Isles of Scilly SAC Subtidal Sediment Data Analysis Report 2017

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MarineSpace Limited

Isles of Scilly Complex SAC Subtidal Sediment Data Analysis Report

for

Natural England

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Executive summary

The aim of this project was to analyse sediment infauna data to quantify any changes in community composition at the Isles of Scilly Complex Special Area of Conservation (SAC). This will contribute towards Natural England (NE) condition assessment using conservation advice for each site and sub-feature.

MarineSpace was commissioned by NE to analyse and report on subtidal sediment grab data collected by the Environment Agency (EA) as part of its Water Framework Directive (WFD) and monitoring from the Isles of Scilly. Data were provided from surveys conducted in 1997, 2001, 2002, 2009, and 2013. The scope of the analysis covered site sub-features: 1) sandbanks which are slightly covered by sea water all the time and 2) mudflats and sandflats not covered by seawater at low tide.

Biodiversity indices (including total number of species in each sample (S), total number of Individuals in each sample (N), Pielou's Evenness Index (J'), Shannon-Weiner Diversity Index (H'), and Simpson index (1-λ')) were tested using a Kruskall-Wallis test by ranks to see if there were significant differences over time. All univariate tests were conducted in the R statistical computing environment.

Community data were examined using the PRIMER v7 software package. ANOSIM was used to test for differences in species composition between groups. SIMPER analysis was then utilised to see which species contributed to similarities and dissimilarities between groups.

<u>Site 1</u> had low to moderate richness and diversity and there were no significant differences in biodiversity indices between years. Community composition was significantly different between years, but was due to small changes in the relative abundance of common species. Sediments were typically medium/fine sands with varying amounts of gravel. Overall, the biotope that best described the community was consistently SS.SCS.CCS.MedLumVen: *Mediomastus fragilis*, *Lumbrineris* spp. and venerid bivalves in circalittoral coarse sand or gravel.

<u>Site 2</u> had low to moderate richness and diversity and there were no significant differences in biodiversity indices between years. Community composition was significantly different between years, but was due to small changes in the relative abundance of common species. Sediments were typically medium/fine sands. Overall, the biotope that best described the community was consistently SS.SSa.IMuSa.FfabMag: *Fabulina fabula* and *Magelona mirabilis* with venerid bivalves and amphipods in infralittoral compacted fine muddy sand.

<u>Site 3</u> had moderate richness and diversity and there were no significant differences in biodiversity indices between years. Community composition was significantly different between years, but was due to small changes in the relative abundance of common species. Sediments were typically medium/fine, slightly muddy sands. Overall, the biotope is one that forms part of the 'offshore muddy sand association' and is best represented by SS.SSa.CMuSa.AbraAirr (*Amphiura brachiata* with *Astropecten irregularis* and other echinoderms in circalittoral muddy sand), with elements of SS.SMu.CSaMu.LkorPpel: *Lagis koreni* and *Phaxas pellucidus* in circalittoral sandy mud.

<u>Site 4</u> had low to moderate richness and diversity and there were no significant differences in biodiversity indices between years. Community composition was significantly different between years, but was due to small changes in the relative abundance of common species. Sediments were typically medium/coarse sands. Overall, the biotope is best represented as a transitional community between SS.SCS.ICS.MoeVen (*Moerella* spp. with venerid bivalves in infralittoral gravelly sand) and SS.SSa.IFiSa.NcirBat (*Nephtys cirrosa* and *Bathyporeia* spp. in infralittoral sand).

Site 5 had low to moderate richness and diversity and there were no significant differences in biodiversity indices between years. Community composition was significantly different between years, but was due to small changes in the relative abundance of common species. Sediments were typically medium/coarse sands with varying amounts of gravel. Overall, the biotope is best represented as SS.SCS.ICS.MoeVen (*Moerella* spp. with venerid bivalves in infralittoral gravelly sand) with some elements of SS.SCS.CCS.MedLumVen (*Mediomastus fragilis*, *Lumbrineris* spp. and venerid bivalves in circalittoral coarse sand or gravel).

Site 6 had low richness and diversity and there were no significant differences in biodiversity indices between years. Community composition was significantly different between years, but was due to small changes in the relative abundance of common species. Sediments were typically medium/fine sands. Overall, the two biotopes are best represented as SS.SCS.ICS.MoeVen (*Moerella* spp. with venerid bivalves in infralittoral gravelly sand) with some elements of SS.SSa.IFiSa.NcirBat (*Nephtys cirrosa* and *Bathyporeia* spp. in infralittoral sand) and impoverished SS.SSa.IMuSa.FfabMag: *Fabulina fabula* and *Magelona mirabilis* with venerid bivalves and amphipods in infralittoral compacted fine muddy sand).

Site 7 had moderate richness and diversity and there were no significant differences in biodiversity indices between years. Community composition was significantly different between years, but was due to small changes in the relative abundance of common species. Sediments were typically coarse sands and gravelly sands. Overall, the biotope is best represented as a transition between SS.SCS.ICS.MoeVen (*Moerella* spp. with venerid bivalves in infralittoral gravelly sand) and SS.SCS.CCS.MedLumVen (*Mediomastus fragilis*, *Lumbrineris* spp. and venerid bivalves in circalittoral coarse sand or gravel).

Site 9 had low richness and diversity and there were no significant differences in biodiversity indices between years. Community composition was significantly different between years, but was due to small changes in the relative abundance of common species. Sediments were typically medium-coarse sands. Overall, the dominant biotope is best represented as SS.SSa.IFiSa.IMoSa Infralittoral mobile clean sand with sparse fauna, with elements of SS.SSa.IFiSa.NcirBat (*Nephtys cirrosa* and *Bathyporeia* spp. in infralittoral sand).

Though there were significant changes in relative species composition observed during the survey period, these were not sufficient to lead to changes in biotope classification, which have not deviated significantly from the 2001 survey. No changes in particular species abundance were indicative of any anthropogenic disturbance.

Based upon the findings of this study and acknowledging limitations with the different sources of survey data, there is no evidence that feature presence or distribution, the presence of typical species, sediment composition and distribution, or species composition of component communities have changed since the 2001 survey outside of what might be expected due to natural change in such a dynamic environment.

Future feature and site condition monitoring surveys should use the experimental design used in the 2001 survey (Allen and Proctor, 2003) in order to provide consistency, make best use of existing monitoring data, and allow robust comparison over time.

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1. Introduction

1.1. Background

Natural England commissioned this project to analyse and report on subtidal sediment grab data collected by the Environment Agency (EA) as part of its Water Framework Directive (WFD) monitoring from the Isles of Scilly Complex SAC.

For a number of years, the EA has been taking benthic grab samples at sites around England to meet the requirements of Article 8 of the WFD in relation to monitoring and, more recently, assisting Natural England in collecting benthic samples from marine protected areas (MPAs) of different designations for site condition monitoring.

In the south west, there is now a time-series of data from sediment grab samples. Natural England commissioned analysis of data from within the Isles of Scilly Complex SAC and sub-features:

- Subtidal coarse sediment;
- Subtidal mixed sediment; and
- Subtidal sand;

1.2. Aims and Objectives

The aim of this project is to analyse sediment infauna data to quantify changes in community composition based upon historical monitoring data. This will contribute towards NE condition assessment using conservation advice for each site and sub-feature. To achieve this aim, the following objectives have been set:

1) Analyse macrofauna data to identify any spatial and temporal changes in community structure within the designated sediment sub-features; and
2) Place any findings in context of the distribution and structure of benthic communities and, where possible, make comments on the use of the data to assess feature condition.

The report analyses changes in sediment, infauna communities and biotopes that have occurred across the MPA using historical survey data (Table 1.1).

Table 1.1: Summary of site monitoring data for Isles of Scilly SAC

Site	Year	Survey Contractor
Isles of Scilly SAC	1997	Ambios Environmental Consultants
	2001-2002	Institute of Estuarine and Coastal Studies
	2009	EA
	2013	EA

Specifically, this report:

- Describes and maps the distribution of sediment types;
- Describes the distribution of characteristic biotopes in each MPA;
- Considers whether any continued change has occurred within the sediments and infaunal communities within the study area; and
- Considers change in faunal communities of MPA sub-features and the applicability of monitoring data to inform feature condition assessments in each MPA.

2. General Approach

2.1. Data Preparation

2.1.1. Faunal Data

Due to the variety of methods employed in different surveys, data were standardised to allow for meaningful statistical analyses.

Prior to data analysis the steps taken to truncate and organise the data included:

- Removal of epifauna due to inconsistencies in enumeration of colonial taxa and the utilisation of infauna-specific sampling methods. Epifauna could be used to aid assignment of biotopes if considered advantageous;
- Removal of meiofauna due to potential bias to assemblages based on high abundance of meiofauna;
- Removal of planktonic data as unrepresentative of benthic assemblages;
- Removal of freshwater and non-marine taxa as unrepresentative of coastal and marine assemblages (including insects);
- Removal of qualifiers (juv, sp., spp., indet, epitoke, larva, zoea, Type A, (?), female and agg) from the datasets and aggregate to parent taxon to ensure standardisation between datasets; and
- Combine taxa from groups with identification inconsistencies due to insufficient identification and QA protocols.

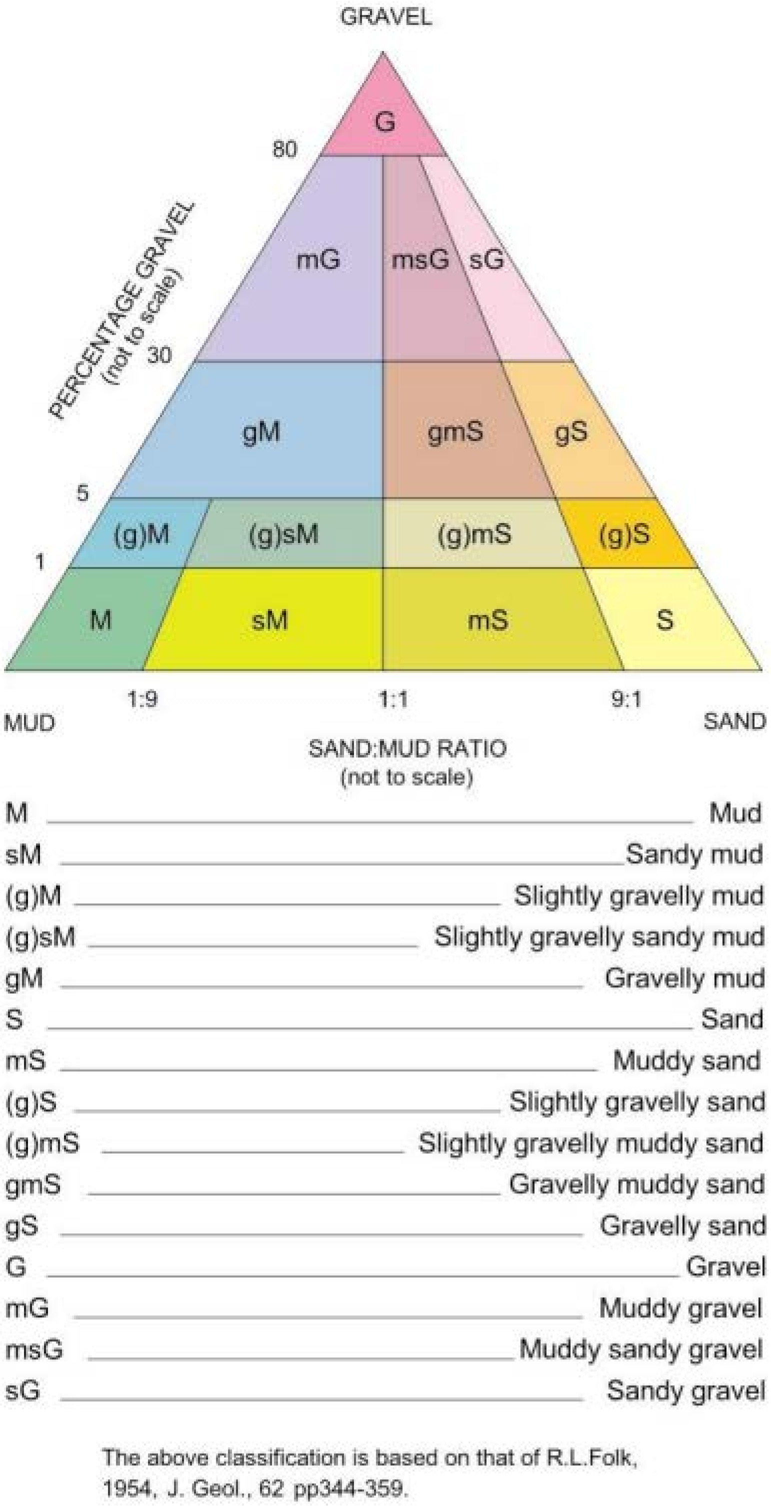
The metadata showed that grab samples had been processed through different sieve mesh sizes depending on the survey. Some surveys processed samples through a 500µm, some used a 1000µm sieve mesh, and some used both. The use of different mesh sieve sizes during sample processing creates problems in statistical analysis due to differences in the amount of fauna retained, including increased species numbers and abundance associated with the use of smaller mesh sizes that are not easily corrected (Reish, 1959).

As the most common sieve size was 1000µm and the prevalent sediment type at Isles of Scilly Complex SAC was Sand, only samples processed through this mesh size were analysed to allow for a robust quantitative analysis (see Section 3.2). An alternative approach would have been to transform the complete dataset to presence-absence, but this would still not have accounted for additional species encountered in the smaller mesh size, nor the presence of additional taxa of smaller body size.

2.1.2. Particle Size Analysis Data

PSA data were split into sediment fractions (µm) for analysis and checked to ensure that the total percentage of sediment added up to 100%. The PSA data were then split into % mud (<63µm), % sand (63 - 1,999µm) and % gravel (2,000 - >63,000µm) components. Folk classifications were assigned to each sample as per Folk (1954) (Figure 2.1) to facilitate biotope classification.

Figure 2.1: Folk Classification System Based on Folk (1954) used in British Geological Survey Sediment Maps (From: Long, 2006)



2.2. Statistical Analysis

Data were analysed both as a complete dataset, to observe changes at a site level, and by site or experimental box, which was the design employed in the 2001 survey (see Section 3.2).

All data analyses were conducted using PRIMER v7 with PERMANOVA+ statistical software (Clarke and Warwick, 2001; Clarke et al., 2014; Clarke and Gorley, 2015).

2.2.1. Univariate Statistics

Data were initially examined through the PRIMER v7 software package (Clarke and Gorley, 2015). Any anomalous or outlier results would have been removed due to their ability to skew or hide significant interactions, but for Isles of Scilly Complex SAC there were none. The DIVERSE routine was used to define univariate biodiversity indices including:

- Total number of Species in each sample (S);
- Total number of Individuals in each sample (N);
- Pielou's Evenness Index (J');
- Shannon-Weiner Diversity Index (H'); and
- Simpson index (1-λ')

Pielou's evenness index (J') considers the evenness of a population in terms of the number of individuals and their dominance. The Simpson index (1-λ') calculates the probability of any two individuals within a sample being the same species and is a complementary measure of evenness. Shannon-Weiner (H') provides an estimate of biodiversity, and considers the overall species numbers along with aspects of dominance.

Biodiversity indices have been displayed spatially within the report as bubbles overlain on maps of MPA sub-features to illustrate any changes in the distribution of biodiversity over time (See Sections 4.3.2, 5.3.2 and 6.3.2; Annexes C-E).

Due to the unbalanced design and in case the data were not normal, the biodiversity indices were tested using a Kruskall-Wallis test by ranks to see if there were significant differences over time. All univariate tests were conducted in the R statistical computing environment (R Core Development Team, 2014).

2.2.2. Multivariate Statistics

A Bray-Curtis resemblance measure between taxa was used to create a similarity matrix (Bray and Curtis, 1957). Both 2- and 3-dimensional non-metric multi-dimensional scaling (nMDS) ordinations were produced to compare stress values and assess the accuracy of the 2-dimensional MDS. Different transformations ($\sqrt{}$-, $\sqrt[4]{}$-, log-transformation) were applied and multiple nMDS plots produced to observe patterns with different weightings of rare species. If the stress value for the 2D plot was high, then principal co-ordinates analysis (PCO) in PERMANOVA was considered as an alternative method of ordination. Sediment data were untransformed as it was presented as % composition.

A hierarchical agglomerative cluster analysis was undertaken on the dissimilarity matrix, using SIMPROF to identify statistically significant differences in groupings.

For a priori structured datasets, ANOSIM was used to test for differences in species composition between groups. A two-way crossed test was used to detect any differences in species composition over time in the different sub-features. SIMPER analysis was then utilised to see which species contributed to similarities and dissimilarities between groups (i.e. which species were most consistently sampled within each site).

2.2.3. Biotope Classification

Faunal assemblages were identified using PRIMER v7 and PERMANOVA+ during multivariate community analysis. A hierarchical agglomerative cluster analysis was also undertaken on the dissimilarity matrix with SIMPROF to identify statistically significant differences in groupings. Multiple statistical tests were applied and compared to identify which species characterise each group of samples. For habitats with relatively low species abundance, it was necessary to consider the raw data to enable a biotope to be assigned.

Groups identified in cluster analysis do not necessarily represent truly different communities. Results were interpreted by experts in order to identify whether patterns shown are real or due to inconsistencies in the data.

Interpretation was aided by expert judgement of sedimentary habitats and using the Marine Habitat Classification for Britain and Ireland (Connor *et al*., 2004) and recent JNCC guidance (Parry, 2015).

Biotopes were assigned based upon all characterising variables used in the classification in order to describe the physical as well as biological, environment (biological zone, substrate, energy level, salinity and species composition) using the guidance provided by Parry (2015).

2.2.4. Spatial Analysis

ArcGIS version 10.4 was used to produce mapping outputs. National Grid OS maps were used for base-mapping. Maps were produced to show:

- Any change in distribution of sediment types across the Isles of Scilly Complex SAC over time; and
- Any change in distribution of biodiversity indices across the Isles of Scilly Complex SAC over time.

3. Isles of Scilly Complex SAC

3.1. Background

The Isles of Scilly are a remote oceanic archipelago, situated nearly 40 km south west of Land's End. This site was designated as an SAC in 2000 under the 1994 Habitat Regulations. The location of the site can be seen in Figure 3.1.

The SAC contains a range of species characteristic of full salinity intertidal and subtidal sandflats and sandbanks. These habitats are important in the UK due to their extent and diversity of their associated communities, including extensive eelgrass beds and rare species only found within the south west, such as the trumpet anemone *Aiptasia mutabilis*. There is also an Annex II plant species present, the shore dock *Rumex rupestris*. The islands are a breeding site for numbers of seabirds including storm petrels and lesser black-backed gulls. The site supports >20,000 breeding seabirds.

The SAC is designated for the presence of sandbanks and the area encompasses extensive sublittoral sandy sediments. They are important due to their extent and diversity, in particular their isolation and the presence of oceanic water contributes to the importance of the site. There are rich communities present in the tide-swept sandbanks, with the fauna including tanaid crustaceans, many species of polychaete worms, and various echinoderm species. The shallow sublittoral sands are colonised by the most extensive eelgrass *Zostera marina* beds in the south of the UK, which have diverse associated fauna and flora (JNCC, 2017c).

The Isles of Scilly archipelago supports extensive areas of intertidal sandflats. This area is particularly important for the rich communities that occur in the coarse sediments, including clean sand, a substrate that is usually poor in species. The lower shore sandflats are notable due to the inclusion of the fringes of eelgrass beds. The eelgrass beds in this area are unusually species rich including various seaweeds, fish and rich sediment communities of anemones, polychaete worms, bivalve molluscs and burrowing echinoderms. Many southern species are also present in the eelgrass beds such as the hermit crab *Cestopagurus timidus* and the spiny cockle *Acanthocardia aculeate.*

The Isles of Scilly are surrounded by reefs and rocky islets. Some of these extend as far as the shallow sublittoral, whereas others extend beyond 50 m in depth. As the islands are exposed directly to the Atlantic Ocean, the communities that have developed on the west-facing reefs are extremely exposed, whereas the east-facing coast is more sheltered and more silted reefs occur. There are a number of warm-water species present in this area including sunset cup-coral *Leptopsammia pruvoti*, pink sea-fans *Eunicella verrucosa*, and Weymouth carpet-coral *Hoplangia durotrix*.

Annex I habitats that are a primary reason for selection of this site:

- Sandbanks which are slightly covered by sea water all the time;
- Mudflats and sandflats not covered by seawater at low tide; and
- Reefs.

Annex II species that are a primary reason for selection of this site

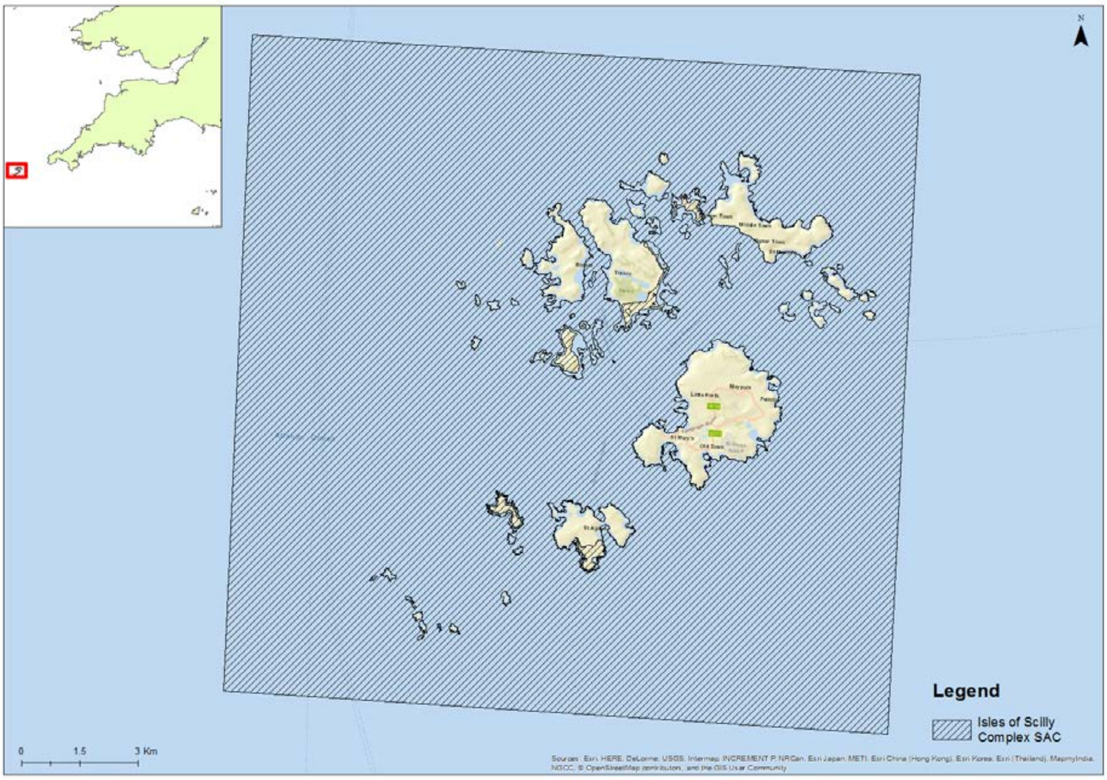
- Shore dock *Rumex rupestris*.

Annex II species present as a qualifying feature, but not a primary reason for site selection:

- Grey seal *Haliochoerus grypus*.

Only the Annex I habitat Subtidal Sandbanks was within the scope of this report.

Figure 3.1: Location of the Isles of Scilly Complex SAC



3.2. Methods

A summary of the survey data that was considered for inclusion in this report is presented in Table 3.1. A map showing the difference in spatial distribution of the sampling arrays is included as Figure 3.2.

Table 3.1: List of Benthic Grab Datasets included in this Report

Site	Year	Survey Contractor	Number of Samples
Isles of Scilly Complex SAC	1997	Ambios Environmental Consultants	55 grabs with species data available. 0.1 m^2 Day grab
	2001-2	Institute of Estuarine and Coastal Studies	10 grabs from each of 10 blocks. 0.1 m^2 Day grab
	2009	EA	24
	2013	EA	57

3.2.1. 1997 Survey

A survey of the Isles of Scilly was conducted between 21 September and 22 October 1997 by Ambios Environment Consultants Ltd to map the extent of subtidal sediment habitats at the Isles of Scilly (Munro and Nunny, 1998). Grab sampling and drop-down video surveys were used to ground-truth accompanying acoustic data. Grab stations were sampled using a 0.1m^2 Day grab and were processed through a 500µm sieve. The survey covered the site using a broad sampling grid of grab samples. Due to the spacing between samples, sufficient could not be linked to linked to other surveys for comparison and so the data were not considered further.

3.2.2. 2001 and 2002 Surveys

The 2001 and 2002 surveys of the Isles of Scilly Complex SAC were conducted by the Institute of Estuarine and Coastal Studies, University of Hull (Allen and Proctor, 2003). The survey boat MV Karina Olsen was used. Sediment samples were collected from eight sites around the Isles of Scilly, at each pre-determined station position a 0.1m^2 Day grab was lowered to the seabed and the resulting sample was recovered. All grab samples were processed through a 1mm sieve. Drop-down video was also taken at each site.

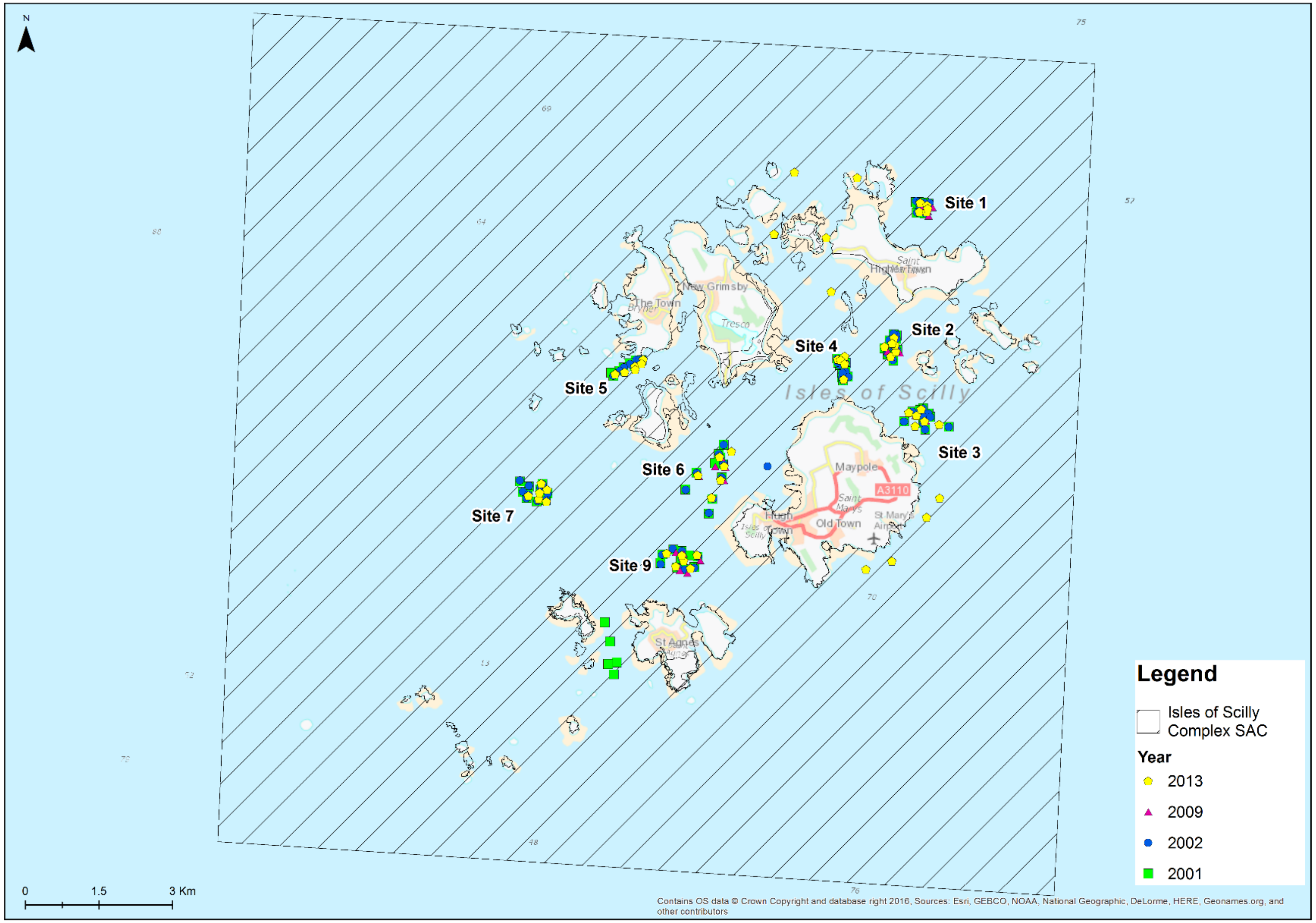
3.2.3. 2009 Survey

The 2009 survey was undertaken by the Environment Agency on 5 April 2009 in order to comply with WFD monitoring requirements. The survey involved taking grab samples using a 0.1m^2 Day grab and the infaunal analysis and PSA was undertaken in the laboratory.

3.2.4. 2013 Survey

The 2013 survey was conducted by APEM in May 2013 on behalf of the Environment Agency. Samples were taken from eleven sites around the Isles of Scilly in order to comply with WFD monitoring requirements. Grab samples were taken using a 0.1m^2 Day grab and PSA and infaunal analysis were conducted in the laboratory.

Figure 3.2: Monitoring survey arrays at the Isles of Scilly Complex SAC and experimental design from the 2001 survey (Allen and Proctor, 2003)



3.3. Results

3.3.1. Site Overview

3.3.1.1. Sediment composition

Particle size distribution (PSD) data were not available for the 1997 survey and so this year was not included in the sediment analysis.

PSD data were available for surveys in 2001, 2009 and 2013, but detailed compositional information was only available for 2009 and 2013. Sites with PSD data in 2001, 2009 and 2013 were assigned to sediment categories based on a modified Folk classification (Long, 2006), in addition to proportions of mud, sand and gravel. For mapping purposes, the Sites have been divided up into east or west sections of the SAC: Sites 1 to 4 in the east and Sites 5 to 9 in the west.

Sediment PSA indicated that in general all grab stations sampled in 2001, 2009 and 2013 had a dominant sand fraction (63-1999µm) with varying gravel content (Table 3.2). Sand (S) was present in 81%, 79% and 72% of all the grab stations sampled at Sites 1 to 9 in 2001, 2009 and 2013 respectively. Gravelly sand (gS) was present in 10%, 8% and 11% of all the stations sampled at Sites 1 to 9 in 2001, 2009 and 2013 respectively. Sandy gravel (sG) was present in 8%, 4% and 17% of all the stations sampled at Sites 1 to 9 in 2001, 2009 and 2013 respectively. Muddy sand (mS) was present in just 8% of the stations sampled in 2009 at Sites 1 to 9. These results broadly support the fact that the majority of the SAC is considered to contain Annex I Subtidal Sandbanks, as far as the sediment type is concerned.

Table 3.2: Range of sediment types sampled at Isles of Scilly Complex SAC within each box between 2001 and 2013

<table>
<tr><th>Site</th><th colspan="6">2001</th><th colspan="6">2009</th><th colspan="6">2013</th></tr>
<tr><td>1</td><td colspan="2">S</td><td colspan="2">gS</td><td colspan="2">sG</td><td colspan="2">S</td><td colspan="2">gS</td><td colspan="2">sG</td><td colspan="3">S</td><td colspan="3">gS</td></tr>
<tr><td>2</td><td colspan="6">S</td><td colspan="6">S</td><td colspan="6">S</td></tr>
<tr><td>3</td><td colspan="6">S</td><td colspan="6">mS</td><td colspan="6">S</td></tr>
<tr><td>4</td><td colspan="6">S</td><td colspan="6"></td><td colspan="6">S</td></tr>
<tr><td>5</td><td colspan="2">S</td><td colspan="2">gS</td><td colspan="2">sG</td><td colspan="6"></td><td colspan="2">S</td><td colspan="2">gS</td><td colspan="2">sG</td></tr>
<tr><td>6</td><td colspan="6">S</td><td colspan="6">S</td><td colspan="3">S</td><td colspan="3">sG</td></tr>
<tr><td>7</td><td colspan="2">S</td><td colspan="2">gS</td><td colspan="2">sG</td><td colspan="6"></td><td colspan="2">S</td><td colspan="2">gS</td><td colspan="2">sG</td></tr>
<tr><td>9</td><td colspan="6">S</td><td colspan="6">S</td><td colspan="6">S</td></tr>
<tr><td>10</td><td colspan="3">gS</td><td colspan="3">sG</td><td colspan="6"></td><td colspan="6">S</td></tr>
<tr><td>11</td><td colspan="6"></td><td colspan="6"></td><td colspan="6">gS</td></tr>
<tr><td>12</td><td colspan="6"></td><td colspan="6"></td><td colspan="6">sG</td></tr>
<tr><td>13</td><td colspan="6"></td><td colspan="6"></td><td colspan="6">G</td></tr>
<tr><td>14</td><td colspan="6"></td><td colspan="6"></td><td colspan="6">S</td></tr>
<tr><td>15</td><td colspan="6"></td><td colspan="6"></td><td colspan="6">msG</td></tr>
<tr><td>16</td><td colspan="6"></td><td colspan="6"></td><td colspan="6">sG</td></tr>
<tr><td>17</td><td colspan="6"></td><td colspan="6"></td><td colspan="6">gS</td></tr>
</table>

All of the sub-features for which the site was designated were sampled at least once during the monitoring surveys (Table 3.3). Individual survey sites will be discussed in more detail in the subsequent chapters. The most well represented sub-feature in terms of occurrence was Subtidal sand, followed by Subtidal coarse sediment.

Table 3.3: Sub-features identified at Isles of Scilly Complex SAC within each sampling box between 2001 and 2013

Site	2001		2009		2013	
1	Sub. Sand	Sub. Coarse	Sub. Sand	Sub. Coarse	Sub. Sand	Sub. Coarse
2	Subtidal Sand		Subtidal Sand		Subtidal Sand	
3	Subtidal Sand		Subtidal Mud		Subtidal Sand	
4	Subtidal Sand				Subtidal Sand	
5	Sub. Sand	Sub. Coarse			Sub. Sand	Sub. Coarse
6	Subtidal Sand		Subtidal Sand		Sub. Sand	Sub. Coarse
7	Sub. Sand	Sub. Coarse			Sub. Sand	Sub. Coarse
9	Subtidal Sand		Subtidal Sand		Subtidal Sand	
10	Sub. Coarse				Subtidal Sand	
11					Subtidal Coarse	
12					Subtidal Coarse	
13					Subtidal Coarse	
14					Subtidal Sand	
15					Subtidal Mixed	
16					Subtidal Coarse	
17					Subtidal Coarse	
21					Subtidal Sand	

PSA data were not available for each Site in consecutive years and so the sediment composition results should be interpreted with caution. Maps of Folk classification and sediment composition are included as Annexes A and B respectively.

Detailed sediment composition information was only available for years 2009 and 2013. For the combined dataset, data clustered into 19 groups and two single samples (Figure 3.3). Each group had a high degree of similarity, reflecting the close proximity of samples from within the same box, but boxes that were geographically close were also most similar (e.g. Box 2 and Box 3). A one-way ANOSIM with Year as a factor indicated that there was no significant difference in composition between 2009 and 2013 (Figure 3.4; Global R = 0.024, Significance level = 26.5%).

Figure 3.3: Dendrogram of sediment composition data for Isles of Scilly Complex SAC 2009 and 2013 benthic surveys

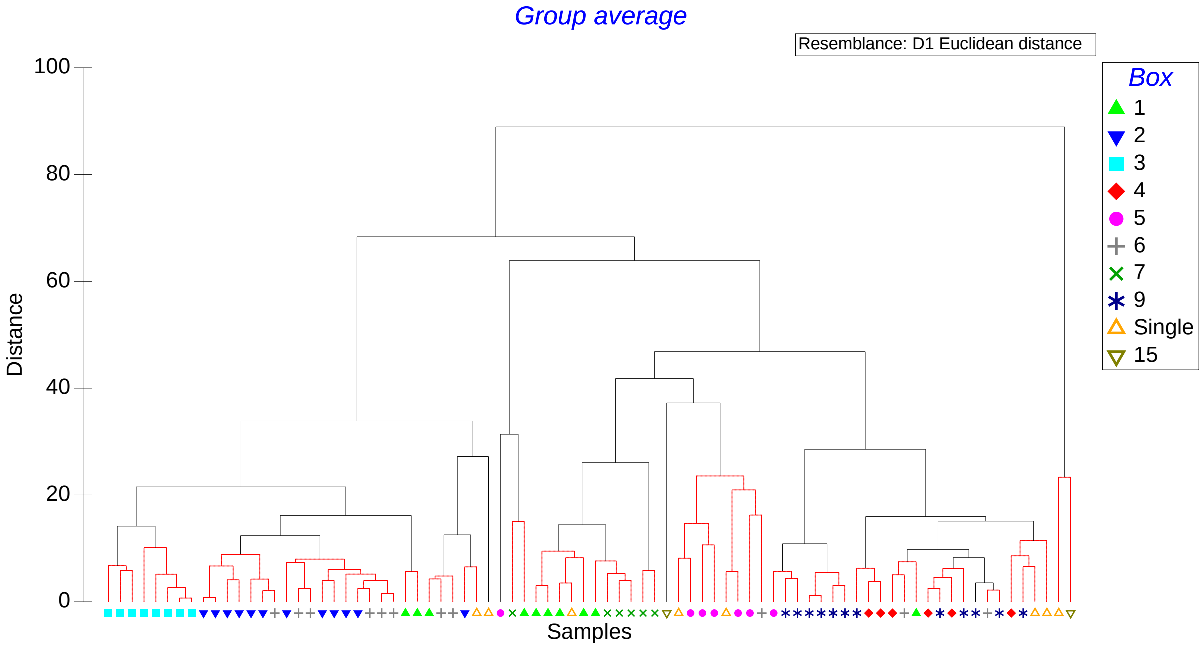


Figure 3.4: nMDS plot of sediment composition data from Isles of Scilly Complex SAC 2009 and 2013 benthic surveys by year (contours from associated dendrogram Figure 3.5)

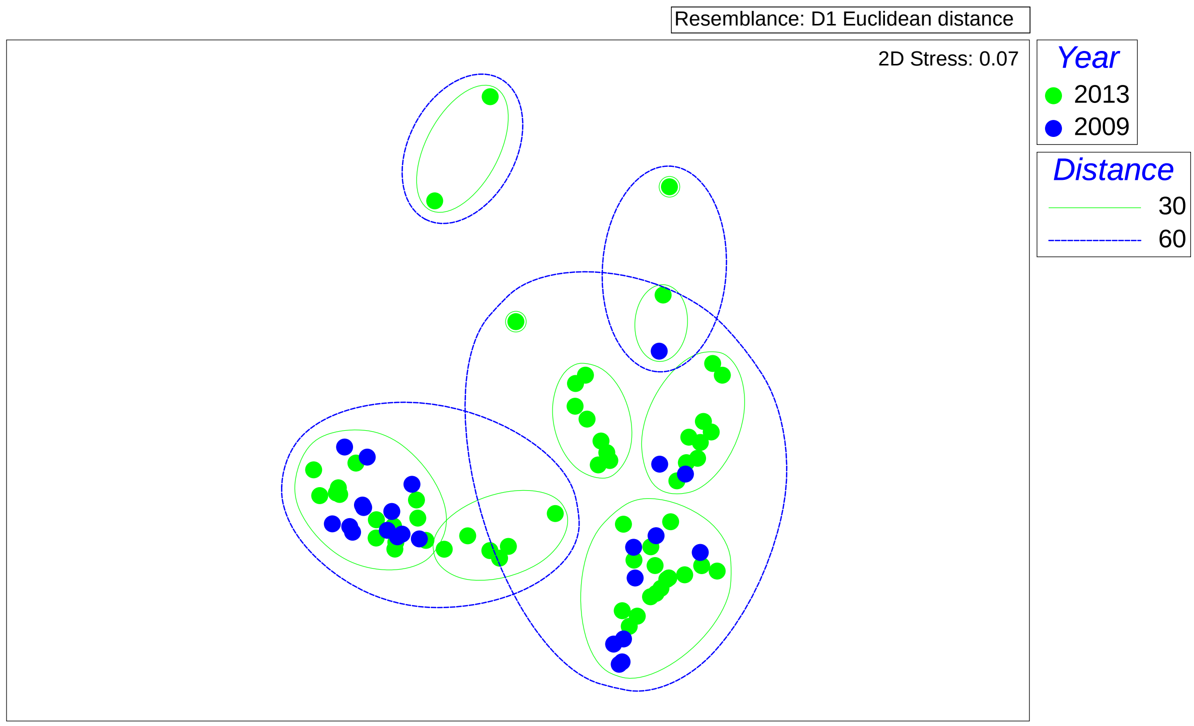
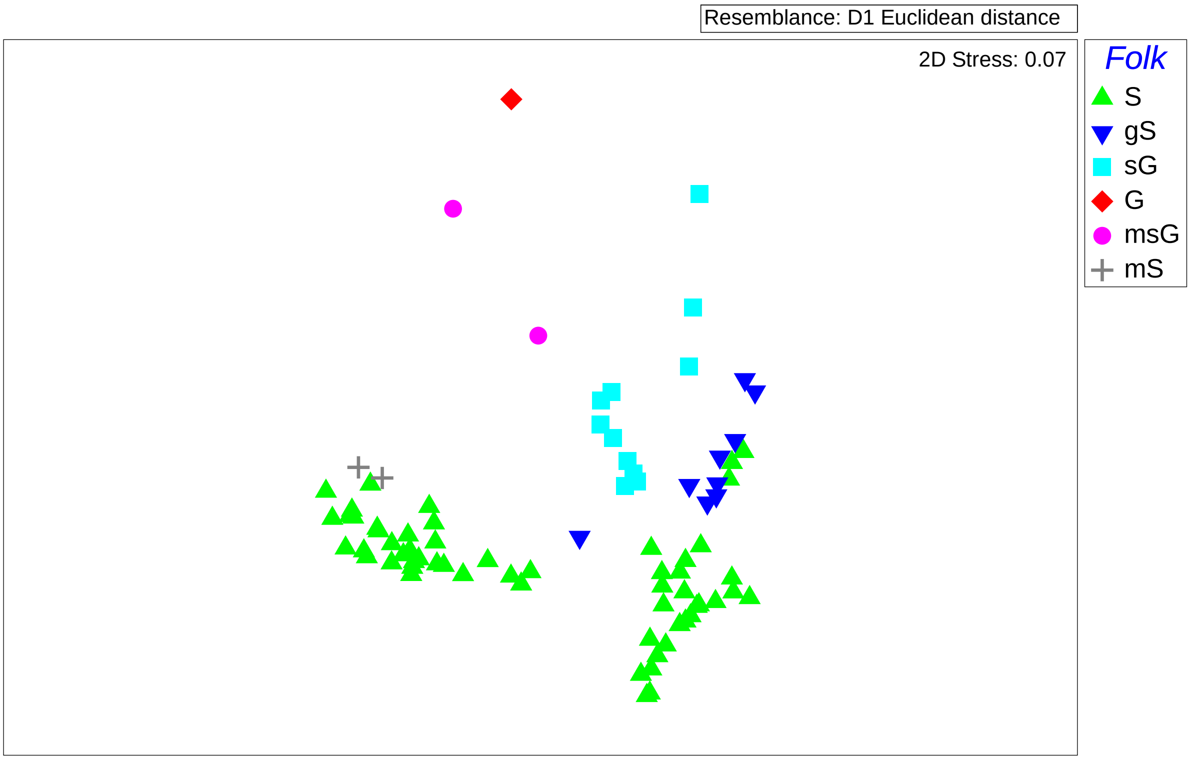


Figure 3.5: nMDS plot of sediment composition data from Isles of Scilly Complex SAC 2009 and 2013 benthic surveys by Folk classification



In general, as with the complete dataset, sediment samples from 2009 and 2013 were predominately Sand, with most of the remaining samples made up of sandy Gravel and gravelly Sand (Figure 3.5). Two samples of muddy sandy Gravel and a single sample of Gravel came from the 2013 survey and were from new survey areas that had not been sampled previously.

Site sediment composition is discussed below in the respective sub-sections for each Site.

3.3.1.2. Benthic community data

Each benthic survey employed a different survey array, so analysis of the entire benthic dataset is included here only for perspective of the whole SAC. The benthic community data appeared similar across all four surveys with no obvious separation of groups (Figure 3.7). Despite this, ANOSIM revealed there to be a small, but statistically significant difference between all years (Table 3.4).

Figure 3.6: nMDS ordination of all benthic community data from Isles of Scilly Complex SAC

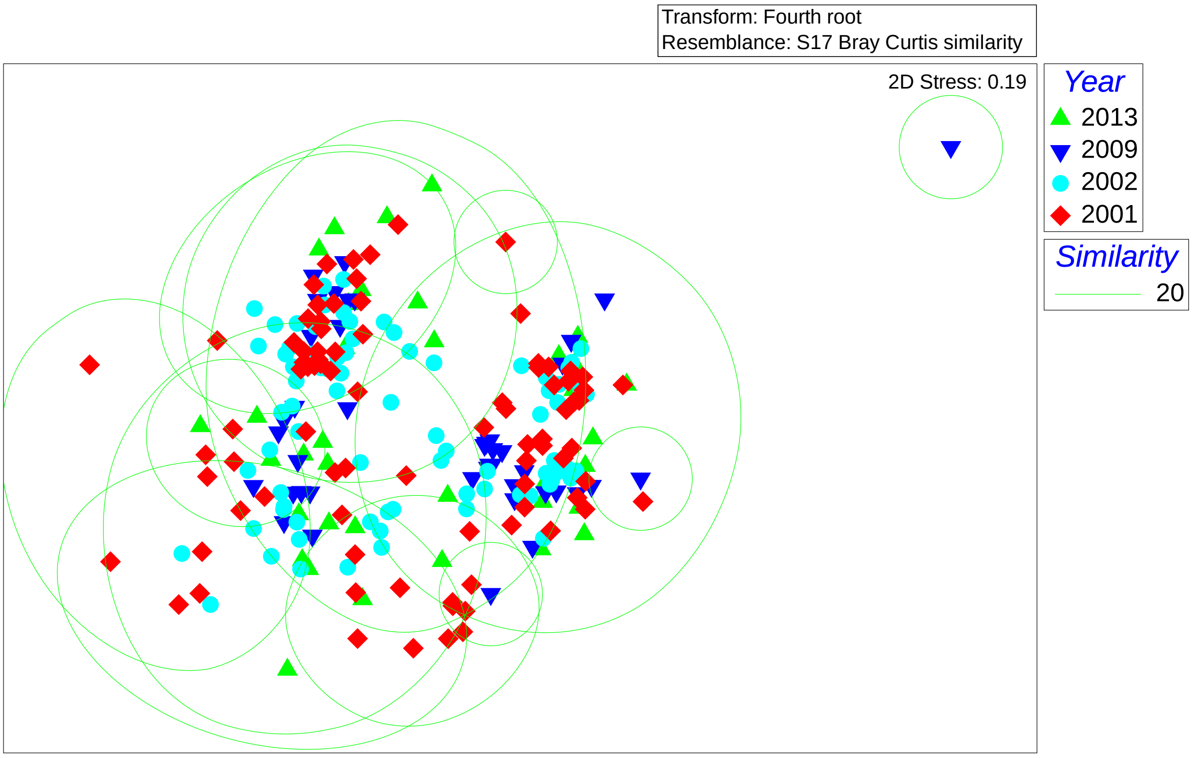


Table 3.4: ANOSIM results of all benthic community data from Isles of Scilly Complex SAC (Global R: 0.098, Significance level: 0.1%)

Groups	R Statistic	Significance Level %	Possible Permutations	Actual Permutations	Number >= Obs
2013, 2009	0.13	0.1	Very large	999	0
2013, 2002	0.175	0.1	Very large	999	0
2013, 2001	0.13	0.1	Very large	999	0
2009, 2002	0.128	0.1	Very large	999	0
2009, 2001	0.106	0.1	Very large	999	0
2002, 2001	0.035	1	Very large	999	9

Compared to the 2001 survey, the benthic community sampled in 2002 had marginally more Nematoda (average abundance of 19.04 in 2002 compared to 17.51 in 2001), *Magelona filiformis* (10.71 to 10.04), and *Pisione remota* (10.04 to 6.35) and fewer *Mediomastus fragilis* (10.89 to 22.76) and *Asbjornsenia pygmaea* (5.48 to 6.73). Whilst in 2009 compared to 2001, there were more Nematoda (90.48 to 17.51), *Magelona filiformis* (14.21 to 10.04), *Urothoe poseidonis* (3.21 to 2.36), and *Echinocyamus pusillus* (11.62 to 3.27) and fewer *Mediomastus fragilis* (21.76 to 22.76). In 2013 compared to 2001, there were more Nematoda (42.50 to 17.51) and *Mediomastus fragilis* (29.67 to 22.76) and fewer *Magelona filiformis* (3.42 to 10.04), *Asbjornsenia pygmaea* (2.25 to 6.73), and *Lagis koreni* (0.19 to 12.27). In general, differences between years were due to changes in the relative abundance of a few characteristic species and though there was variation over time, there were no major trends. Given that the survey arrays were different between years, these results should be interpreted with caution. Data are analysed by site in the following sections.

3.3.2. Site 1 Scilly Isles

Sampling stations at Site 1 were all located to the north of St Martin's, where water depths ranged from 20m to 22m (Allen and Proctor, 2003). Sampling effort, measured as the number of grab samples (n), at Site 1 varied over the monitoring period, with 10 samples taken in 2001 and 2002, 9 in 2009, and only 2 in 2013.

3.3.2.1. Diversity indices

The number of species (S) and number of individuals (N) varied at the site between years (Table 3.5; Figure 3.8). A Kruskal-Wallis test shows that there was no statistically significant difference in number of species (S) between years, $\chi^2(22) = 20.2$, $p = 0.571$.

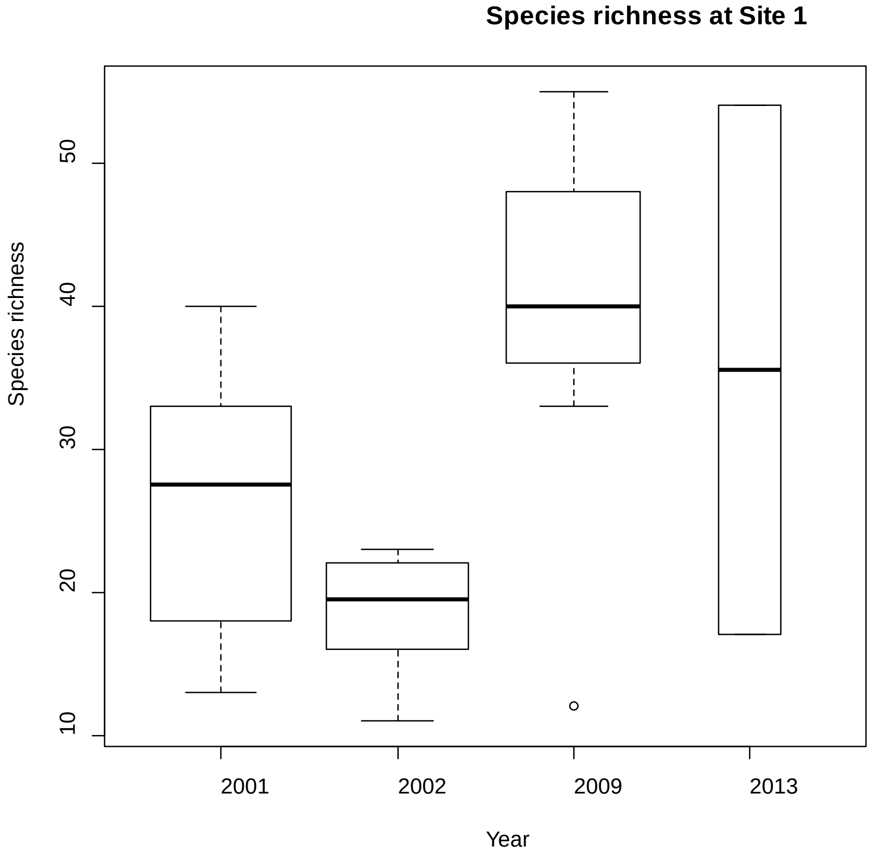
A Kruskal-Wallis test shows that there was no statistically significant difference in number of individuals (N) between years, χ^2 (29) = 29.3, p = 0.448. Species richness, measured by Margalef's index of species richness (D), varied in 2001 and 2002 but remained consistent in 2009 and 2010 (Table 3.5). A Kruskal-Wallis test shows that there was no statistically significant difference in species richness (S) between years, χ^2 (30) = 30.0, p = 0.466. Between years, the evenness of species (J') present in samples remained relatively consistent at Site 1 (Table 3.5). A Kruskal-Wallis test shows that there was no statistically significant difference in species evenness (J') between years, χ^2 (22) = 21.0, p = 0.522.

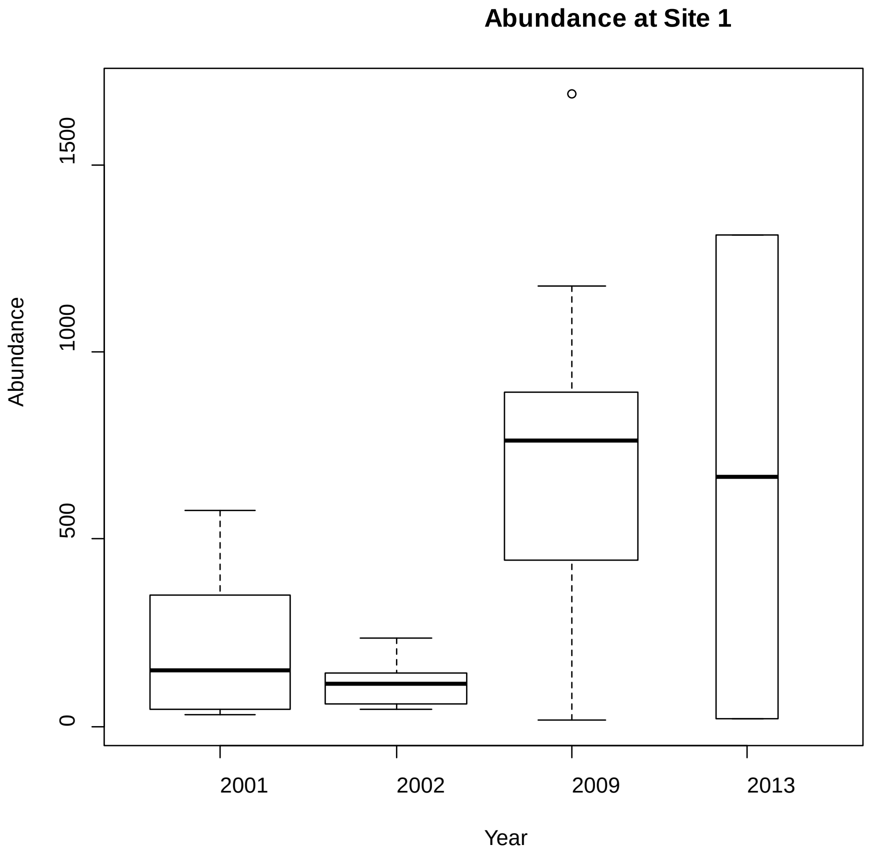
Table 3.5: Mean diversity statistics of benthic communities at Site 1 (n = mean number of samples, S = number of Species in each sample, N = number of Individuals in each sample, D = Margalef's index for species richness, J' = Pielou's evenness index, H'(log_e) = Shannon's diversity index, 1-λ' = Simpson's dominance Index)

	2001	2002	2009	2013
n	10	10	9	2
S	26.50 ± 9.348	18.30 ± 4.111	39.56 ± 12.60	35.50 ± 26.16
N	218.3 ± 204.87	115.3 ± 61.49	755.4 ± 486.26	666.5 ± 912.87
D	5.189 ± 1.315	3.756 ± 0.862	6.030 ± 1.097	6.319 ± 1.504
J'	0.666 ± 0.246	0.610 ± 0.143	0.611 ± 0.151	0.738 ± 0.332
H'(loge)	2.085 ± 0.681	1.763 ± 0.454	2.152 ± 0.276	2.381 ± 0.530
1-λ'	0.724 ± 0.215	0.686 ± 0.156	0.760 ± 0.112	0.855 ± 0.172

The results should be interpreted with caution due to the effects of different survey contractors, benthic laboratories, and sample sizes. However, the lack of any statistically significant differences suggests that there has been no changes in biodiversity over the survey period.

Figure 3.7: Species richness and abundance of benthic macrofaunal from Site 1





3.3.2.2. Faunal assemblages

At Site 1, benthic community structure differed between years which is reflected in the spread of data (Figure 3.9). An ANOSIM test indicated that differences in benthic community structure between years are significant, although the effect of sampling year is relatively weak (Global R = 0.395, p = 0.1%). Pairwise comparisons indicate significant differences between samples in 2009 and all other years (2001, 2002 and 2013) (Table 3.6). In addition, pairwise comparisons indicate significant differences between samples in 2002 and both 2001 and 2013 (Table 3.6).

Figure 3.8: Non-metric multi-dimension scaling ordination of benthic community structure at Site 1

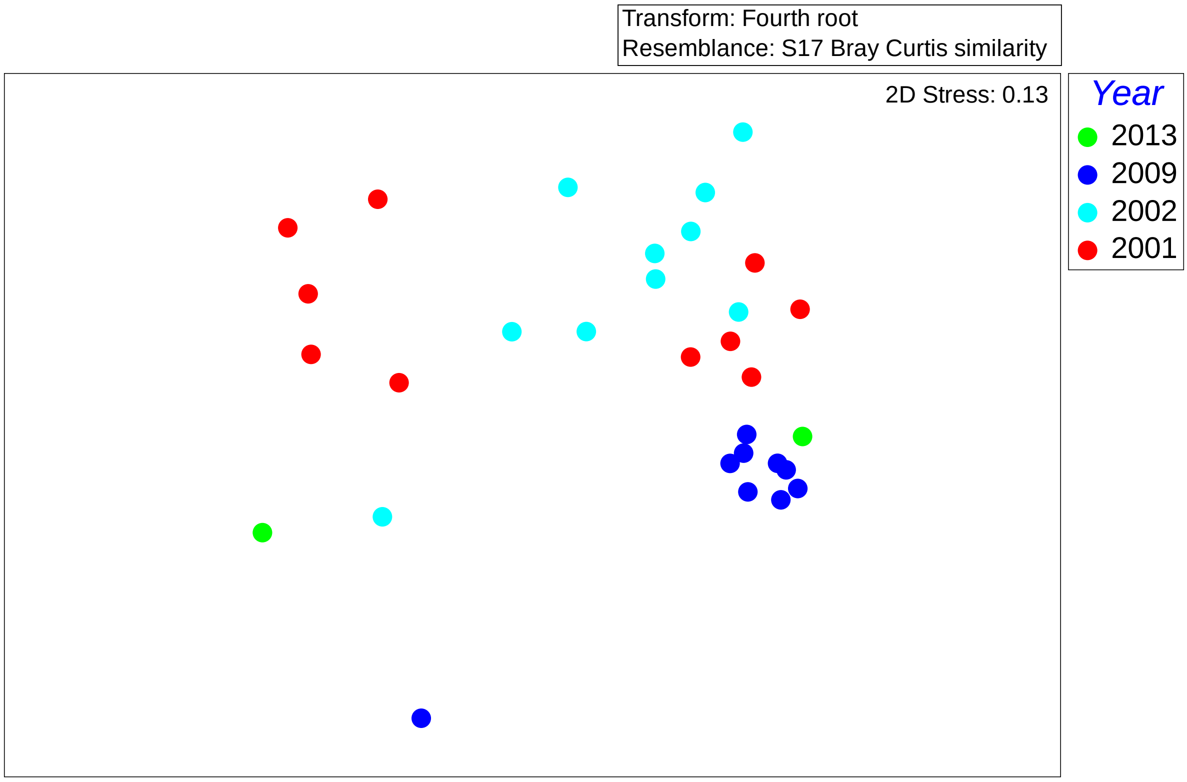


Table 3.6: ANOSIM of benthic community data from Site 1 over consecutive monitoring surveys (*denotes significance at the 5% level)

Groups	R Statistic	Significance Level %	Possible Permutations	Actual Permutations	Number >= Obs
2013, 2009	0.73	*3.6	55	55	2
2013, 2002	0.68	*3.0	66	66	2
2013, 2001	0.283	7.6	66	66	5
2009, 2002	0.601	*0.1	92378	999	0
2009, 2001	0.436	*0.1	92378	999	0
2002, 2001	0.186	*2.1	92378	999	20

SIMPER analysis for each year indicated sample pairs have an average similarity of 25.94% in 2001 with a maximum contribution (4.84%) from the spionid polychaete *Mediomastus fragilis* (Table 3.7). Average similarity was 34.83% in 2002 and 50.39% in 2009 and in both years, nematodes contributed the most to similarity (8.45% in 2002 and 4.77% in 2009 respectively). In 2013, there were only two samples and the average similarity was 10.31%, with the majority (2.36%) contribution from the sabellid polychaete *Owenia fusiformis*.

Table 3.7: SIMPER analysis of benthic community data from Site 1 by monitoring survey

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Group 2001 – average similarity: 25.94%					
Mediomastus fragilis	2.57	4.84	2.33	18.66	18.66
Lumbrineris latreilli	0.94	2.28	1.18	8.80	27.45
Nemertea	0.74	1.53	0.87	5.91	33.37
Nematoda	0.96	0.95	0.52	3.67	37.03
Asbjornsenia pygmaea	0.77	0.88	0.69	3.41	40.44
Phaxas pellucidus	0.62	0.87	0.49	3.36	43.80
Pista cristata	0.84	0.82	0.52	3.14	46.94
Protodorvillea kefersteini	0.94	0.76	0.51	2.94	49.88
Magelona filiformis	0.59	0.76	0.37	2.92	52.80
Poecilochaetus serpens	0.52	0.73	0.50	2.83	55.63
Group 2002 – average similarity: 34.83%					
Nematoda	2.37	8.45	1.86	24.26	24.26
Protodorvillea kefersteini	1.42	5.15	3.42	14.78	39.04
Mediomastus fragilis	1.67	4.31	1.18	12.37	51.42
Pisione remota	0.84	2.04	0.91	5.86	57.27
Magelona filiformis	0.77	1.58	0.69	4.54	61.82
Asbjornsenia pygmaea	0.68	1.26	0.51	3.63	65.44
Glycera	0.72	1.08	0.52	3.09	68.53
Pista cristata	0.56	0.99	0.52	2.84	71.37
Syllis cornuta	0.52	0.95	0.52	2.73	74.10
Psamathe fusca	0.61	0.92	0.52	2.63	76.73
Group 2009 – average similarity: 50.39%					
Nematoda	3.89	4.77	1.8	9.47	9.47
Echinocyamus pusillus	2.24	3.22	5.8	6.39	15.86
Mediomastus fragilis	2.72	3.09	1.65	6.14	21.99
Nemertea	1.73	2.67	4.46	5.3	27.29
Glycera lapidum	2.06	2.58	1.79	5.12	32.41
Grania	2.03	2.52	1.81	5.01	37.42
Pista mediterranea	1.80	2.15	1.67	4.26	41.68
Pisione remota	1.77	2.13	1.68	4.23	45.91
Protodorvillea kefersteini	1.86	2.09	1.77	4.15	50.06
Aonides paucibranchiata	1.69	2.04	1.77	4.04	54.10
Group 2013 – average similarity: 10.31%					
Owenia fusiformis	1.25	2.36	#######	22.92	22.92
Nemertea	1.47	1.99	#######	19.27	42.19
Polynoidae	1.00	1.99	#######	19.27	61.46
Lumbrineris	1.09	1.99	#######	19.27	80.73
Urothoe elegans	1.00	1.99	#######	19.27	100.00

NB: due to there only being two grab samples from the 2013 survey, SD cannot be calculated

3.3.2.3. Biotopes

The sediment types at Site 1 ranged from Sand, gravelly Sand and sandy Gravel in 2001 and 2009 to only Sand and gravelly Sand in 2013 with a marginally decreased Gravel content. These constitute Subtidal Sand and Subtidal Coarse sub-features which were both present in all years.

In general, the characterising benthic species were similar across years, with the exception of 2013, where there were only two samples taken and similarity between the two samples was very low (10%).

Of the other years, *Mediomastus fragilis*, *Nematoda*, *Protodorvillea kefersteini* and *Pista cristata* were all characterising species. In the 2001 monitoring report, Allen and Proctor (2003) identified two dominant biotopes within Site 1 which were likely variants of:

- A complex of SS.SCS.CCS.MedLumVen: *Mediomastus fragilis*, *Lumbrineris* spp. and venerid bivalves in circalittoral coarse sand or gravel and SS.SCS.ICS.MoeVen: *Moerella* spp. with venerid bivalves in infralittoral gravelly sand; and
- SS.SSa.IMuSa.FfabMag: *Fabulina fabula* and *Magelona mirabilis* with venerid bivalves and amphipods in infralittoral compacted fine muddy sand.

Data from 2002 and 2009, showed less of a clear split into the two main biotopes and this was reflected in a high similarity between grabs (35 and 50% compared to 26%). Samples from these years (and 2009 in particular) showed more resemblance to the SS.SCS.CCS.MedLumVen biotope.

Though 2013 samples were very different in terms of species composition, the low sampling effort makes it difficult to interpret the biotope with any confidence.

Though there were small significant differences detected in species composition between years at Site 1, the changes were mainly caused by small shifts in the relative abundance of the same characteristic species (Nematoda, *Mediomastus fragilis, Protodorvillea kefersteini,* and *Echinocyamus pusillus*). These characteristic species are not known to be indicative of any anthropogenic disturbance.

3.3.3. Site 2 Scilly Isles

Sampling stations at Site 2 were all located to the south of St Martin's, with water depths from 3m to 6m (Allen and Proctor, 2003). Sampling effort, measured as the number of grab samples (n), at Site 2 was fairly consistent over the monitoring period, with 10 samples taken in 2001, 2002 and 2009, and 6 in 2013.

3.3.3.1. Diversity indices

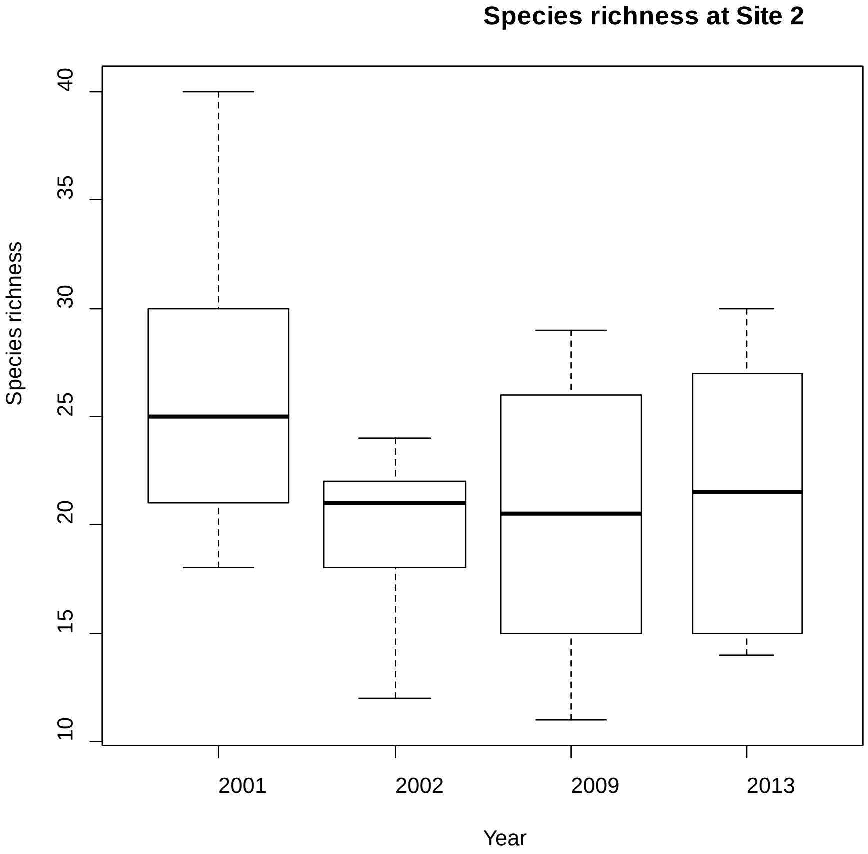
The mean number of species per sample (S) and number of individuals (N) varied at the site between years (Table 3.8). A Kruskal-Wallis test shows that there was no statistically significant difference in number of species (S) between years, $\chi^2(18) = 18.093$, $p = 0.450$.

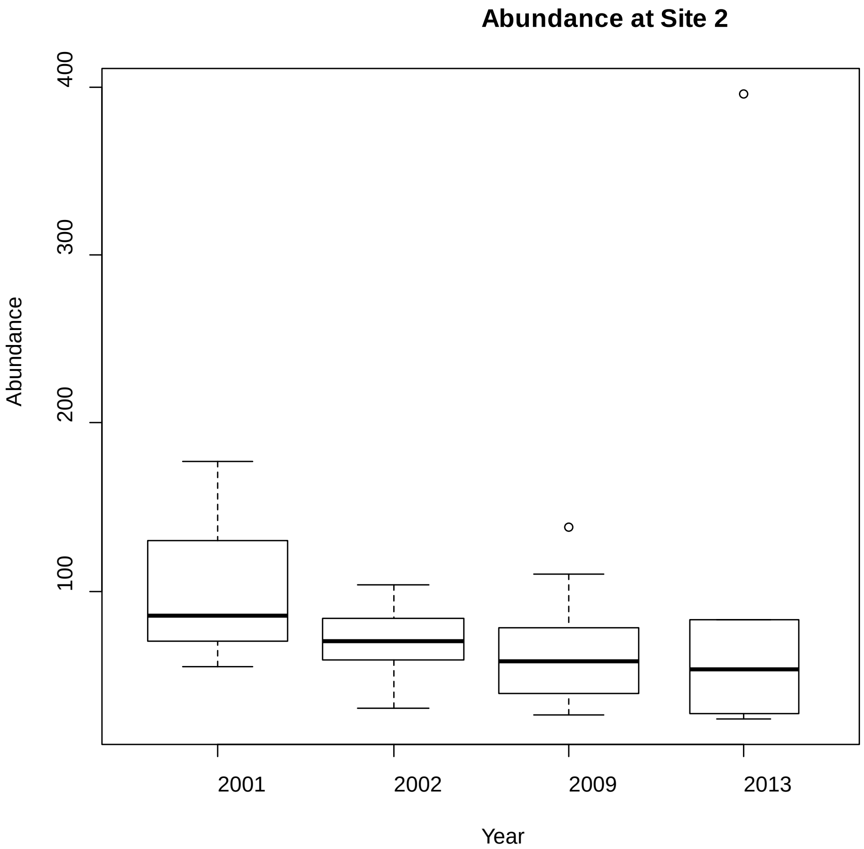
A Kruskal-Wallis test shows that there was no statistically significant difference in number of individuals (N) between years, $\chi^2(32) = 34.207$, $p = 0.362$. Species richness, measured by Margalef's index of species richness (D) and evenness of species (J') present in samples, are greatest in 2001 and are similar in 2002, 2009 and 2013 (Table 3.8). A Kruskal-Wallis test shows that there was no statistically significant difference in species richness (D) between years, $\chi^2(35) = 35.000$, $p = 0.468$. A Kruskal-Wallis test shows that there was no statistically significant difference in species evenness (J') between years, $\chi^2(35) = 35.00$, $p = 0.468$. The Shannon-Wiener diversity index (H'(loge)) and Simpson's index of dominance (1-λ') were consistent between years (Table 3.8). A Kruskal-Wallis test shows that there was no statistically significant difference in Shannon-Wiener (H'(loge)) or Simpson's index of dominance (1-λ') between years, $\chi^2(35) = 35.00$, $p = 0.468$.

Table 3.8: Mean diversity statistics of benthic communities at Site 2 (n = mean number of samples, S = number of Species in each sample, N = number of Individuals in each sample, D = Margalef's index for species richness, J' = Pielou's evenness index, H'(loge) = Shannon's diversity index, 1-λ' = Simpson's dominance Index)

	2001	2002	2009	2013
n	10	10	10	6
S	26.10 ± 7.25	19.80 ± 3.58	19.90 ± 6.30	21.50 ± 6.53
N	98.80 ± 41.00	69.10 ± 23.83	67.10 ± 34.86	106.17 ± 143.89
D	5.517 ± 1.35	4.519 ± 0.89	4.533 ± 1.12	4.906 ± 0.69
J'	0.783 ± 0.104	0.809 ± 0.080	0.826 ± 0.079	0.834 ± 0.186
H'(loge)	2.526 ± 0.388	2.397 ± 0.259	2.430 ± 0.363	2.487 ± 0.458
1-λ'	0.865 ± 0.072	0.866 ± 0.055	0.870 ± 0.065	0.870 ± 0.160

Figure 3.9: Species richness and abundance of benthic macrofaunal from Site 2





3.3.3.2. Faunal assemblages

At Site 2 benthic community structure differed between years, which is reflected in the spread of data in Figure 3.11. An ANOSIM test indicated a significant difference in benthic community structure between years and the effect of sampling year is relatively strong (Global R = 0.663, p = 0.1%). The relatively large Global R values indicated relatively large differences in community structure between years. Pairwise comparisons showed the largest differences to be between 2013 and 2009, 2013 and 2002, 2013 and 2001, as well as 2009 and 2002, and 2009 and 2001 (Table 3.9).

Figure 3.10: Non-metric multi-dimension scaling ordination of benthic community structure from Site 2 (Bray-Curtis similarity and $\sqrt[4]{}$-transformation)

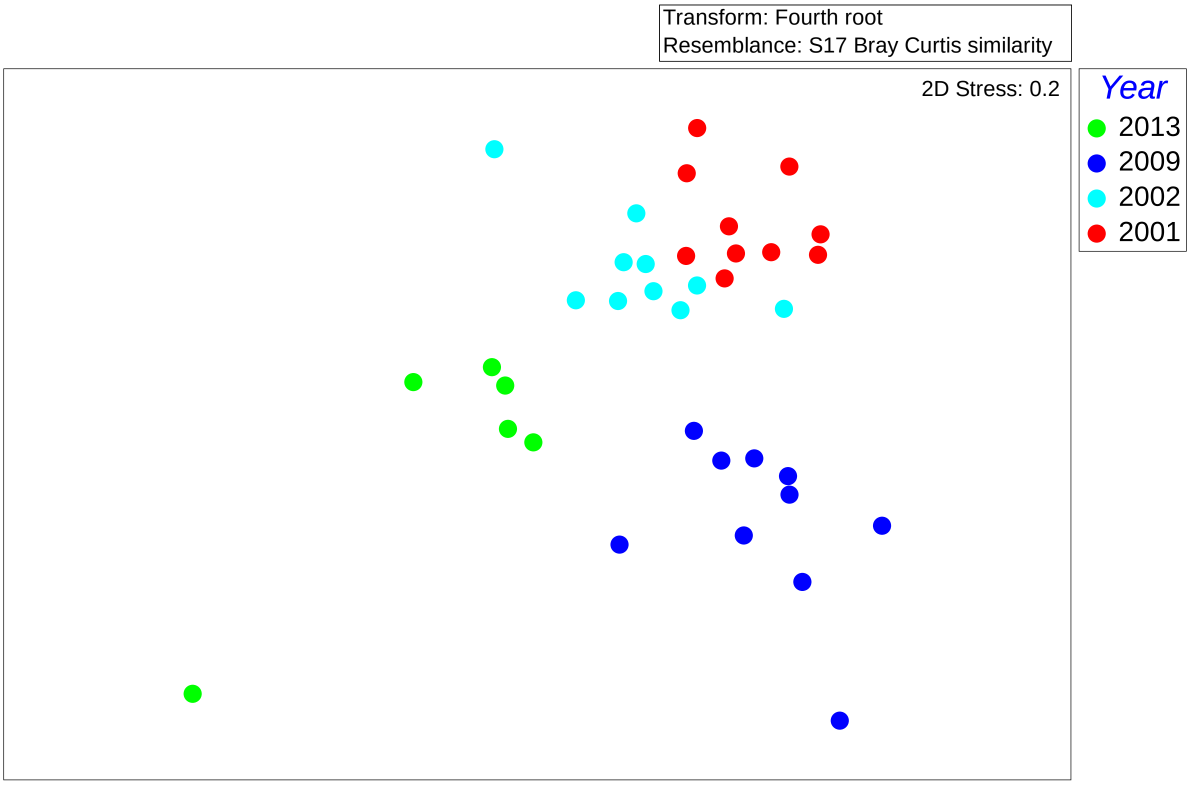


Table 3.9: ANOSIM of benthic community data from Site 2 over consecutive monitoring surveys

Groups	R Statistic	Significance Level %	Possible Permutations	Actual	Number >= Observed
2013, 2009	0.674	0.1	8008	999	0
2013, 2002	0.757	0.1	8008	999	0
2013, 2001	0.833	0.1	8008	999	0
2009, 2002	0.754	0.1	92378	999	0
2009, 2001	0.802	0.1	92378	999	0
2002, 2001	0.328	0.1	92378	999	0

At Site 2, SIMPER analysis for each year indicated sample pairs have an average similarity of 49.82% in 2001, with a maximum contribution (5.80%) from the spionid polychaete *Magelona filiformis* (Table 3.10). Average similarity was 54.08% in 2002, with a maximum contribution (6.82%) from the amphipod *Perioculodes longimanus*. Average similarity was 46.72% in 2009, with a maximum contribution (46.72%) also from *Magelona filiformis*. Average similarity was 46.49% in 2013, with a maximum contribution (4.75%) from species in the order Decapoda.

Table 3.10: SIMPER analysis of benthic community data from Site 2 by monitoring survey

Species	Av.Abu	Av.Sim	Sim/SD	Contri%	Cum%
Group 2001 – average similarity: 49.82%					
Magelona filiformis	2.08	5.80	4.97	11.64	11.64
Perioculodes longimanus	1.62	4.56	3.52	9.14	20.79
Caulleriella alata	1.66	4.44	4.80	8.9	29.69
Spiophanes bombyx	1.43	4.05	4.41	8.14	37.83
Spio filicornis	1.36	4.01	3.93	8.05	45.88
Scoloplos (Scoloplos) armiger	1.14	3.38	5.63	6.79	52.67
Nephtys hombergii	0.99	2.62	1.84	5.26	57.93
Megaluropus agilis	1.05	2.41	1.18	4.83	62.76
Urothoe poseidonis	1.04	2.31	1.24	4.64	67.40
Aricidea (Aricidea) minuta	0.98	2.14	1.19	4.30	71.71
Group 2002 – average similarity: 54.08%					
Perioculodes longimanus	1.80	6.82	5.89	12.61	12.61
Magelona filiformis	1.74	5.51	1.90	10.18	22.80
Phaxas pellucidus	1.39	5.08	3.93	9.40	32.20
Scoloplos (Scoloplos) armiger	1.16	4.50	5.68	8.32	40.52
Urothoe poseidonis	1.41	4.00	1.67	7.40	47.92
Synchelidium maculatum	1.07	3.72	1.87	6.87	54.80
Spiophanes bombyx	0.96	2.92	1.23	5.39	60.19
Nemertea	0.91	2.73	1.24	5.05	65.24
Abra alba	0.86	2.12	0.92	3.92	69.16
Caulleriella alata	0.94	2.06	0.91	3.81	72.96
Group 2009 – average similarity: 46.72%					
Magelona filiformis	1.71	5.08	1.85	10.88	10.88
Paraspio decorata	1.27	4.97	4.89	10.64	21.53
Urothoe poseidonis	1.49	4.68	1.64	10.02	31.54
Nephtys hombergii	1.19	4.30	1.72	9.21	40.76
Perioculodes longimanus	1.31	4.08	1.83	8.73	49.48
Aricidea (Aricidea) minuta	1.20	3.13	1.23	6.70	56.19
Abra prismatica	0.99	2.91	1.22	6.23	62.41
Dosinia exoleta	0.79	2.43	0.89	5.21	67.62
Magelona johnstoni	0.74	1.43	0.68	3.05	70.67
Nematoda	0.77	1.39	0.68	2.97	73.65
Group 2013 - average similarity: 46.49%					
Decapoda	1.23	4.75	4.06	10.21	10.21
Spio symphyta	1.32	4.38	4.92	9.43	19.64
Magelona filiformis	1.32	3.96	1.33	8.51	28.16
Tanaopsis graciloides	1.06	3.4	1.3	7.31	35.47
Urothoe poseidonis	1.09	3.37	1.26	7.24	42.71
Perioculodes longimanus	1.26	3.36	1.28	7.23	49.93
Megaluropus agilis	1.00	3.14	1.33	6.75	56.68
Harmothoe glabra	0.92	3.02	1.30	6.50	63.18
Phaxas pellucidus	0.86	2.97	1.30	6.38	69.56
Nephtys hombergii	0.95	2.87	1.27	6.17	75.74

3.3.3.3. Biotopes

The only sediment type sampled at Site 2 was Sand, which represents the Subtidal Sand sub-feature.

The stations at Site 2 were relatively consistent within year with similarity between stations ranging from 46% to 54%. As the difference in similarity between stations was relatively low no further division has been carried out although some further sub-divisions are apparent.

In the 2001 monitoring report, Allen and Proctor (2003) identified one dominant biotope within Site 1 which was a likely variant of:

- SS.SSa.IMuSa.FfabMag: *Fabulina fabula* and *Magelona mirabilis* with venerid bivalves and amphipods in infralittoral compacted fine muddy sand.

Though *F. fabulina* was only recorded once in the 2001 survey, it was recorded 69 times in total across the four surveys, validating the initial biotope characterisation. Characterising species of Site 2 common across all survey years were *Magelona filiformis*, *Perioculodes longimanus*, and *Urothoe poseidonis*.

Dissimilarity was greatest between 2001 and 2013 surveys (70.16%). This was caused by the presence of *Spio filicornis* in 2001 but not 2013 and the presence of *Spio symphyta* in 2013 but not in 2001. Although separate species, *Spio symphyta* was only described in 2011, so it is highly likely that these were in fact the same species of *Spio*. Also contributing to the observed dissimilarity were the presence of *Scoloplos armiger* in 2001 only and the presence of *Tanaopsis graciloides*, *Harmothoe glabra*, and *Magelona johnstoni* in 2013 only. These characteristic species are not known to be indicative of any anthropogenic disturbance. In particular, *Scoloplos armiger* is a fairly tolerant species in terms of disturbacne though it may increase as a result of organic input (Hiscock *et al*., 2004).

3.3.4. Site 3 Scilly Isles

Sampling stations at Site 3 were situated to the north west of St Mary's, where water depths ranged from 13m to 16m (Allen and Proctor, 2003). Sampling effort, measured as the number of grab samples (n), at Site 3 varied over the monitoring period, with 10 samples taken in 2001 and 2002, 4 in 2009, and 6 in 2013.

3.3.4.1. Diversity indices

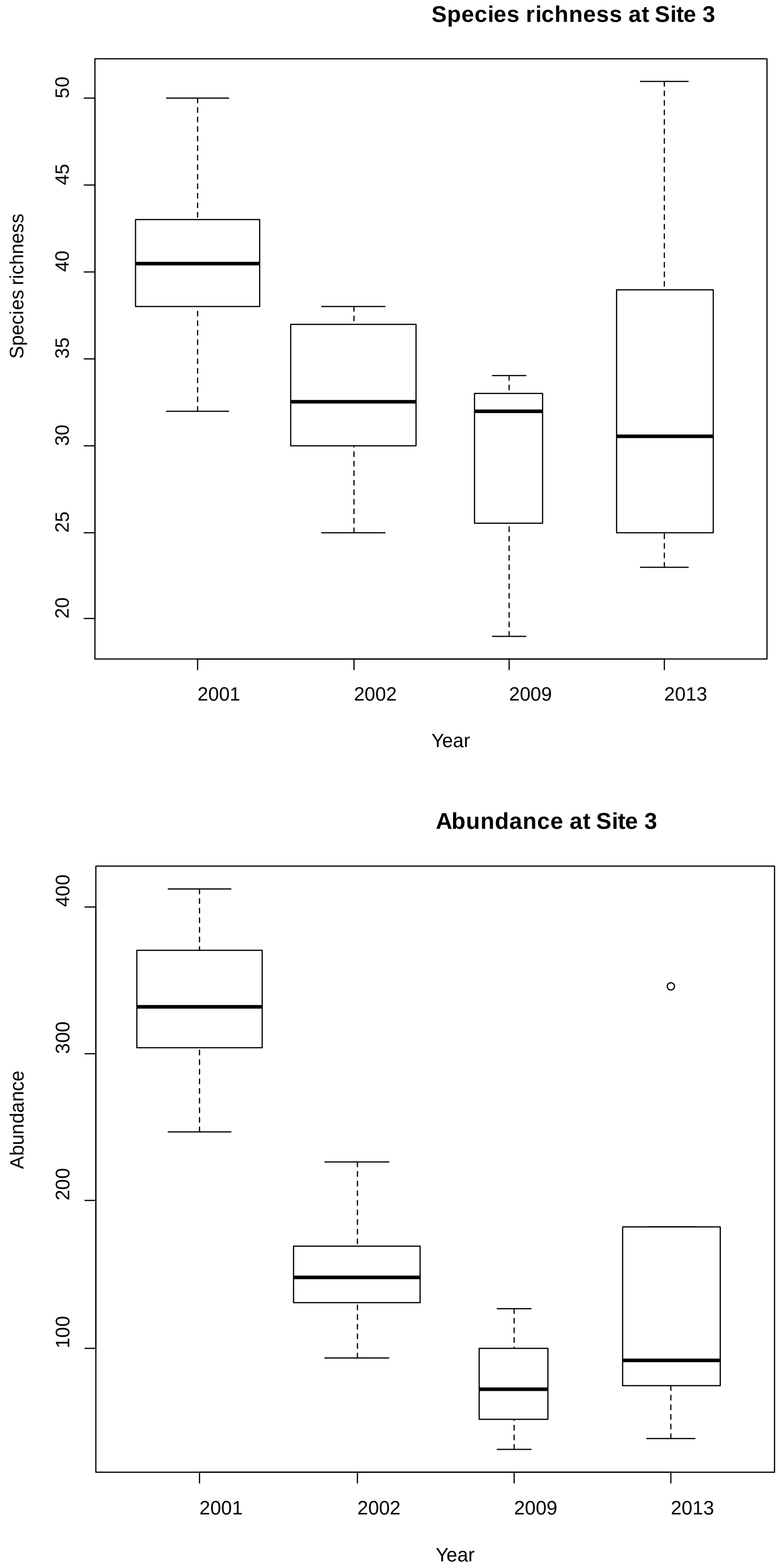
The mean number of species per sample (S) and number of individuals (N) varied at the site between years (Table 3.11).

A Kruskal-Wallis test shows that there was no statistically significant difference in number of species (S) between years, $\chi^2(18) = 21.388$, $p = 0.260$. A Kruskal-Wallis test shows that there was no statistically significant difference in number of individuals (N) between years, $\chi^2(29) = 29.000$, $p = 0.465$. Species richness, measured by Margalef's index of species richness (D) was consistent between years (Table 3.11). A Kruskal-Wallis test shows that there was no statistically significant difference in species richness (D) between years, $\chi^2(28) = 28.000$, $p = 0.464$. Between years, the evenness of species (J') present in samples and, therefore, species diversity (H'(loge)) and species dominance (1-λ') remained relatively consistent at Site 3 (Table 3.11). A Kruskal-Wallis test shows that there was no statistically significant difference in the Shannon-Wiener diversity index (H'(loge)) between years, $\chi^2(29) = 29.000$, $p = 0.465$. Likewise, A Kruskal-Wallis test shows that there was no statistically significant difference in the Simpson index, $\chi^2(28) = 28.000$, $p = 0.464$.

Table 3.11: Mean diversity statistics of benthic communities at Site 3 (n = mean number of samples, S = number of Species in each sample, N = number of Individuals in each sample, D = Margalef's Index for species richness, J' = Pielou's evenness index, H'(loge) = Shannon's diversity index, 1-λ' = Simpson's dominance Index)

	2001	2002	2009	2013
n	10	10	4	6
S	40.50 ± 5.17	32.60 ± 4.06	21.50 ± 15.20	33.17 ± 10.40
N	335.40 ± 48.8	149.60 ± 39.8	57.75 ± 54.6	137.17 ± 113.0
D	6.819 ± 0.992	6.347 ± 0.705	6.434 ± 1.056	6.801 ± 1.331
J'	0.674 ± 0.064	0.810 ± 0.047	0.876 ± 0.098	0.804 ± 0.134
H'(loge)	2.493 ± 0.291	2.817 ± 0.193	2.164 ± 1.453	2.773 ± 0.443
1-λ'	0.833 ± 0.064	0.907 ± 0.035	0.930 ± 0.047	0.883 ± 0.094

Figure 3.11: Species richness and abundance of benthic macrofaunal from Site 3



3.3.4.2. Faunal assemblages

At Site 3 benthic community structure differed between years which is reflected in the spread of data in Figure 3.13. An ANOSIM test indicated significant differences in benthic community structure between years and the effect of sampling year is relatively strong (Global R = 0.752, p = 0.1%). Pairwise comparisons show the differences to be between 2013 and 2002, 2013 and 2001, 2009 and 2002, 2009 and 2001 as well as 2002 and 2001 (Table 3.12). The relatively large and similar Global R values indicate that, in general, the differences between groups is large (Table 3.12).

Figure 3.12: Non-metric multi-dimension scaling ordination of benthic community structure from Site 3 (Bray-Curtis similarity and $^4\sqrt{}$-transformation)

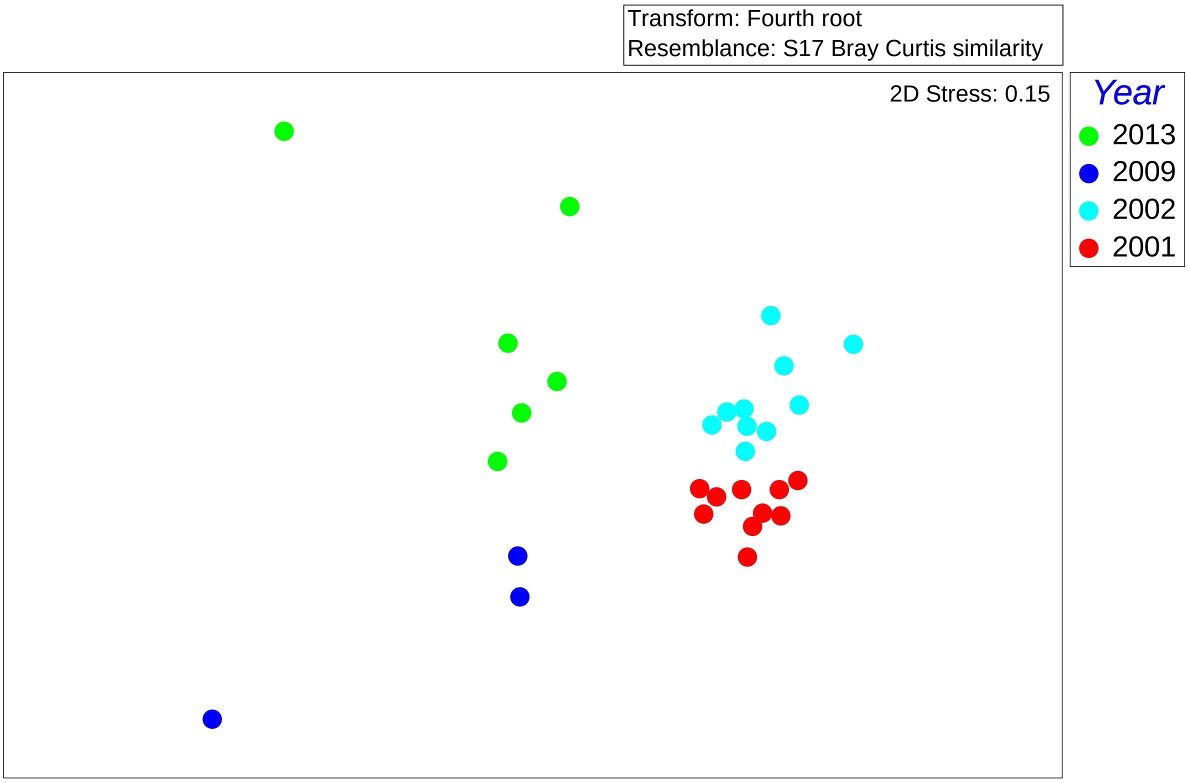


Table 3.12: ANOSIM of benthic community data from Site 3 over consecutive monitoring surveys

Groups	R Statistic	Significance Level %	Possible Permutations	Actual Permutations	Number >= Observed
2013, 2009	0.407	4.8	84	84	4
2013, 2002	0.797	0.1	8008	999	0
2013, 2001	0.812	0.1	8008	999	0
2009, 2002	0.975	0.3	286	286	1
2009, 2001	0.989	0.3	286	286	1
2002, 2001	0.667	0.1	92378	999	0

At Site 3, SIMPER analysis for each year indicated sample pairs have an average similarity of 61.02% in 2001 with a maximum contribution (5.06%) from the terebellid polychaete *Lagis koreni* (Table 3.13). Average similarity was 57.69% in 2002 with the majority (4.35%) contribution from *Magelona filiformis*. Average similarity was 49.40% in 2009 with the majority (4.12%) contribution from the Gammaridean amphipod *Harpinia antennaria*. Average similarity was 40.68% in 2013 with the majority (2.88%) contribution from *Magelona filiformis*.

Table 3.13: SIMPER analysis of benthic community data from Site 3 by monitoring survey

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum%
Group 2001 – average similarity: 61.02%					
Lagis koreni	3.08	5.06	5.27	8.29	8.29
Magelona filiformis	2.69	4.58	12.60	7.51	15.80
Phaxas pellucidus	2.29	3.69	4.77	6.05	21.85
Acrocnida brachiata	1.94	3.23	6.89	5.30	27.14
Kurtiella bidentata	1.91	3.11	6.06	5.10	32.24
Tharyx killariensis	1.81	2.71	5.57	4.44	36.68
Sthenelais limicola	1.45	2.45	8.75	4.01	40.69
Harpinia antennaria	1.52	2.36	1.92	3.86	44.56
Abra alba	1.41	2.32	7.12	3.79	48.35
Spiophanes bombyx	1.39	2.25	7.68	3.68	52.03
Group 2002 – average similarity: 57.69%					
Magelona filiformis	2.05	4.35	9.95	7.55	7.55
Acrocnida brachiata	1.94	4.27	8.02	7.41	14.95
Phaxas pellucidus	1.90	3.95	5.52	6.86	21.81
Kurtiella bidentata	1.81	3.70	4.43	6.42	28.23
Amphiura filiformis	1.66	3.52	4.16	6.11	34.34
Sthenelais limicola	1.55	3.28	5.29	5.69	40.02
Abra alba	1.44	3.10	7.11	5.37	45.4
Harpinia antennaria	1.41	3.04	5.23	5.27	50.66
Dosinia	1.15	2.16	1.92	3.75	54.41
Perioculodes longimanus	1.09	2.10	1.88	3.64	58.06
Group 2009 – average similarity: 49.40%					
Harpinia antennaria	1.47	4.12	8.69	8.33	8.33
Nephtys hombergii	1.38	4.03	6.6	8.16	16.49
Amphiuridae	1.31	3.75	9.99	7.59	24.09
Ampelisca tenuicornis	1.21	3.43	3.38	6.94	31.03
Thyasira flexuosa	1.17	3.28	4.21	6.64	37.67
Turbellaria	1.17	3.27	5.04	6.61	44.28
Kurtiella bidentata	1.13	3.27	5.04	6.61	50.89
Urothoe poseidonis	1.13	3.22	15.38	6.53	57.42
Nemertea	1.11	3.06	6.60	6.20	63.62
Malmgrenia marphysae	1.06	3.06	6.60	6.20	69.82
Group 2013 – average similarity: 40.68					
Magelona filiformis	1.57	2.88	1.28	7.07	7.07
Nephtys hombergii	1.21	2.80	5.58	6.88	13.94
Harpinia antennaria	1.26	2.10	1.31	5.17	19.12
Lumbrineris	1.09	1.86	1.33	4.57	23.68
Phaxas pellucidus	1.05	1.84	1.26	4.52	28.2
Ampelisca tenuicornis	0.96	1.82	1.29	4.47	32.68
Galathowenia oculata	1.25	1.80	1.30	4.44	37.11
Amphiura filiformis	1.24	1.77	1.32	4.35	41.46
Kurtiella bidentata	1.12	1.70	1.33	4.18	45.64
Nemertea	0.92	1.62	1.30	3.99	49.62

3.3.4.3. Biotopes

The sediment types at Site 3 ranged from Sand in 2001 and 2013 to muddy Sand in 2009. The increase in relative silt content in 2009 was sufficient to shift the characterisation of the sub-feature from Subtidal Sand in 2001 and 2013, to Subtidal Mud in 2009.

The communities samples at Site 3 were relatively consistent within year, with similarity ranging from 41% to 61%. As the difference in similarity between stations was relatively low no further division has been carried out although some further sub-divisions are apparent.

In the 2001 monitoring report, Allen and Proctor (2003) identified one dominant biotope within Site 1 which was a likely variant of:

- SS.SMu.CSaMu.LkorPpel: *Lagis koreni* and *Phaxas pellucidus* in circalittoral sandy mud.

Based upon analysis of the community data, there were significant differences between years. *Lagis koreni* was only present as a dominant characterising species in 2001. In all years, there was a consistent characterising species *Kurtiella* (formally *Mysella*) *bidantata* and in 2001 and 2002 also *Acrocnida* (formally *Amphiura*) *brachiata*. This closely resembles the biotope SS.SSa.CMuSa.AbraAirr (*Amphiura brachiata* with *Astropecten irregularis* and other echinoderms in circalittoral muddy sand). This biotope is thought to form part of the 'offshore muddy sand association' described by other workers (Jones 1951; Mackie 1990). It is possible that in some areas this biotope forms an epifaunal overlay which may cover a range of biotopes in years of good recruitment but does not develop into a settled or established community. This may explain why it is found in relation to SSA.LkorPpel (*Lagis koreni* with *Phaxas pellucida* in non-cohesive infralittoral muddy sand); namely, in varying degrees across the surveys in relation to natural recruitment success.

Dissimilarity was greatest between 2002 and 2009 surveys (83.59%). This was caused by the relatively higher abundance of *Magelona filiformis*, *Phaxas pellucidus*, *Acrocnida brachiata*, and *Amphiura filiformis* in 2002 and more *Tharyx killariensis* in 2009. These species were in the top six taxa contributing to dissimilarity between all years and were consistently higher in years where more samples were taken. Due to the heterogeneous distribution of many of these taxa, it is possible that the reduced sampling power in 2009 and 2013 led to a lower average abundance of these taxa.

In addition, high abundances of *Lagis koreni* in 2001 contributed most to dissimilarities between that year and all others. The tubeworm *Lagis koreni* can be an indicator of physical disturbance, but like many of these species is typically ephemeral in dynamic coastal systems. As such, it is not possible to attribute the higher abundance of this species in 2001 to any anthropogenic disturbance over succession, recruitment success or natural distance such as storms.

3.3.6. Site 4 Scilly Isles

Sampling stations at Site 4 were situated to the north of St Mary's adjacent to Crow Bar, with depth ranging from 1.3m to 3.2m CD (Allen and Proctor, 2003). Sampling effort, measured as the number of grab samples (n), at Site 4 varied over the monitoring period, with 10 samples taken in 2001 and 2002, and 6 in 2013. No samples were taken at Site 4 in 2009.

3.3.6.1. Diversity indices

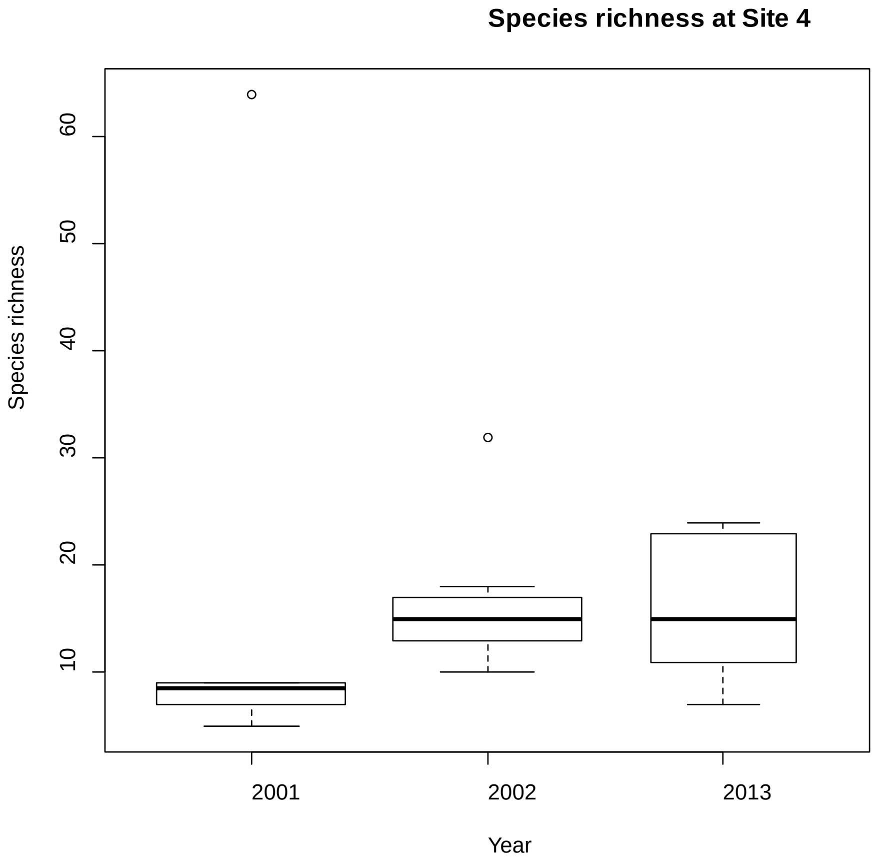
The mean number of species per sample (S) and number of individuals (N) varied at the site between years (Table 3.14). Similarly, species richness, measured by Margalef's index of species richness (D) and the evenness of species (J') both varied between sampling years (Table 3.14). Samples in 2013 demonstrated a higher species diversity (H'(loge)) and species dominance (1-λ') compared with 2001 and 2002 (Table 3.14).

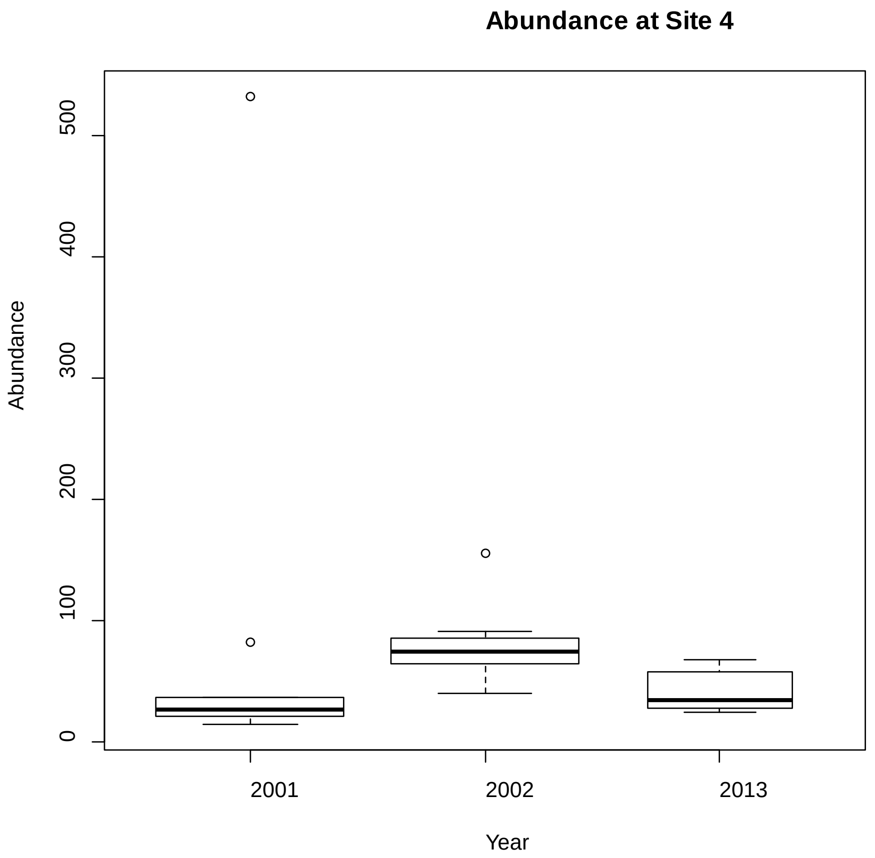
A Kruskal-Wallis rank sum test shows that there was no statistically significant difference in number of species (S) between years, $\chi^2(12) = 18.906$, $p = 0.091$. A Kruskal-Wallis rank sum test shows that there was no statistically significant difference in number of individuals (N) between years, $\chi^2(22) = 21.211$, $p = 0.508$. A Kruskal-Wallis rank sum test shows that there was no statistically significant difference in species richness (D) between years, $\chi^2(25) = 25.000$, $p = 0.462$. A Kruskal-Wallis rank sum test shows that there was no statistically significant difference in the Shannon-Wiener diversity index (H'(loge)) between years, $\chi^2(25) = 25.000$, $p = 0.462$. Likewise, a Kruskal-Wallis rank sum test shows that there was no statistically significant difference in the Simpson index, $\chi^2(25) = 25.000$, $p = 0.462$.

Table 3.14: Mean diversity statistics of benthic communities at Site 4

	2001	2002	2013
n	10	10	6
S	13.20 ± 17.92	16.00 ± 6.34	15.83 ± 6.77
N	81.30 ± 159.87	76.80 ± 32.39	40.50 ± 17.95
D	2.806 ± 2.582	3.451 ± 1.127	4.009 ± 1.515
J'	0.732 ± 0.112	0.684 ± 0.107	0.859 ± 0.080
H'(loge)	1.631 ± 0.603	1.863 ± 0.424	2.320 ± 0.552
1-λ'	0.713 ± 0.149	0.726 ± 0.119	0.878 ± 0.087

Figure 3.13: Species richness and abundance of benthic macrofaunal from Site 4





3.3.6.2. Faunal assemblages

At Site 4 benthic community structure differed between years which is reflected in the spread of data in Figure 3.14. An ANOSIM test indicated significant differences in benthic community structure between years and the effect of sampling year is relatively strong (Global R = 0.674, p = 0.1%). Pairwise comparisons show the differences to be between 2013 and 2002, 2013 and 2001 as well as 2002 and 2001 (Table 3.15).

Figure 3.14: Non-metric multi-dimension scaling ordination of benthic community structure from Site 4 (Bray-Curtis similarity and $\sqrt[4]{}$-transformation)

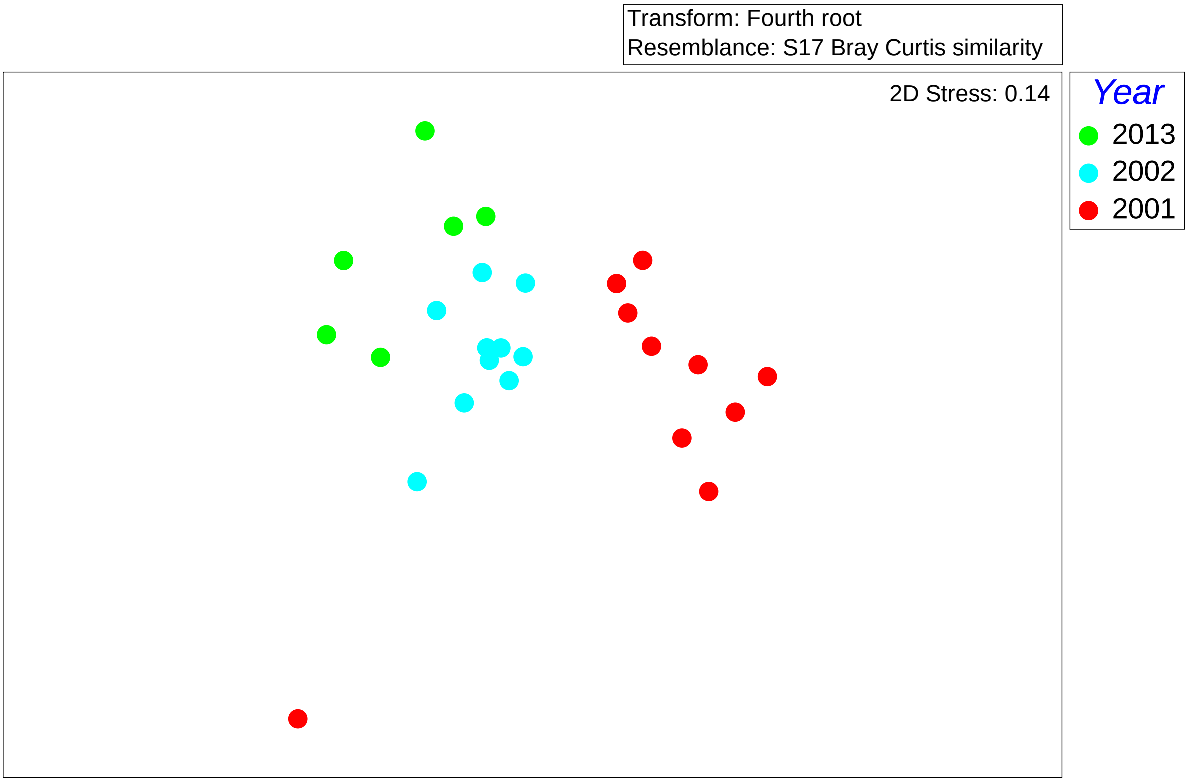


Table 3.15: ANOSIM of benthic community data from Site 4 over consecutive monitoring surveys

Groups	R Statistic	Significance Level %	Possible Permutations	Actual Permutations	Number >= Observed
2013, 2002	0.68	0.1	8008	999	0
2013, 2001	0.671	0.1	8008	999	0
2002, 2001	0.688	0.1	92378	999	0

At Site 4 SIMPER analysis for each year indicated sample pairs have an average similarity of 37.11% in 2001 with a maximum contribution (15.02%) from the Gammaridean amphipod *Urothoe poseidonis* (Table 3.16). Sample pairs have an average similarity of 52.37% in 2002 with a maximum contribution (10.61%) from the tellind bivalve *Asbjornsenia pygmaea*. Sample pairs have an average similarity of 37.93% in 2013 with a maximum contribution (7.88%) from *Urothoe poseidonis*.

Table 3.16: SIMPER analysis of benthic community data from Site 4 by monitoring survey

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum%
Group 2001 – average similarity: 37.11%					
Urothoe poseidonis	1.74	15.02	1.84	40.47	40.47
Asbjornsenia pygmaea	1.21	10.21	1.84	27.52	67.99
Perioculodes longimanus	0.66	3.02	0.52	8.15	76.14
Haustorius arenarius	0.61	2.29	0.52	6.17	82.31
Pontocrates altamarinus	0.46	1.43	0.39	3.86	86.17
Bathyporeia guilliamsoniana	0.52	1.37	0.39	3.68	89.85
Nephtys hombergii	0.54	0.97	0.31	2.61	92.46
Group 2002 – average similarity: 52.37					
Asbjornsenia pygmaea	2.28	10.61	3.62	20.25	20.25
Haustorius arenarius	1.54	7.06	1.71	13.48	33.73
Urothoe brevicornis	1.34	6.09	3.60	11.64	45.37
Polygordius	1.10	4.53	1.64	8.66	54.03
Bathyporeia guilliamsoniana	0.94	3.35	1.19	6.40	60.42
Megaluropus agilis	0.90	3.12	1.20	5.95	66.37
Nephtys cirrosa	0.86	3.00	1.21	5.73	72.10
Nematoda	0.87	2.44	0.87	4.67	76.77
Perioculodes longimanus	0.85	2.41	0.89	4.61	81.38
Iphinoe trispinosa	0.84	2.26	0.89	4.32	85.70
Group 2013 – average similarity: 37.93					
Urothoe brevicornis	1.51	7.88	2.82	20.78	20.78
Pontocrates altamarinus	1.40	7.27	3.65	19.17	39.95
Copepoda	0.90	3.72	1.24	9.81	49.76
Bathyporeia elegans	0.95	3.42	1.29	9.02	58.78
Haustorius arenarius	0.87	2.62	0.48	6.91	65.69
Asbjornsenia pygmaea	0.92	2.20	0.77	5.81	71.49
Nematoda	0.87	2.02	0.78	5.32	76.82
Nemertea	0.79	1.90	0.77	5.00	81.82
Grania	0.64	1.00	0.48	2.64	84.45
Megaluropus agilis	0.72	0.93	0.48	2.44	86.90

3.3.6.3. Biotopes

The sediment types at Site 4 when sampled in 2001 and 2013 were both Sand, corresponding to the Subtidal Sand subfeature.

Within each year, the macrofaunal samples within Site 4 were relatively dissimilar with 37% to 52% similarity. However, there was more similarity in macrofaunal samples within year than between years. There was an average dissimilarity of 77.28% in benthic communities between 2001 and 2002, caused by the presence of *Urothoe poseidonis* in 2001 only and *Urothoe brevicornis* in 2002 only. Both species are very similar, differing in that *Urothoe brevicornis* has a much smaller carpus of the fifth pereopod, so this difference may be due to a misidentification.

Allen and Proctor (2001) identified a transitional community within Site 4 between SS.SCS.ICS.MoeVen (*Moerella* spp. with venerid bivalves in infralittoral gravelly sand) and SS.SSa.IFiSa.NcirBat (*Nephtys cirrosa* and *Bathyporeia* spp. in infralittoral sand).

Dissimilarity was greatest between 2001 and 2013 surveys (90.44%). This was primarily caused by four amphipod species (*Urothoe poseidonis*, *Urothoe brevicornis*, *Haustorius arenarius* and *Pontocrates altamarinus*) and a small difference in the average abundance of the bivalve *Asbjornsenia pygmaea*. These taxa consistently contributed to the deviance between all years and were present in all years with the exception of *Urothoe poseidonis* (absent in 2002) and *Urothoe brevicornis* (absent in 2001). The similarity of these two species and the subsequent identification of both species in 2009 and 2013 (along with *Urothoe* sp. in some years) suggests that this is a case of misidentification. Furthermore, a switch from *Urothoe poseidonis* to *Urothoe brevicornis* (or vice-versa) is not known to be indicative of any anthropogenic disturbance. They are both known to increase due to physical disturbance, but this trend was not observed during analysis (Hiscock et al., 2004).

Regardless of the dissimilarities, common characteristic taxa across the three surveys were consistently *Urothoe* spp., *Asbjornsenia pygmaea*, *Haustorius arenarius*, and *Bathyporeia* spp, which still suggest a complex of SS.SCS.ICS.MoeVen and SS.SSa.IFiSa.NcirBat. This consistency indicated that the biotopes have remained unchanged from the 2001 survey.

3.3.7. Site 5 Scilly Isles

Site 5 was located to the west of Tresco and grab stations were extremely shallow ranging from 4m to 7m depth (Allen and Proctor, 2003). Sampling effort, measured as the number of grab samples (n), at Site 5 varied over the monitoring period, with 10 samples taken in 2001 and 2002, and 3 in 2013. No sampling was conducted in 2009.

3.3.7.1. Diversity indices

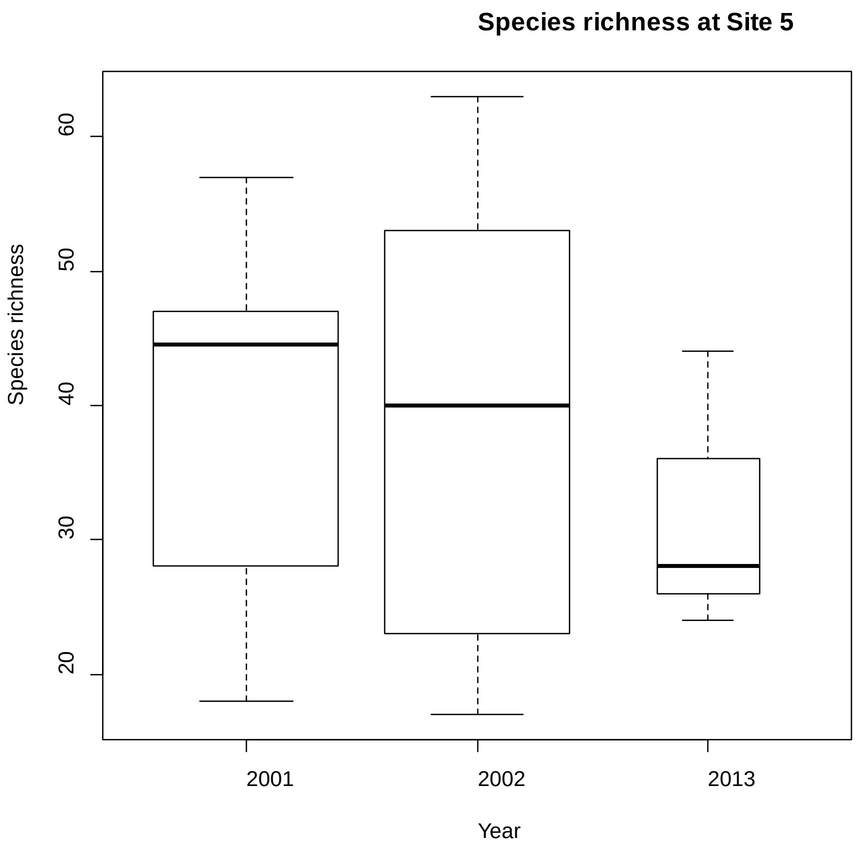
The mean number of species per sample (S) and number of individuals (N) varied at the site between years (Table 3.17). Species richness, measured by Margalef's index of species richness (D) and the evenness of species (J') generally remained consistent between years (Table 6.11). Hence, species diversity (H'(loge)) and species dominance (1-λ') remained consistent between years (Table 3.17).

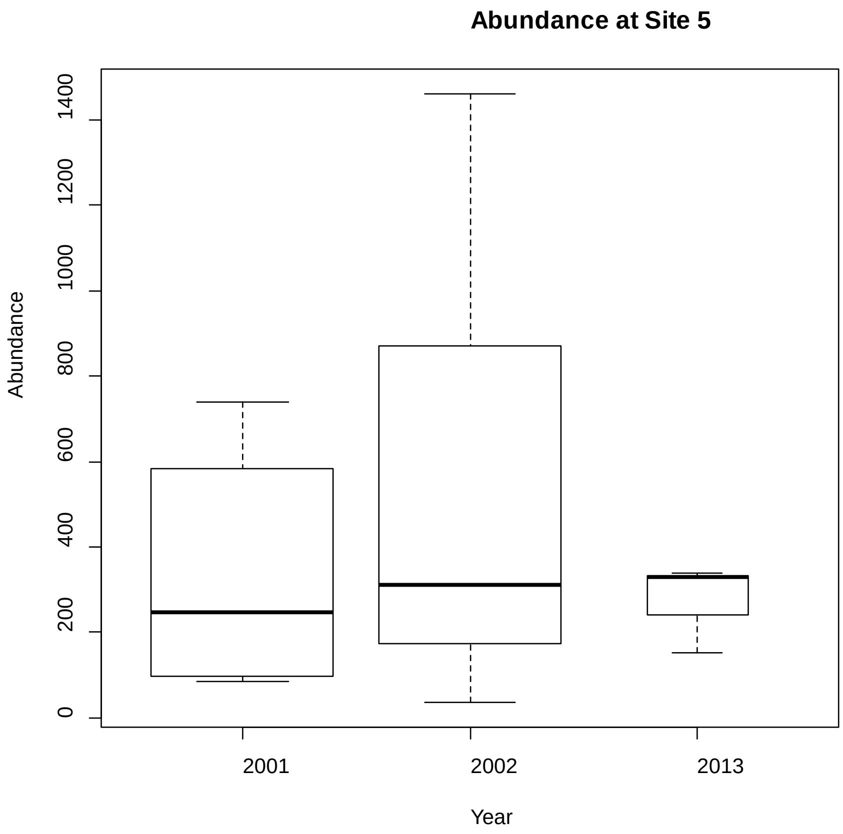
A Kruskal-Wallis rank sum test shows that there was no statistically significant difference in number of species (S) between years, $\chi^2(17) = 14.551$, p = 0.628. A Kruskal-Wallis rank sum test shows that there was no statistically significant difference in number of individuals (N) between years, $\chi^2(22) =$ 22.000, p = 0. 460. A Kruskal-Wallis rank sum test shows that there was no statistically significant difference in species richness (D) between years, $\chi^2(22) = 22.000$, p = 0. 460. A Kruskal-Wallis rank sum test shows that there was no statistically significant difference in the Shannon-Wiener diversity index (H'(loge)) between years, $\chi^2(22) = 22.000$, p = 0. 460. Likewise, a Kruskal-Wallis rank sum test shows that there was no statistically significant difference in the Simpson index, $\chi^2(22) = 22.000$, p = 0. 460.

Table 3.17: Mean diversity statistics of benthic communities at Site 5 (n = mean number of samples, S = number of Species in each sample, N = number of Individuals in each sample, D = Margalef's index for species richness, J' = Pielou's evenness index, H'(loge) = Shannon's diversity index, 1-λ' = Simpson's dominance index)

	2001	2002	2013
n	10	10	3
S	38.60 ± 12.99	39.00 ± 16.83	32.00 ± 10.58
N	335.40 ± 259.8	523.90 ± 490.3	273.67 ± 104.6
D	6.690 ± 1.508	6.405 ± 1.903	5.541 ± 1.623
J'	0.738 ± 0.909	0.735 ± 0.128	0.682 ± 0.082
H'(loge)	2.656 ± 0.440	2.610 ± 0.459	2.335 ± 0.285
1-λ'	0.858 ± 0.094	0.864 ± 0.110	0.824 ± 0.067

Figure 3.15: Species richness and abundance of benthic macrofaunal from Site 5





3.3.7.2. Faunal assemblages

At Site 5 benthic community structure differed between years which is reflected in the spread of data in Figure 3.15. An ANOSIM test indicated that differences in benthic community structure between years are significant (Global R = 0.203, p = 2.1%), but only between 2002 and 2013 (Table 3.18).

Figure 3.16: Non-metric multi-dimension scaling ordination of benthic community structure from Site 5 (Bray-Curtis similarity and $^4\sqrt{}$-transformation)

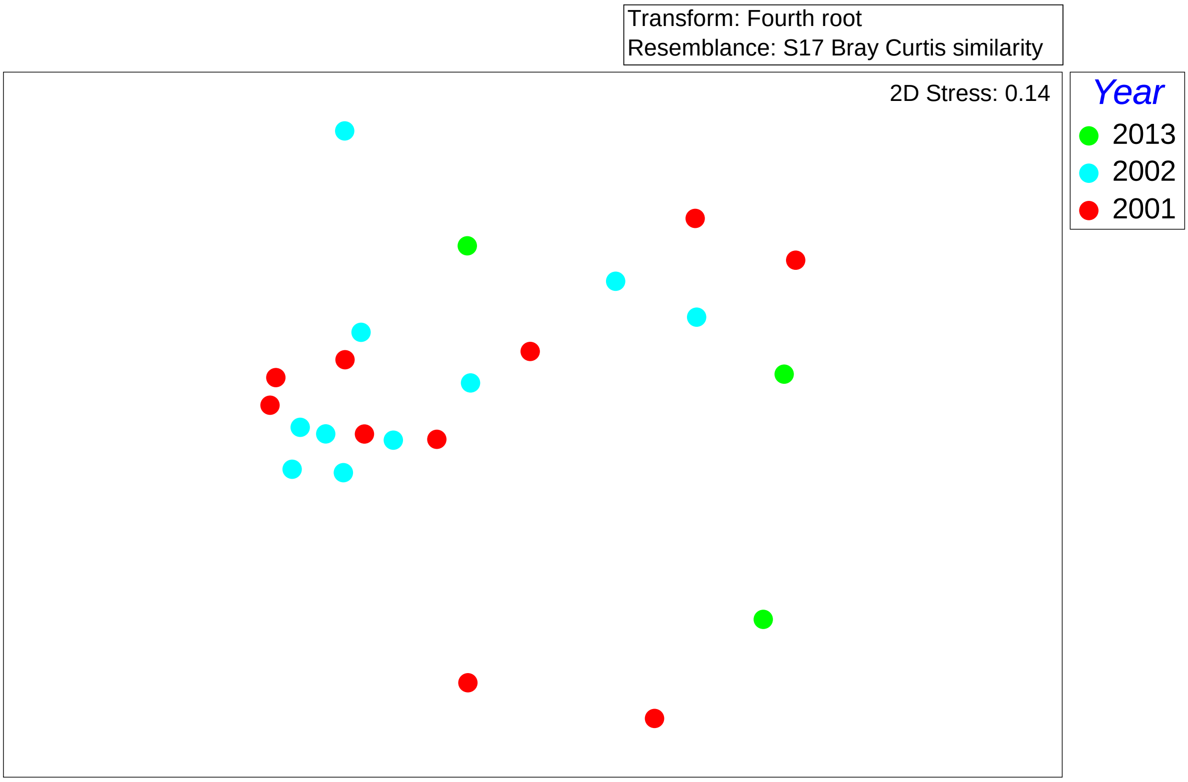


Table 3.18: ANOSIM of benthic community data from Site 5 over consecutive monitoring surveys

Groups	R Statistic	Significance Level %	Possible Permutations	Actual Permutations	Number >= Observed
2013, 2002	0.543	1.7	286	286	5
2013, 2001	0.318	5.6	286	286	16
2002, 2001	0.076	9.6	92378	999	95

At Site 5 SIMPER analysis for each year indicated sample pairs have an average similarity of 35.15% in 2001 with a maximum contribution (2.76%) from the polychaete *Glycera lapidum* (Table 3.19). Average similarity was 43.89% in 2002 and 28.18% in 2013 and in both years, nematodes contributed most to the similarity in sample pairs (3.17% in 2002 and 5.7% in 2013 respectively).

Table 3.19: SIMPER analysis of benthic community data from Site 5 by monitoring survey

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum%
Group 2001 – average similarity: 35.15%					
Glycera lapidum	1.69	2.76	4.14	7.87	7.87
Asbjornsenia pygmaea	1.77	2.69	1.30	7.66	15.52
Timoclea ovata	1.18	1.90	1.67	5.41	20.93
Mediomastus fragilis	1.83	1.63	0.89	4.63	25.57
Aonides paucibranchiata	1.31	1.59	1.14	4.53	30.1
Grania	1.40	1.45	1.22	4.13	34.23
Decapoda	0.92	1.34	1.08	3.82	38.05
Nematoda	1.16	1.18	0.85	3.37	41.42
Echinocyamus pusillus	0.92	1.15	0.83	3.26	44.68
Caulleriella alata	0.95	1.10	1.22	3.13	47.81
Group 2002 – average similarity: 43.89%					
Nematoda	2.14	3.17	2.39	7.23	7.23
Glycera lapidum	1.84	2.82	3.25	6.43	13.66
Mediomastus fragilis	2.17	2.32	1.68	5.29	18.94
Grania	1.93	2.25	1.74	5.13	24.07
Protodorvillea kefersteini	1.66	2.23	1.62	5.08	29.16
Aonides paucibranchiata	1.44	2.03	1.73	4.63	33.79
Syllis cornuta	1.55	2.02	1.63	4.6	38.39
Polygordius	1.48	1.85	1.75	4.22	42.60
Pisione remota	1.08	1.78	1.09	4.07	46.67
Psamathe fusca	1.49	1.68	1.11	3.82	50.49
Group 2013 – average similarity: 28.18%					
Nematoda	2.77	5.70	9.15	20.24	20.24
Grania	1.73	3.40	6.77	12.07	32.31
Asbjornsenia pygmaea	1.77	3.15	6.83	11.19	43.49
Nephtys cirrosa	1.27	2.58	3.08	9.15	52.64
Glycera lapidum	1.47	2.53	5.50	8.96	61.61
Pisione remota	1.20	2.47	3.83	8.75	70.36
Nemertea	1.06	2.30	6.48	8.15	78.50
Exogone naidina	1.06	1.27	0.58	4.50	83.00
Protodriloides chaetifer	0.80	0.90	0.58	3.18	86.19
Urothoe brevicornis	0.88	0.90	0.58	3.18	89.37

3.3.7.3. Biotopes

The sediment types at Site 5 were characterised as Sand, gravelly Sand and Sandy gravel in both 2001 and 2013. These correspond to Subtidal Sand and Subtidal Coarse sub-features which were both present in all years.

Macrofauna stations were variable within each survey year, with similarity ranging from 28% to 44%. There were significant differences between benthic communities in 2002 and 2013, though sampling effort was very low in 2013. This difference was largely attributable to the higher abundance of Nematoda and *Rissoa parva* in 2013 compared to 2002 and the presence of *Aonides oxycephala* and *Orchomene humilis* in 2002 only.

Allen and Proctor (2001) identified the communities of Site 5 to be variants of SS.SCS.ICS.MoeVen (*Moerella* spp. with venerid bivalves in infralittoral gravelly sand) with some elements of SS.SCS.CCS.MedLumVen (*Mediomastus fragilis*, *Lumbrineris* spp. and venerid bivalves in circalittoral coarse sand or gravel).

Common characteristic species across the three surveys were *Glycera lapidum*, *Asbjornsenia pygmaea*, *Mediomastus fragilis*, and *Grania* sp., which suggest a complex of SS.SCS.ICS.MoeVen and SS.SCS.CCS.MedLumVen. This consistency in characteristic species and sediment types indicated that the biotopes have remained unchanged from the 2001 survey. Any differences between years were caused by taxa that were not the main contributors to similarity within years.

Dissimilarity was greatest between 2001 and 2013 surveys (81.52). This was primarily caused by a higher average abundance of Nematoda and *Rissoa parva* in 2013 and a lower average abundance of polychaetes *Mediomastus fragilis* and *Aonides oxycephala*. This were also the main differences between average taxa abundance in 2002 and 2013. Dissimilarity between 2001 and 2002 was smallest of all the years and was primarily due to small changes in the abundance of *Mediomastus fragilis* and *Aonides oxycephala,* where average abundance was higher in 2002 than 2001. *Mediomastus fragilis* can respond positively to both physical disturbance and nutrient enrichment (Hiscock et al., 2004), though the limited variability in abundance (26.7-58.5) across all four surveys was not sufficient to indicate that these were the cause for change.

3.3.8. Site 6 Scilly Isles

Site 6 was situated in St Mary's Road between St Mary's and Samson, with water depths ranging from 8m to 15m (Allen and Proctor, 2003). The sampling effort was similar over the survey period with 10 grab stations sampled in 2001 and 2002, 9 in 2009, and 3 in 2013.

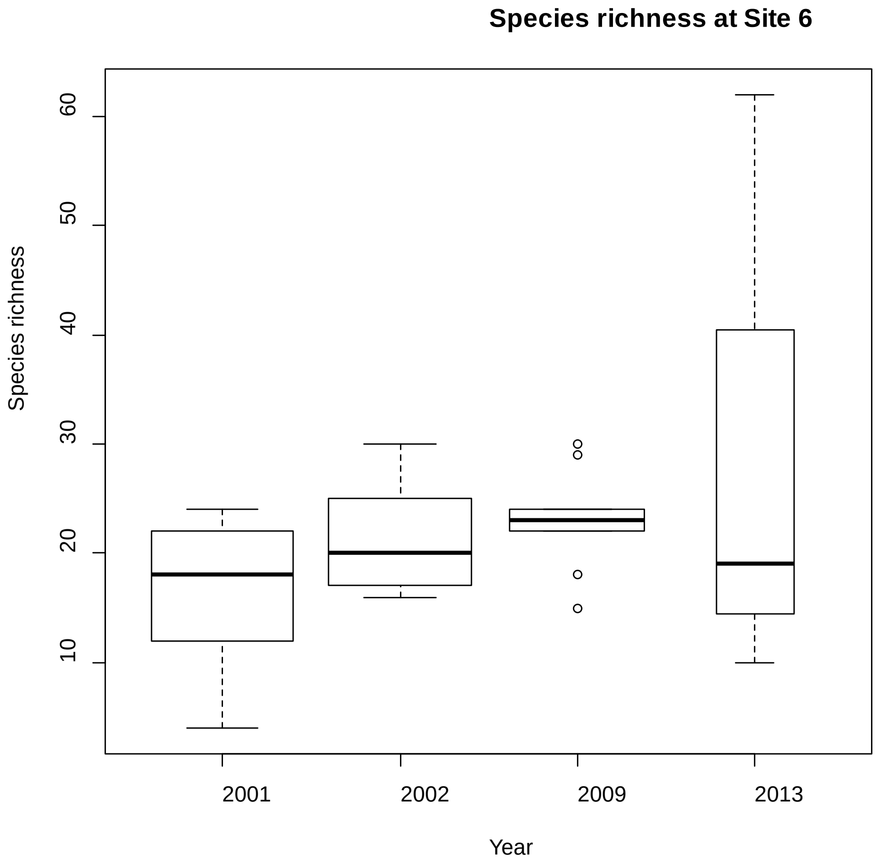
3.3.8.1. Diversity indices

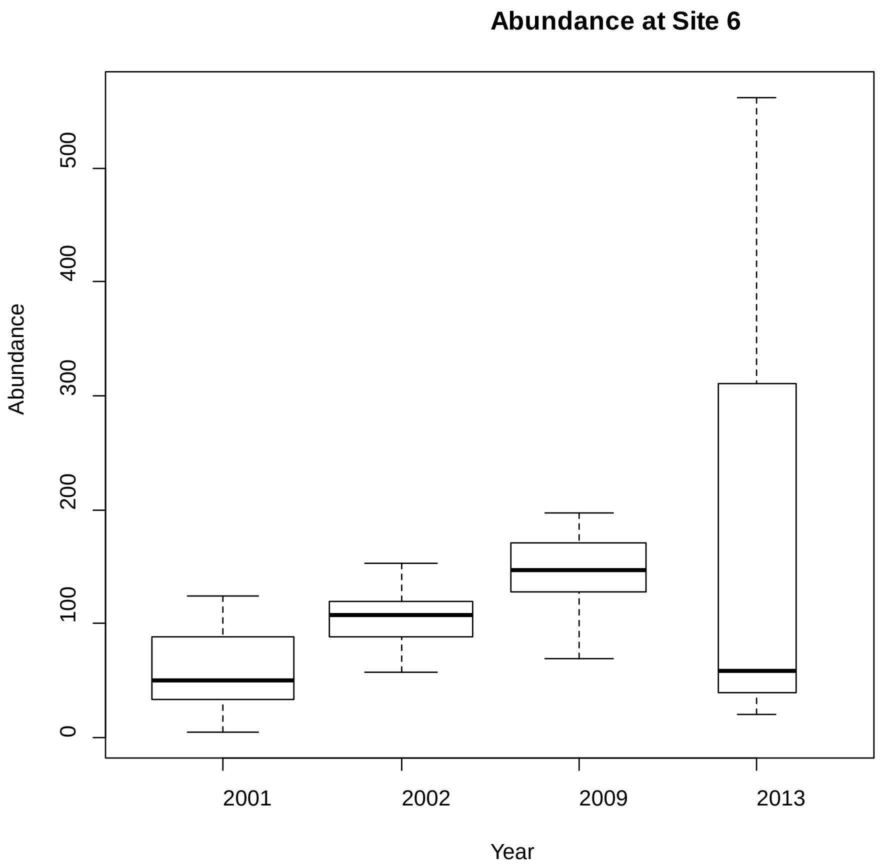
The mean number of species per sample (S) and number of individuals (N) varied at the site between years (Table 3.20). Species richness, measured by Margalef's index of species richness (D) and the evenness of species (J') generally remained consistent between years (Table 3.20). Hence, species diversity (H'(loge)) and species dominance (1-λ') remained consistent between years (Table 3.20). A Kruskal-Wallis rank sum test shows that there was no statistically significant difference in number of species (S) between years, $\chi^2(18) = 19.733$, p = 0.348. A Kruskal-Wallis rank sum test shows that there was no statistically significant difference in number of individuals (N) between years, $\chi^2(28) = 30.38$, p = 0. 345. A Kruskal-Wallis rank sum test shows that there was no statistically significant difference in species richness (D) between years, $\chi^2(31) = 31.000$, p = 0. 466. A Kruskal-Wallis rank sum test shows that there was no statistically significant difference in the Shannon-Wiener diversity index (H'(loge)) between years, $\chi^2(31) = 31.000$, p = 0. 466. Likewise, a Kruskal-Wallis rank sum test shows that there was no statistically significant difference in the Simpson index, $\chi^2(31) = 31.000$, p = 0. 466.

Table 3.20: Mean diversity statistics of benthic communities at Site 6 (n = mean number of samples, S = number of Species in each sample, N = number of Individuals in each sample, D = Margalef's index for species richness, J' = Pielou's evenness index, H'(loge) = Shannon's diversity index, 1-λ' = Simpson's dominance index)

	2001	2002	2009	2013
n	10	10	9	3
S	16.10 ± 6.806	21.10 ± 4.795	22.89 ± 4.702	30.33 ± 27.791
N	57.0 ± 40.0	105.7 ± 25.6	142.0 ± 42.5	213.7 ± 302.3
D	3.843 ± 1.156	4.334 ± 0.969	4.434 ± 0.774	5.684 ± 3.493
J'	0.831 ± 0.084	0.634 ± 0.093	0.689 ± 0.037	0.847 ± 0.131
H'(loge)	2.189 ± 0.450	1.922 ± 0.321	2.139 ± 0.119	2.569 ± 0.383
1-λ'	0.862 ± 0.070	0.704 ± 0.108	0.796 ± 0.026	0.901 ± 0.029

Figure 3.17: Species richness and abundance of benthic macrofaunal from Site 6





3.3.8.2. Faunal assemblages

At Site 6 benthic community structure differed between years which is reflected in the spread of data in Figure 3.16. An ANOSIM test indicated that differences in benthic community structure between years are significant, although the effect of year is relatively weak (Global R = 0.462, p = 0.1%). Pairwise comparisons show the differences to be between 2009 and 2002, and 2009 and 2001 (Table 3.21).

Figure 3.18: Non-metric multi-dimension scaling ordination of benthic community structure from Site 6 (Bray-Curtis similarity and $\sqrt[4]{}$-transformation)

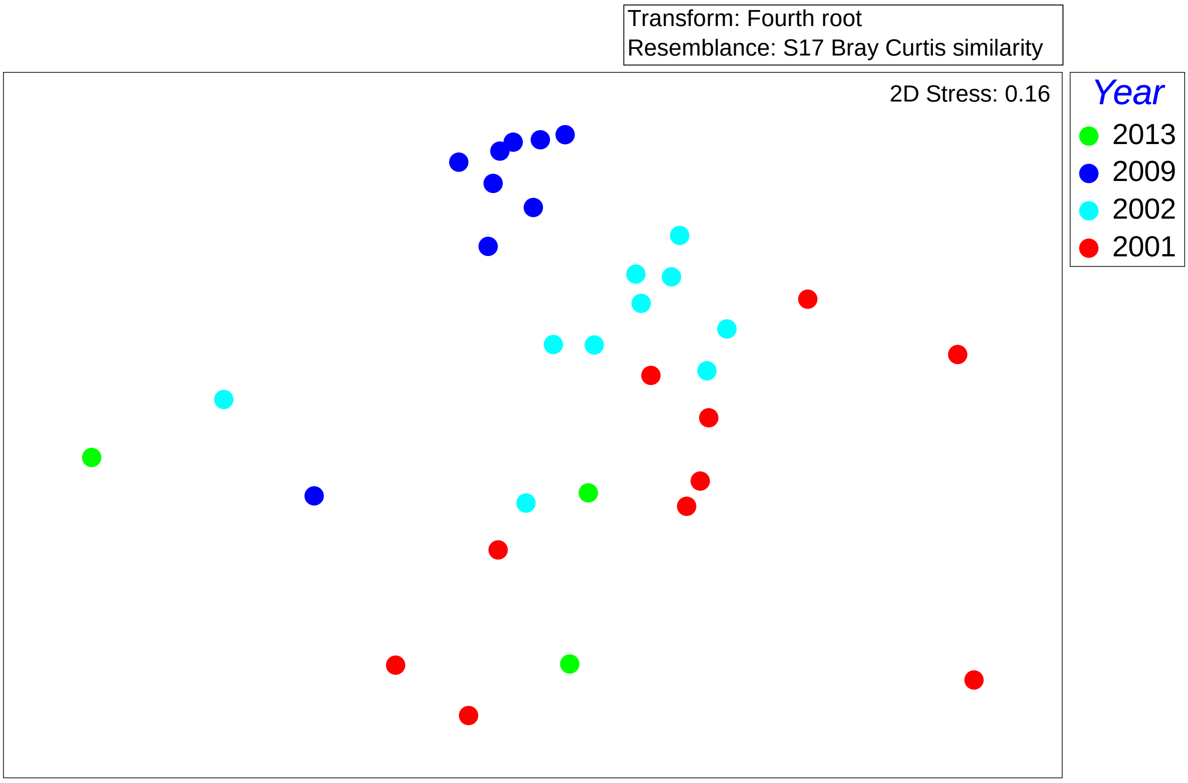


Table 3.21. ANOSIM of benthic community data from Site 6 over consecutive monitoring surveys

Groups	R Statistic	Significance Level %	Possible Permutations	Actual Permutations	Number >= Observed
2013, 2009	0.793	0.9	220	220	2
2013, 2002	0.678	1.0	286	286	3
2013, 2001	0.285	12.2	286	286	35
2009, 2002	0.584	0.1	92378	999	0
2009, 2001	0.554	0.1	92378	999	0
2002, 2001	0.252	0.2	92378	999	1

At Site 6 SIMPER analysis for each year indicated sample pairs have an average similarity of 29.03% in 2001, with a maximum contribution (4.56%) from the spionid polychaete *Spiophanes bombyx* (Table 3.22). Average similarity was 43.22% in 2002 and 49.50% in 2009, with a maximum contribution from the polychaete *Magelona filiformis* both years (7.75% in 2002 and 6.70% in 2009 respectively). Average similarity was 21.21% in 2013, with a maximum contribution (3.75%) from the sea urchin *Echinocyamus pusillus*.

Table 3.22. SIMPER analysis of benthic community data from Site 6 by monitoring survey

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum%
Group 2001 - average similarity: 29.03%					
Spiophanes bombyx	1.36	4.56	1.08	15.69	15.69
Phaxas pellucidus	0.82	3.07	0.81	10.57	26.26
Perioculodes longimanus	0.95	2.59	0.88	8.92	35.17
Magelona filiformis	0.91	2.42	0.67	8.33	43.50
Iphinoe trispinosa	0.84	2.33	0.65	8.02	51.53
Nephtys cirrosa	0.88	2.28	0.90	7.84	59.36
Abra prismatica	0.90	1.79	0.69	6.15	65.51
Asbjornsenia pygmaea	0.85	1.51	0.51	5.20	70.71
Timoclea ovata	0.73	1.38	0.69	4.76	75.47
Echinocyamus pusillus	0.81	1.26	0.53	4.33	79.80
Group 2002 - average similarity: 43.22%					
Magelona filiformis	2.37	7.75	2.32	17.94	17.94
Echinocyamus pusillus	1.68	5.03	3.56	11.65	29.59
Perioculodes longimanus	1.17	3.58	1.81	8.29	37.88
Magelona mirabilis	1.15	3.17	1.23	7.34	45.23
Iphinoe trispinosa	1.07	2.46	0.91	5.69	50.91
Nemertea	0.87	2.34	1.25	5.41	56.32
Spiophanes bombyx	0.89	1.89	0.89	4.38	60.69
Phaxas pellucidus	0.74	1.80	0.91	4.17	64.87
Urothoe poseidonis	0.77	1.38	0.68	3.19	68.05
Owenia fusiformis	0.64	1.30	0.69	3.00	71.05
Group 2009 - average similarity: 49.50%					
Magelona filiformis	2.35	6.70	1.80	13.53	13.53
Nematoda	2.00	5.82	6.08	11.75	25.29
Aricidea (Aricidea) minuta	1.56	4.16	1.80	8.41	33.70
Echinocyamus pusillus	1.54	3.89	4.11	7.86	41.56
Nemertea	1.25	3.72	5.97	7.52	49.08
Magelona johnstoni	1.46	3.69	1.15	7.45	56.53
Urothoe poseidonis	1.27	3.49	1.72	7.04	63.57
Bathyporeia elegans	1.29	3.18	1.15	6.43	70.00
Pseudocuma	0.95	2.52	1.81	5.08	75.09
Magelona mirabilis	0.82	1.64	0.83	3.31	78.40
Group 2013 - average similarity: 21.21%					
Echinocyamus pusillus	1.39	3.75	1.47	17.67	17.67
Asbjornsenia pygmaea	1.24	3.37	1.68	15.87	33.53
Nemertea	1.20	3.26	1.60	15.39	48.92
Owenia fusiformis	1.20	3.26	1.60	15.39	64.32
Nephtys cirrosa	0.88	2.46	0.58	11.62	75.93
Perioculodes longimanus	0.67	1.87	0.58	8.83	84.76
Synchelidium maculatum	0.89	0.71	0.58	3.37	88.13
Timoclea ovata	0.84	0.71	0.58	3.37	91.50

3.3.8.3. Biotopes

The sediment types at Site 6 when sampled in 2001 and 2009 were both Sand, but in addition to Sand, sandy Gravel habitats were also sampled in 2013. These correspond to Subtidal Sand and Subtidal Coarse subfeatures respectively.

Within each year, the macrofaunal samples within Site 4 were relatively dissimilar with 21% to 50% similarity. However, there was more similarity in macrofaunal samples within year than between years. Pairwise comparisons show the statistically significant differences to be between 2009 and 2002, and 2009 and 2001. These differences were caused in part by the higher abundance of *Magelona filiformis*, *Magelona johnstoni*, Nematoda and *Echinocyamus pusillus* in 2009.

Allen and Proctor (2001) identified that communities across the site were relatively consistent and characterised by *Spiophanes bombyx*, the amphipod *Perioculodes longimanus, Nephtys cirrosa* and *Phaxas pellucida.* Two distinct biotopes were identified:

- SS.SCS.ICS.MoeVen (*Moerella* spp. with venerid bivalves in infralittoral gravelly sand) with some elements of SS.SSa.IFiSa.NcirBat (*Nephtys cirrosa* and *Bathyporeia* spp. in infralittoral sand); and
- Impoverished SS.SSa.IMuSa.FfabMag: *Fabulina fabula* and *Magelona mirabilis* with venerid bivalves and amphipods in infralittoral compacted fine muddy sand).

Characterising species of Site 6 common across all survey years were *Magelona* spp., *Echinocyamus pusillus* and *Perioculodes longimanus*. Differences between years were consistently caused by small changes in the relative abundance of *Magelona* spp., *Bathyporeia* spp., *Iphinoe trispinosa*, *Spiophanes bombyx* and *Asbjornsenia pygmaea*. These shifts indicate a fluctuation in the balance between the two dominant biotopes, but there is no obvious trend in community structure from 2001 to 2013 and 2013 composition is more similar to 2001 and 2002 than 2009 (though with a smaller sample size). This consistency in species composition and sediment type indicate that the biotopes have remained unchanged from the 2001 survey.

Dissimilarity was greatest between 2009 and 2013 surveys (90.6%). This was primarily caused by a higher average abundance of *Magelona filiformis* and Nematoda in 2009 and a higher average abundance of *Mediomastus fragilis* in 2013. Dissimilarity between both all year was mainly caused by shifts in the abundance of *Magelona filiformis* and *Mediomastus fragilis.* There was no obvious trend or pattern to these shifts: *Magelona filiformis* was abundant in 2002 and 2009 and *Mediomastus fragilis* was abundant (though highly variable) in 2013. Due to the limited number of grab samples taken in 2013 compared to other years, a single grab would contribute more to average dissimilarity than years with more samples.

3.3.9. Site 7 Scilly Isles

Site 7 was located situated in the North West Channel to the south west of Samson, with depths ranging from between 28m and 35m CD (Allen and Proctor, 2003). The site was only sampled in 2001 and 2002 with 10 grab stations sampled on each occasion.

3.3.9.1. Diversity indices

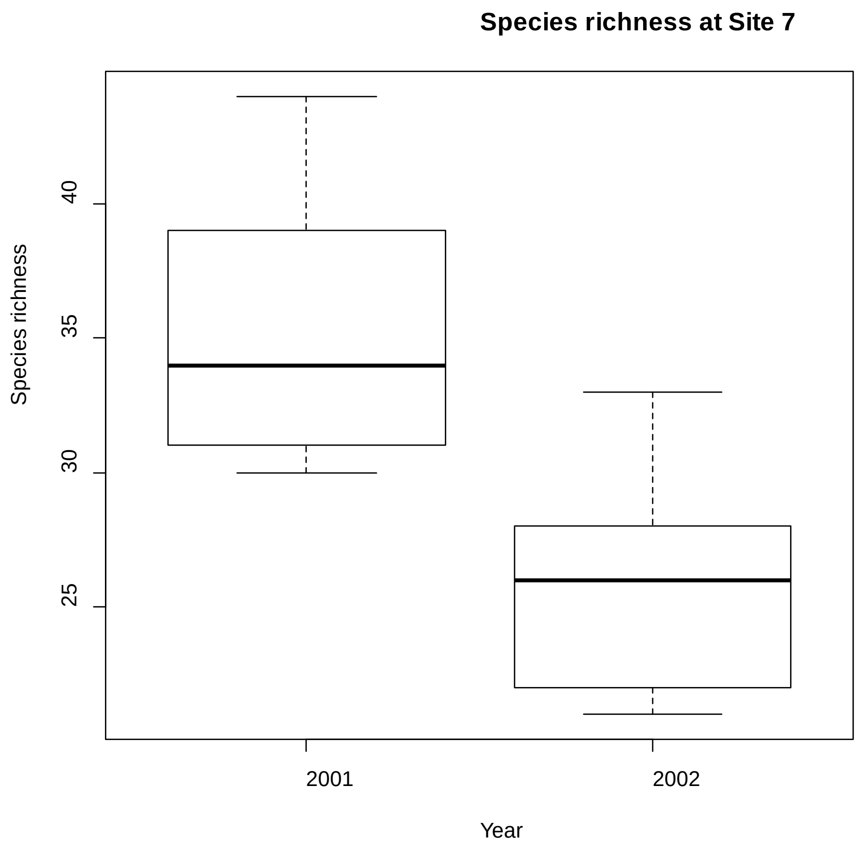
The mean number of samples (n) at Site 7 was consistent in 2001 and 2002 (10 samples). The mean number of species per sample (S) and number of individuals (N) varied at the site between years (Table 3.23). Species richness, measured by Margalef's index of species richness (D) and the evenness of species (J') generally remained consistent between years (Table 3.23). Hence, species diversity (H'(loge)) and species dominance (1-λ') remained consistent between years (Table 3.23).

A Kruskal-Wallis rank sum test shows that there was no statistically significant difference in number of species (S) between years, $\chi^2(12) = 15.200$, p = 0.231. A Kruskal-Wallis rank sum test shows that there was no statistically significant difference in number of individuals (N) between years, $\chi^2(18) =$ 17.100, p = 0. 516. A Kruskal-Wallis rank sum test shows that there was no statistically significant difference in species richness (D) between years, $\chi^2(19) = 19.000$, p = 0.457. A Kruskal-Wallis rank sum test shows that there was no statistically significant difference in the Shannon-Wiener diversity index (H'(loge)) between years, $\chi^2(19) = 19.000$, p = 0. 457. Likewise, a Kruskal-Wallis rank sum test shows that there was no statistically significant difference in the Simpson index, $\chi^2(19) = 19.000$, p = 0. 457.

Table 3.23: Mean diversity statistics of benthic communities at Site 7 Mean diversity statistics of benthic communities at Site 5 (n = mean number of samples, S = number of Species in each sample, N = number of Individuals in each sample, D = Margalef's index for species richness, J' = Pielou's evenness index, H'(loge) = Shannon's diversity index, 1-λ' = Simpson's dominance index)

	2001	2002
n	10	10
S	25.80 ± 4.714	35.00 ± 4.050
N	252.40 ± 98.67	355.60 ± 43.35
D	4.495 ± 0.820	5.839 ± 0.735
J'	0.626 ± 0.097	0.651 ± 0.056
H'(loge)	2.030 ± 0.375	2.312 ± 0.216
1-λ'	0.796 ± 0.116	0.807 ± 0.039

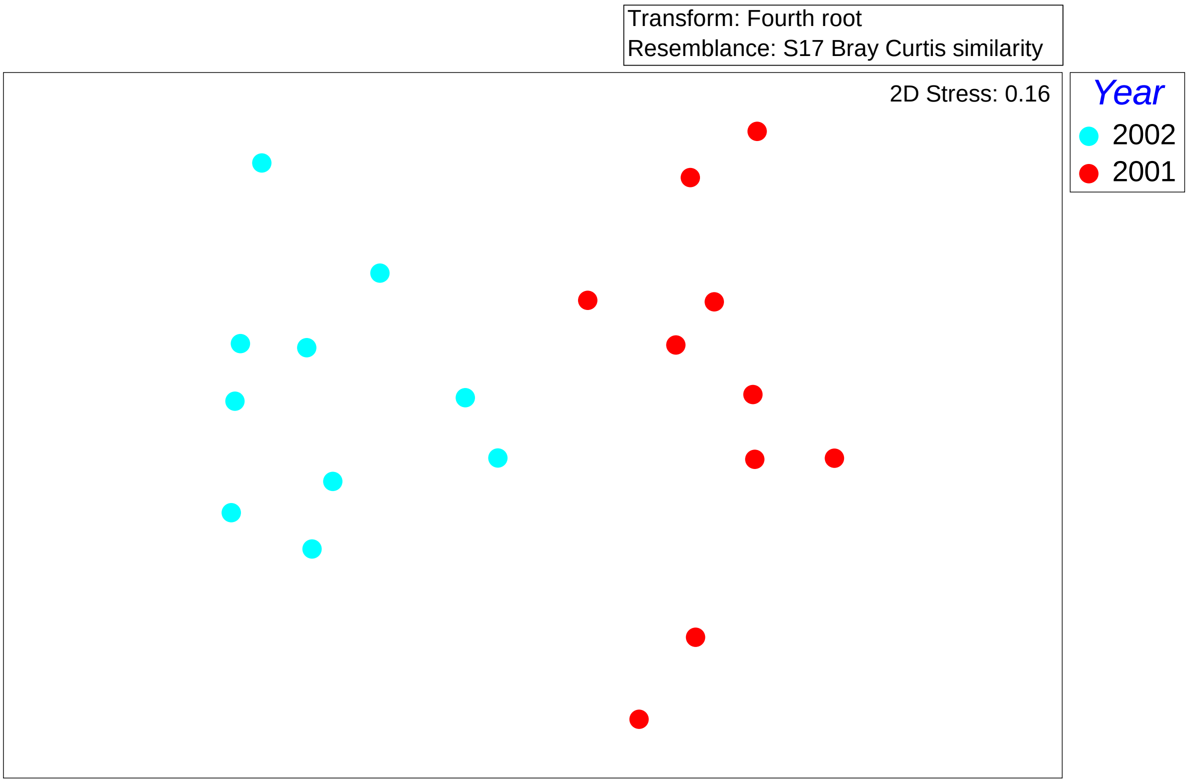
Figure 3.19: Species richness and abundance of benthic macrofaunal from Site 7



3.3.9.2. Faunal assemblages

At Site 7 benthic community structure differed between years, reflected in the spread of data in Figure 3.17. An ANOSIM test indicated that differences in benthic community structure between 2002 and 2001 are significant and the effect of sampling year is strong (Global R = 0.743, p = 0.1%).

Figure 3.20: Non-metric multi-dimension scaling ordination of benthic community structure from Site 7 (Bray-Curtis similarity and $\sqrt[4]{}$-transformation)



At Site 7 SIMPER analysis for each year indicated sample pairs have an average similarity of 61.87% in 2001, with a maximum contribution (5.87%) from nematodes (Table 3.24). Average similarity was 63.85% in 2002, with a maximum contribution (8.00%) from the polychaete *Syllis cornuta*.

Table 3.24: SIMPER analysis of benthic community data from Site 7 by monitoring survey

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum%
Group 2001 - average similarity: 61.87%					
Nematoda	3.19	5.87	8.2	9.49	9.49
Pisione remota	2.57	4.78	5.66	7.73	17.22
Polygordius	2.21	3.97	5.08	6.42	23.63
Asbjornsenia pygmaea	2.04	3.75	4.14	6.05	29.69
Glycera lapidum	1.64	3.09	7.73	5	34.69
Grania	1.77	3.07	6.08	4.97	39.65
Goodallia triangularis	1.96	2.67	1.19	4.32	43.98
Echinocyamus pusillus	1.57	2.64	4.06	4.26	48.24
Syllis cornuta	1.41	2.61	6.65	4.22	52.45
Glycymeris glycymeris	1.36	2.6	11.14	4.2	56.66
Group 2002 - average similarity: 63.85%					
Pisione remota	2.90	8.00	10.6	12.54	12.54
Nematoda	2.76	7.27	10.02	11.39	23.92
Polygordius	2.68	7.14	8.2	11.18	35.11
Grania	1.76	4.55	7.4	7.13	42.23
Glycera lapidum	1.53	3.45	1.86	5.4	47.63
Protodorvillea kefersteini	1.38	3.39	5.16	5.32	52.95
Sphaerosyllis bulbosa	1.28	3.37	7.37	5.27	58.22
Psamathe fusca	1.21	3.17	7.06	4.96	63.18
Syllis cornuta	1.18	3.03	10.6	4.75	67.93
Nemertea	1.16	2.61	1.76	4.09	72.02

3.3.9.3. Biotopes

The sediment types at Site 7 in 2001 and 2002 were Sand, gravelly Sand and Sandy gravel, corresponding to the Subtidal Sand and Subtidal Coarse subfeatures. Within each year, the macrofaunal samples within Site 7 were relatively similar with 62% to 64% similarity. However, there was more similarity in macrofaunal samples within year than between years.

Allen and Proctor (2003) found that the benthic community was relatively consistent and characterised by Nematoda, *Pisione remota*, *Polygordius* sp., *Moerella pygmaea*, *Grania* sp., *Echinocyamus pusillus* and *Glycera lapidum*. These taxa were observed in both 2001 and 2002, with the same characteristic species despite small, but statistically significant, differences between years. The dissimilarity between years was moderate (46%) and caused by differences in the relative abundance of bivalves *Goodallia triangularis*, *Gari tellinella*, *Timoclea ovata*, and *Glycymeris glycymeris*, which were all more abundant in 2001. *Goodallia triangularis* and *Glycymeris glycymeris* are both potential indicators of physical disturbance (Hiscock et al., 2004).

Across both surveys, the benthic community at Site 7 broadly resembles the biotope SS.SCS.ICS.MoeVen (*Moerella* spp. with venerid bivalves in infralittoral gravelly sand). However, fluctuations in bivalve abundance and moderate depth at the site mean it should be a better fit to SS.SCS.CCS.MedLumVen (*Mediomastus fragilis*, Lumbrineris spp. and venerid bivalves in circalittoral coarse sand or gravel) and in reality, it probably represents a transition between the two. The characteristic biotopes at Site 7 remained similar between 2001 and 2002 surveys.

3.3.10. Site 9 Scilly Isles

Site 9 was located between St Mary's and St Agnes in St Mary's Sound, with water depths ranging from between 8m and 13m CD (Allen and Proctor, 2003). Sampling effort, measured as the number of grab samples (n), at Site 1 varied over the monitoring period, with 10 samples taken in 2001, 2002, and 2009, and 4 in 2013.

3.3.10.1. Diversity indices

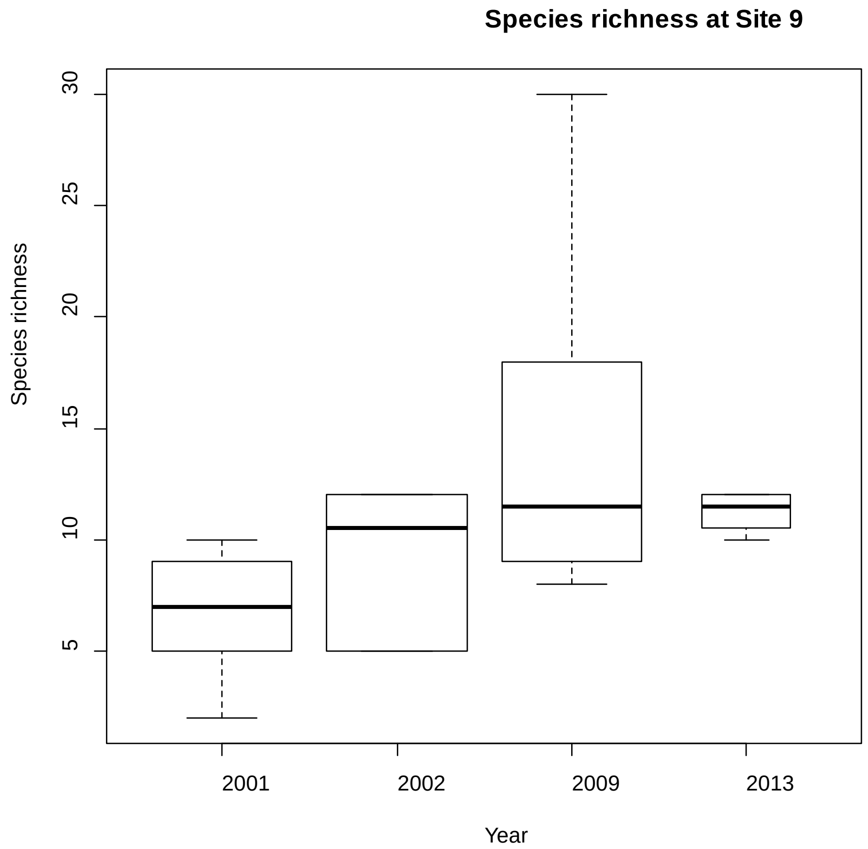
The mean number of samples (n) at Site 9 was consistent in 2001, 2002 and 2009 (10 samples) but only 4 samples were taken in 2013. The mean number of species per sample (S) and number of individuals (N) varied significantly at the site between years (Table 3.25). Species richness, measured by Margalef's index of species richness (D) and the evenness of species (J') generally remained consistent between years. Hence, species diversity (H'(loge)) and species dominance (1-λ') remained consistent between years (Table 3.25).

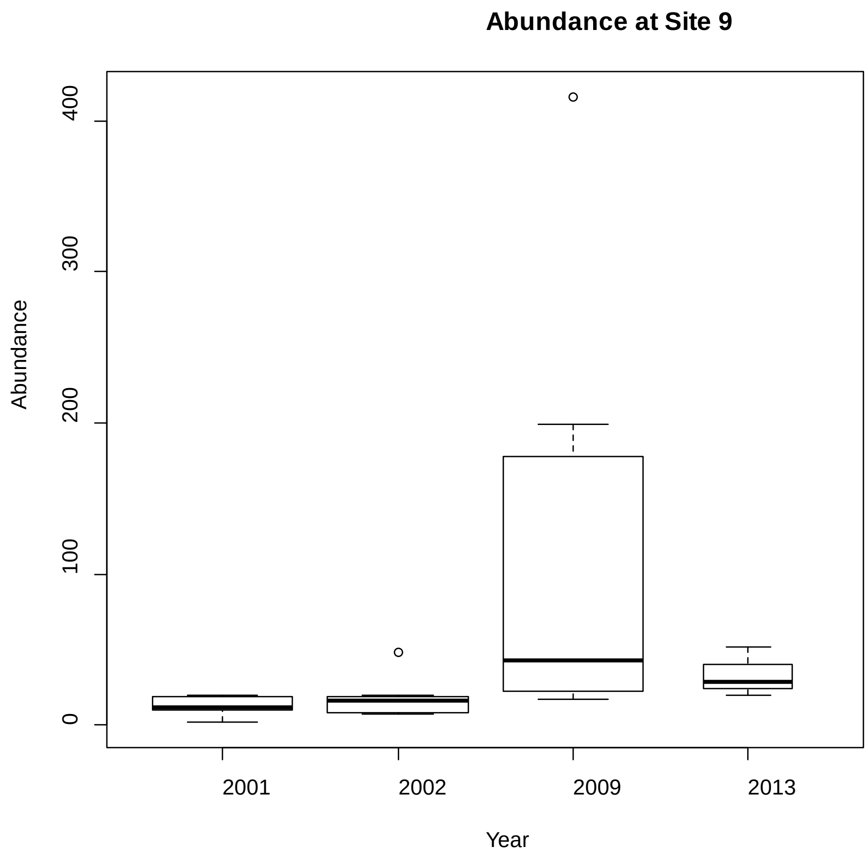
A Kruskal-Wallis rank sum test shows that there was no statistically significant difference in number of species (S) between years, $\chi^2(13) = 13.273$, $p = 0.427$. A Kruskal-Wallis rank sum test shows that there was no statistically significant difference in number of individuals (N) between years, $\chi^2(23) = 26.261$, p = 0. 289. A Kruskal-Wallis rank sum test shows that there was no statistically significant difference in species richness (D) between years, $\chi^2(31) = 33.000$, $p = 0.370$. A Kruskal-Wallis rank sum test shows that there was no statistically significant difference in the Shannon-Wiener diversity index (H'(loge)) between years, $\chi^2(31) = 30.815$, $p = 0.476$. Likewise, a Kruskal-Wallis rank sum test shows that there was no statistically significant difference in the Simpson index, $\chi^2(29) = 30.085$, $p = 0.410$.

Table 3.25: Mean diversity statistics of benthic communities at Site 9 (n = mean number of samples, S = number of Species in each sample, N = number of Individuals in each sample, D = Margalef's index of species richness, J' = Pielou's evenness index, H'(loge) = Shannon's diversity index, 1-λ' = Simpson's dominance index)

	2001	2002	2009	2013
n	10	10	10	4
S	6.90 ± 2.558	9.00 ± 3.127	14.00 ± 6.880	11.25 ± 0.957
N	12.60 ± 5.70	17.20 ± 11.95	101.90 ± 128.9	32.25 ± 13.77
D	2.387 ± 0.682	2.917 ± 0.817	3.118 ± 0.936	3.024 ± 0.345
J'	0.893 ± 0.081	0.920 ± 0.038	0.797 ± 0.101	0.850 ± 0.100
H'(loge)	1.639 ± 0.443	1.964 ± 0.378	2.002 ± 0.238	2.052 ± 0.212
1-λ'	0.855 ± 0.108	0.895 ± 0.050	0.831 ± 0.051	0.850 ± 0.077

Figure 3.21: Species richness and abundance of benthic macrofaunal from Site 9





3.3.10.2. Faunal assemblages

At Site 9 benthic community structure differed between years which is reflected in the spread of data in Figure 3.18. An ANOSIM test indicated that differences in benthic community structure between years are significant, although the effect of year is relatively weak (Global R = 0.523, p = 0.1%). Pairwise comparisons showed the differences to be between 2009 and 2001, and 2002 and 2001 (Table 3.26).

Figure 3.22: Non-metric multi-dimension scaling ordination of benthic community structure from Site 9 (Bray-Curtis similarity and $^4\surd$-transformation)

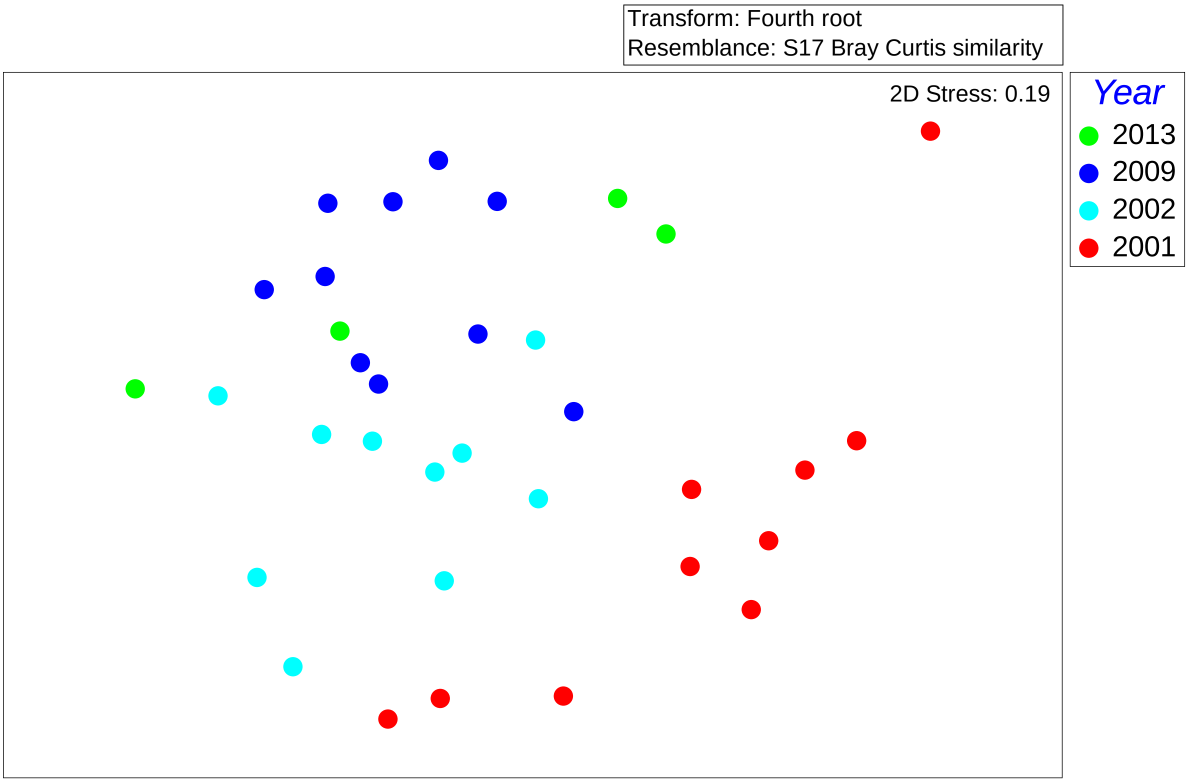


Table 3.26: ANOSIM of benthic community data from Site 9 over consecutive monitoring surveys

Groups	R Statistic	Significance Level %	Possible Permutations	Actual Permutations	Number >= Observed
2013, 2009	0.569	0.7	1001	999	6
2013, 2002	0.447	0.4	1001	999	3
2013, 2001	0.605	0.2	1001	999	1
2009, 2002	0.368	0.2	92378	999	1
2009, 2001	0.728	0.1	92378	999	0
2002, 2001	0.511	0.1	92378	999	0

At Site 9 SIMPER analysis for each year indicated sample pairs have an average similarity of 30.70% in 2001, with a maximum contribution (7.07%) from nematodes (Table 3.27). Average similarity was 40.44% in 2002, with a maximum contribution (10.49%) from the Gammaridean amphipod *Urothoe brevicornis*. Average similarity was 45.90% in 2009, with a maximum contribution (7.10%) from the polychaete *Nephtys cirrosa*. Average similarity was 25.15% in 2013, with a maximum contribution (10.28%) from nematodes.

Table 3.27: SIMPER analysis of benthic community data from Site 9 by monitoring survey

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum%
Group 2001 - average similarity: 30.70%					
Asbjornsenia pygmaea	0.95	7.07	0.88	23.02	23.02
Thracia villosiuscula	0.62	3.65	0.69	11.90	34.92
Eurydice spinigera	0.56	3.23	0.52	10.53	45.46
Urothoe brevicornis	0.58	2.86	0.51	9.32	54.78
Glycera lapidum	0.58	2.72	0.52	8.87	63.65
Paradoneis lyra	0.55	2.50	0.52	8.15	71.80
Pisione remota	0.46	1.70	0.39	5.55	77.35
Chamelea gallina	0.49	1.56	0.38	5.08	82.43
Echinocyamus pusillus	0.45	1.50	0.39	4.88	87.32
Timoclea ovata	0.40	1.41	0.38	4.59	91.91
Group 2002 - average similarity: 40.44%					
Urothoe brevicornis	1.18	10.49	1.71	25.95	25.95
Nematoda	1.05	8.23	1.76	20.35	46.30
Eurydice spinigera	0.89	5.96	1.20	14.74	61.03
Polygordius	0.69	3.68	0.67	9.10	70.13
Nemertea	0.55	2.13	0.51	5.26	75.39
Grania	0.50	2.12	0.51	5.24	80.63
Nephtys cirrosa	0.43	1.15	0.39	2.85	83.48
Pisione remota	0.53	1.12	0.39	2.76	86.23
Asbjornsenia pygmaea	0.42	1.02	0.39	2.52	88.75
Syllis cornuta	0.40	1.00	0.39	2.48	91.23
Group 2009 - average similarity: 45.90%					
Nephtys cirrosa	1.24	7.10	2.57	15.48	15.48
Nematoda	1.88	7.04	1.68	15.34	30.81
Nemertea	1.49	6.18	1.61	13.47	44.28
Asbjornsenia pygmaea	1.01	4.78	1.58	10.42	54.70
Grania	1.11	4.51	1.10	9.83	64.53
Urothoe brevicornis	0.85	2.91	0.80	6.34	70.87
Protodriloides chaetifer	0.96	2.49	0.85	5.42	76.29
Protodrilus	0.68	2.26	0.68	4.93	81.22
Polygordius	0.93	1.80	0.65	3.91	85.14
Pisione remota	1.01	1.40	0.51	3.05	88.19
Echinocyamus pusillus	0.80	1.27	0.50	2.77	90.96
Group 2013 - average similarity: 25.15%					
Nematoda	1.54	10.28	6.94	40.88	40.88
Echinocyamus pusillus	1.10	3.98	0.91	15.81	56.70
Nemertea	0.80	3.61	0.91	14.36	71.06
Goodallia triangularis	0.80	1.70	0.41	6.77	77.84
Urothoe brevicornis	0.70	1.66	0.41	6.60	84.44
Eurydice spinigera	0.59	1.43	0.41	5.70	90.14

3.3.10.3. Biotopes

The only sediment type sampled at Site 9 in 2001, 2009 and 2013 was Sand, which represents the Subtidal Sand sub-feature.

The macrofaunal samples from Site 9 were relatively dissimilar within each survey, with similarity ranging from 25% to 46%. As the difference in similarity between stations was relatively low no further division has been carried out although some further sub-divisions are apparent. Pairwise comparisons showed the significant differences to be between 2009 and 2001, and 2002 and 2001. There were higher abundances of *Asbjornsenia pygmaea* in 2001 compared to the other two years and lower numbers of Nematoda and *Pisione remota*.

Allen and Proctor (2003) identified four groups at Site 7, but concluded that the Site is characterised by an impoverished version of SS.SCS.ICS.MoeVen (*Moerella* spp. with venerid bivalves in infralittoral gravelly sand) combined with SS.SSa.IFiSa.IMoSa (Infralittoral mobile clean sand with sparse fauna) and SS.SSa.IFiSa.NcirBat (*Nephtys cirrosa* and *Bathyporeia* spp. in infralittoral sand) and is likely to be transitional between these biotopes.

Dissimilarity was greatest between 2001 and 2009 surveys (91.7%). This was primarily caused by a moderate average abundance of Nematoda and Nemertea in 2009, both of which were absent in 2001. In general, the average abundance of Nematoda was one of the taxa that contributed most to dissimilarity.

Characteristic species common across the sampling years included *Urothoe brevicornis*, *Eurydice spinigera* and *Asbjornsenia pygmaea*. This indicated that the dominant biotope is probably SS.SSa.IFiSa.IMoSa except following periods of lower sediment disturbance where it may transition to SS.SSa.IFiSa.NcirBat. Very sparse gravel may be the reason that the 2001 survey identified SS.SCS.ICS.MoeVen. The consistent presence of dominant characteristic species and stable sediment type indicated that the biotope composition has remained consistent at Site 9 from 2001 to 2013.

4. Conclusions

- There were a number of issues associated with the benthic survey data supplied that took considerable time to address before analysis could begin. These steps typically involved some form of truncation and standardisation due to the varied survey designs and sampling and processing techniques, but there were also problems with missing data and a lack of supporting information that meant some data were not able to be used.
- The benthic data analysed came from a number of different surveys that used different survey techniques, processing methods and experimental designs. As such, any results should be interpreted with caution.
- The seabed sediments within the Isles of Scilly Complex SAC are dominated by Sand and sediment type was fairly consistent across the 2001, 2009 and 2013 surveys. There is a variable Gravel content at the sampling sites, which was consistently greater at Site 1 (north of St Martin's), Site 5 (west of Tresco), and Site 7 (North West Channel to the south west of Samson). The only site found to have a significant silt content was Site 3 (north west of St Mary's) and then only in 2009.
- There were changes in the sediment types sampled at Site 1, Site 3, and Site 6 over the three surveys, but typically only in a single year and no trends were identified. In general, the sediment types remained equivalent over the survey period.
- Detailed sediment composition data were only available for 2009 and 2013. These data showed no significant difference between the sampling years.
- Site 1 had low to moderate richness and diversity and there were no significant differences in biodiversity indices between years. Community composition was significantly different between years, but was due to small changes in the relative abundance of common species. Sediments were typically medium/fine sands with varying amounts of gravel. Overall, the biotope that best described the community was consistently SS.SCS.CCS.MedLumVen: *Mediomastus fragilis*, *Lumbrineris* spp. and venerid bivalves in circalittoral coarse sand or gravel.
- Site 2 had low to moderate richness and diversity and there were no significant differences in biodiversity indices between years. Community composition was significantly different between years, but was due to small changes in the relative abundance of common species. Sediments were typically medium/fine sands. Overall, the biotope that best described the community was consistently SS.SSa.IMuSa.FfabMag: *Fabulina fabula* and *Magelona mirabilis* with venerid bivalves and amphipods in infralittoral compacted fine muddy sand.
- Site 3 had moderate richness and diversity and there were no significant differences in biodiversity indices between years. Community composition was significantly different between years, but was due to small changes in the relative abundance of common species. Sediments were typically medium/fine, slightly muddy sands. Overall, the biotope is one that forms part of the 'offshore muddy sand association' and is best represented by SS.SSa.CMuSa.AbraAirr (*Amphiura brachiata* with *Astropecten irregularis* and other echinoderms in circalittoral muddy sand), with elements of SS.SMu.CSaMu.LkorPpel: *Lagis koreni* and *Phaxas pellucidus* in circalittoral sandy mud.
- Site 4 had low to moderate richness and diversity and there were no significant differences in biodiversity indices between years. Community composition was significantly different between years, but was due to small changes in the relative abundance of common species. Sediments were typically medium/coarse sands. Overall, the biotope is best represented as a transitional community between SS.SCS.ICS.MoeVen (*Moerella* spp. with venerid bivalves

in infralittoral gravelly sand) and SS.SSa.IFiSa.NcirBat (*Nephtys cirrosa* and *Bathyporeia* spp. in infralittoral sand).

- Site 5 had low to moderate richness and diversity and there were no significant differences in biodiversity indices between years. Community composition was significantly different between years, but was due to small changes in the relative abundance of common species. Sediments were typically medium/coarse sands with varying amounts of gravel. Overall, the biotope is best represented as SS.SCS.ICS.MoeVen (*Moerella* spp. with venerid bivalves in infralittoral gravelly sand) with some elements of SS.SCS.CCS.MedLumVen (*Mediomastus fragilis*, *Lumbrineris* spp. and venerid bivalves in circalittoral coarse sand or gravel).
- Site 6 had low richness and diversity and there were no significant differences in biodiversity indices between years. Community composition was significantly different between years, but was due to small changes in the relative abundance of common species. Sediments were typically medium/fine sands. Overall, the two biotopes are best represented as SS.SCS.ICS.MoeVen (*Moerella* spp. with venerid bivalves in infralittoral gravelly sand) with some elements of SS.SSa.IFiSa.NcirBat (*Nephtys cirrosa* and *Bathyporeia* spp. in infralittoral sand) and impoverished SS.SSa.IMuSa.FfabMag: *Fabulina fabula* and *Magelona mirabilis* with venerid bivalves and amphipods in infralittoral compacted fine muddy sand).
- Site 7 had moderate richness and diversity and there were no significant differences in biodiversity indices between years. Community composition was significantly different between years, but was due to small changes in the relative abundance of common species. Sediments were typically coarse sands and gravelly sands. Overall, the biotope is best represented as a transition between SS.SCS.ICS.MoeVen (*Moerella* spp. with venerid bivalves in infralittoral gravelly sand) and SS.SCS.CCS.MedLumVen (*Mediomastus fragilis*, *Lumbrineris* spp. and venerid bivalves in circalittoral coarse sand or gravel).
- Site 9 had low richness and diversity and there were no significant differences in biodiversity indices between years. Community composition was significantly different between years, but was due to small changes in the relative abundance of common species. Sediments were typically medium-coarse sands. Overall, the dominant biotope is best represented as SS.SSa.IFiSa.IMoSa Infralittoral mobile clean sand with sparse fauna, with elements of SS.SSa.IFiSa.NcirBat (*Nephtys cirrosa* and *Bathyporeia* spp. in infralittoral sand).
- Though there were changes in relative species composition observed during the survey period, these were not sufficient to lead to changes in biotope classification, which have not deviated significantly from the 2001 survey.
- The favourable condition table for the relevant subfeatures of the Isles of Scilly Complex SAC is given in Table 4.1. Two targets are relevant to this sediment analysis: 1) Average PSA parameters should not deviate significantly from an established baseline, subject to natural change; and 2) Composite species, abundance and diversity should not deviate significantly from an established baseline, subject to natural change. Based upon the survey data used within the scope of the project, any observed changes have been minor and within what could reasonably be expected through natural change, so it is concluded that the condition of the site has effectively been maintained over the survey period.
- Future feature and site condition monitoring surveys should use the experimental design used in the 2001 survey (Allen and Proctor, 2003) in order to provide consistency, make best use of existing monitoring data, and allow robust comparison over time.

Table 4.1: Favourable condition table for the Isles of Scilly Complex SAC

Feature	Sub-feature	Attribute	Measure	Target	Comments
Subtidal sandbanks		Sediment character	Particle size analysis (PSA). Parameters include percentage sand/silt/gravel, mean and median grain size, and sorting coefficient, used to characterise sediment type. Sediment character to be measured during summer, once per reporting cycle.	Average PSA parameters should not deviate significantly from an established baseline, subject to natural change.	Sediment character defined by particle size analysis is key to the structure of the feature, and reflects all of the physical processes acting on it. Particle size composition varies across the feature and can be used to indicate spatial distribution of sediment types thus reflecting the stability of the feature and the processes supporting it.
	Sand & gravel communities	Species composition of characteristic biotopes	Presence, abundance and diversity of composite species from a range of biotopes (to be determined) measured once per reporting cycle.	Composite species, abundance and diversity should not deviate significantly from an established baseline, subject to natural change	Species composition is an important contributor to the structure of the sub-feature. The presence, relative abundance and diversity of characterising and notable species gives an indication of the quality of the sub-feature and change in composition may indicate cyclic changes/trends in subtidal sand and gravel communities. The current list of biotopes is given in Appendix III. Further data collection and analysis is required to achieve a comprehensive list of biotopes, the species composition of which will be measured.

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Annexes

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