bivalve I									
Alvania fenestrata									
Clanculus spp.									
Epitonium kraussi									
Marginella spp.									
Nassarius spp.	0.17			0.8	0.1	0.6	1.71	1.66	
Ocenebra spp.									
Pyramidella spp.									
Solariella agulhasensis									
Tricolia capensis									
Turris spp.									
Volutocorbis abyssicola									
Amphipholis squamata									
PHYLUM ECHINODERMATA									
Ophionereis porrecta									

Species	DB5.4	DB5.5	DB5.6
PHYLUM CNIDARIA			
Anthozoa A			
PHYLUM NEMERTEA			
Cerebratulus spp.			
Lineus spp.			
Nemertea B			
PHYLUM ANNELIDA			
Eunicidae			
Lumbrineris spp.	0.4		
Arabella spp.	0.6		0.23
Diopatra spp.	0.6	0.14	
Epidiopatra spp.			
Nereidae			
Nereis spp.			
Perinereis/Pseudonereis spp.			
Micronereides capensis			
Nephtyidae			
Nephtys spp.			
Spionidae			
Prionospio pinnata	0.1		
Spio spp.			
Laonice cirrata			
Haploscoloplos spp.			
Phylo spp.			
Capitellidae			
Notomastus spp.			
Maldanidae			
Euclymene luderitziana			
Maldanella capensis			
Petaloproctus spp.			
Sabellides spp.			
Ampharetidae			
Amphicteis gunneri			
Terebellides spp.			
Amaeana trilobata/Polycirrus			
Ancistrosyllis parva			
Flabelligeridae			
Flabelligera spp.			
Pectinaria capensis			
Cossura coasta			
PHYLUM ARTHROPODA			
Tanaid A			
Copepoda A			
Isopod A			
Ampelisca spp.			0.1
Aoro kergeuleni			
Aorcho delgadus			
Corophiid Q			
Guernea rhomba			
Rhachotropis spp.			
Elasmopus affinis			
Ceradocus natalensis			
Maera spp.			
Urothoe spp.			
Leucothoe spp.			
Listriella lindae			
Acidostoma obesum			
Hippomedon longimanus			

APPENDIX B:

GEOLOGICAL DATA

GEOLOGICAL DATA FOR SAMPLES FROM THE NORTHERN RESEARCH AREA.

(VC - VERY COARSE, C - COARSE, M - MEDIUM, F - FINE, VF - VERY FINE).

Samples	Mean particle size (phi)	%Gravel (<-1phi)	%VCSand (-1 to 0phi)	%CSand (0 to 1phi)	%MSand (1 to 2phi)	%FSand (2 to 3phi)	%VFSand (3 to 4phi)	%Mud (>4phi)
R1.1	2.82	0.17	0.87	1.61	2.82	39.51	33.1	21.9
R1.2	2.41	0.33	8.79	2.42	3.02	48.64	31.94	4.85
R1.3	2.69	0	21.19	3.29	5.79	38.73	17.48	13.5
R1.5	2.74	0.87	2.14	2.22	2.92	41.37	32.34	18
R1.6	2.48	0.26	0.88	6.33	9.12	45.99	22.69	14.7
R1.10	2.55	0	0.45	3.77	4.96	51.95	24.46	14.4
R1.11	2.76	0.01	1.05	0.89	3.06	51.03	25.31	18
R2.1	2.42	0.12	6.43	1.5	3.32	33.11	24.7	30.8
R2.2	2.49	0	5.54	1.41	3.36	38.71	25.41	25.6
R2.3	2.67	0.21	4.04	1.33	2.96	31.67	32.29	27.5
R2.4	2.63	0	10.88	1.38	6.7	36.45	9.85	34.7
R2.5	2.98	0	0.24	0.1	0.74	9.93	13.37	75.6
R2.6	2.4	0.15	4.16	1.07	1.95	23.39	23.81	45.5
R2.8	2.07	0.49	2.43	9.74	12.46	31.75	12.33	30.8
R3.1	2.02	6.67	4.47	7.69	5.17	12.91	14.72	48.4
R3.3	1.08	10.86	7.1	9.13	8.19	6.33	1.62	49
R3.5	0.91	54.42	6.06	8.34	3.5	4.3	3.58	19.8
R3.6	2.46	0.2	8.7	0.56	3.56	9.28	8.53	69.2
R3.8	2.03	1.06	4.14	8.63	8.34	11.04	17.01	49.8
R3.9	2.26	0.44	-	-	-	-	-	67.2
R3.10	2.24	0.11	4.79	3.32	7.53	12.98	14.96	56.3
R4.1	2.74	0.08	0.11	1.19	3.11	12.02	11.92	71.6
R4.2	-	10.2	-	-	-	-	-	53.8
R4.3	2.01	1.99	2.28	5.3	5.9	12.32	16.26	56
R4.4	2.52	1.2	1.17	3.33	4.52	13.92	17.81	58.1
R4.5	1.33	17.56	2.61	8.66	8.18	6.45	2.35	54.2

Samples	Mean particle size (phi)	%Gravel (<-1phi)	%VCSand (-1 to 0phi)	%CSand (0 to 1phi)	%MSand (1 to 2phi)	%FSand (2 to 3phi)	%VFSand (3 to 4phi)	%Mud (>4phi)
S1.1	2.24	5.29	3.91	16.42	7.03	32.85	27.61	6.91
S1.5	1.94	35.7	7.52	11.66	3.21	21.94	15.39	4.58
S1.11	2.4	1.5	0.5	11.13	15.03	35.9	29	6.94
S1.14	2.73	0.67	0.72	3.19	8.15	42.68	36.53	8.06
S1.15	2.55	21.05	0.92	7.34	4.8	32.44	25.39	8.06
S1.17	2.43	1.94	0.56	8.83	14.25	39.75	27.86	6.99
S2.2	2.7	3.12	1.11	4.07	4.1	21.05	26.21	40.3
S2.3	2.83	0.99	1.26	1.51	2.79	35.74	28.02	26.7
S2.4	2.69	0.31	0.47	2.38	6.47	44.18	23.52	22.4
S2.5	2.83	1.13	0.53	2.39	2.87	34.89	28.05	30.1
S2.6	2.92	0.2	0.3	1.65	2.15	29.48	32.07	34.2
S2.7	2.43	0.14	1.87	6.38	10.17	32.92	23.28	25.2
S3.1	0.68	8.69	6.07	16.65	6.36	0.05	0.72	61.5
S3.2	0.58	28.77	2.11	8.34	1.29	0.31	0.21	59
S3.3	1.03	41.34	0.26	10.22	6.05	0.75	0.54	40.8
S3.4	1.34	16.84	0.51	3.94	2.97	1.67	0.84	73
S3.5	0.91	39.3	0.47	6.92	2.7	0.4	0.24	50
S3.7	1.02	16.59	1.56	1.81	1.81	0.81	0.45	77
S4.2	2.18	17.62	0.26	1.38	3.59	6.33	2.56	68.3
S4.6	1.7	14.86	1.87	5.42	7.77	11.67	2.06	56.4
S4.8	0.82	24.61	6.42	17.9	7.92	2.85	1.07	39.2
S4.9	1.51	38.57	1.57	6.54	16.49	7.58	1.76	27.5
S4.13	2.02	33.88	1.49	3.14	6.37	9.09	5.24	40.8
S4.14	0.99	13.15	8.29	20.73	21.99	4.91	2	28.9

GEOLOGICAL DATA FOR SAMPLES FROM THE SOUTHERN RESEARCH AREA.

(VC - VERY COARSE, C - COARSE, M - MEDIUM, F - FINE, VF - VERY FINE).

Samples	Mean particle size (phi)	%Gravel (<-1phi)	%VCSand (-1 to 0phi)	%CSand (0 to 1phi)	%MSand (1 to 2phi)	%FSand (2 to 3phi)	%VFSand (3 to 4phi)	%Mud (>4phi)
R5.1	2.22	0.1	6.14	10.69	30.89	21.21	3.64	27.4
R5.3	1.99	0.33	1.83	2.72	33.86	28.96	0	32.3
R5.4	1.72	1.31	7	0.81	6.66	30.77	24.95	28.5
R5.5	2.36	0	0.08	0.8	10.72	27.14	7.24	54
R5.6	2.42	0	0.22	1.7	9.5	31.62	11.94	44.7
R5.7	2.57	1.07	1.95	3.56	3.87	26.38	21.52	41.7
R5.8	2.63	0	0.28	2.22	7.71	28.94	20.72	40.1
R5.9	2.6	0.07	0.09	0.5	6.6	21.35	12.24	59.2
R6.7	2.85	0	0.49	0.59	3.46	23.55	25.25	46.5
R6.10	2.24	0	-	-	-	-	-	71.3
S5.2	2.3	0.36	0.46	3.19	19.3	22.68	14.36	39.7
S5.3	1.81	0.89	0.82	13.08	33.2	26.72	6.58	18.7
S5.5	1.94	1.48	0.87	9.67	24.45	22.91	8.49	32.1
S5.6	2.39	0.06	0.27	0.99	17.95	27.56	13.31	39.9
S5.9	2.18	0.11	0.49	3.5	27.68	36.81	10.07	21.3
S5.11	2.44	0.7	0.12	2.64	7.53	18.03	11.02	60
S6.1	1.52	8.66	1.96	12.02	21.08	12.09	2.07	42.1
S6.2	2.63	0.25	0.27	2.05	5.24	25.55	15.32	51.3
S6.3	1.95	8.38	1.03	6.64	33.42	28.38	7.66	14.5
S6.4	2.37	0.32	0.73	2.37	7.92	25.37	10.6	52.7
S6.5	1.97	7.55	0.99	4.25	6.73	8.63	4.97	66.9
S6.6	0.73	55.26	2.25	5.27	2.09	0.82	0.33	34
DB1.1	0.8	7.403	8.76	34.56	14.77	6.02	5.54	23.4
DB1.2	1.73	12.505	3.7	10.96	6.28	13.47	8.58	44.5
DB1.3	0.9	36.589	2.53	11.53	7.87	1.65	1.23	38.6
DB1.4	1.7	0	1.02	7.28	9.45	8.83	3.76	69.6
DB1.5	1.6	3.271	1.13	7.12	9.17	6.45	2.71	70.1
DB1.6	1.53	0	0.12	6.15	7.72	4.57	1.2	80.2

Samples	Mean particle size (phi)	%Gravel (<-1phi)	%VCSand (-1 to 0phi)	%CSand (0 to 1phi)	%MSand (1 to 2phi)	%FSand (2 to 3phi)	%VFSand (3 to 4phi)	%Mud (>4phi)
DB2.1	1.58	2.232	0.54	9.82	11.02	7.78	2.49	66.1
DB2.2	1.25	16.46	1.99	20.32	8.9	8.1	2.84	41.4
DB2.3	2.01	35.023	1.75	4.05	4.65	11.38	4.74	38.4
DB2.4	1.87	2.744	1.8	4.66	9.92	16.72	2.86	61.3
DB2.5	0.69	32.97	6.84	27.62	7.04	2.57	0.9	22
DB2.6	2.27	25.99	0.79	3.57	5.7	9.53	8.31	46.1
DB3.1	1.41	13.682	0.77	9.13	7.04	4.45	2	62.9
DB3.2	2.15	0	0.8	3.26	8.29	14.98	5.39	67.3
DB3.3	1.52	32.147	2.99	7.28	3.6	7.66	3.01	43.3
DB3.4	2.25	0	0.13	1.55	8.89	14.67	4.82	69.9
DB3.5	1.86	7.63	1.71	5.97	4.56	8.83	4.93	66.4
DB3.6	2.25	7.725	0.92	2.94	4.84	13.97	6.13	63.5
DB4.1	2.21	0	0.52	3.35	5.32	13.13	4.77	72.1
DB4.2	2.63	0	0.1	0.67	2.8	15.45	7.02	74
DB4.3	2.53	0	0.3	2.13	3.54	14.6	8.04	71.4
DB4.4	2.19	1.65	1.28	6.01	5.67	12.21	10.15	63
DB4.5	2.69	0	0.39	1.77	3.85	16.16	15.24	62.6
DB4.6	2.64	0	0.24	2.11	3.73	14.94	12.86	66.1
DB5.1	1.71	10.12	0.55	3.81	13.73	5.5	2.4	63.9
DB5.2	1.74	3.881	2.74	4.43	10.4	9.87	3.68	65
DB5.3	2.36	0	0.19	1.41	5.66	9.46	5.63	77.6
DB5.4	2.33	2.558	0.48	7.29	13.41	20.56	18.67	37
DB5.5	2.23	0.936	0.12	2.23	6.84	8.35	5.21	76.3
DB5.6	1.29	2.602	0.16	6.2	4.84	1.89	0.8	83.5