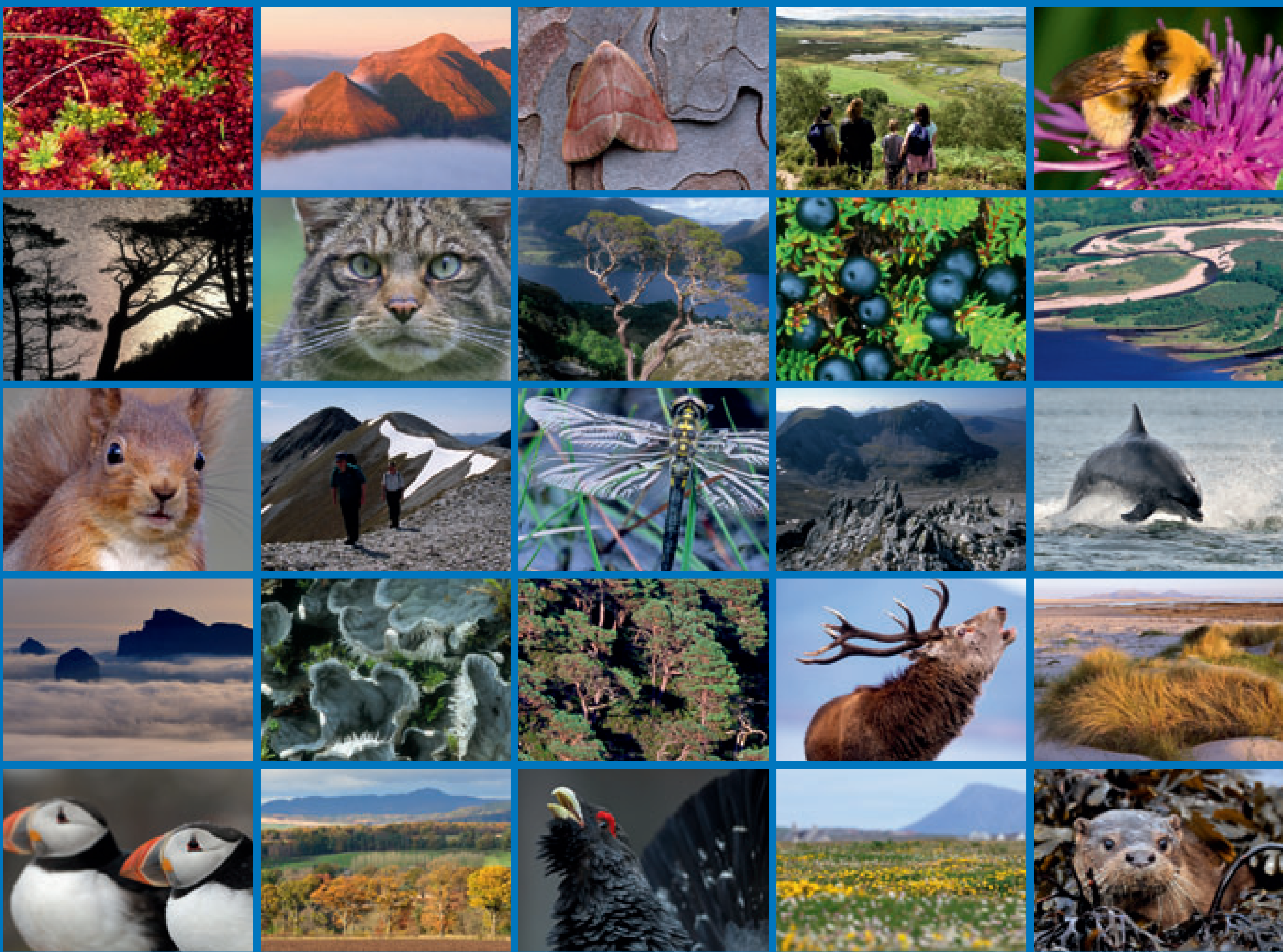
Scottish Natural Heritage
Commissioned Report No. 503

Infaunal analysis of grab samples collected from the North Minch area, 2011



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COMMISSIONED REPORT

Commissioned Report No. 503

Infaunal analysis of grab samples collected from the North Minch area, 2011

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COMMISSIONED REPORT

Summary

Infaunal analysis of grab samples collected from the North Minch area, 2011

Commissioned Report No. 503 (Project No. 13445).
Contractor: Seastar Survey Ltd.
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Background

During 2011 a survey was undertaken by Scottish Natural Heritage (SNH) in the North Minch area to gather qualitative biological data to help inform our understanding of the importance of large scale features (LSFs) within Scottish waters (specifically Glacially Eroded Deeps and also Banks and Mounds). LSFs represent areas of functional significance for the overall health and diversity of Scottish seas. They are intended to complement Marine Protected Area (MPA) search feature habitats and species which, whilst not necessarily containing these MPA search features, have a benefit by supporting wider ecosystem function. Several survey methods were employed to gather data, including using grabs to collect sediment samples.

Seastar Survey Ltd. was contracted by SNH to undertake the infaunal analysis of the grab samples taken during the survey of the North Minch area, including identifying all the faunal components within the grab samples, sediment particle size analysis (PSA), and assigning a biotope to each sample. This report presents the results from these analyses, and a brief interpretation of the data.

Main findings

- A total of 17 Day grab samples were collected during The Minch 2011 survey.
- The sediment at the majority of the locations were classified as ‘sand’ with >70 % sand fraction. Only one location (MG13) was classified as ‘sandy gravel’.
- The macrofauna was dominated by Annelida (66.8 %) and Mollusca (13.1 %).
- The Cirratulid *Chaetozone gibber* and the Oweniid *Owenia fusiformis* were the most abundant species. Other relatively abundant taxa include *Abra alba, Lumbrineris gracilis, Notomastus latericeus* and *Aonides paucibranchiata.*
- Species diversity was low to medium but equitability was found to be high overall.
- A total of four biotope complexes were identified: **SS.SSa.OSa**, **SS.SMx.OMx**, **SS.SCS.OCS** and **SS.SMu.OMu** with **SS.SSa,OSa.Ofus.AfiI** also present which is of particular note as this biotope is an offshore PMF and MPA search feature.
- A lancelet (*Branchiostoma lanceolatum*), infrequently recorded in Scottish waters, and an individual within the Pilargidae family (species unknown) were recorded in the study. The latter may be a new species but identification remains unknown.

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This work was funded by Marine Scotland as part of the Scottish MPA project.

1 INTRODUCTION

1.1 Background and objectives

During 2011 a survey was undertaken by Scottish Natural Heritage (SNH) in the North Minch area to gather biological data to help inform our understanding of the importance of large scale features (LSFs) within Scottish waters (specifically Glacially Eroded Deeps and also Banks and Mounds). LSFs represent areas of functional significance for the overall health and diversity of Scottish seas. These are intended to complement Marine Protected Area (MPA) search feature habitats and species which, whilst not necessarily containing these MPA search features, have a benefit by supporting wider ecosystem function. Specific examples of these features may contribute to the MPA network through supporting features at a range of trophic levels; for example, areas of high primary productivity through to possible aggregations of mobile top predators.

A combination of underwater video, grabs and fish traps were used to collect information on the benthos that utilise these features (‘Deeps’ and ‘Banks and Mounds’), whilst also allowing rough comparisons to be made between the communities (epibiota and infauna) found on and off the features. The 2011 survey area encompassed a region from the North Minch, including the East Shiant Bank and Shiant Islands, south to the Little Minch (Figure 2.1). Details of the video analysis can be seen in SNH Commissioned Report No.507 (Moore, 2012).

Seastar Survey Ltd. was contracted by SNH to undertake the infaunal analysis of the grab samples taken during the survey of the North Minch area, including identifying all the faunal components within the grab samples, sediment particle size analysis (PSA), and assigning a biotope to each sample. This report presents the results from these analyses, and a brief interpretation of the data.

2 METHODS

2.1 Infaunal sample collection

The collection of infaunal samples was carried out by SNH in collaboration with Marine Scotland Science and Heriot Watt University using a 0.1 m^2 Day grab deployed from the *RV Alba na Mara.* A total of 17 grab stations were sampled between 23rd October – 2nd November 2011 in the North Minch area (Table 2.1 and Figures 2.1 to 2.3 with more details in Appendix 01). Single grabs were collected at each station to gain a broad understanding of the biotopes present on the seabed. The samples (see examples in Figure 2.4) each had a 5 cm core subsample retrieved for particle size analysis (PSA), before being sieved by hand through a 1 mm mesh size. Any material retained on the sieve was transferred to a labelled container before being fixed with a buffered 4% formaldehyde solution.

Figure 2.1. Locations of grab sampling stations for The Minch infaunal survey 2011.

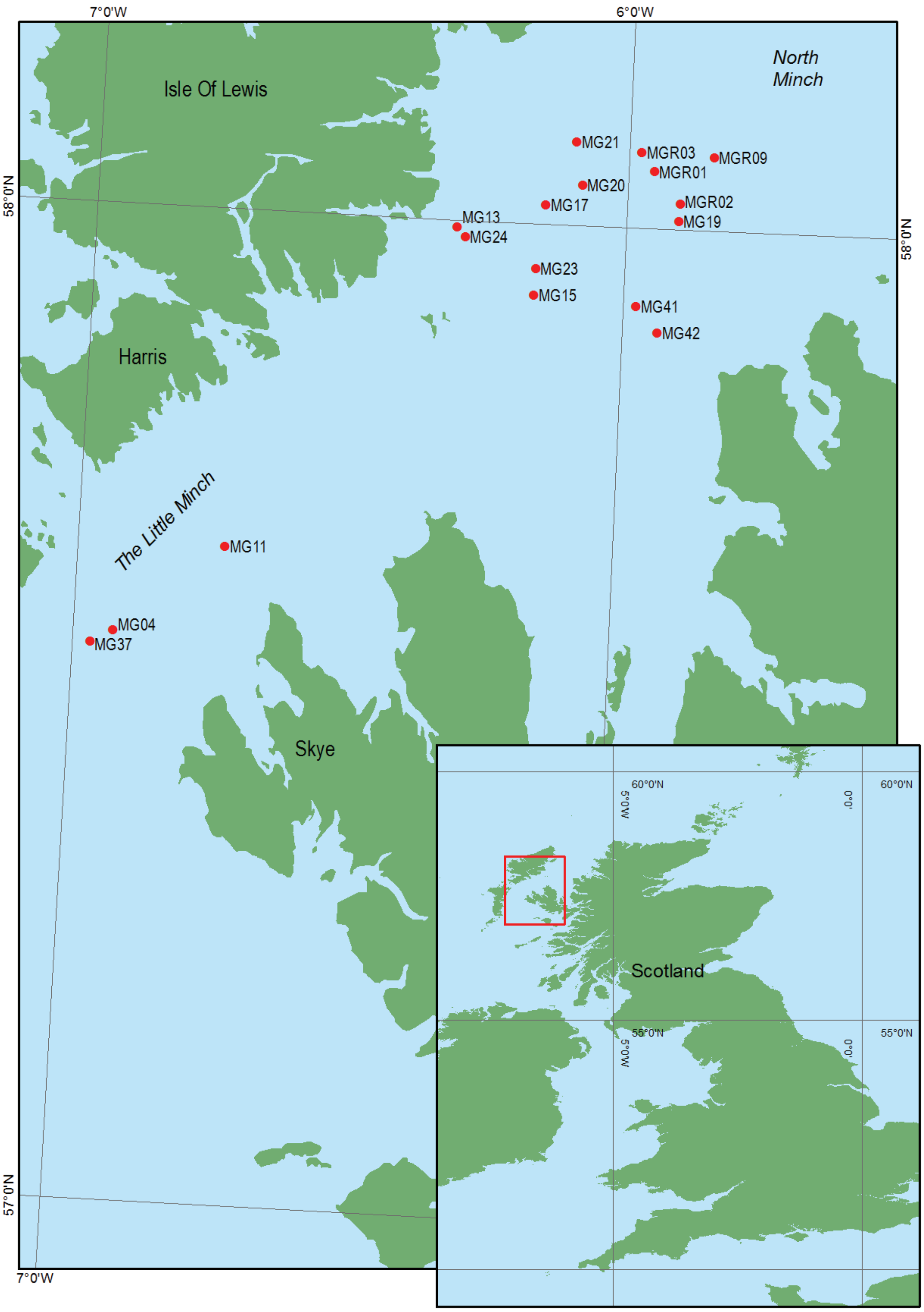


Figure 2.2. Locations of grab sampling stations in the North Minch.

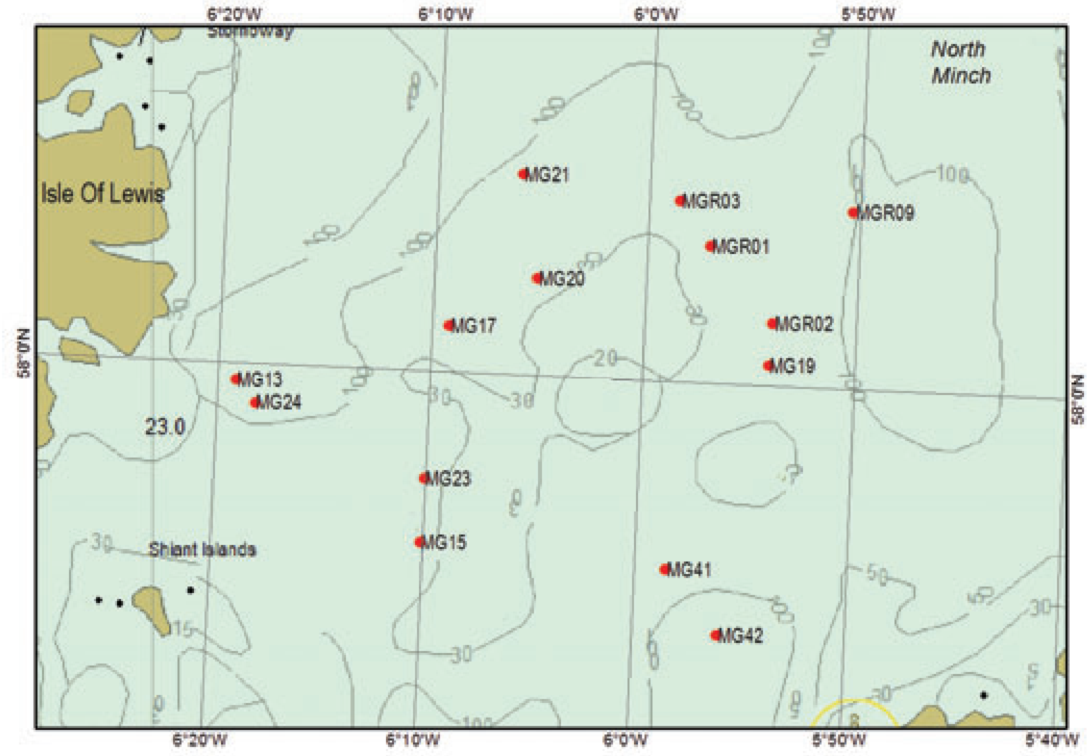
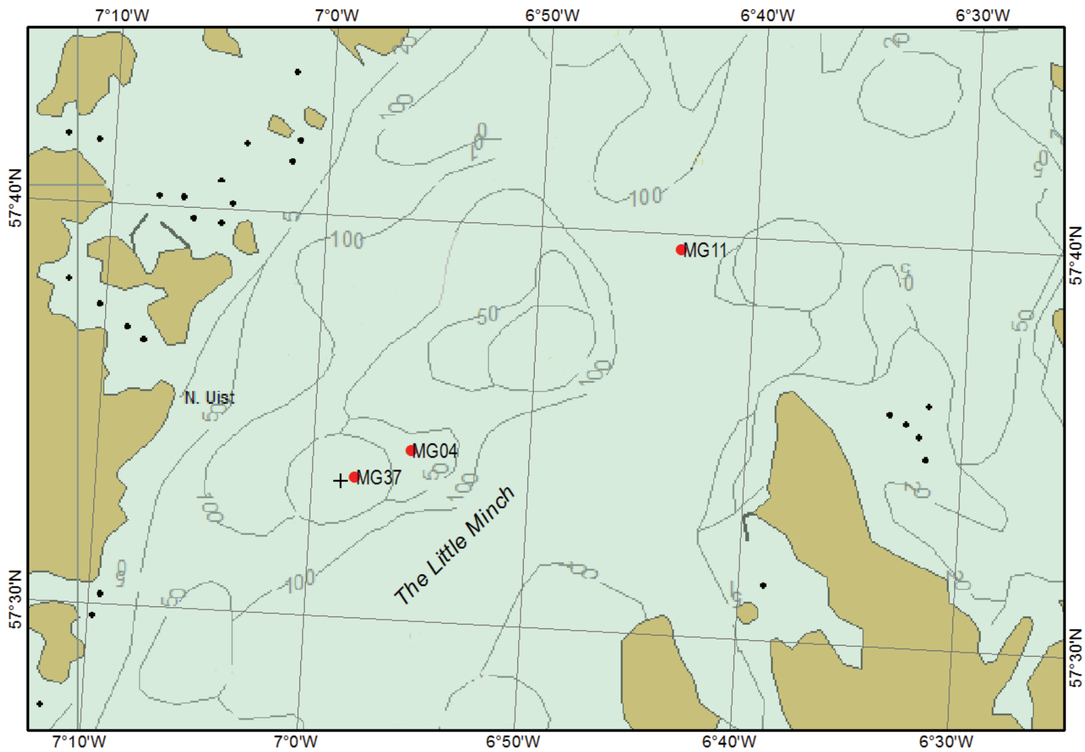


Figure 2.3. Locations of grab sampling stations in The Little Minch.



Tabe 2.1. Locations of grab sampling stations for The Minch infaunal survey 2011.

Date	Station	Location	Time (GMT)	Position		Depth (m)
				Lattitude	Longitude	
23/10/2011	MG41	Shiant Bank	10:04	57.9221	-5.9745	110
25/10/2011	MG04	Southern Little Minch	11:41	57.5709	-6.9239	60
25/10/2011	MG37	Southern Little Minch	14:24	57.5586	-6.9659	90
25/10/2011	MG11	Northern Little Minch	18:00	57.6608	-6.7235	152
26/10/2011	MG15	Shiant Bank	10:11	57.9288	-6.1678	54
26/10/2011	MG23	Shiant Bank	11:04	57.9553	-6.1666	60
26/10/2011	MG42	Shiant Bank	16:34	57.8962	-5.9323	153
01/11/2011	MG13	Shiant Islands	08:59	57.9931	-6.3182	152
01/11/2011	MG24	Shiant Islands	09:17	57.9838	-6.3023	200
01/11/2011	MG17	Shiant Bank	10:05	58.0199	-6.1527	64
01/11/2011	MG20	Shiant Bank	10:30	58.0412	-6.0849	75
01/11/2011	MG21	Shiant Bank	11:00	58.0840	-6.0996	98
02/11/2011	MGR01	Shiant Bank	09:55	58.0576	-5.9500	77
02/11/2011	MGR03	Shiant Bank	10:10	58.0762	-5.9752	81
02/11/2011	MGR02	Shiant Bank	10:59	58.0267	-5.8984	94
02/11/2011	MG19	Shiant Bank	11:28	58.0092	-5.9004	85
02/11/2011	MGR09	Shiant Bank	12:06	58.0744	-5.8384	105

Figure 2.4. Examples of sediment grab samples collected by SNH during The Minch infaunal sampling survey 2011 (image A – station MG19; image B – MG24; image C – MG04 with PSA sub-sampling; and D – MG37).

2.2 Sediment sample analysis

2.2.1 Sediment Particle Size Analysis (PSA)

Particle size analysis (PSA) was undertaken at Seastar Survey's laboratory, using a combination of wet and dry sieving techniques at 1 phi intervals as per standard protocols. The PSA followed the sediment grades used by the Marine Nature Conservation Review (MNCR) as described below:

Pebble – medium	(>8 mm)
Pebble – small	(4-8 mm)
Granule	(2-4 mm)
Sand, very coarse	(1000-2000 µm)
Sand, coarse	(500-1000 µm)
Sand, medium	(250-500 µm)
Sand, fine	(125-250 µm)
Sand, very fine	(63-125 µm)
Silt and clay (mud)	(<63 µm)

For each sediment sample, the dry weight of the whole sediment sample was determined and any muddy samples were disaggregated using a suitable method (e.g. sodium hexametaphosphate). The sample was wet sieved on a 63 µm mesh, then dried (at 100 °C) and re-weighed to establish the weight percentage of the <63 µm fraction. The remainder of the sample was dry sieved with a nest of sieves in the range of -4 to 4 phi of mesh sizes to yield weight percentage data for particle size fractions at half phi intervals, with 63 µm being the smallest sieve size and 16 mm the maximum. The sub 63 µm fraction was then measured using a Mastersizer 2000 laser granulometer, which can analyse particles in the size range of 0.04 µm – 2000 µm. Sediment statistics were calculated using Gradistat v.4.0 (Blott and Pye, 2001).

The phi ( ) grain size measure is based on the Wentworth sediment class divisions but using $\log_2$ rather than $\log_{10}$ (see Leeder, 1982), thus = - $\log_2$ mm. The Wentworth grain size (sieve mesh size) series of 8 mm, 4 mm, 2 mm, 1 mm, 0.5 mm, 0,25 mm and 0.125 mm are therefore calculated as 2^3, 2^2, 2^1, 2^0, 2^{-1}, 2^{-2} and 2^{-3}; giving units of -3, -2, -1, 0, 1, 2 and 3.

2.2.2 Macrofaunal processing and analysis

The processing of the macrofaunal sediment samples took place at Seastar Survey's laboratory in Southampton. The sediment samples were gently re-sieved on 1 mm sieves and sorted (using trays and low-magnification microscopes). The fauna were subsequently identified to the lowest practical taxonomic level with reference to WoRMS (Appletans *et al*., 2011) for species nomenclature, and assigned an MCS biocode according to Howson and Picton (1997) where applicable. A full list of taxa encountered and abundances per sample were recorded on a standard species/ sample matrix (Appendix 02). A reference collection was created and a Quality Control exercise was carried out by Artoo Marine Ecological Consultants to check the identification results. The invertebrate specimens collected were separated by species and station, preserved in alcohol and stored in glass sample vials with polyethylene closures to facilitate their incorporation into the collections of The National Museums of Scotland.

The macrofaunal sediment data are given in number of individuals/0.1 m^2. The data analyses comprised both univariate and multivariate analyses all of which were calculated using Primer (Plymouth Routines in Multivariate Ecological Research) v 6 (Clarke and Warwick, 2001). The univariate analysis included the total number of individuals (N), total number of species (S), species diversity where the Shannon-Wiener (H'), Pielou's (J), Margalef's (d) diversity and Simpson's Dominance indices (see e.g. Gage and Tyler, 1991; Fowler and Cohen, 1992; Clarke and Warwick, 2001) were used with the natural log (log_e) being the chosen parameter in the case of the Shannon-Wiener diversity index.

The multivariate analysis was carried out using cluster analysis and ordination (non-metric multi-dimensional scaling, MDS). These data were then transformed to square root to down-weigh the importance of common types of macrofauna in relation to rarer types. The transformed data were then analysed using the Bray-Curtis similarity coefficient (using Primer v.6) followed by a cluster analysis where the sites were group averaged and the resultant dendrogram plotted. Non-metric multi-dimensional scaling (MDS) was then carried out to further assess the presence of any similarities between sites (Clarke and Warwick, 2001). The SIMPER routine in PRIMER was subsequently used to assess the difference in characteristic species/ taxa in the sample clusters. Spearman's rank correlation coefficient (see e.g. Fowler and Cohen, 1992) was then used to assess any correlations with the particle size analysis variables and depth. The BIOENV routine in PRIMER was used to carry out this task on untransformed but normalised abiotic data.

2.2.3 Assignment of biotopes

A biotope complex was assigned to each grab station according to the Marine Biotope Classification for Britain and Ireland (Connor *et al*., 2004). The sediment type derived from the PSA results and the characteristic species identified from each sample were used to categorize the biotope for each sample. Where insufficient fauna were collected to adequately categorise a biotope, then the sediment type from the PSA analysis was primarily used. It should also be noted that biotopes were attributed based on a single sample collected at each station. Multiple samples would be required to increase confidence of the final assigning of the biotopes.

3 RESULTS

3.1 Particle size analysis

Table 3.1 summarises the PSA results (see further detail (full statistical analyses) in Appendix 03). All the samples had a sand fraction >50%, ranging from ~60 – 91% of the total sediment weight. MG13, located in the North Minch, had the highest component of gravel (30%) in the sediment, and was the only sample to be classified as sandy gravel. The other samples had gravel fractions ranging from 0 – 10% of the sediment weight. Mud fractions ranged from 6 – 40% of the sediment, although only exceeded 17% in two samples (MGR09 and MG21). Seven samples were classified as muddy sand with a component of gravel (MGR09, MG11, MG19, MG24, MG37, MG41 and MG42), and one sample was classified as purely muddy sand (MG21). The other eight samples were all classified as sand with a component of gravel (MGR01, MGR02, MGR03, MG04, MG15, MG17, MG20 and MG23). All of the sediment samples were either very poorly or poorly sorted. Muddy sand (with or without a gravel component) was typically found at depths greater than ~90 m. Gravelly and slightly gravelly sand was found at depths <95 m. The sediment samples have been displayed on a modified Folk triangle (Folk, 1954) in Figure 3.1.

Table 3.1. Summary of the Particle Size Analysis (sediment weight by percentage) from grab samples collected by SEPA in The Minch Area (mud, sand and gravel refer to all size fractions within each category).

Sample	Gravel (%)	Sand (%)	Mud (%)	Depth (m)	Classification (Folk system adapted by BGS)	Sorting Index
	(Wentworth scale)					
MG04	19.74	74.34	6.43	60	Gravelly Sand	Poorly Sorted
MG11	4.30	85.80	10.38	152	Slightly Gravelly Muddy Sand	Poorly Sorted
MG13	30.62	63.65	6.23	152	Sandy Gravel	Very Poorly Sorted
MG15	9.65	83.16	7.05	54	Gravelly Sand	Poorly Sorted
MG17	6.61	85.76	7.79	64	Gravelly Sand	Poorly Sorted
MG19	3.08	84.09	12.95	85	Slightly Gravelly Muddy Sand	Poorly Sorted
MG20	2.76	90.76	6.74	75	Slightly Gravelly Sand	Poorly Sorted
MG21	0.05	59.46	40.39	98	Muddy Sand	Very Poorly Sorted
MG23	5.07	88.01	7.49	60	Gravelly Sand	Poorly Sorted
MG24	9.70	79.72	11.00	200	Gravelly Muddy Sand	Very Poorly Sorted
MG37	8.75	82.14	9.33	90	Gravelly Muddy Sand	Poorly Sorted
MG41	0.30	85.49	14.46	110	Muddy Sand	Poorly Sorted
MG42	0.49	82.67	16.50	153	Muddy Sand	Poorly Sorted
MGR01	2.86	91.34	5.27	77	Slightly Gravelly Sand	Poorly Sorted
MGR02	4.58	86.37	8.12	94	Slightly Gravelly Sand	Poorly Sorted
MGR03	4.29	88.78	6.08	81	Slightly Gravelly Sand	Poorly Sorted
MGR09	0.07	66.90	32.48	105	Muddy Sand	Poorly Sorted

Figure 3.1. Modified Folk triangle showing classification of the North Minch sediment samples.

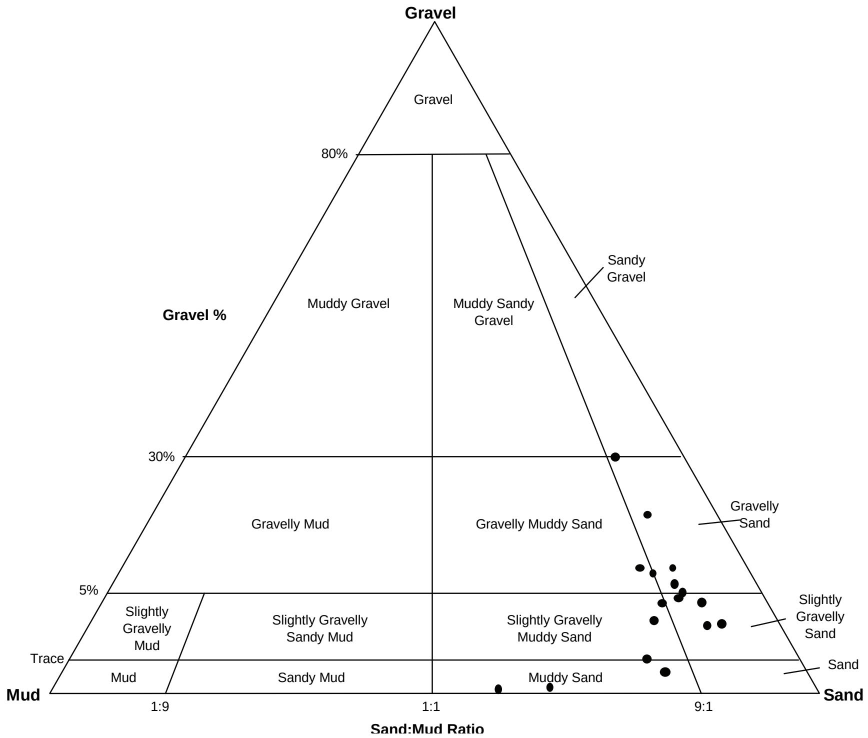


Table 3.3 shows the total percentage weight for each sample for every half phi interval. The sub 63 µm fraction was further examined by laser granulometry, and the results are summarised in Table 3.2, with the clay and silt values expressed as percentages of total weight of the whole sediment samples. All samples had ~1 % or less clay, with silt representing the majority of the sub 63 µm fraction.

Table 3.2. Summary table of the sub 63 µm fraction from The Minch sediment samples (NB. values for clay and silt are expressed as a percentage of the total weight of the whole sediment sample).

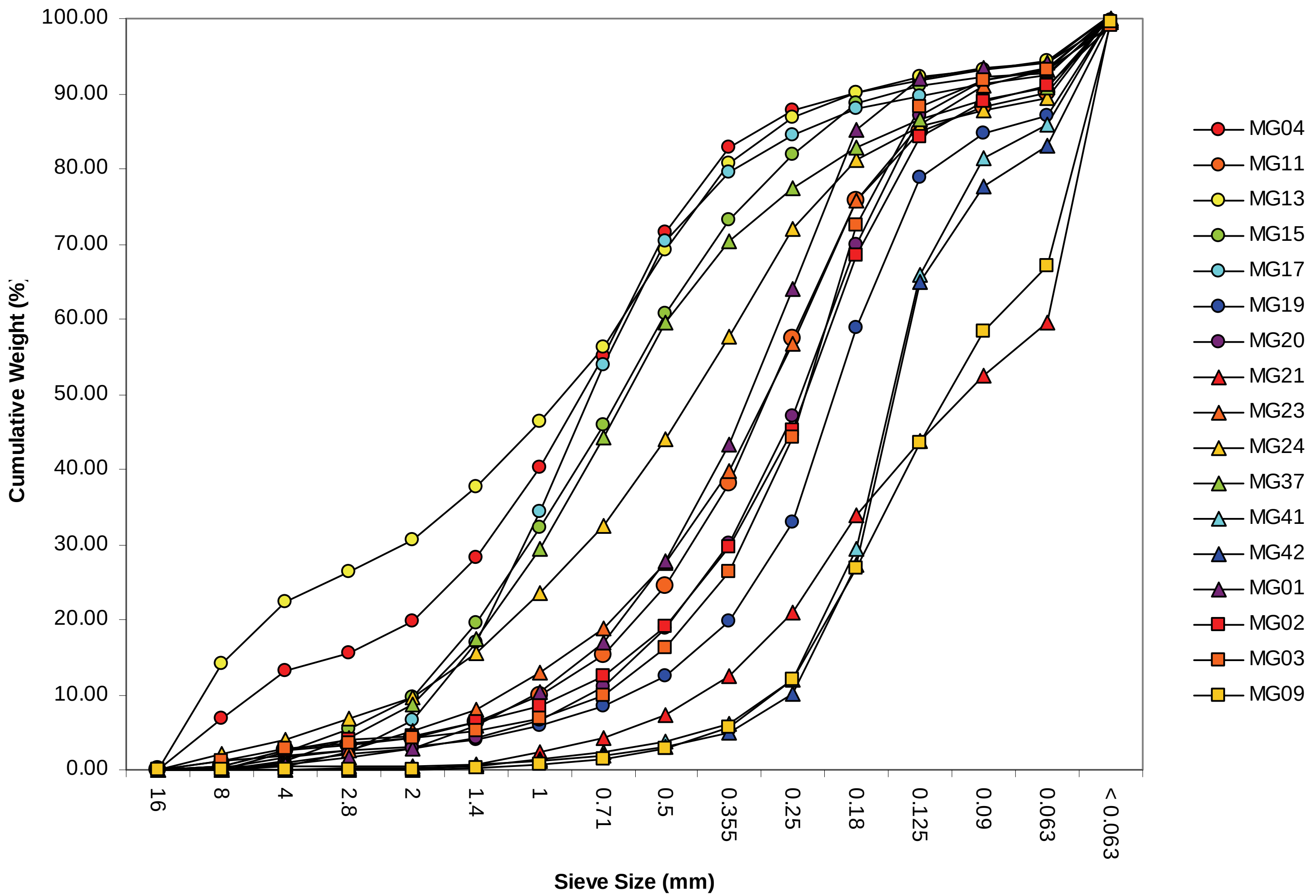
Station	**Clay (%)**	**Silt (%)**		
		Fine	**Medium**	**Coarse**
MG04	0.16	1.88	2.82	1.57
MG11	0.28	3.09	4.49	2.52
MG13	0.17	1.68	2.86	1.52
MG15	0.12	1.95	3.53	1.46
MG17	0.12	2.19	3.77	1.70
MG19	0.35	3.85	5.95	2.80
MG20	0.27	2.16	2.97	1.35
MG21	1.02	8.69	17.38	13.29
MG23	0.00	1.97	3.55	1.97
MG24	0.19	2.80	4.85	3.17
MG37	0.17	2.42	3.98	2.77
MG41	0.14	1.15	1.72	1.00
MG42	0.17	1.32	2.31	1.32
MGR01	0.15	1.50	2.41	1.20
MGR02	0.21	2.50	3.75	1.67
MGR03	0.23	1.80	2.70	1.35
MGR09	0.64	7.64	13.38	10.83

Figure 3.3 shows the cumulative percentage sediment weight for each sample for every half phi interval. In general, the cumulative frequency curves are relatively similar for all the samples. MGR01, MGR02, MGR03, and MG11 are particularly similar to each other, as are MG41 and MG42. The higher percentages of gravel seen in MG13 and MG04 can be seen, as can the higher mud fractions in MGR09 and MG21. Apart from MGR09 and MG21, all the samples were composed of ~80% gravel and sand.

Table 3.3. Total percentage sediment weight of grab samples from The Minch area (grey indicates 'gravel' fraction, light yellow 'sand' fraction, and brown the 'mud' fraction). NB. Processing differential results in the total percentage for each location to be excess of/less than 100%.

Location	Sieve Size (mm)															
	16	**8**	**4**	**2.8**	**2**	**1.4**	**1**	**0.71**	**0.5**	**0.355**	**0.25**	**0.18**	**0.125**	**0.09**	**0.063**	**< 0.063**
MG04	0.00	6.72	6.40	2.52	4.10	8.48	12.01	14.88	16.49	11.22	4.98	2.24	1.73	1.32	0.98	6.43
MG11	0.00	0.45	2.07	0.78	1.01	1.94	3.52	5.47	9.16	13.68	19.25	18.55	9.04	3.21	1.98	10.38
MG13	0.00	14.10	8.21	4.12	4.18	7.13	8.52	10.04	12.77	11.68	6.14	3.25	1.98	1.15	0.99	6.23
MG15	0.00	0.00	2.31	3.10	4.25	9.88	12.75	13.54	14.86	12.45	8.76	6.89	2.21	1.12	0.69	7.05
MG17	0.00	0.00	0.44	2.00	4.16	10.29	17.56	19.43	16.42	9.13	5.11	3.49	1.72	1.50	1.12	7.79
MG19	0.00	1.14	0.73	0.73	0.47	1.00	1.73	2.55	4.20	7.30	13.19	25.65	20.17	5.73	2.57	12.95
MG20	0.00	0.00	0.96	1.07	0.73	1.38	2.42	4.58	7.71	11.38	16.74	22.96	17.08	4.87	1.64	6.74
MG21	0.00	0.00	0.00	0.00	0.05	0.54	1.72	1.92	3.10	5.26	8.30	12.97	10.02	8.65	6.98	40.39
MG23	0.00	0.25	1.42	0.97	2.42	3.02	4.79	5.94	8.59	12.23	17.08	18.98	10.26	5.09	2.02	7.49
MG24	0.00	2.02	1.98	2.80	2.90	5.71	8.03	9.07	11.47	13.67	14.27	9.17	4.47	2.24	1.61	11.00
MG37	0.00	0.00	1.28	2.88	4.59	8.56	12.11	14.79	15.29	10.80	7.09	5.47	3.78	2.66	1.60	9.33
MG41	0.00	0.00	0.00	0.13	0.17	0.27	0.80	0.97	1.32	2.43	5.89	17.35	36.64	15.39	4.43	14.46
MG42	0.00	0.49	0.00	0.00	0.00	0.17	0.49	0.73	1.08	2.03	5.15	17.26	37.58	12.70	5.47	16.50
MGR01	0.00	0.00	0.63	0.99	1.24	2.91	4.56	6.60	10.90	15.48	20.70	21.18	6.92	1.36	0.73	5.27
MGR02	0.00	0.48	2.09	1.49	0.52	1.77	2.21	3.82	6.67	10.53	15.51	23.27	15.92	4.54	2.13	8.12
MGR03	0.00	1.19	1.64	0.60	0.86	0.86	1.66	3.14	6.22	10.29	17.73	28.37	15.73	3.52	1.26	6.08
MGR09	0.00	0.00	0.00	0.07	0.00	0.12	0.49	0.81	1.37	2.85	6.38	14.70	16.78	14.72	8.68	32.48

Figure 3.2. Cumulative percentage sediment weight for grab samples from The Minch survey area.



3.2 Macrofaunal analysis

The macrofaunal analysis revealed a total of 1375 individuals and 197 taxa (see Appendix 02) in The Minch Day grab samples (including meiofauna, epi-fauna and one Cephalochordate individual). Overall the macrofauna was dominated by Annelida (66.8 %) followed by Mollusca (13.1 %) and Crustacea (6.7 %), the latter excluding the Cirripedia. The Echinoderms contributed 4.4 %, Nematoda 4.4 % and Nemertea 1.7 % with the remaining groups (Ascidiacea, Sipuncula, Cirripedia, Phoronida, Anthozoa, Pycnogonida, Cephalocordata and Turbellaria) contributing the final 2.8 %. The meiofauna, epi-fauna and the Cephalochordate were all excluded from the univariate and multivariate analyses.

Of particular note is the presence of *Branchiostoma lanceolatum*, a member of the lancelets, which comprise some 22 species of fish-like marine Cephalochordates (animals without a spinal column). This taxon has a global distribution but in the UK it is generally described as having a south-western distribution (Appeltans *et al*., 2011; MarLIN, 2012a). There are records from Anglesey, the south-east coasts of Ireland and two sightings off the coasts of East Yorkshire and Northern Ireland but with this survey it has now also been recorded as far north as Scotland (see also The Scottish Government, 2011).

In addition, an individual from the Pilargidae family was present (genus and species unknown). Little is known about this group but the family has been recorded in the United Kingdom, Africa and Asia (Appeltans *et al.*, 2011.). However, this taxon could not be identified and appears not to have previously been recorded in the United Kingdom (Bamber, pers. comm.).

3.2.1 Macrofaunal abundance

The abundance of the identified macrofauna (excluding meiofauna, epifauna and the Cephalochordata) are given in Appendix 02 with a summary of the most abundant taxa overall given in Table 3.4. As with the overall data, Annelida is the most abundant group overall with the Cirratulid *Chaetozone gibber* and the Oweniid *Owenia fusiformis* being most abundant. Other relatively abundant taxa include *Abra prismatica, Lumbrineris gracilis* and *Notomastus latericeus*.

- *Chaetozone gibber* is an opportunistic species typically found in muddy sediments but there are few descriptions of this taxon possibly as a result of past taxonomic difficulties. *C. gibber* has been shown to be tolerant to hydrocarbons and even favour conditions where these compounds are found (Hiscock *et al*., 2005).

- *Owenia fusiformis* is found buried in sand or muddy sand. It is a thin, cylindrical, segmented worm, up to 10 cm long, that lives in a tough flexible tube buried in the sand with its anterior end just protruding from the surface.

- *Abra prismatica* is an inhabitant of a range of substrata including mixed and muddy sands and may be found from the low water-mark offshore to a depth of about 60 m (see Hayward and Ryland, 1990; NHMW, 2012). *Abra* spp. has been shown to be intolerant to physical disturbance and deoxygenation (Hiscock *et al*., 2005).

- *Lumbrineris gracilis* belongs to the Lumbrineris are a free-living burrowing genus that live in mucus-lined burrows in gravel, muddy sand and shelly substrata (Hayward and

Ryland, 1990). *L. gracilis* has been shown to be intolerant to hydrocarbons, synthetic chemicals and substratum loss (Hiscock *et al*., 2005).

- *Notomastus latericeus* is a polychaete worm belonging to the Family Capitellidae. *N. latericeus* lives in convoluted burrows in clean or muddy sand (Hayward and Ryland, 1990). It has been shown to be tolerant to hydrocarbons and even favour conditions where compounds are found but this taxon is intolerant to substratum loss (Hiscock *et al*., 2005).

Table 3.4. Abundance (ind./0.1 m^2) of the main macrofaunal taxa in The Minch 2011 survey.

MCS A	MCS N	Taxon	Species	Abundance
P	833	*Chaetozone*	*gibber*	114
P	1098	*Owenia*	*fusiformis*	80
W	2062	*Abra*	*prismatica*	64
P	1099	TEREBELLIDA	spp.	35
P	579	*Lumbrineris*	*gracilis*	33
P	921	*Notomastus*	*latericeus*	33
P	723	*Aonides*	*paucibranchiata*	27
P	822	Cirratulidae	sp.	27
P	906	*Capitella*	sp.	25
W	1571	*Nucula*	*sulcata*	25
G	1	NEMERTEA	spp.	24
ZB	-	Ophiuroidea	sp.	23
P	255	*Glycera*	sp.	21
P	569	Lumbrineridae	sp.	21
S	413	*Atylus*	*vedlomensis*	19
W	1627	*Yoldiella*	*philippiana*	19
P	260	*Glycera*	*lapidum*	17
P	271	*Goniada*	*maculata*	17
P	747	*Minuspio*	*cirrifera*	17
P	823	*Aphelochaeta*	sp.	17
P	878	*Diplocirrus*	*glaucus*	17
P	824	*Aphelochaeta*	*marioni*	16
P	834	*Chaetozone*	*setosa*	15
P	873	Flabelligeridae	sp.	15
P	1090	Oweniidae	sp.	15
P	720	Spionidae	sp.	14
P	568	*Nematonereis*	*unicornis*	13
P	690	*Cirrophorus*	*branchiatus*	13
P	-	*Euclymene*	sp. A	13
ZB	154	*Amphiura*	*filiformis*	13
P	-	*Glycera*	*unicornis*	11
P	502	*Nephtys*	*kersivalensis*	11
P	584	*Scoletoma*	*impatiens*	11
P	796	*Spiophanes*	*kroyeri*	11
P	425	*Sphaerosyllis*	*bulbosa*	10
P	783	*Scolelepis*	*squamata*	10
W	11	*Falcidens*	*crossotus*	10

3.2.2 Diversity

The results for the species diversity analyses are given in Table 3.5. The total number of individuals at each station range from 6 to 120 individuals per sample with the total number of taxa ranging from 4 to 57 taxa per sample indicating that there some differences between the samples, and potentially between the stations.

The species diversity (Shannon-Wiener diversity index) overall is low to medium with diversity being highest at station MG04 but relatively high values are also found at stations MG11, MG15, MG17, MG23 and MG37. The lowest species diversity value is found at station MG21 and it must be noted that the sample was found to have leaked on arrival at the laboratory.

The equitability (J) results suggest an equal distribution between species at most of the stations. Most values are close to 0.9 with the lowest equitability found at station MG01, indicating a relatively higher dominance by a smaller number of different species but even at 0.76 equitability has to be considered medium to high.

Table 3.5. Total number of individuals (N), number of species (S), Margalef's species richness (d), Pielou's equitability index (J) and Shannon-Wiener diversity index (H') for all the samples in the 2011 The Minch Day grab survey.

Station	S	N	d	J'	H'(log_e)	1-Lambda
MGR01	34	94	7.26	0.76	2.68	0.87
MGR02	26	48	6.46	0.85	2.78	0.91
MGR03	25	49	6.17	0.87	2.81	0.92
MG04	57	120	11.70	0.93	3.75	0.98
MGR09	8	17	2.47	0.93	1.94	0.89
MG11	47	95	10.10	0.91	3.52	0.97
MG13	32	51	7.88	0.94	3.26	0.97
MG15	51	111	10.62	0.92	3.63	0.97
MG17	45	90	9.78	0.95	3.61	0.98
MG19	33	85	7.20	0.83	2.91	0.92
MG20	38	83	8.37	0.89	3.25	0.95
MG21	4	6	1.67	0.96	1.33	0.87
MG23	40	69	9.21	0.93	3.42	0.97
MG24	36	112	7.42	0.89	3.19	0.95
MG37	49	107	10.27	0.89	3.45	0.96
MG41	40	110	8.30	0.89	3.30	0.95
MG42	20	47	4.93	0.95	2.84	0.95

3.2.3 Macrofaunal composition

The results from the cluster and ordination analyses are given in Figures 3.3 and 3.4. These results exclude station MG21 as the bucket with the sample was found to have leaked on arrival at the laboratory. Considering the low numbers of taxa and species present this sample was considered unrepresentative of the actual community in this location and therefore excluded from detailed analysis.

The results from the cluster analysis suggest three main communities among all the Day grab samples from The Minch (Figure 3.3). These communities are also apparent in the ordination analysis but perhaps less certain (Figure 3.4). Station MGR09 appears to be a community different to all the other communities.

Figure 3.3. Cluster analysis of The Minch 2011 macrofaunal sample data (excluding MG21).

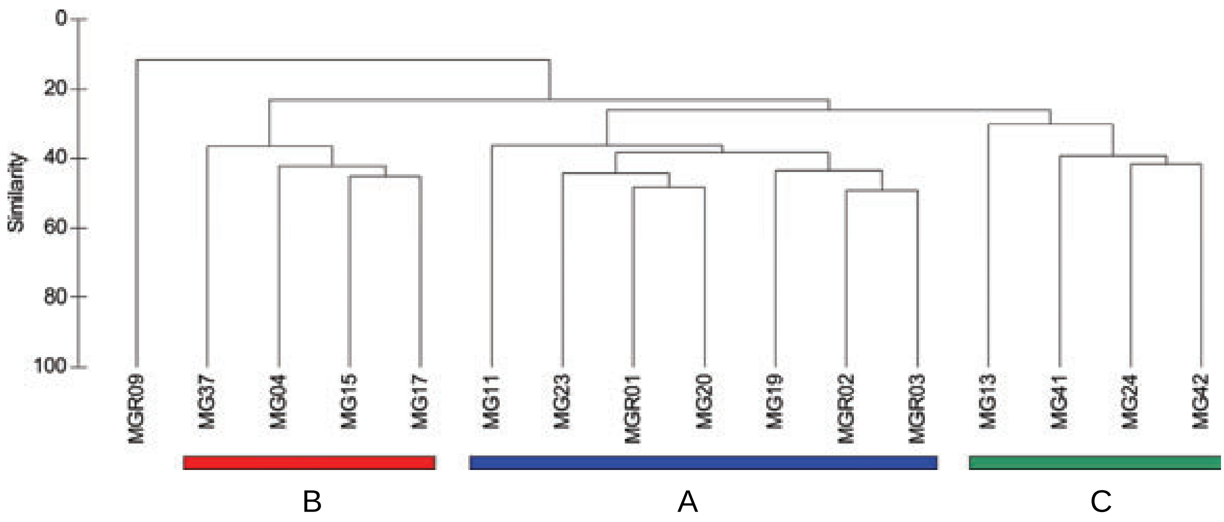
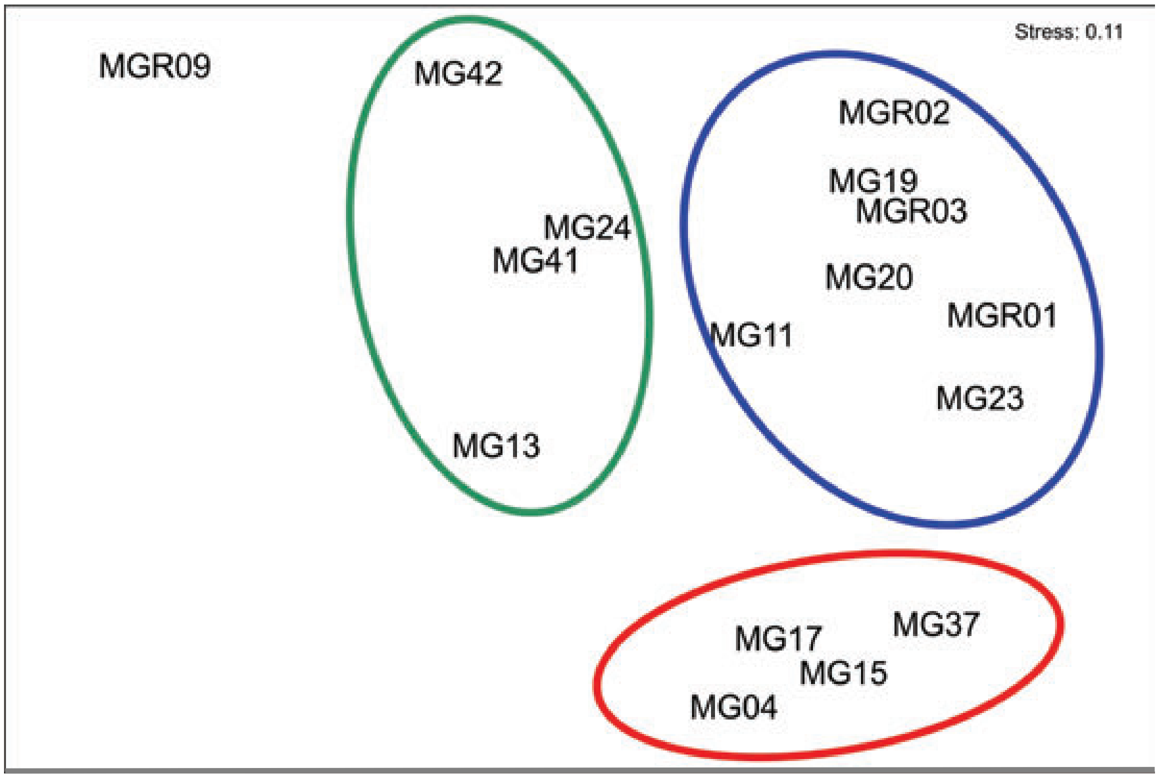


Figure 3.4. Ordination analysis of The Minch 2011 macrofaunal sample data (excluding MG21).



A SIMPER analysis was undertaken to assess any similarities between the different clusters (Table 3.6). The characteristic fauna in the three groups are different, suggesting the clusters are related to actual community and abiotic differences.

Table 3.6. SIMPER analysis of The Minch 2011 macrofaunal samples.

Cluster	MCS code		Taxa/species		Contribution (%)
A	P	833	*Chaetozone*	*gibber*	17.3
	P	1098	*Owenia*	*fusiformis*	11.5
	W	2062	*Abra*	*prismatica*	6.9
	P	906	*Capitella*	sp.	5.0
	P	579	*Lumbrineris*	*gracilis*	4.4
	P	502	*Nephtys*	*kersivalensis*	4.4
	P	1090	Oweniidae	sp.	4.3
	P	271	*Goniada*	*maculata*	4.2
	P	822	Cirratulidae	sp.	3.4
	P	1099	TEREBELLIDA	spp.	3.2
	P	-	*Euclymene*	sp. A	2.5
	W	1627	*Yoldiella*	*philippiana*	2.0
	P	107	*Sthenelais*	*boa*	1.9
B	S	413	*Atylus*	*vedlomensis*	6.4
	G	1	NEMERTEA	spp.	6.0
	P	723	*Aonides*	*paucibranchiata*	5.6
	P	747	*Minuspio*	*cirrifera*	4.7
	P	579	*Lumbrineris*	gracilis	4.7
	P	1099	TEREBELLIDA	spp.	4.6
	P	720	Spionidae	sp.	4.5
	P	568	*Nematonereis*	*unicornis*	4.4
	P	690	*Cirrophorus*	*branchiatus*	4.1
	P	718	*Poecilochaetus*	*serpens*	3.9
	P	569	Lumbrineridae	sp.	3.9
	W	2104	*Timoclea*	*ovata*	3.7
	P	255	*Glycera*	sp.	3.5
	P	921	*Notomastus*	*latericeus*	3.2
	P	425	*Sphaerosyllis*	*bulbosa*	2.9
C	W	2062	*Abra*	*prismatica*	12.6
	W	1571	*Nucula*	*sulcata*	10.4
	P	834	*Chaetozone*	*setosa*	7.7
	P	569	Lumbrineridae	sp.	7.5
	P	878	*Diplocirrus*	*glaucus*	4.5
	P	824	*Aphelochaeta*	*marioni*	3.9
	P	584	*Scoletoma*	*impatiens*	3.7
	S	1409	*Calocaris*	*macandreae*	3.7
	P	1099	TEREBELLIDA	spp.	3.4
	P	-	*Glycera*	*unicornis*	3.3
	P	833	*Chaetozone*	*gibber*	3.1
	W	1925	*Astarte*	*sulcata*	3.1
	P	906	*Capitella*	sp.	2.9

3.2.4 Limitations

The macrofaunal identification was slightly hampered by the large number of damaged animals making this process challenging. In particular, the Terebellids and many of the polychaete taxa were difficult to identify to a low taxonomic level (see Appendix 02) but overall the results are believed to be representative for the samples taken.

3.3 Designation of biotopes

All the locations sampled during The Minch 2011 survey are from a depth greater than 60 m and therefore fall under offshore sediments. The dominant fauna and the sediment classification of the samples were used to define the most appropriate biotope for each site. The classification process was completed prior to any statistical analyses of the data. Table 3.7 and Figure 3.5 summarises the biotopes assigned to the sites sampled around the Minch and although there were several biotope complexes present, only one biotope (**SS.SSa.OSa.OfusAfil**) was an offshore Priority Marine Features and Marine Protected Area search feature.

Of note are the similarities between biotope classifications (biotope complex level) and the cluster analysis results above despite obvious differences in the positions of the sample locations.

Figure 3.5. Biotope complexes of samples collected during The Minch 2011 survey.

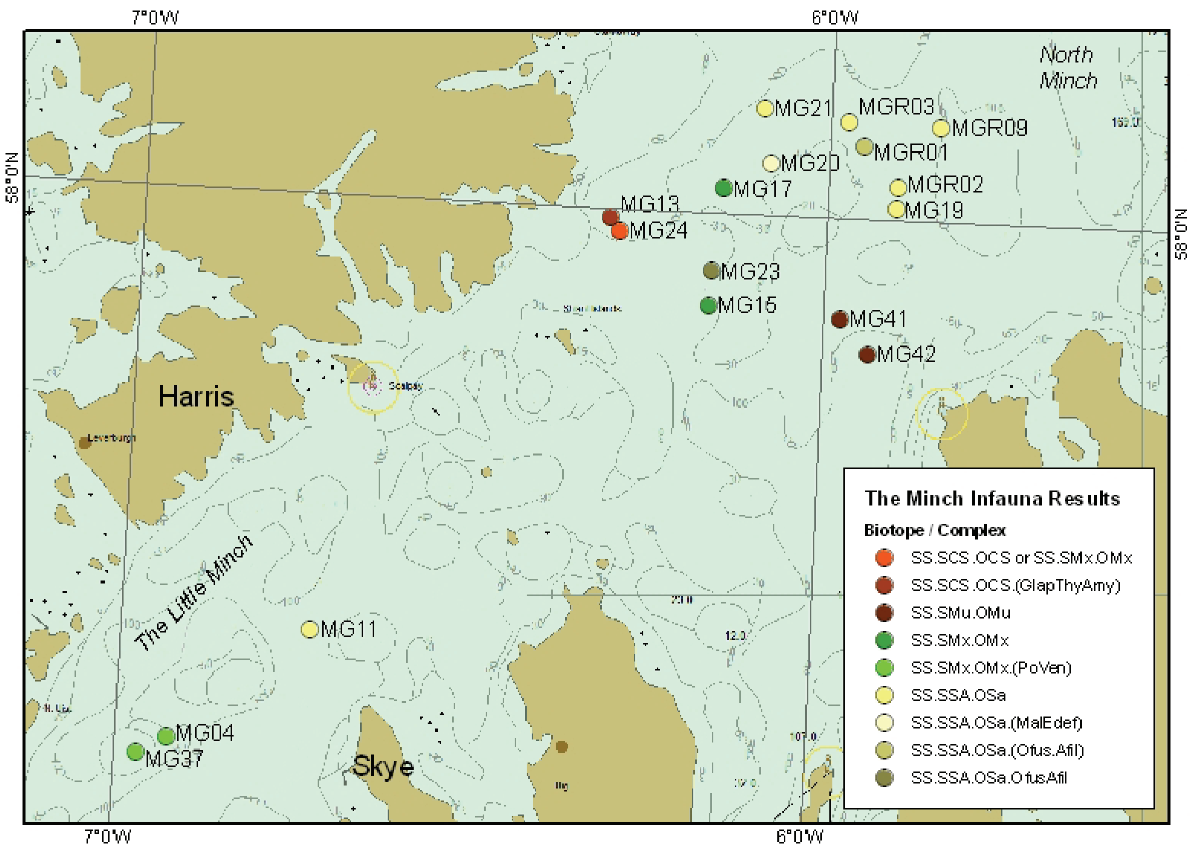


Table 3.7. Summary of biotopes assigned to samples taken during The Minch survey 2011.

Station	Biotope	Depth (m)	Sediment description	Characterising fauna
MGR01	**SS.SSa.OSa.(Ofus.Afil)**	77	(g) S	*Chaetozone gibber*, *Owenia fusiformis*
MGR02	**SS.SSa.OSa**	94	(g) S	*Chaetozone gibber*
MGR03	**SS.SSa.OSa**	81	(g) S	*Chaetozone gibber*
MG04	**SS.SMx.OMx.(PoVen)**	60	gS	Diverse number of polychaetes, amphipods and bivalves. High numbers of nematodes.
MGR09	**SS.SSa.OSa**	105	mS	*
MG11	**SS.SSa.OSa**	152	(g) mS	Diverse fauna. Polychaetes present include *Chaetozone gibber*, *Owenia fusiformis, Pholoe synophtalmica*
MG13	**SS.SCS.OCS.(GlapThyAmy)**	152	sG	Diverse polychaetes incl. *Glycera lapidum, Lumbrineris gracilis,* cirratulids
MG15	**SS.SMx.OMx**	54	gS	Diverse polychaetes incl. *Laonice bahusiensis, Aonides paucibranchiata,* glycerids, *Notomastus*
MG17	**SS.SMx.OMx**	64	gS	Diverse polychaetes incl. glycerids, *Aonides paucibranchiata*
MG19	**SS.SSa.OSa**	85	(g) mS	*Lumbrineris gracils, Chaetozone gibba, Owenia fusiformis,* nematods
MG20	**SS.SSa.OSa.(MalEdef)**	75	(g) S	*Chaetozone gibba*, *Abra prismatica*, terebellid and maldanid polychaetes
MG21	**SS.SSa.OSa**	98	mS	*
MG23	**SS.SSa.OSa.OfusAfil**	60	gS	*Amphiura*, owenidd polychaetes, *Chaetozone*

Station	Biotope	Depth (m)	Sediment description	Characterising fauna
MG24	**SS.SCS.OCS or SS.SMx.OMx**	200	gmS	Nuculoida bivalves, *Abra prismatica*, *Glycera,* Lumbrinerid and cirratulid polychaetes
MG37	**SS.SMx.OMx.(PoVen)**	90	gmS	Diverse infauna incl. polychaetes *Chaetozone gibber, Lumbrineris gracilis, Nematonereis unicornis* and occasional veneroid bivalves
MG41	**SS.SMu.OMu**	110	mS	*Abra prismatica, Calocaris macandreae,* terebellid and flabelligerid polychaetes
MG42	**SS.SMu.OMu**	153	mS	*Abra prismatica, Calocaris macandreae,* lumbrinerid polychaetes, *Notomastus latericeus*

*NB. * denotes when a sample has no particular characterising fauna – in these samples the sediment description was used to designate a biotope.*

The sediment at MGR01 was characterised by slightly gravelly sand, with the polychaetes *Chaetozone gibber* and *Owenia fusiformis* dominating the infauna. The best fitting biotope for the site was *Owenia fusiformis* and *Amphiura filiformis* in offshore circalittoral sand or muddy sand (**SS.SSa.OSa.OfusAfil**), although the *Amphiura* that characterises this biotope were not found in high numbers. Both MGR02 and MGR03 had high numbers of *C. gibber*, but no significant numbers of other infauna. From the sediment composition of gravelly sand, these sites were best defined by the offshore circalittoral sand biotope complex (**SS.SSA.OSa**). None of the fauna that characterise either of the biotopes were found in high enough numbers to further distinguish the biotopes present at these sites.

MG04 had a mixture of different polychaete, bivalve and amphipod species, with nematode worms and the spionid worm *Aonides paucibranchiata* present in the highest numbers. The sediment at the site was characterised as gravelly sand. The mixture of different fauna present suggested that the biotope complex, offshore circalittoral mixed sediment (**SS.SMx.OMx**), was the best fit for the sample. The lack of significant numbers of venerid bivalves (only a single specimen of *Timoclea ovata* was present) stopped the biotope polychaete-rich deep *Venus* community in offshore mixed sediments (**SS.SMx.OMx.PoVen**) from being appropriate for this site.

Site MG11 had a similarly diverse mix of fauna to site MG04, but with fewer amphipods and some holothurians being present. The polychaete *Owenia fusiformis* was present in fairly high numbers. The sediment description for this site was slightly gravelly muddy sand. Overall, the infaunal and sediment composition of the site was somewhere between **SS.SMx.OMx** and **SS.SSa.OSa**. However, the presence of some polychaetes such as *O. fusiformis, Pholoe synophthalmica* and *Chaetozone gibber* and the lack of *Aonides paucibranchiata* suggested that the biotope complex was more likely to be **SS.SSa.OSa.**

Site MGR09 was faunally sparse, with only a few polychaetes and the bivalve *Nucula sulcata* found, all occurring in low numbers. The sample from site MG21 had probably lost most of its contents during transportation, so only a few polychaetes were present. The biotopes for these sites were therefore defined according to their sediment description of muddy sand as the biotope complex **SS.SSa.OSa**.

The sediment at site MG13 was sandy gravel. There was a range of polychaetes present, including more robust species such as *Glycera lapidum, Lumbrineris gracilis* and some cirratulids, along with some ophiuroids. The mix of polychaetes suggested that the site belonged to the offshore circalittoral coarse sediment (**SS.SCS.OCS**) biotope complex, possibly *Glycera lapidum*, *Thyasira* spp. and *Amythasides macroglossus* in offshore gravelly sand (**SS.SCS.OCS.GlapThyAmy**), although the characterising *Thyasira* and *Amythasides* were not present. MG15 was again dominated by a diverse mix of polychaetes, many of which were similar taxa to those found at site MG13. However, the presence of some of the characterising polychaete species such as *Laonice bahusiensis* and *Aonides paucibranchiata* suggest that the site was probably better described by the **SS.SMx.OMx** biotope complex. MG17 also had a mixture of polychaete species, some of which were present in both MG13 and MG15. The presence of *Aonides paucibranchiata* and the sediment being gravelly sand as opposed to sandy gravel suggested that the biotope complex **SS.SMx.OMx** was the best fit for this site.

High numbers of the polychaete worms *Lumbrineris gracilis, Chaetozone gibba, Owenia fusiformis* and nematode were present in sample MG19. The sediment here was slightly gravelly muddy sand. Some *Nephtys* species were also found, which usually characterise shallower sandy sediments. The best biotope complex fit for the site is **SS.SSa.OSa**. Although high numbers of *O. fusiformis* were found in the sample there was only a single *Amphiura* present, therefore precluding the **SS.SSa.OSa.OfusAfil** biotope. The occasional maldanid polychaete was also present, but no cumaceans were found, precluding the **SS.SSa.OSa.MalEdef** biotope.

The bivalve *Abra* and the polychaete *Chaetozone* were found in high numbers in sample MG20. There were not many oweniid polychaetes in the sample, but some maldanid and terebellids were present. The biotope complex **SS.SSa.OSa** best described the fauna found, with the lack of the cumacean *Eudorellopsis deformis* preventing the biotope **SS.SSa.OSa.MalEdef** from being more appropriate.

The characterising fauna from MG23 comprised some ophiuroids (including *Amphiura*) and relatively high numbers of oweniid polychaetes *Owenia fusiformis* and *Myriochele heeri*. *Chaetozone gibber* was also present. The presence of these species suggested that the biotope **SS.SSa.OSa.OfusAfil** would be appropriate for the site.

MG24 had mixed sediment of gravelly muddy sand. Nuculoida bivalves (*Nucula minuta*, *Yoldiella philippiana* and *Nuculana minuta*) and *Abra prismatica* were all found in high numbers, as were *Glycera,* cirratulid and lumbrinerid polychaetes. This mixture of fauna does not fit into any one biotope complex particularly well. The bivalve *Abra* is usually found in soft sediments, as are the burrowing shrimp *Calocaris macandreae* found in the sample. However, the mixture of robust polychaetes is more typical of coarse sediments. The best biotope complex for this site would be either **SS.SCS.OCS** to reflect the polychaete component of the infauna, or **SS.SMx.OMx** to take into account the presence of the bivalves, burrowing crustaceans and the sediment classification for the sample.

A diverse mix of fauna including several polychaetes, amphipod and bivalve taxa were present in sample MG37. The polychaetes *Lumbrineris gracilis*, *Chaetozone gibber* and *Nematonereis unicornis* were numerically dominant in the sample. Occasional veneroid bivalves (*Timoclea ovata* and *Venus casina*) were also present. Considering the range of fauna present and the sediment classification of gravelly muddy sand, then the biotope complex **SS.SMx.OMx** would be most appropriate for the site, possibly even the biotope **SS.SMx.OMx.PoVen**.

The sample from MG41 had high numbers of the bivalve *Abra prismatica*, flabelligerid and terebellid polychaetes, and the burrowing shrimp *Calocaris macandreae*. MG42 also had high numbers of *C. macandreae*, but with a slightly different polychaete assemblage to MG41, with generally fewer taxa and fewer numbers. The most notable polychaetes from MG42 were lumbrinerids and *Notomastus latericeus*. Similar bivalves were present at both sites, although MG42 had much lower numbers of *A. prismatica*. The fauna from both MG41 and MG42 were characteristic of soft sediments, although did not adequately place the samples within any of the biotopes of the **SS.SMu.OMu** biotope complex.

3.4 Comparisons between macrofaunal trends and the abiotic data

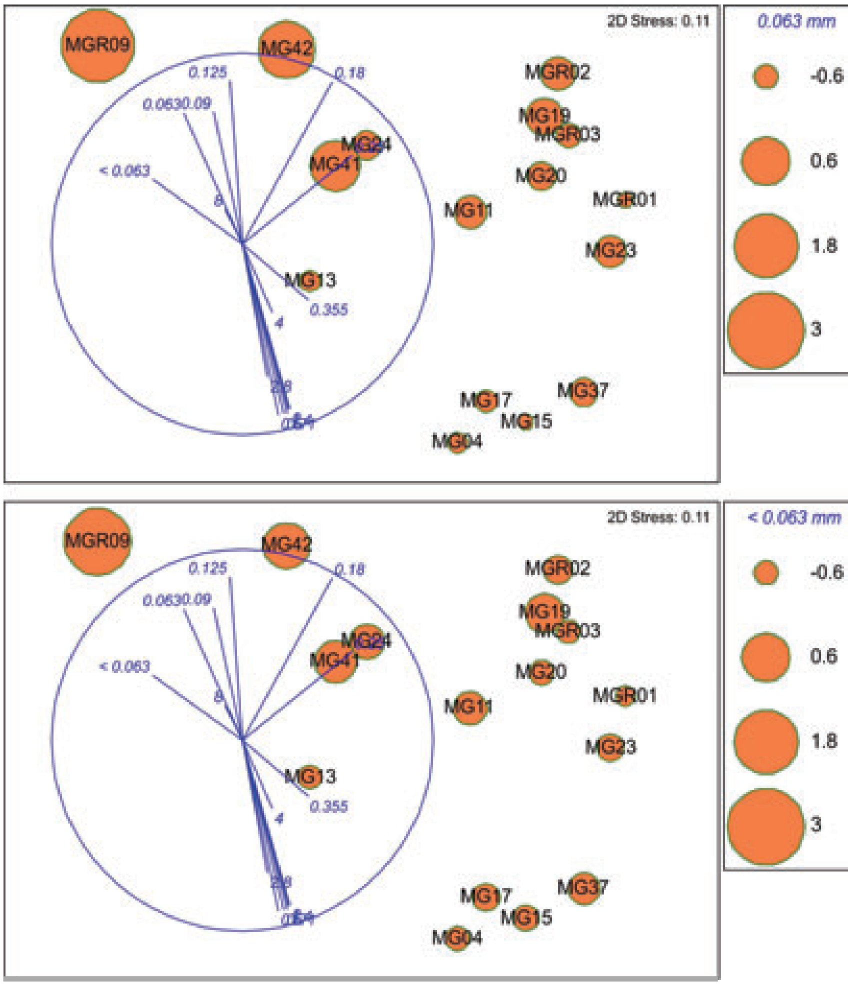
In this study the abiotic parameters available include sediment particle size data and depth records but other parameters are also likely to influence the biological communities in the survey area. The available data were compared to the cluster and ordination analyses results (see Table 3.8 and Figure 3.6 as well as Appendix 04). Table 3.8 illustrates that all the samples in cluster A have been classified as **SS.SSA.OSa**, all samples in cluster B have been classified as **SS.SMx.OMx** whilst the samples in cluster C have been classified as either **SS.SCS.OCS** or **SS.SMu.OMu**. Of interest is also the fact that the samples in cluster C were all from depths of 110 m or more, whilst the cluster B samples were from relatively shallow depths (54 m to 90 m).

Table 3.8. Summary of results for each sample and cluster group (colours as Figure 3.4).

Station	Biotope	Depth (m)	Sediment description	Gravel (%)	Sand (%)	Mud (%)
MGR01	SS.SSa.OSa.(OfusAfil)	77	(g) S	2.86	91.34	5.27
MGR02	SS.SSa.OSa	94	(g) S	4.58	86.37	8.12
MGR03	SS.SSa.OSa	81	(g) S	4.29	88.78	6.08
MGR09	SS.SSa.OSa	105	mS	0.07	66.9	32.48
MG11	SS.SSa.OSa	152	(g) mS	4.3	85.8	10.38
MG19	SS.SSa.OSa	85	(g) mS	3.08	84.09	12.95
MG20	SS.SSa.OSa.(MalEdef)	75	(g) S	2.76	90.76	6.74
MG21	SS.SSa.OSa	98	mS	0.05	59.46	40.39
MG23	SS.SSa.OSa.OfusAfil	60	gS	5.07	88.01	7.49
MG04	SS.SMx.OMx.(PoVen)	60	gS	19.74	74.34	6.43
MG15	SS.SMx.OMx	54	gS	9.65	83.16	7.05
MG17	SS.SMx.OMx	64	gS	6.61	85.76	7.79
MG37	SS.SMx.OMx.(PoVen)	90	gmS	8.75	82.14	9.33
MG13	SS.SCS.OCS.(GlapThyAmy)	152	sG	30.62	63.65	6.23
MG24	SS.SCS.OCS or SS.SMx.OMx	200	gmS	9.7	79.72	11
MG41	SS.SMu.OMu	110	mS	0.3	85.49	14.46
MG42	SS.SMu.OMu	153	mS	0.49	82.67	16.5

Further analyses of the data using the ordination data suggest a correlation between macrofaunal community and both sediment grain size and depth. The visual analysis of the MDS plots (abiotic bubble plots) suggest that the strongest correlations between the macrofaunal ordination results and abiotic parameters are with the finer sediment size fractions the 0.063 mm and <0.063 mm sediment grain size fractions in particular (see vectors in Figure 3.5). Depth also has some influence but appears to be less important than sediment grain size. There are no apparent trends with latitude or longitude (in terms of the MDS data).

Figure 3.6. Macrofaunal community MDS plot with abiotic bubble analysis.



In an attempt to assess these results further the Spearman rank correlation coefficient (r_s) was used and the strongest correlation was with a combination of the 0.063 mm and 1.4 mm size fractions (r_s = 0.73). As individual parameters the largest correlations were (in order) 0.5 mm (r_s = 0.585), 0.71 mm (r_s = 0.525), 2 mm (r_s = 0.509). The correlation with depth was low (r_s = 0.25). With the abiotic data available it therefore appears as if sediment grain size is the primarily controller of the distributions of the faunal communities seen. However, there are many other potential parameters that are likely to influence these distributions and compositions.

4 DISCUSSION

The 2011 benthic survey in The Minch encompassed a region from the North Minch, including the East Shiant Bank and Shiant Islands, south to the Little Minch (Figures 2.1 to 2.3). The aims included the collection of qualitative biological data to help inform SNH's understanding of the importance of large scale features (LSFs) within Scottish waters. The 2011 survey included a combination of sampling equipment but the current analysis only refers to the Day grab sample data, hence any reference to the LSFs or any other large features has not been possible.

4.1 Summary of the main habitats

The four main biotope complexes found in this study are **SS.SSa.OSa**, **SS.SMx.OMx**, **SS.SCS.OCS** and **SS.SMu.OMu**.

The offshore (deep) circalittoral biotope complex **SS.SSa.OSa** consists of habitats with fine sands but very little data are available for these habitats (see Connor *et al*., 2004). However, the biotopes included in this complex are dominated by a diverse range of polychaetes (e.g. *Goniada maculata*, *Pholoe inornata*, *Diplocirrus glaucus*, *Chaetozone setosa* and *Spiophanes kroyeri*), amphipods, bivalves and echinoderms. The majority of samples from The Minch were classified in this group and most of them are found close together in the northern part of the study area. The habitat is typified by slightly gravelly muddy sand, with polychaetes such as *Chaetozone* spp. and *Owenia fusiformis* dominating the infauna. Some samples could have been classified **SS.SSa.OSa.OfusAfil** but the *Amphiura* that characterises this biotope were not found in high numbers. It is possible that this genus was present in higher numbers at these locations but additional sampling effort and perhaps replicate sampling would be required to assess this further. Another option was to classify this group as either **SS.SCS.CCS.MedLumVen** or **SS.SSa.CMuSa** but the depth range is right at the limit (or beyond) of these biotopes and the relative contribution of *Chaetozone* spp. and *Owenia fusiformis* is not sufficiently significant.

The **SS.SMx.OMx** biotope complex is described as offshore (deep) circalittoral habitats with slightly muddy mixed gravelly sand (see Connor *et al*., 2004). This habitat may cover large areas of the offshore continental shelf although, as with the **SS.SSa.OSa** complex, there are relatively few data available. The **SS.SMx.OMx** habitats are often highly diverse with a high number of infaunal polychaete and bivalve species illustrated by for example sample MG04 which had a mixture of different polychaete, bivalve and amphipod species, with nematode worms and the spionid worm *Aonides paucibranchiata* present at the highest numbers. However, there was a lack of significant numbers of venerid bivalves (only a single specimen of *Timoclea ovata* was present) which prevented a more detailed classification.

The final two biotope complexes (**SS.SCS.OCS** and **SS.SMu.OMu**) are both present in the third cluster (cluster C). Although the fauna from both MG41 and MG42 were characteristic of soft sediments, a classification into biotopes within the **SS.SMu.OMu** biotope complex was not possible. These samples initially appear different to the fauna within MG13 and MG24 but there are similarities. Both samples contain robust fauna such as *Glycera lapidum, Lumbrineris gracilis* and some cirratulids but there are differences including the sediment grain size distribution. The sampling locations are furthermore on opposite sides of the North Minch with potential differences in several abiotic parameters. Another potential biotope for this group was **SS.SSA.CMuSa** but as with many current biotopes The Minch stations were too deep to allow such a classification.

Of note is the presence of **SS.SSa,OSa.OfusAfil**, an offshore PMF and MPA search feature. This biotope was found at station MG23 and therefore needs particular attention during the reporting as part of the LSF survey.

4.2 Limitations

The seabed environment in The Minch is complex with several banks, channels and deeper areas making any analysis of the relatively low number of sediment samples challenging. In addition, the epifaunal results together with any acoustic data would greatly aid any detailed analysis of the infaunal data to allow large-scale features to be identified.

A final consideration is the lack of detail in the biotope classification system in terms of the biological communities found in the deeper and offshore areas around the United Kingdom (Connor *et al*., 2004). It has therefore been challenging to classify the samples at a high level (5 or 6). The remit for this brief study does not include a detailed analysis in terms of the broader biological communities present in The Minch but the data should aid any reviews or broad-scale studies in the area.

There were only 17 samples included in study. Additional sampling with more sample locations and replicates may have allowed for a more detailed assessment of biotopes in The Minch area. The presence of a lancelet is of particular interest as this taxon is a new record in the area. The presence of an individual of the Pilargidae family is also of interest but it was not possible to identify this individual to genus or species level so whether this is a new species remains unknown.

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APPENDIX 01. SNH field sample log – The Minch infaunal survey 2011.

Date	Station	Location	Start Time (GMT)	Latitude (SOL)	Longitude (SOL)	Start Depth (m)
23/10/2011	MG40 - Attempt 1. No sample	Shiant Bank	09:05	57.949495	-5.940923	68
23/10/2011	MG40 - Attempt 2. No sample	Shiant Bank	09:07	57.949972	-5.940772	69
23/10/2011	MG40 - Misfire	Shiant Bank	09:10	57.950655	-5.940580	72
23/10/2011	MG40 - Attempt 3. No sample	Shiant Bank	09:14	57.951337	-5.940623	75
23/10/2011	MG41	Shiant Bank	10:04	57.922087	-5.974517	110
25/10/2011	MG4	Southern Little Minch	11:41	57.570882	-6.923937	60
25/10/2011	MG37 - Attempt 1 - no sample	Southern Little Minch	14:19	57.557102	-6.964813	90
25/10/2011	MG37	Southern Little Minch	14:24	57.558647	-6.965892	90
25/10/2011	MG11 - Attempt 1. Poor sample	Northern Little Minch	17:55	57.658363	-6.726778	153
25/10/2011	MG11	Northern Little Minch	18:00	57.660778	-6.723457	152
26/10/2011	MG15 - Misfire	Shiant Bank	10:09	57.928805	-6.167832	54
26/10/2011	MG15	Shiant Bank	10:11	57.928815	-6.167828	54
26/10/2011	MG23	Shiant Bank	11:04	57.955300	-6.166595	60
26/10/2011	MG42 - Missfire	Shiant Bank	16:30	57.895162	-5.934772	150
26/10/2011	MG42	Shiant Bank	16:34	57.896227	-5.932297	153
28/10/2011	MG23 - Missfire	Shiant Bank	11:38	57.990805	-6.041957	34
28/10/2011	MG23 - Missfire	Shiant Bank	11:40	57.991122	-6.041462	34
28/10/2011	MG23 - Missfire	Shiant Bank	11:42	57.991638	-6.041043	35
28/10/2011	MG23 - Empty	Shiant Bank	11:47	57.992453	-6.043935	40
01/11/2011	MG13 - Rocks only	Shiant Islands	08:53	57.993073	-6.318163	155
01/11/2011	MG13 - Poor sample, but best available	Shiant Islands	08:59	57.993073	-6.318163	152
01/11/2011	MG24	Shiant Islands	09:17	57.983773	-6.302300	200
01/11/2011	MG17	Shiant Bank	10:05	58.019925	-6.152653	64
01/11/2011	MG20	Shiant Bank	10:30	58.041150	-6.084868	75
01/11/2011	MG21 - Missfire	Shiant Bank	10:57	58.082788	-6.101750	97
01/11/2011	MG21	Shiant Bank	11:00	58.083977	-6.099558	98
02/11/2011	MGR01 - Rock only	Shiant Bank	09:50	58.056627	-5.950300	77
02/11/2011	MGR01	Shiant Bank	09:55	58.057550	-5.949988	77
02/11/2011	MGR03	Shiant Bank	10:10	58.076177	-5.975215	81
02/11/2011	MGR02 - No sample	Shiant Bank	10:50	58.023680	-5.899935	92
02/11/2011	MGR02 - No sample	Shiant Bank	10:55	58.025143	-5.899170	94
02/11/2011	MGR02	Shiant Bank	10:59	58.026743	-5.898387	94
02/11/2011	MG19 - Shells only	Shiant Bank	11:20	58.006893	-5.901920	89
02/11/2011	MG19 - Missfire	Shiant Bank	11:24	58.007985	-5.901200	85
02/11/2011	MG19	Shiant Bank	11:28	58.009182	-5.900373	85
02/11/2011	MGR09	Shiant Bank	12:06	58.074378	-5.838372	105

APPENDIX 02. Macrofaunal species matrix - The Minch infaunal survey 2011.

						Site																
MCS A	MCS N	Taxon	Species	Authority	Qualifier	MGR01	MGR02	MGR03	MG04	MGR09	MG11	MG13	MG15	MG17	MG19	MG20	MG21	MG23	MG24	MG37	MG41	MG42
D	583	ANTHOZOA	spp.		Dam.														1	1		
F	2	TURBELLARIA	sp.				1															
G	1	NEMERTEA	spp.		Dam./Indet.		1		5			1	1	5				1	2	7	1	
HD	1	NEMATODA	sp.		indet.	1		4	14				5	10	12	5			4	5		
N	1	SIPUNCULA	sp.		Dam.			1	1	1									1		1	
N	12	Golfingia	sp.	Lankester, 1885				1														
N	17	Golfingia	vulgaris	(de Blainville, 1827)											1							1
N	47	Aspidosiphon	muelleri	Diesing, 1851								2							1			
P	19	Aphrodita	aculeata	Linnaeus, 1758										1							2	
P	25	Polynoidae	spp.		Dam.								1							1		
P	50	Harmothoe	spp.		Dam.		1		2		1	1	2								2	
P	59	Harmothoe	fragilis	Moore, 1910					1													
P	68	Malmgreniella	marphysae	(Saint-Joseph, 1888)		1																
P	94	Pholoe	synophtalmica	Claparède, 1868			1				3	2							2	1		
P	96	Sigalionidae	sp.		Dam.															1		
P	107	Sthenelais	boa	(Johnston, 1839)		1	1	1							1							
P	114	Phyllodocidae	sp.		Dam./juv.								2	1								
P	118	Eteone	longa	(Fabricius, 1780)									2							1		
P	136	Pseudomystides	limbata	(Saint-Joseph, 1888)					1				1									
P	139	Anaitides	sp.	Czerniavsky, 1882	Dam./juv.										1							
P	150	Eulalia	sp.	Savigny, 1817	juv.									1								
P	155	Eulalia	mustela	Pleijel, 1987					2													
P	169	Nereiphylla	lutea	(Malmgren, 1865)					1											2		
P	254	Glyceridae	sp.										1					1	1			
P	255	Glycera	sp.	Savigny, 1818	Dam./juv.				3			1	5	7	1	1			3			
P	-	Glycera	unicornis	Lamarck, 1818			1	1		1					1				4		2	1
P	257	Glycera	celtica	OConnor, 1987										3								
P	260	Glycera	lapidum	Quatrefages, 1866					4		1	4		2						2	4	
P	266	Goniadidae	sp.		Juv.								1							2		
P	268	Glycinde	nordmanni	(Malmgren, 1866)							1									1		
P	271	Goniada	maculata	Oersted, 1843		3	1	2	3		1		1			1		1	3	1		
P	300	Gyptis	propinqua	Marion & Bobretzky, 1875					2					2								
P	319	Podarkeopsis	capensis	(Day, 1963)														1				
P	346	Syllidae	sp.		Dam.			1			1									1		
P	349	Syllis	cornuta	(Rathke, 1843)					1		2				1	1		1				
P	372	Syllis	vittata	(Grube, 1840)					2				2									
P	380	Eusyllis	blomstrandi	Malmgren, 1867								2										
P	418	Exogone	sp.	Oersted, 1845					1													
P	421	Exogone	hebes	(Webster & Benedict, 1884)			1															
P	422	Exogone	naidina	Oersted, 1845																	1	
P	424	Sphaerosyllis	sp.	Claparède, 1863					1					1								
P	425	Sphaerosyllis	bulbosa	Southern, 1914					4				4	2								
P	427	Sphaerosyllis	hystrix	Claparède, 1863										1								
P	458	Nereididae	sp.		juv.								2									
P	494	Nephtys	spp.		Dam.										3				1		1	
P	498	Nephtys	cirrosa	Ehlers, 1868				1						1				1				
P	501	Nephtys	incisa	Malmgren, 1865						1							2				1	
P	502	Nephtys	kersivalensis	McIntosh, 1908		1	1	1							3	3		1			1	
P	539	Aponuphis	bilineata	(Baird, 1870)									2									
P	564	Marphysa	bellii	(Audouin & Milne-Edwards, 1833)															1			
P	568	Nematonereis	unicornis	(Grube, 1840)					2				2	1						8		
P	569	Lumbrineridae	sp.	de Blainville, 1828	Dam.				2	4	2	1	1	2			2		2	1	2	2
P	579	Lumbrineris	gracilis	(Ehlers, 1868)		1	2	1	1		1	1	3	2	3	2			2	13	1	
P	584	Scoletoma	impatiens	(Claparède, 1868)															6	1	1	3
P	591	Drilonereis	filum	(Claparède, 1868)							1											
P	597	Notocirrus	scoticus	McIntosh, 1869		1														1		
P	672	Scoloplos	armiger	(O F Müller, 1776)												1						
P	674	Paraonidae	sp.		Dam./ juv.	1									1					1		
P	675	Aricidea	sp.	Webster, 1879	Dam.			1								1		1				
P	684	Aricidea (Acmira)	catherinae	Laubier, 1967		1												1				
P	690	Cirrophorus	branchiatus	Ehlers, 1908					3		2		1	1	1			1		4		
P	693	Levinsenia	gracilis	(Tauber, 1879)													1					
P	699	Paradoneis	lyra	(Southern, 1914)					1													
P	718	Poecilochaetus	serpens	Allen, 1904					1				1	2						2		
P	720	Spionidae	sp.		Dam.	2			1			1	4	2		1		1		2		
P	723	Aonides	paucibranchiata	Southern, 1914		1		2	12				4	5				2		1		

						Site																
MCS A	MCS N	Taxon	Species	Authority	Qualifier	MGR01	MGR02	MGR03	MG04	MGR09	MG11	MG13	MG15	MG17	MG19	MG20	MG21	MG23	MG24	MG37	MG41	MG42
P	725	Genus A	(spionidae) sp.	Mackie, in prep										2								
P	731	*Laonice*	sp.	Malmgren, 1867									3									
P	733	*Laonice*	*bahusiensis*	Soderstrom, 1920									4									
P	735	*Laonice*	*sarsi*	Soderstrom, 1920		1			2					2				3				
P	738	*Malacoceros*	*tetracerus*	(Schmarda, 1861)									1							1		
P	747	*Minuspio*	*cirrifera*	(Wiren, 1883)					1		2	1	4	3	1			2		2	1	
P	765	*Prionospio*	*fallax*	Soderstrom, 1920							1										1	
P	774	*Pseudopolydora*	*pulchra*	(Carazzi, 1895)									1									
P	783	*Scolelepis*	*squamata*	(Abildgaard, 1806)		1			1				2	5				1				
P	787	*Spio*	sp.	Fabricius, 1785	Dam.																1	
P	793	*Spiophanes*	sp.	Grube, 1860	Dam.													1				
P	794	*Spiophanes*	*bombyx*	(Claparède, 1870)														1		1		
P	795	*Spiophanes*	*cf. wigleyi*	Pettibone, 1962			1													1		
P	796	*Spiophanes*	*kroyeri*	Grube, 1860				1			2		2	2		2					2	
P	804	*Magelona*	*alleni*	Wilson, 1958		1										1		1				
P	806	*Magelona*	*minuta*	Eliason, 1962																	2	
P	822	Cirratulidae	sp.		Dam./Indet.	1		3	1		2	4		1	4	3			6	2		
P	823	*Aphelochaeta*	sp.	Blake, 1991		3		2					1						11			
P	824	*Aphelochaeta*	*marioni*	(Saint-Joseph, 1894)		2					2	1		3		2			4			2
P	833	*Chaetozone*	*gibber*	Woodham & Chambers, 1994		23	14	13	1		7	1			17	14		5	2	13	4	
P	834	*Chaetozone*	*setosa*	Malmgren, 1867			1	1	1	2	2	2		1					1		2	2
P	873	Flabelligeridae	sp.		Dam.		2		1												12	
P	878	*Diplocirrus*	*glaucus*	(Malmgren, 1867)	Dam.					2	2								2		8	3
P	903	Capitellidae	*sp.*		Dam.									1								
P	906	*Capitella*	sp.	de Blainville, 1828		1	2	2			1		3	1	7	4			2		1	1
P	914	*Dasybranchus*	*caducus*	(Grube, 1846)			1			2					3							
P	919	*Mediomastus*	*fragilis*	Rasmussen, 1973					5				2	2								
P	921	*Notomastus*	*latericeus*	M Sars, 1851		2			3		6		12		1			1		4		4
P	938	Maldanidae	spp.		Dam.		1		2		1				2	1						
P	963	*Euclymene*	*lumbricoides*	(Quatrefages, 1866)			1															
P	964	*Euclymene*	*oerstedii*	(Claparède, 1863)																1		
P	-	*Euclymene*	sp. A	(Claparède, 1863)			1				2			1	1	1		1		2	4	
P	971	*Praxillella*	*affinis*	(M Sars, 1872)							1					1						4
P	997	*Ophelia*	sp.	Savigny, 1818	Dam.								1									
P	1012	*Ophelina*	sp.	Oersted, 1843	Dam.	1										1						
P	1027	*Scalibregma*	*inflatum*	Rathke, 1843		1										1					1	
P	1090	Oweniidae	sp.		Dam./Indet.	2	1	1			1		1	3		3		2		1		
P	1093	*Galathowenia*	*oculata*	Zaks, 1922		1							1							1		
P	1096	*Myriochele*	*heeri*	Malmgren, 1867							1				1			5				
P	1098	*Owenia*	*fusiformis*	Chiaje, 1842		25	3	5			13		5	3	16	1		9				
P	1099	TEREBELLIDA	spp.		Dam./Indet.			2	2		4		9	1	2	3		1	1	3	5	2
P	1102	*Amphictene*	*auricoma*	(O F Müller, 1776)							1					1			1			
P	1107	*Lagis*	*koreni*	(Malmgren, 1866)					1		1											
P	1125	Ampharetinae	spp.		Dam./Indet.		1					1	1	2				3	1			
P	1133	*Ampharete*	sp.	Malmgren, 1866	Dam.	4	1				1							1				
P	1175	*Terebellides*	*stroemi*	M Sars, 1835		1		1					1			1		2			3	
P	1190	*Eupolymnia*	*nesidensis*	(Chiaje, 1828)																1		
P	1217	*Pista*	*cristata*	(O F Müller, 1776)							1											
P	1235	*Polycirrus*	sp.	Grube, 1850					1				1					1				
P	1256	Sabellida	sp.						3													
P	1316	*Pseudopotamilla*	*reniformis*	(Bruguiere, 1789)					1													
P	-	Pilargidae	sp.																		1	
P	1402	Oligochaeta	sp.											1								
Q	44	*Anoplodactylus*	*petiolatus*	(Kröyer, 1844)												1		1				
R	22	*Scalpellum*	*scalpellum*	(Linnaeus, 1767)												1						
R	340	*Acartia*	sp.	Dana, 1846	Dam.	1							1	2								
R	2710	*Propontocypris*	*trigonella*	(G O Sars, 1870)																		1
S	98	Gammeridea	sp.		Dam./Indet.							1										
S	109	*Eusirus*	*longipes*	Boeck, 1861	Dam.				1													
S	125	*Monoculodes*	*carinatus*	(Bate, 1856)										1								
S	133	*Pontocrates*	*altamarinus*	(Bate & Westwood, 1862)										1								
S	140	*Westwoodilla*	*caecula*	(Bate, 1856)																	2	1
S	176	*Leucothoe*	sp.	Leach, 1814	Dam./Indet.				1													
S	213	*Stenothoe*	*marina*	(Bate, 1856)												1				1		
S	248	*Urothoe*	*elegans*	(Bate, 1856)		1										1		1			1	
S	254	*Harpinia*	*antennaria*	Meinert, 1890							2											1

														Site								
MCS A	**MCS N**	**Taxon**	**Species**	**Authority**	**Qualifier**	**MGR01**	**MGR02**	**MGR03**	**MG04**	**MGR09**	**MG11**	**MG13**	**MG15**	**MG17**	**MG19**	**MG20**	**MG21**	**MG23**	**MG24**	**MG37**	**MG41**	**MG42**
S	274	*Acidostoma*	*nodiferum*	Stephensen, 1923											1							
S	296	*Hippomedon*	*denticulatus*	(Bate, 1857)										2								
S	413	*Atylus*	*vedlomensis*	(Bate & Westwood, 1862)					8				2	5						4		
S	423	*Ampelisca*	sp.	Kröyer, 1842	Dam./Indet.															1		
S	438	*Ampelisca*	*spinipes*	Boeck, 1861					1		1			1	1	4				1		
S	442	*Ampelisca*	*typica*	(Bate, 1856)		1							1							1		
S	502	*Animoceradocus*	*semiserratus*	(Bate, 1862)																1		
S	503	*Cheirocratus*	sp.	Norman, 1867	Dam./Indet.									1								
S	506	*Cheirocratus*	*sundevalli*	(Rathke, 1843)					1		1											
S	519	*Othomaera*	*othonis*	(H Milne-Edwards, 1830)					1							1						
S	541	*Gammaropsis*	*maculata*	(Johnston, 1828)											1							
S	588	*Leptocheirus*	*hirsutimanus*	(Bate, 1862)					4				2									
S	657	*Phtisica*	*marina*	Slabber, 1769	Dam.															1		
S	955	*Astacilla*	*longicornis*	(Sowerby, 1806)														1			1	
S	1194	*Bodotria*	*arenosa*	(Goodsir, 1842)									1	1								
S	1202	*Iphinoe*	*tenella*	G O Sars, 1878												1					1	1
S	1339	*Caridion*	*steveni*	Lebour, 1930	Dam.																4	
S	1409	*Calocaris*	*macandreae*	Bell, 1846							1								1		3	3
S	1445	Paguridae	sp.		Dam./Indet.				2						1							
S	1461	*Pagurus*	*forbesii*	Bell, 1845									1									
S	1472	*Galathea*	*intermedia*	Liljeborg, 1851	Dam.				1											1		
S	1508	*Ebalia*	*tuberosa*	(Pennant, 1777)									1									
W	3	Chaeteodermatida	*sp.*		Dam.														1			
W	9	*Chaetoderma*	*nitidulum*	Lovén, 1844													1					
W	11	*Falcidens*	*crossotus*	Salvini-Plawen, 1968							1	1						3	1		4	
W	54	*Leptochiton*	*cancellatus*	(G B Sowerby II, 1840)					2			1	1							1		
W	223	*Testudinalia*	*testudinalis*	(O F Müller, 1776)					1													
W	490	*Lunatia*	*montagui*	(Forbes, 1838)															1	1		
W	727	*Neptunea*	*antiqua*	(Linnaeus, 1758)							1											
W	908	*Evalea*	sp.	A. Adams, 1860																		2
W	1320	*Onchidoris*	*cf. muricata*						1		1	1										
W	1519	*Antalis*	*entalis*	(Linnaeus, 1758)								1										
W	1571	*Nucula*	*sulcata*	Bronn, 1831						4		2	1		2	1			6		6	3
W	1595	*Nuculana*	*minuta*	(O F Müller, 1776)															6			
W	1627	*Yoldiella*	*philippiana*	(Nyst, 1844)		3		2								3		1	5			5
W	1708	*Modiolula*	*phaseolina*	(Philippi, 1844)							1											
W	1814	*Monia*	*squama*	(Linnaeus, 1761)								7										
W	1906	*Kurtiella*	*bidentata*	(Montagu, 1803)																2		
W	1925	*Astarte*	*sulcata*	(da Costa, 1778)					1			1						1	2		3	
W	1950	*Parvicardium*	*minimum*	(Philippi, 1836)												2						
W	1975	*Spisula*	*elliptica*	(Brown, 1827)									1									
W	2006	*Phaxas*	*pellucidus*	(Pennant, 1777)											1							
W	2062	*Abra*	*prismatica*	(Montagu, 1808)		1	5	1			6	2		1	2	9		1	16		15	5
W	2091	*Venus*	*casina*	(Linnaeus, 1758)		1													1	1		
W	2104	*Timoclea*	*ovata*	(Pennant, 1777)		2			1				1	1		2		1		2		
W	2157	*Corbula*	*gibba*	(Olivi, 1792)															2			1
W	2166	*Hiatella*	*arctica*	(Linnaeus, 1767)			1															
ZA	5	*Phoronis*	*cf. muelleri*	Selys-Longchamps, 1903							1		1		1	1						
ZB	102	*Leptasterias*	*muelleri*	(M Sars, 1846)					2													
ZB	124	*Ophiothrix*	*fragilis*	(Abildgaard, 1789)	Dam.							1			1							
ZB	143	*Ophiactis*	*balli*	(Thompson, 1840)								1										
ZB	152	*Amphiura*	*chiajei*	Forbes, 1843			1	1							1							
ZB	154	*Amphiura*	*filiformis*	(O F Müller, 1776)	Dam.	1					3	2				4		2	1			
ZB	-	Ophiuroidea	sp.		Indet. Juv			1	6			1			1	1		3	9		1	
ZB	167	*Ophiocten*	*affinis*	(Lütken, 1858)					1											1		
ZB	193	*Psammechinus*	*miliaris*	(Gmelin, 1778)	Juv.							1										
ZB	212	*Echinocyamus*	*pusillus*	(O F Müller, 1776)		1																
ZB	222	*Echinocardium*	sp.	J E Gray, 1825	Dam/ indet. Juv				2			1						1			1	
ZB	223	*Echinocardium*	*cordatum*	(Pennant, 1777)	Dam.						2											
ZB	228	*Brissopsis*	*lyrifera*	(Forbes, 1841)	Dam.							1										
ZB	229	*Holothurioidea*	sp.		Dam.						1									1		
ZB	261	*Thyone*	sp.	Jaeger, 1833							2											
ZB	275	*Ocnus*	*lacteus*	(Forbes & Goodsir, 1839)							1											
ZD	122	*Distomus*	*variolosus*	Gaertner in Pallas, 1774														12				
		Branchiostoma	*lanceolatum*	(Pallas, 1774)									1									

APPENDIX 03. SEDIMENT SAMPLE STATISTICS

NB. See Blott and Pye (2001) for details on statistical formulae used in the calculation of grain size parameters

SAMPLE: MG04	SIEVING ERROR:	-0.5%
	SAMPLE TYPE:	Trimodal, Poorly Sorted
	TEXTURAL GROUP:	Gravelly Sand
	SEDIMENT NAME:	Medium Gravelly Coarse Sand
METHOD OF MOMENTS Arithmetic (mm)	MEAN:	1717.3
	SORTING:	2410.7
	SKEWNESS:	2.388
	KURTOSIS:	7.867
METHOD OF MOMENTS Geometric (mm)	MEAN:	725.5
	SORTING:	4.763
	SKEWNESS:	-1.192
	KURTOSIS:	5.302
METHOD OF MOMENTS Logarithmic (φ)	MEAN:	0.463
	SORTING:	2.252
	SKEWNESS:	1.192
	KURTOSIS:	5.302
FOLK AND WARD METHOD (mm)	MEAN:	879.2
	SORTING:	3.952
	SKEWNESS:	0.004
	KURTOSIS:	1.780
FOLK AND WARD METHOD (φ)	MEAN:	0.186
	SORTING:	1.983
	SKEWNESS:	-0.004
	KURTOSIS:	1.780
FOLK AND WARD METHOD (Description)	MEAN:	Coarse Sand
	SORTING:	Poorly Sorted
	SKEWNESS:	Symmetrical
	KURTOSIS:	Very Leptokurtic
	MODE 1 (mm):	605.0
	MODE 2 (mm):	9600.0
	MODE 3 (mm):	4800.0
	MODE 1 (φ):	0.747
	MODE 2 (φ):	-3.243
	MODE 3 (φ):	-2.243
	D_{10} (mm):	164.9
	D_{50} (mm):	793.9
	D_{90} (mm):	4699.3
	(D_{90} / D_{10}) (mm):	28.49
	(D_{90} - D_{10}) (mm):	4534.3
	(D_{75} / D_{25}) (mm):	3.579
	(D_{75} - D_{25}) (mm):	1148.8
	D_{10} (φ):	-2.232
	D_{50} (φ):	0.333
	D_{90} (φ):	2.600
	(D_{90} / D_{10}) (φ):	-1.165
	(D_{90} - D_{10}) (φ):	4.833
	(D_{75} / D_{25}) (φ):	-1.734
	(D_{75} - D_{25}) (φ):	1.839

SAMPLE: MG11	SIEVING ERROR:	-0.5%
	SAMPLE TYPE:	Unimodal, Poorly Sorted
	TEXTURAL GROUP:	Slightly Gravelly Muddy Sand
	SEDIMENT NAME:	Slightly Fine Gravelly Very Coarse Silty Medium Sand
METHOD OF MOMENTS Arithmetic (mm)	MEAN:	546.7
	SORTING:	984.5
	SKEWNESS:	5.413
	KURTOSIS:	40.01
METHOD OF MOMENTS Geometric (mm)	MEAN:	244.0
	SORTING:	4.119
	SKEWNESS:	-0.978
	KURTOSIS:	4.528
METHOD OF MOMENTS Logarithmic (φ)	MEAN:	2.035
	SORTING:	2.042
	SKEWNESS:	0.978
	KURTOSIS:	4.528
FOLK AND WARD METHOD (mm)	MEAN:	292.2
	SORTING:	3.134
	SKEWNESS:	-0.094
	KURTOSIS:	1.962
FOLK AND WARD METHOD (φ)	MEAN:	1.775
	SORTING:	1.648
	SKEWNESS:	0.094
	KURTOSIS:	1.962
FOLK AND WARD METHOD (Description)	MEAN:	Medium Sand
	SORTING:	Poorly Sorted
	SKEWNESS:	Symmetrical
	KURTOSIS:	Very Leptokurtic
	MODE 1 (mm):	215.0
	MODE 2 (mm):	
	MODE 3 (mm):	
	MODE 1 (φ):	2.237
	MODE 2 (φ):	
	MODE 3 (φ):	
	D_{10} (mm):	57.67
	D_{50} (mm):	284.4
	D_{90} (mm):	982.8
	(D_{90} / D_{10}) (mm):	17.04
	(D_{90} - D_{10}) (mm):	925.1
	(D_{75} / D_{25}) (mm):	2.704
	(D_{75} - D_{25}) (mm):	309.4
	D_{10} (φ):	0.025
	D_{50} (φ):	1.814
	D_{90} (φ):	4.116
	(D_{90} / D_{10}) (φ):	164.0
	(D_{90} - D_{10}) (φ):	4.091
	(D_{75} / D_{25}) (φ):	2.398
	(D_{75} - D_{25}) (φ):	1.435

SAMPLE: MG13		
	SIEVING ERROR:	-0.5%
	SAMPLE TYPE:	Trimodal, Very Poorly Sorted
	TEXTURAL GROUP:	Sandy Gravel
	SEDIMENT NAME:	Sandy Medium Gravel
METHOD OF MOMENTS Arithmetic (mm)	MEAN:	2445.2
	SORTING:	3166.0
	SKEWNESS:	1.506
	KURTOSIS:	3.781
METHOD OF MOMENTS Geometric (mm)	MEAN:	888.7
	SORTING:	5.566
	SKEWNESS:	-0.942
	KURTOSIS:	4.295
METHOD OF MOMENTS Logarithmic (φ)	MEAN:	0.170
	SORTING:	2.477
	SKEWNESS:	0.942
	KURTOSIS:	4.295
FOLK AND WARD METHOD (mm)	MEAN:	1090.9
	SORTING:	4.806
	SKEWNESS:	0.050
	KURTOSIS:	1.135
FOLK AND WARD METHOD (φ)	MEAN:	-0.126
	SORTING:	2.265
	SKEWNESS:	-0.050
	KURTOSIS:	1.135
FOLK AND WARD METHOD (Description)	MEAN:	Very Coarse Sand
	SORTING:	Very Poorly Sorted
	SKEWNESS:	Symmetrical
	KURTOSIS:	Leptokurtic
	MODE 1 (mm):	9600.0
	MODE 2 (mm):	605.0
	MODE 3 (mm):	4800.0
	MODE 1 (φ):	-3.243
	MODE 2 (φ):	0.747
	MODE 3 (φ):	-2.243
	D_{10} (mm):	170.3
	D_{50} (mm):	873.0
	D_{90} (mm):	8811.8
	(D_{90} / D_{10}) (mm):	51.74
	$(D_{90} - D_{10})$ (mm):	8641.5
	(D_{75} / D_{25}) (mm):	7.544
	$(D_{75} - D_{25})$ (mm):	2720.2
	D_{10} (φ):	-3.139
	D_{50} (φ):	0.196
	D_{90} (φ):	2.554
	(D_{90} / D_{10}) (φ):	-0.813
	$(D_{90} - D_{10})$ (φ):	5.693
	(D_{75} / D_{25}) (φ):	-0.768
	$(D_{75} - D_{25})$ (φ):	2.915

SAMPLE: MG15	SIEVING ERROR:	-0.2%
	SAMPLE TYPE:	Unimodal, Poorly Sorted
	TEXTURAL GROUP:	Gravelly Sand
	SEDIMENT NAME:	Very Fine Gravelly Coarse Sand
METHOD OF MOMENTS Arithmetic (mm)	MEAN:	947.9
	SORTING:	946.3
	SKEWNESS:	2.125
	KURTOSIS:	8.159
METHOD OF MOMENTS Geometric (mm)	MEAN:	513.7
	SORTING:	4.102
	SKEWNESS:	-1.600
	KURTOSIS:	5.870
METHOD OF MOMENTS Logarithmic (φ)	MEAN:	0.961
	SORTING:	2.036
	SKEWNESS:	1.600
	KURTOSIS:	5.870
FOLK AND WARD METHOD (mm)	MEAN:	615.7
	SORTING:	3.292
	SKEWNESS:	-0.209
	KURTOSIS:	1.468
FOLK AND WARD METHOD (φ)	MEAN:	0.700
	SORTING:	1.719
	SKEWNESS:	0.209
	KURTOSIS:	1.468
FOLK AND WARD METHOD (Description)	MEAN:	Coarse Sand
	SORTING:	Poorly Sorted
	SKEWNESS:	Fine Skewed
	KURTOSIS:	Leptokurtic
	MODE 1 (mm):	605.0
	MODE 2 (mm):	
	MODE 3 (mm):	
	MODE 1 (φ):	0.747
	MODE 2 (φ):	
	MODE 3 (φ):	
	D_{10} (mm):	150.5
	D_{50} (mm):	644.5
	D_{90} (mm):	1976.1
	(D_{90} / D_{10}) (mm):	13.13
	(D_{90} - D_{10}) (mm):	1825.6
	(D_{75} / D_{25}) (mm):	3.666
	(D_{75} - D_{25}) (mm):	882.2
	D_{10} (φ):	-0.983
	D_{50} (φ):	0.634
	D_{90} (φ):	2.732
	(D_{90} / D_{10}) (φ):	-2.780
	(D_{90} - D_{10}) (φ):	3.715
	(D_{75} / D_{25}) (φ):	-5.723
	(D_{75} - D_{25}) (φ):	1.874

SAMPLE: MG17	SIEVING ERROR:	-0.2%
	SAMPLE TYPE:	Unimodal, Poorly Sorted
	TEXTURAL GROUP:	Gravelly Sand
	SEDIMENT NAME:	Very Fine Gravelly Coarse Sand
METHOD OF MOMENTS Arithmetic (mm)	MEAN:	908.5
	SORTING:	722.5
	SKEWNESS:	1.728
	KURTOSIS:	7.769
METHOD OF MOMENTS Geometric (mm)	MEAN:	529.7
	SORTING:	4.134
	SKEWNESS:	-1.906
	KURTOSIS:	6.314
METHOD OF MOMENTS Logarithmic (φ)	MEAN:	0.917
	SORTING:	2.048
	SKEWNESS:	1.906
	KURTOSIS:	6.314
FOLK AND WARD METHOD (mm)	MEAN:	655.7
	SORTING:	3.080
	SKEWNESS:	-0.388
	KURTOSIS:	1.780
FOLK AND WARD METHOD (φ)	MEAN:	0.609
	SORTING:	1.623
	SKEWNESS:	0.388
	KURTOSIS:	1.780
FOLK AND WARD METHOD (Description)	MEAN:	Coarse Sand
	SORTING:	Poorly Sorted
	SKEWNESS:	Very Fine Skewed
	KURTOSIS:	Very Leptokurtic
	MODE 1 (mm):	855.0
	MODE 2 (mm):	
	MODE 3 (mm):	
	MODE 1 (φ):	0.247
	MODE 2 (φ):	
	MODE 3 (φ):	
	D_{10} (mm):	114.8
	D_{50} (mm):	759.3
	D_{90} (mm):	1777.4
	(D_{90} / D_{10}) (mm):	15.49
	(D_{90} - D_{10}) (mm):	1662.6
	(D_{75} / D_{25}) (mm):	2.869
	(D_{75} - D_{25}) (mm):	780.4
	D_{10} (φ):	-0.830
	D_{50} (φ):	0.397
	D_{90} (φ):	3.123
	(D_{90} / D_{10}) (φ):	-3.764
	(D_{90} - D_{10}) (φ):	3.953
	(D_{75} / D_{25}) (φ):	-4.839
	(D_{75} - D_{25}) (φ):	1.521

SAMPLE: MG19	SIEVING ERROR:	-0.1%
	SAMPLE TYPE:	Unimodal, Poorly Sorted
	TEXTURAL GROUP:	Slightly Gravelly Muddy Sand
	SEDIMENT NAME:	Slightly Very Fine Gravelly Very Coarse Silty Fine Sand
METHOD OF MOMENTS Arithmetic (mm)	MEAN:	434.8
	SORTING:	1128.4
	SKEWNESS:	6.701
	KURTOSIS:	51.70
METHOD OF MOMENTS Geometric (mm)	MEAN:	166.6
	SORTING:	4.087
	SKEWNESS:	-0.668
	KURTOSIS:	4.321
METHOD OF MOMENTS Logarithmic (φ)	MEAN:	2.585
	SORTING:	2.031
	SKEWNESS:	0.668
	KURTOSIS:	4.321
FOLK AND WARD METHOD (mm)	MEAN:	199.3
	SORTING:	2.950
	SKEWNESS:	-0.128
	KURTOSIS:	2.263
FOLK AND WARD METHOD (φ)	MEAN:	2.327
	SORTING:	1.561
	SKEWNESS:	0.128
	KURTOSIS:	2.263
FOLK AND WARD METHOD (Description)	MEAN:	Fine Sand
	SORTING:	Poorly Sorted
	SKEWNESS:	Fine Skewed
	KURTOSIS:	Very Leptokurtic
	MODE 1 (mm):	215.0
	MODE 2 (mm):	
	MODE 3 (mm):	
	MODE 1 (φ):	2.237
	MODE 2 (φ):	
	MODE 3 (φ):	
	D_{10} (mm):	33.53
	D_{50} (mm):	201.1
	D_{90} (mm):	618.6
	(D_{90} / D_{10}) (mm):	18.45
	(D_{90} - D_{10}) (mm):	585.0
	(D_{75} / D_{25}) (mm):	2.312
	(D_{75} - D_{25}) (mm):	175.6
	D_{10} (φ):	0.693
	D_{50} (φ):	2.314
	D_{90} (φ):	4.898
	(D_{90} / D_{10}) (φ):	7.068
	(D_{90} - D_{10}) (φ):	4.205
	(D_{75} / D_{25}) (φ):	1.714
	(D_{75} - D_{25}) (φ):	1.209

SAMPLE: MG20		
	SIEVING ERROR:	-0.3%
	SAMPLE TYPE:	Unimodal, Poorly Sorted
	TEXTURAL GROUP:	Slightly Gravelly Sand
	SEDIMENT NAME:	Slightly Very Fine Gravelly Fine Sand
METHOD OF MOMENTS Arithmetic (mm)	MEAN:	420.6
	SORTING:	629.9
	SKEWNESS:	4.712
	KURTOSIS:	28.81
METHOD OF MOMENTS Geometric (mm)	MEAN:	232.6
	SORTING:	3.226
	SKEWNESS:	-1.076
	KURTOSIS:	5.872
METHOD OF MOMENTS Logarithmic (φ)	MEAN:	2.104
	SORTING:	1.690
	SKEWNESS:	1.076
	KURTOSIS:	5.872
FOLK AND WARD METHOD (mm)	MEAN:	262.1
	SORTING:	2.517
	SKEWNESS:	0.041
	KURTOSIS:	1.598
FOLK AND WARD METHOD (φ)	MEAN:	1.932
	SORTING:	1.332
	SKEWNESS:	-0.041
	KURTOSIS:	1.598
FOLK AND WARD METHOD (Description)	MEAN:	Medium Sand
	SORTING:	Poorly Sorted
	SKEWNESS:	Symmetrical
	KURTOSIS:	Very Leptokurtic
	MODE 1 (mm):	215.0
	MODE 2 (mm):	
	MODE 3 (mm):	
	MODE 1 (φ):	2.237
	MODE 2 (φ):	
	MODE 3 (φ):	
	D_{10} (mm):	100.6
	D_{50} (mm):	238.9
	D_{90} (mm):	771.8
	(D_{90} / D_{10}) (mm):	7.676
	$(D_{90} - D_{10})$ (mm):	671.3
	(D_{75} / D_{25}) (mm):	2.578
	$(D_{75} - D_{25})$ (mm):	253.8
	D_{10} (φ):	0.374
	D_{50} (φ):	2.065
	D_{90} (φ):	3.314
	(D_{90} / D_{10}) (φ):	8.869
	$(D_{90} - D_{10})$ (φ):	2.940
	(D_{75} / D_{25}) (φ):	2.076
	$(D_{75} - D_{25})$ (φ):	1.366

SAMPLE: MG21	SIEVING ERROR:	0.1%
	SAMPLE TYPE:	Unimodal, Very Poorly Sorted
	TEXTURAL GROUP:	Slightly Gravelly Muddy Sand
	SEDIMENT NAME:	Slightly Very Fine Gravelly Fine Silty Fine Sand
METHOD OF MOMENTS Arithmetic (mm)	MEAN:	184.6
	SORTING:	248.8
	SKEWNESS:	3.219
	KURTOSIS:	16.68
METHOD OF MOMENTS Geometric (mm)	MEAN:	55.79
	SORTING:	5.525
	SKEWNESS:	-0.054
	KURTOSIS:	1.451
METHOD OF MOMENTS Logarithmic (φ)	MEAN:	4.164
	SORTING:	2.466
	SKEWNESS:	0.054
	KURTOSIS:	1.451
FOLK AND WARD METHOD (mm)	MEAN:	71.02
	SORTING:	4.662
	SKEWNESS:	-0.260
	KURTOSIS:	0.837
FOLK AND WARD METHOD (φ)	MEAN:	3.816
	SORTING:	2.221
	SKEWNESS:	0.260
	KURTOSIS:	0.837
FOLK AND WARD METHOD (Description)	MEAN:	Very Fine Sand
	SORTING:	Very Poorly Sorted
	SKEWNESS:	Fine Skewed
	KURTOSIS:	Platykurtic
	MODE 1 (mm):	215.0
	MODE 2 (mm):	
	MODE 3 (mm):	
	MODE 1 (φ):	2.237
	MODE 2 (φ):	
	MODE 3 (φ):	
	D_{10} (mm):	7.770
	D_{50} (mm):	99.27
	D_{90} (mm):	420.2
	(D_{90} / D_{10}) (mm):	54.08
	$(D_{90} - D_{10})$ (mm):	412.5
	(D_{75} / D_{25}) (mm):	10.34
	$(D_{75} - D_{25})$ (mm):	203.6
	D_{10} (φ):	1.251
	D_{50} (φ):	3.333
	D_{90} (φ):	7.008
	(D_{90} / D_{10}) (φ):	5.603
	$(D_{90} - D_{10})$ (φ):	5.757
	(D_{75} / D_{25}) (φ):	2.568
	$(D_{75} - D_{25})$ (φ):	3.370

SAMPLE: MG23		
	SIEVING ERROR:	-0.6%
	SAMPLE TYPE:	Unimodal, Poorly Sorted
	TEXTURAL GROUP:	Gravelly Sand
	SEDIMENT NAME:	Very Fine Gravelly Medium Sand
METHOD OF MOMENTS Arithmetic (mm)	MEAN:	561.8
	SORTING:	877.2
	SKEWNESS:	4.894
	KURTOSIS:	37.35
METHOD OF MOMENTS Geometric (mm)	MEAN:	274.0
	SORTING:	3.737
	SKEWNESS:	-0.944
	KURTOSIS:	4.928
METHOD OF MOMENTS Logarithmic (φ)	MEAN:	1.868
	SORTING:	1.902
	SKEWNESS:	0.944
	KURTOSIS:	4.928
FOLK AND WARD METHOD (mm)	MEAN:	315.0
	SORTING:	3.076
	SKEWNESS:	0.027
	KURTOSIS:	1.617
FOLK AND WARD METHOD (φ)	MEAN:	1.667
	SORTING:	1.621
	SKEWNESS:	-0.027
	KURTOSIS:	1.617
FOLK AND WARD METHOD (Description)	MEAN:	Medium Sand
	SORTING:	Poorly Sorted
	SKEWNESS:	Symmetrical
	KURTOSIS:	Very Leptokurtic
	MODE 1 (mm):	215.0
	MODE 2 (mm):	
	MODE 3 (mm):	
	MODE 1 (φ):	2.237
	MODE 2 (φ):	
	MODE 3 (φ):	
	D_{10} (mm):	93.22
	D_{50} (mm):	285.4
	D_{90} (mm):	1219.4
	(D_{90} / D_{10}) (mm):	13.08
	(D_{90} - D_{10}) (mm):	1126.2
	(D_{75} / D_{25}) (mm):	3.033
	(D_{75} - D_{25}) (mm):	367.7
	D_{10} (φ):	-0.286
	D_{50} (φ):	1.809
	D_{90} (φ):	3.423
	(D_{90} / D_{10}) (φ):	-11.961
	(D_{90} - D_{10}) (φ):	3.709
	(D_{75} / D_{25}) (φ):	2.848
	(D_{75} - D_{25}) (φ):	1.601

SAMPLE: MG24	SIEVING ERROR:	-0.4%
	SAMPLE TYPE:	Unimodal, Very Poorly Sorted
	TEXTURAL GROUP:	Gravelly Muddy Sand
	SEDIMENT NAME:	Very Fine Gravelly Very Coarse Silty Medium Sand
METHOD OF MOMENTS Arithmetic (mm)	MEAN:	925.7
	SORTING:	1539.2
	SKEWNESS:	4.001
	KURTOSIS:	21.29
METHOD OF MOMENTS Geometric (mm)	MEAN:	355.0
	SORTING:	5.128
	SKEWNESS:	-0.965
	KURTOSIS:	3.944
METHOD OF MOMENTS Logarithmic (φ)	MEAN:	1.494
	SORTING:	2.358
	SKEWNESS:	0.965
	KURTOSIS:	3.944
FOLK AND WARD METHOD (mm)	MEAN:	431.8
	SORTING:	4.097
	SKEWNESS:	-0.113
	KURTOSIS:	1.569
FOLK AND WARD METHOD (φ)	MEAN:	1.211
	SORTING:	2.035
	SKEWNESS:	0.113
	KURTOSIS:	1.569
FOLK AND WARD METHOD (Description)	MEAN:	Medium Sand
	SORTING:	Very Poorly Sorted
	SKEWNESS:	Fine Skewed
	KURTOSIS:	Very Leptokurtic
	MODE 1 (mm):	302.5
	MODE 2 (mm):	
	MODE 3 (mm):	
	MODE 1 (φ):	1.747
	MODE 2 (φ):	
	MODE 3 (φ):	
	D_{10} (mm):	49.50
	D_{50} (mm):	427.9
	D_{90} (mm):	1958.2
	(D_{90} / D_{10}) (mm):	39.56
	(D_{90} - D_{10}) (mm):	1908.7
	(D_{75} / D_{25}) (mm):	4.241
	(D_{75} - D_{25}) (mm):	717.9
	D_{10} (φ):	-0.970
	D_{50} (φ):	1.225
	D_{90} (φ):	4.336
	(D_{90} / D_{10}) (φ):	-4.473
	(D_{90} - D_{10}) (φ):	5.306
	(D_{75} / D_{25}) (φ):	24.13
	(D_{75} - D_{25}) (φ):	2.084

SAMPLE: MG37	SIEVING ERROR:	-0.2%
	SAMPLE TYPE:	Unimodal, Poorly Sorted
	TEXTURAL GROUP:	Gravelly Muddy Sand
	SEDIMENT NAME:	Very Fine Gravelly Coarse Silty Coarse Sand
METHOD OF MOMENTS Arithmetic (mm)	MEAN:	869.4
	SORTING:	865.0
	SKEWNESS:	2.052
	KURTOSIS:	8.227
METHOD OF MOMENTS Geometric (mm)	MEAN:	434.6
	SORTING:	4.653
	SKEWNESS:	-1.441
	KURTOSIS:	4.695
METHOD OF MOMENTS Logarithmic (φ)	MEAN:	1.202
	SORTING:	2.218
	SKEWNESS:	1.441
	KURTOSIS:	4.695
FOLK AND WARD METHOD (mm)	MEAN:	525.1
	SORTING:	3.739
	SKEWNESS:	-0.324
	KURTOSIS:	1.471
FOLK AND WARD METHOD (φ)	MEAN:	0.929
	SORTING:	1.903
	SKEWNESS:	0.324
	KURTOSIS:	1.471
FOLK AND WARD METHOD (Description)	MEAN:	Coarse Sand
	SORTING:	Poorly Sorted
	SKEWNESS:	Very Fine Skewed
	KURTOSIS:	Leptokurtic
	MODE 1 (mm):	605.0
	MODE 2 (mm):	
	MODE 3 (mm):	
	MODE 1 (φ):	0.747
	MODE 2 (φ):	
	MODE 3 (φ):	
	D_{10} (mm):	73.42
	D_{50} (mm):	620.0
	D_{90} (mm):	1896.5
	(D_{90} / D_{10}) (mm):	25.83
	(D_{90} - D_{10}) (mm):	1823.1
	(D_{75} / D_{25}) (mm):	4.047
	(D_{75} - D_{25}) (mm):	849.9
	D_{10} (φ):	-0.923
	D_{50} (φ):	0.690
	D_{90} (φ):	3.768
	(D_{90} / D_{10}) (φ):	-4.081
	(D_{90} - D_{10}) (φ):	4.691
	(D_{75} / D_{25}) (φ):	-10.540
	(D_{75} - D_{25}) (φ):	2.017

SAMPLE: MG41	SIEVING ERROR:	-0.2%
	SAMPLE TYPE:	Unimodal, Poorly Sorted
	TEXTURAL GROUP:	Slightly Gravelly Muddy Sand
	SEDIMENT NAME:	Slightly Very Fine Gravelly Very Coarse Silty Fine Sand
METHOD OF MOMENTS Arithmetic (mm)	MEAN:	184.5
	SORTING:	224.5
	SKEWNESS:	7.321
	KURTOSIS:	80.29
METHOD OF MOMENTS Geometric (mm)	MEAN:	109.2
	SORTING:	3.262
	SKEWNESS:	-1.237
	KURTOSIS:	4.160
METHOD OF MOMENTS Logarithmic (φ)	MEAN:	3.195
	SORTING:	1.706
	SKEWNESS:	1.237
	KURTOSIS:	4.160
FOLK AND WARD METHOD (mm)	MEAN:	134.3
	SORTING:	2.349
	SKEWNESS:	-0.329
	KURTOSIS:	2.360
FOLK AND WARD METHOD (φ)	MEAN:	2.896
	SORTING:	1.232
	SKEWNESS:	0.329
	KURTOSIS:	2.360
FOLK AND WARD METHOD (Description)	MEAN:	Fine Sand
	SORTING:	Poorly Sorted
	SKEWNESS:	Very Fine Skewed
	KURTOSIS:	Very Leptokurtic
	MODE 1 (mm):	152.5
	MODE 2 (mm):	
	MODE 3 (mm):	
	MODE 1 (φ):	2.737
	MODE 2 (φ):	
	MODE 3 (φ):	
	D_{10} (mm):	26.86
	D_{50} (mm):	146.4
	D_{90} (mm):	280.9
	(D_{90} / D_{10}) (mm):	10.46
	(D_{90} - D_{10}) (mm):	254.1
	(D_{75} / D_{25}) (mm):	1.901
	(D_{75} - D_{25}) (mm):	92.48
	D_{10} (φ):	1.832
	D_{50} (φ):	2.772
	D_{90} (φ):	5.219
	(D_{90} / D_{10}) (φ):	2.849
	(D_{90} - D_{10}) (φ):	3.387
	(D_{75} / D_{25}) (φ):	1.393
	(D_{75} - D_{25}) (φ):	0.927

SAMPLE: MG42	SIEVING ERROR:	0.3%
	SAMPLE TYPE:	Unimodal, Poorly Sorted
	TEXTURAL GROUP:	Slightly Gravelly Muddy Sand
	SEDIMENT NAME:	Slightly Medium Gravelly Very Coarse Silty Fine Sand
METHOD OF MOMENTS Arithmetic (mm)	MEAN:	211.1
	SORTING:	676.1
	SKEWNESS:	13.20
	KURTOSIS:	182.9
METHOD OF MOMENTS Geometric (mm)	MEAN:	101.4
	SORTING:	3.479
	SKEWNESS:	-0.960
	KURTOSIS:	4.113
METHOD OF MOMENTS Logarithmic (φ)	MEAN:	3.302
	SORTING:	1.799
	SKEWNESS:	0.960
	KURTOSIS:	4.113
FOLK AND WARD METHOD (mm)	MEAN:	123.0
	SORTING:	2.451
	SKEWNESS:	-0.436
	KURTOSIS:	2.264
FOLK AND WARD METHOD (φ)	MEAN:	3.024
	SORTING:	1.293
	SKEWNESS:	0.436
	KURTOSIS:	2.264
FOLK AND WARD METHOD (Description)	MEAN:	Very Fine Sand
	SORTING:	Poorly Sorted
	SKEWNESS:	Very Fine Skewed
	KURTOSIS:	Very Leptokurtic
	MODE 1 (mm):	152.5
	MODE 2 (mm):	
	MODE 3 (mm):	
	MODE 1 (φ):	2.737
	MODE 2 (φ):	
	MODE 3 (φ):	
	D_{10} (mm):	20.94
	D_{50} (mm):	144.8
	D_{90} (mm):	252.9
	(D_{90} / D_{10}) (mm):	12.08
	$(D_{90} - D_{10})$ (mm):	232.0
	(D_{75} / D_{25}) (mm):	1.943
	$(D_{75} - D_{25})$ (mm):	91.61
	D_{10} (φ):	1.983
	D_{50} (φ):	2.788
	D_{90} (φ):	5.577
	(D_{90} / D_{10}) (φ):	2.812
	$(D_{90} - D_{10})$ (φ):	3.594
	(D_{75} / D_{25}) (φ):	1.398
	$(D_{75} - D_{25})$ (φ):	0.959

SAMPLE: MGR01	SIEVING ERROR:	0.5%
	SAMPLE TYPE:	Unimodal, Poorly Sorted
	TEXTURAL GROUP:	Slightly Gravelly Sand
	SEDIMENT NAME:	Slightly Very Fine Gravelly Medium Sand
METHOD OF MOMENTS Arithmetic (mm)	MEAN:	511.7
	SORTING:	608.3
	SKEWNESS:	3.882
	KURTOSIS:	22.46
METHOD OF MOMENTS Geometric (mm)	MEAN:	311.1
	SORTING:	3.075
	SKEWNESS:	-1.412
	KURTOSIS:	6.988
METHOD OF MOMENTS Logarithmic (φ)	MEAN:	1.684
	SORTING:	1.621
	SKEWNESS:	1.412
	KURTOSIS:	6.988
FOLK AND WARD METHOD (mm)	MEAN:	353.1
	SORTING:	2.359
	SKEWNESS:	0.082
	KURTOSIS:	1.443
FOLK AND WARD METHOD (φ)	MEAN:	1.502
	SORTING:	1.238
	SKEWNESS:	-0.082
	KURTOSIS:	1.443
FOLK AND WARD METHOD (Description)	MEAN:	Medium Sand
	SORTING:	Poorly Sorted
	SKEWNESS:	Symmetrical
	KURTOSIS:	Leptokurtic
	MODE 1 (mm):	215.0
	MODE 2 (mm):	
	MODE 3 (mm):	
	MODE 1 (φ):	2.237
	MODE 2 (φ):	
	MODE 3 (φ):	
	D_{10} (mm):	143.3
	D_{50} (mm):	318.4
	D_{90} (mm):	1029.2
	(D_{90} / D_{10}) (mm):	7.181
	(D_{90} - D_{10}) (mm):	885.9
	(D_{75} / D_{25}) (mm):	2.593
	(D_{75} - D_{25}) (mm):	337.9
	D_{10} (φ):	-0.042
	D_{50} (φ):	1.651
	D_{90} (φ):	2.803
	(D_{90} / D_{10}) (φ):	-67.419
	(D_{90} - D_{10}) (φ):	2.844
	(D_{75} / D_{25}) (φ):	2.594
	(D_{75} - D_{25}) (φ):	1.375

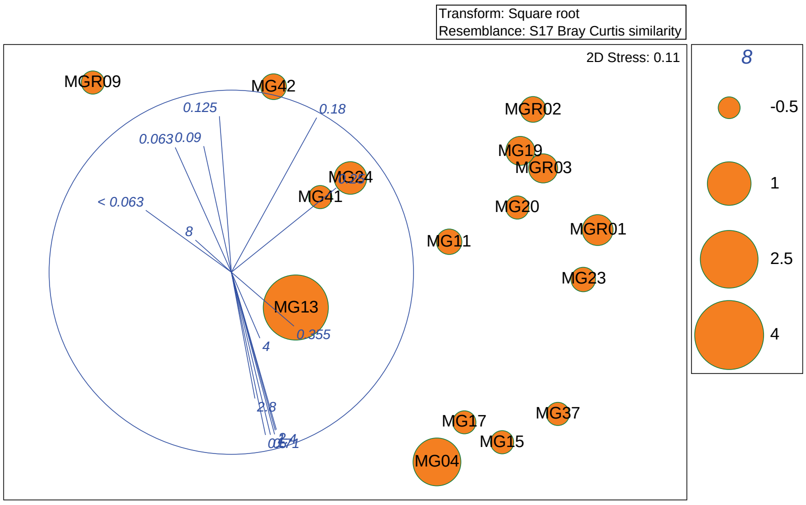
SAMPLE: MGR02		
	SIEVING ERROR:	0.9%
	SAMPLE TYPE:	Unimodal, Poorly Sorted
	TEXTURAL GROUP:	Slightly Gravelly Sand
	SEDIMENT NAME:	Slightly Fine Gravelly Fine Sand
METHOD OF MOMENTS Arithmetic (mm)	MEAN:	519.5
	SORTING:	1026.8
	SKEWNESS:	5.266
	KURTOSIS:	37.18
METHOD OF MOMENTS Geometric (mm)	MEAN:	230.3
	SORTING:	3.715
	SKEWNESS:	-0.724
	KURTOSIS:	5.048
METHOD OF MOMENTS Logarithmic (φ)	MEAN:	2.118
	SORTING:	1.893
	SKEWNESS:	0.724
	KURTOSIS:	5.048
FOLK AND WARD METHOD (mm)	MEAN:	261.1
	SORTING:	2.884
	SKEWNESS:	0.067
	KURTOSIS:	1.884
FOLK AND WARD METHOD (φ)	MEAN:	1.938
	SORTING:	1.528
	SKEWNESS:	-0.067
	KURTOSIS:	1.884
FOLK AND WARD METHOD (Description)	MEAN:	Medium Sand
	SORTING:	Poorly Sorted
	SKEWNESS:	Symmetrical
	KURTOSIS:	Very Leptokurtic
	MODE 1 (mm):	215.0
	MODE 2 (mm):	
	MODE 3 (mm):	
	MODE 1 (φ):	2.237
	MODE 2 (φ):	
	MODE 3 (φ):	
	D_{10} (mm):	85.00
	D_{50} (mm):	234.8
	D_{90} (mm):	886.2
	(D_{90} / D_{10}) (mm):	10.43
	$(D_{90} - D_{10})$ (mm):	801.2
	(D_{75} / D_{25}) (mm):	2.643
	$(D_{75} - D_{25})$ (mm):	258.1
	D_{10} (φ):	0.174
	D_{50} (φ):	2.090
	D_{90} (φ):	3.556
	(D_{90} / D_{10}) (φ):	20.41
	$(D_{90} - D_{10})$ (φ):	3.382
	(D_{75} / D_{25}) (φ):	2.105
	$(D_{75} - D_{25})$ (φ):	1.402

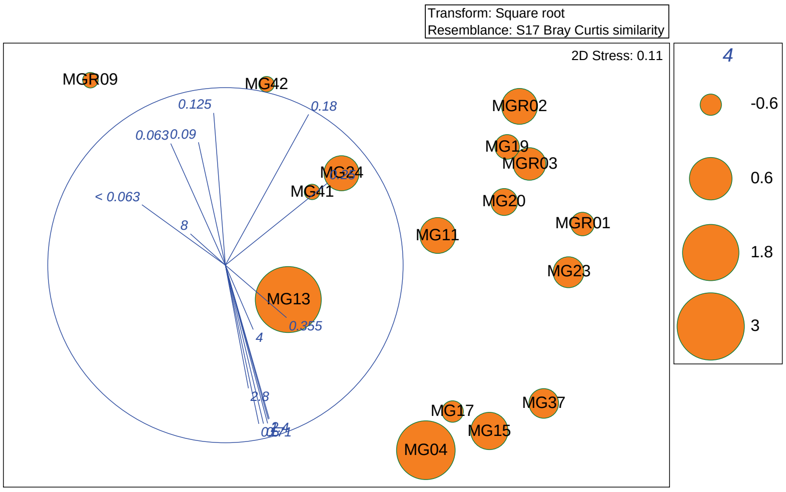
SAMPLE: MGR03		
	SIEVING ERROR:	0.9%
	SAMPLE TYPE:	Unimodal, Poorly Sorted
	TEXTURAL GROUP:	Slightly Gravelly Sand
	SEDIMENT NAME:	Slightly Fine Gravelly Fine Sand
METHOD OF MOMENTS Arithmetic (mm)	MEAN:	526.5
	SORTING:	1214.4
	SKEWNESS:	5.817
	KURTOSIS:	40.07
METHOD OF MOMENTS Geometric (mm)	MEAN:	240.8
	SORTING:	3.281
	SKEWNESS:	-0.605
	KURTOSIS:	6.440
METHOD OF MOMENTS Logarithmic (φ)	MEAN:	2.054
	SORTING:	1.714
	SKEWNESS:	0.605
	KURTOSIS:	6.440
FOLK AND WARD METHOD (mm)	MEAN:	256.0
	SORTING:	2.413
	SKEWNESS:	0.105
	KURTOSIS:	1.948
FOLK AND WARD METHOD (φ)	MEAN:	1.966
	SORTING:	1.271
	SKEWNESS:	-0.105
	KURTOSIS:	1.948
FOLK AND WARD METHOD (Description)	MEAN:	Medium Sand
	SORTING:	Poorly Sorted
	SKEWNESS:	Coarse Skewed
	KURTOSIS:	Very Leptokurtic
	MODE 1 (mm):	215.0
	MODE 2 (mm):	
	MODE 3 (mm):	
	MODE 1 (φ):	2.237
	MODE 2 (φ):	
	MODE 3 (φ):	
	D_{10} (mm):	114.5
	D_{50} (mm):	234.9
	D_{90} (mm):	712.3
	(D_{90} / D_{10}) (mm):	6.221
	$(D_{90} - D_{10})$ (mm):	597.8
	(D_{75} / D_{25}) (mm):	2.174
	$(D_{75} - D_{25})$ (mm):	202.6
	D_{10} (φ):	0.490
	D_{50} (φ):	2.090
	D_{90} (φ):	3.127
	(D_{90} / D_{10}) (φ):	6.387
	$(D_{90} - D_{10})$ (φ):	2.637
	(D_{75} / D_{25}) (φ):	1.792
	$(D_{75} - D_{25})$ (φ):	1.120

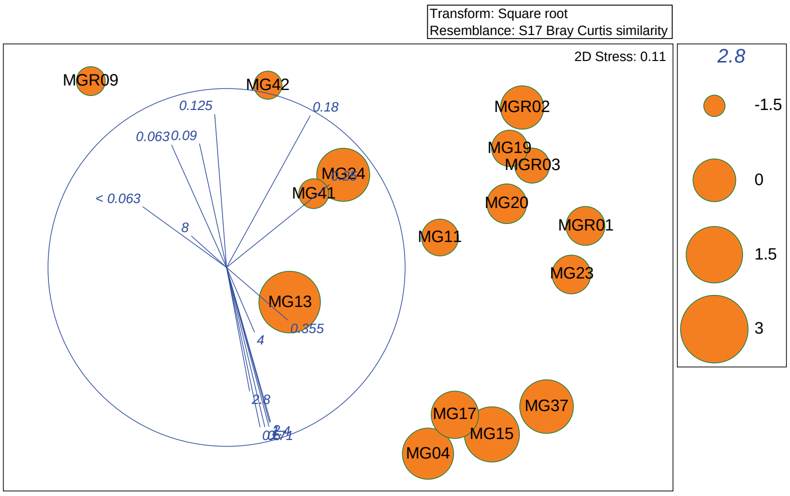
SAMPLE: MGR09		
	SIEVING ERROR:	0.5%
	SAMPLE TYPE:	Unimodal, Poorly Sorted
	TEXTURAL GROUP:	Slightly Gravelly Muddy Sand
	SEDIMENT NAME:	Slightly Very Fine Gravelly Very Coarse Silty Fine Sand
METHOD OF MOMENTS Arithmetic (mm)	MEAN:	148.0
	SORTING:	180.9
	SKEWNESS:	6.815
	KURTOSIS:	92.31
METHOD OF MOMENTS Geometric (mm)	MEAN:	60.87
	SORTING:	4.488
	SKEWNESS:	-0.406
	KURTOSIS:	1.680
METHOD OF MOMENTS Logarithmic (φ)	MEAN:	4.038
	SORTING:	2.166
	SKEWNESS:	0.406
	KURTOSIS:	1.680
FOLK AND WARD METHOD (mm)	MEAN:	72.52
	SORTING:	3.707
	SKEWNESS:	-0.421
	KURTOSIS:	0.980
FOLK AND WARD METHOD (φ)	MEAN:	3.785
	SORTING:	1.890
	SKEWNESS:	0.421
	KURTOSIS:	0.980
FOLK AND WARD METHOD (Description)	MEAN:	Very Fine Sand
	SORTING:	Poorly Sorted
	SKEWNESS:	Very Fine Skewed
	KURTOSIS:	Mesokurtic
	MODE 1 (mm):	152.5
	MODE 2 (mm):	
	MODE 3 (mm):	
	MODE 1 (φ):	2.737
	MODE 2 (φ):	
	MODE 3 (φ):	
	D_{10} (mm):	9.152
	D_{50} (mm):	109.0
	D_{90} (mm):	281.4
	(D_{90} / D_{10}) (mm):	30.74
	$(D_{90} - D_{10})$ (mm):	272.2
	(D_{75} / D_{25}) (mm):	5.726
	$(D_{75} - D_{25})$ (mm):	155.1
	D_{10} (φ):	1.830
	D_{50} (φ):	3.198
	D_{90} (φ):	6.772
	(D_{90} / D_{10}) (φ):	3.701
	$(D_{90} - D_{10})$ (φ):	4.942
	(D_{75} / D_{25}) (φ):	2.044
	$(D_{75} - D_{25})$ (φ):	2.517

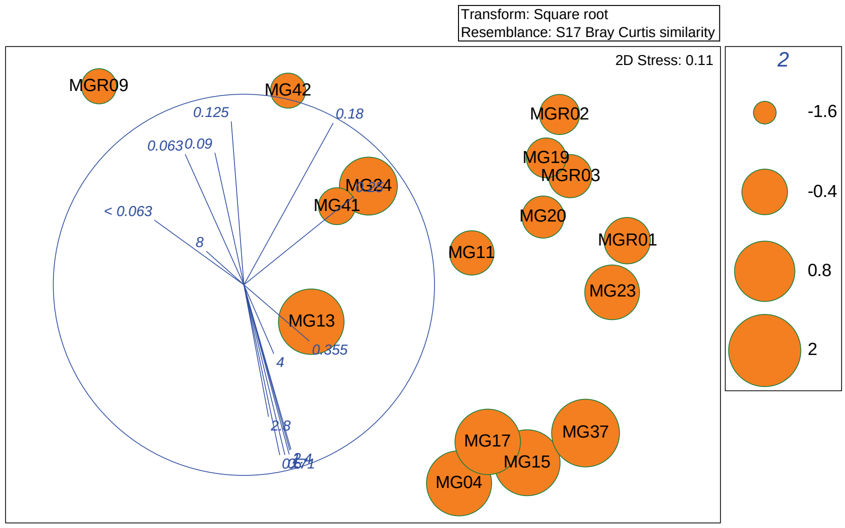
APPENDIX 04. MDS analysis results - abiotic bubble analysis

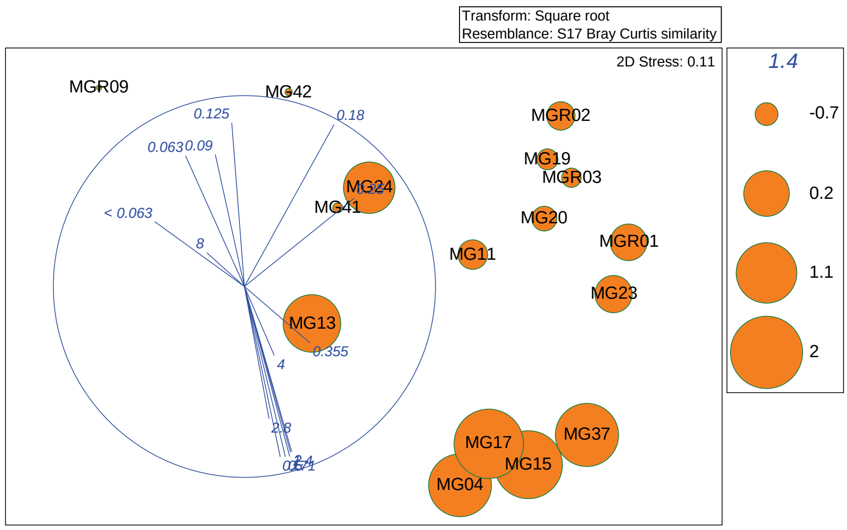
Normalised PSA data

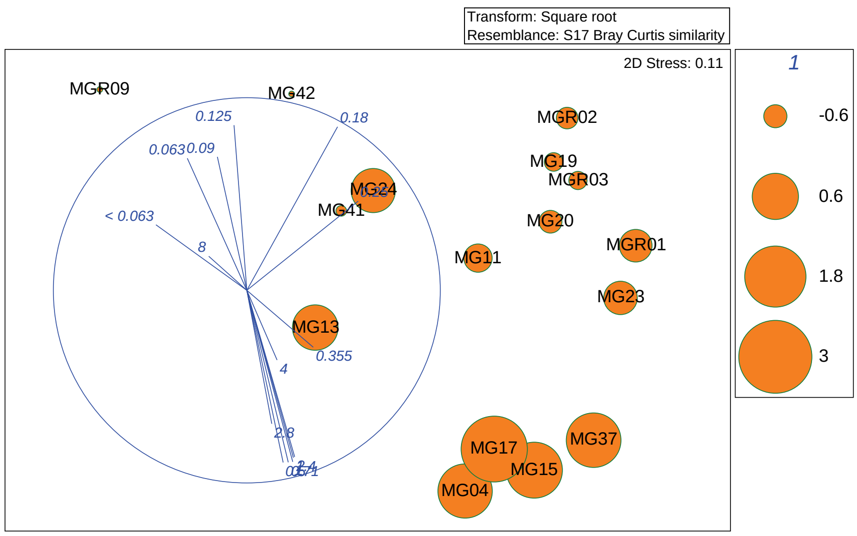


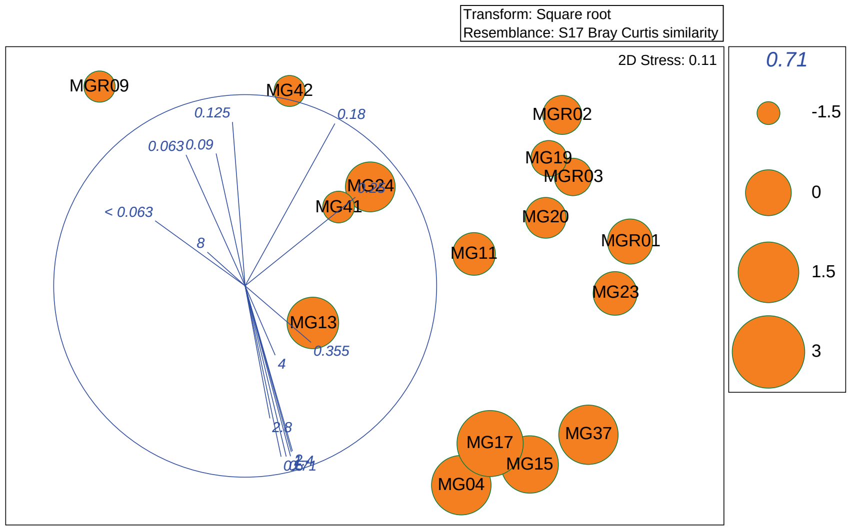


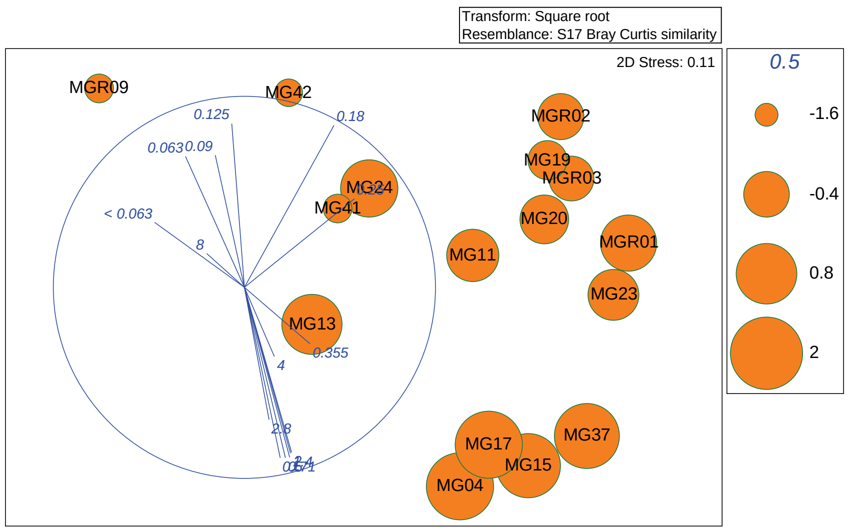


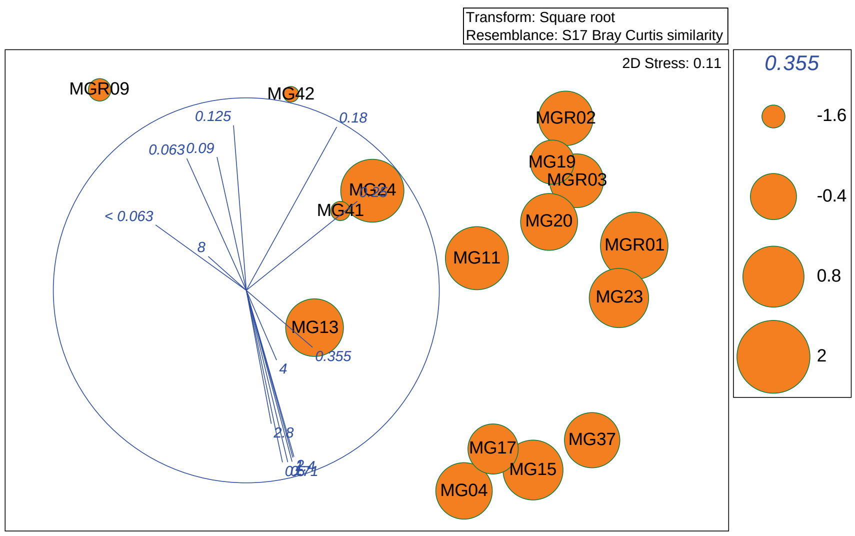

Transform: Square root
Resemblance: S17 Bray Curtis similarity
2D Stress: 0.11
2
-1.6
-0.4
0.8
2
MGR09
MG42
MGR02
MG19
MGR03
MG24
MG41
MG20
MGR01
MG11
MG23
MG13
MG17
MG37
MG15
MG04
0.125
0.18
0.063
0.09
< 0.063
8
0.355
4
2.8

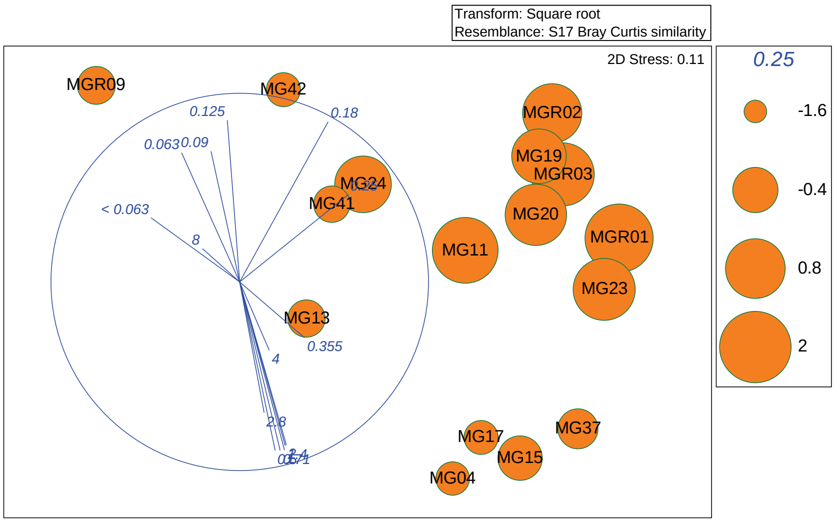

Transform: Square root
Resemblance: S17 Bray Curtis similarity
2D Stress: 0.11
1.4
-0.7
0.2
1.1
2
MGR09
MG42
MGR02
MG19
MGR03
MG24
MG41
MG20
MGR01
MG11
MG23
MG13
MG17
MG37
MG15
MG04
0.125
0.18
0.063
0.09
< 0.063
8
0.355
4
2.8

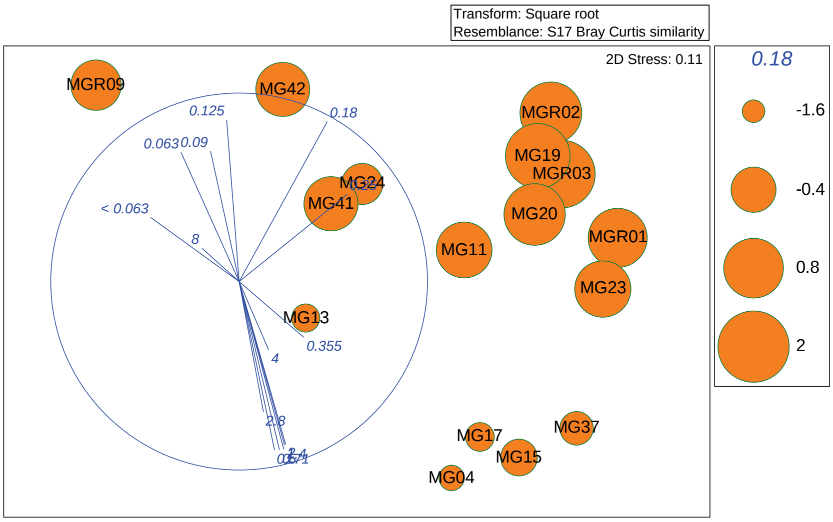

Transform: Square root
Resemblance: S17 Bray Curtis similarity
2D Stress: 0.11
1
-0.6
0.6
1.8
3
MGR09
MG42
MGR02
MG19
MGR03
MG24
MG41
MG20
MGR01
MG11
MG23
MG13
MG17
MG37
MG15
MG04
0.125
0.18
0.063
0.09
< 0.063
8
0.355
4
2.8


Transform: Square root
Resemblance: S17 Bray Curtis similarity
2D Stress: 0.11
0.71
-1.5
0
1.5
3
MGR09
MG42
MGR02
MG19
MGR03
MG24
MG41
MG20
MGR01
MG11
MG23
MG13
MG17
MG37
MG15
MG04
0.125
0.18
0.063
0.09
< 0.063
8
0.355
4
2.8


Transform: Square root
Resemblance: S17 Bray Curtis similarity
2D Stress: 0.11
0.5
-1.6
-0.4
0.8
2
MGR09
MG42
MGR02
MG19
MGR03
MG24
MG41
MG20
MGR01
MG11
MG23
MG13
MG17
MG37
MG15
MG04
0.125
0.18
0.063
0.09
< 0.063
8
0.355
4
2.8


Transform: Square root
Resemblance: S17 Bray Curtis similarity
2D Stress: 0.11
0.355
-1.6
-0.4
0.8
2
MGR09
MG42
MGR02
MG19
MGR03
MG24
MG41
MG20
MGR01
MG11
MG23
MG13
MG17
MG37
MG15
MG04
0.125
0.18
0.063
0.09
< 0.063
8
0.355
4
2.8


Transform: Square root
Resemblance: S17 Bray Curtis similarity
2D Stress: 0.11
MGR09
MG42
MGR02
MG19
MGR03
MG24
MG41
MG20
MGR01
MG11
MG23
MG13
MG37
MG17
MG15
MG04
0.125
0.18
0.063
0.09
< 0.063
8
0.355
4
2.8
0.25
-1.6
-0.4
0.8
2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Resemblance: S17 Bray Curtis similarity
2D Stress: 0.11
MGR09
MG42
MGR02
MG19
MGR03
MG24
MG41
MG20
MGR01
MG11
MG23
MG13
MG37
MG17
MG15
MG04
0.125
0.18
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0.09
< 0.063
8
0.355
4
2.8
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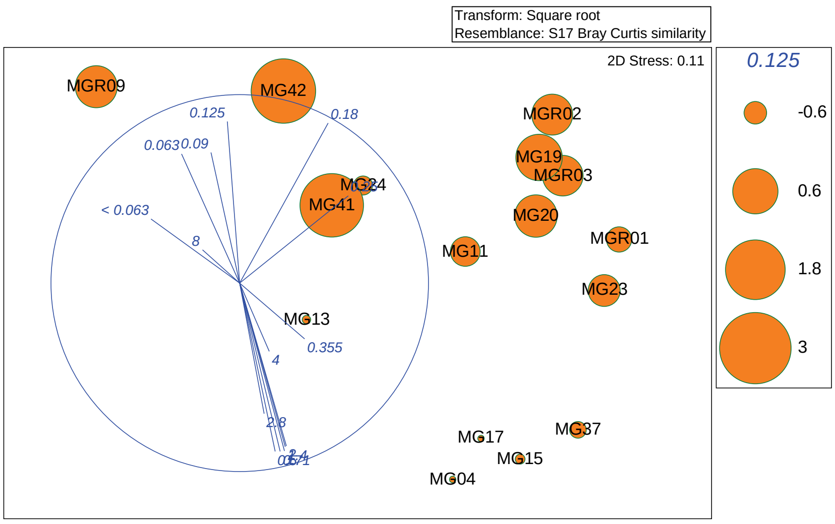
-1.6
-0.4
0.8
2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2D Stress: 0.11
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MGR01
MG11
MG23
MG13
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MG04
0.125
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8
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0.6
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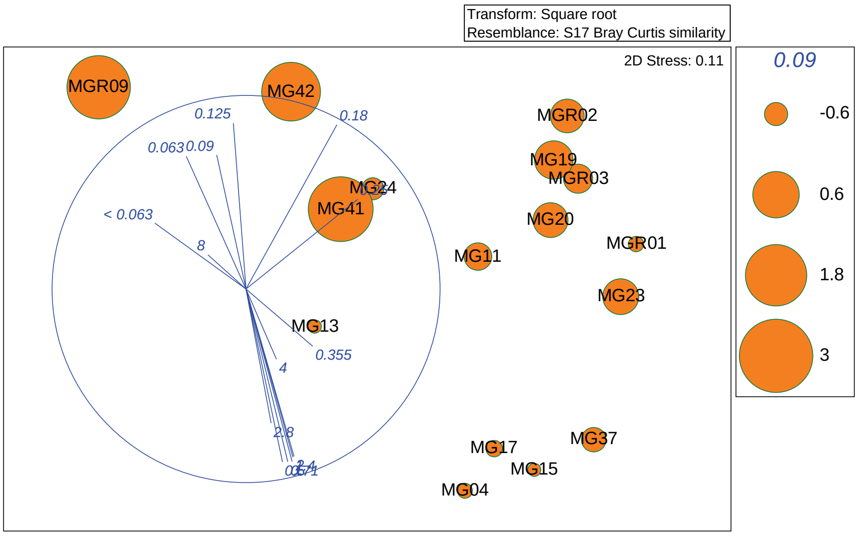
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0.125
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2.8
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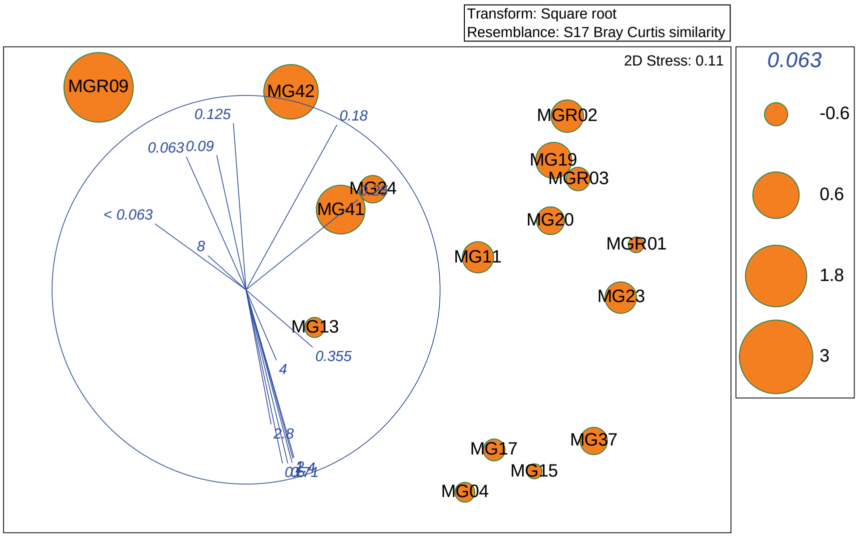
0.6
1.8
3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2D Stress: 0.11
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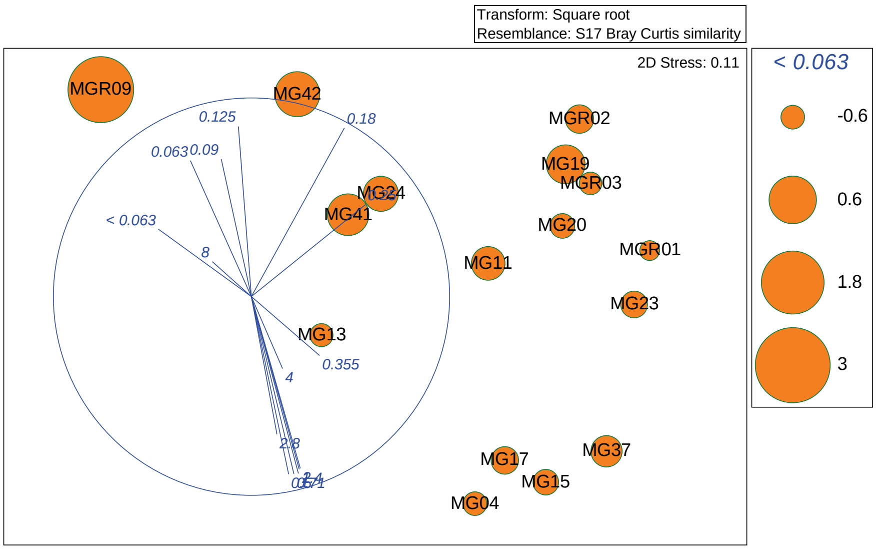
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2D Stress: 0.11
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0.355
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2.8
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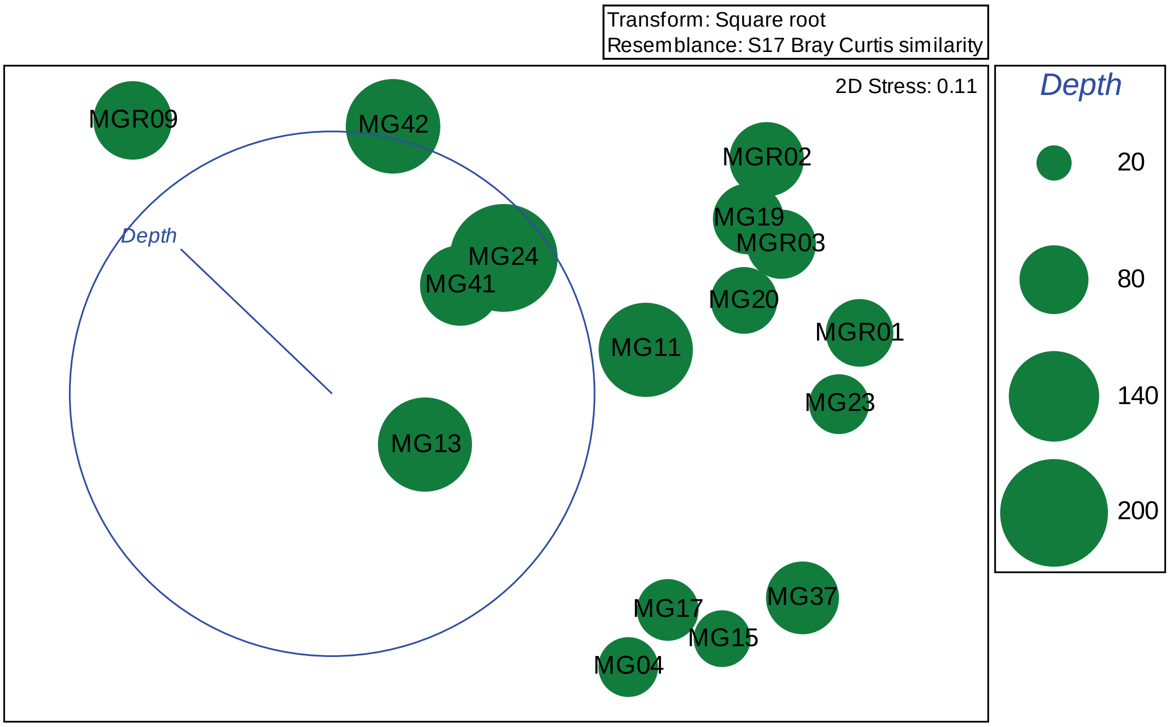
0.6
1.8
3

Depth (m)


Transform: Square root
Resemblance: S17 Bray Curtis similarity
2D Stress: 0.11
Depth
MGR09
MG42
MGR02
MG19
MGR03
MG24
MG41
MG20
MGR01
MG11
MG23
MG13
MG37
MG17
MG15
MG04
Depth
20
80
140
200

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