Balliemeanoch Pumped Storage Hydro

Environmental Impact Assessment Report

Volume 5: Appendices
Appendix 8.2: Subtital Benthic Survey Report - Addendum

ILI (Borders PSH) Ltd

July 2024

Delivering a better world

Quality information

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1	July 2024	Submission	DL	David Lee	Technical Director

Distribution List

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1. Introduction

1.1 Project Background

ILI (Borders PSH) Ltd (hereafter referred to as the 'Applicant') proposes to construct a PSH scheme (herein referred to as the "Development") close to Lochan Airigh approximately 4.4 km to the south of the village of Portsonachan and 9 km northwest of Inveraray in Argyll and Bute. The Development will use a headpond at Loch Nant, with its tailrace discharging into Loch Awe.

A marine facility is being constructed to aid with the delivery of large materials to site, which will consist of a jetty at Inveraray, Loch Fyne. The Development will have a storage capacity expected of up to 45,000 Mega Watt hours (MWh) and up to 1,500 MW installed electrical generation capacity (subject to further investigation and feasibility works).

AECOM has been commissioned by the Applicant to provide an Environmental Impact Assessment (EIA) and Marine Protected Area (MPA). To assist with these assessments, AECOM has undertaken survey works and quantitative sampling of the subtidal habitats present near the Marine Facility in Loch Fyne.

1.2 Aims and Objectives

The purpose of this report is to present the results of the subtidal benthic surveys, which includes grab sampling, supplemented with drop-down camera surveys (DDC) to ground-truth seabed data, identify benthic habitat and biotope types in the study area around the Marine Facility, and highlight key receptors (e.g. Priority Marine Features) that may be affected by the proposed Development.

This report is intended to form part of the benthic ecological baseline characterisation study that will be undertaken to inform the EIA, HRA and WFD assessment to be completed as part of the Development. Consideration will be given to overall environmental quality within the study area, to help inform assessment of impacts to marine receptors near the Marine Facility.

1.3 Study Area

The study area for the Marine Facility encompassed the shallow subtidal to depths of 6 m in Loch Fyne near Inveraray. The study area was chosen on the basis that it would include extent of the Marine Facility and jetty development, characterising benthic habitats and identifying benthic receptors that have the potential to be affected by the proposed Development.

The proposed Development is situated within the Upper Loch Fyne and Loch Goil Nature Conservation Marine Protection Area (NCMPA) (*Figure 8.1 Marine Facility Study Area and Protected Sites (Volume 3: Figures))* which was designated in July 2014 under the Marine (Scotland) Act 2010 and came into force in August 2014. This site is designated for the following protected features (SNH, 2013):

- Burrowed mud (habitat)
- Flame shell (*Limaria hians*) beds (habitat);
- Horse mussel (*Modiolus modiolus*) beds (habitat)
- Ocean quahog (*Arctica islandica*) (low or limited mobility species); and
- Sublittoral mud and specific mixed sediment communities (habitat).

2. Methodology

2.1 Field Surveys

Benthic surveys were undertaken to characterise the intertidal and subtidal habitats and species present within the study area. An initial desk-based study was undertaken to identify any protected areas and habitats and species expected to be present within the study area. Benthic surveys took place in December 2021 by experienced marine ecologists.

Subtidal surveys were undertaken using drop-down cameras and grab sampling. The camera surveys were initially conducted to determine broad sediment type and identify features of interest (e.g. Annex I reef habitats or Priority Marine Features), with grab stations then selected based on the observed sediment types, avoiding areas of potential stony reef, whilst providing coverage of the different sediment types present.

A total of 10 grab sampling stations were selected (*Figure 2-1*, *Table 2-1*), with samples collected in triplicate for laboratory-based macroinvertebrate analysis and sediment particle size analysis (PSA). At each station, a 0.045 m^2 Van Veen grab was used to obtain a total of six sediment samples. The first and second, third and fourth, and firth and six samples were pooled to provide three replicate 0.1m^2 samples from each station. Sub-samples were removed for PSA analysis whilst the remaining sample was emptied onto a 1 mm sieve net laid over 4.0 mm sieve table and washed through using gentle rinsing with a seawater hose. The remaining sample destined for faunal sorting and identification was backwashed into a suitable sized sample container and diluted with a 10% formalin solution added to fix the sample prior to third-party laboratory analysis.

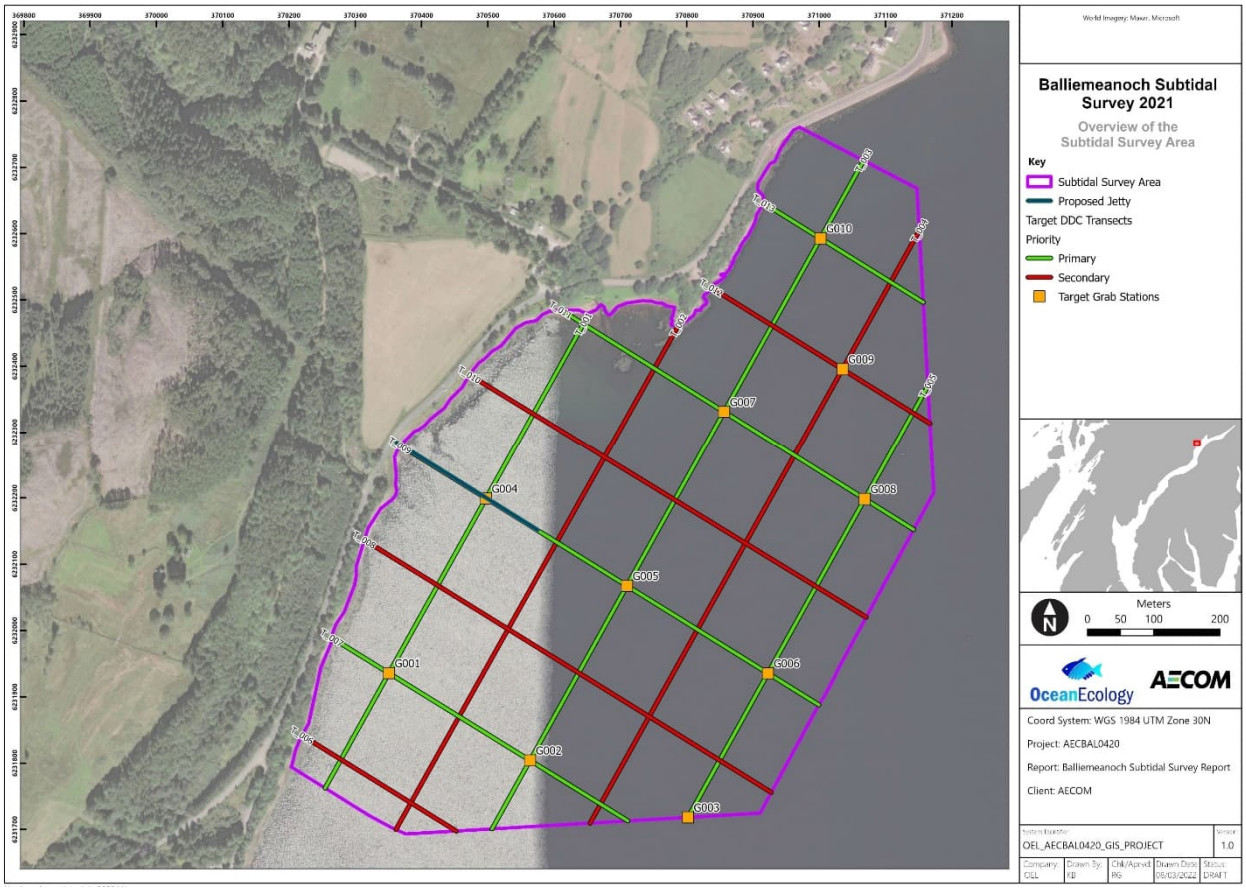

Figure 2-1: Grab sampling locations in relation to drop-down camera transects and proposed jetty location

Table 2-1: Grab sampling station coordinates

Station	Location	Decimal Degrees		British National Grid (BNG)	
		Latitude	Longitude	Easting	Northing
G003A	Loch Fyne	56.212866	-5.083146	370804.594	6231723.709
G003B	Loch Fyne	56.212851	-5.083038	370811.241	6231721.837
G003C	Loch Fyne	56.212866	-5.083083	370808.501	6231723.591
G006A	Loch Fyne	56.214800	-5.081118	370936.848	6231935.111
G006B	Loch Fyne	56.214785	-5.081136	370935.681	6231933.476
G006C	Loch Fyne	56.214850	-5.081280	370926.971	6231940.979
G008A	Loch Fyne	56.217231	-5.079171	371065.735	6232201.972
G008B	Loch Fyne	56.217216	-5.079153	371066.801	6232200.270
G008C	Loch Fyne	56.217166	-5.079063	371072.213	6232194.538
G010A	Loch Fyne	56.220619	-5.080550	370991.618	6232581.547
G010B	Loch Fyne	56.220619	-5.080604	370988.270	6232581.648
G010C	Loch Fyne	56.220584	-5.080568	370990.385	6232577.686
G004A	Loch Fyne	56.217051	-5.088500	370486.713	6232199.436
G004B	Loch Fyne	56.217016	-5.088103	370511.209	6232194.795
G001A	Loch Fyne	56.214665	-5.090519	370353.476	6231937.735
G002A	Loch Fyne	56.213502	-5.087085	370562.484	6231801.869
G002B	Loch Fyne	56.213502	-5.087003	370567.569	6231801.715
G002C	Loch Fyne	56.213482	-5.087067	370563.533	6231799.610
G005A	Loch Fyne	56.215898	-5.084885	370706.968	6232064.350
G005B	Loch Fyne	56.215918	-5.085102	370693.581	6232066.983
G005C	Loch Fyne	56.215918	-5.084804	370712.058	6232066.424
G007A	Loch Fyne	56.218384	-5.082632	370855.024	6232336.751
G007B	Loch Fyne	56.218299	-5.082632	370854.739	6232327.293
G007C	Loch Fyne	56.218334	-5.082848	370841.464	6232331.592
G009A	Loch Fyne	56.219000	-5.079937	371024.184	6232400.248
G009B	Loch Fyne	56.218950	-5.079667	371040.756	6232394.179
G009C	Loch Fyne	56.219015	-5.079883	371027.582	6232401.816
G004C	Loch Fyne	56.216500	-5.086800	370590.259	6232134.931
G001B	Loch Fyne	56.214234	-5.088446	370480.560	6231885.878
G001C	Loch Fyne	56.214249	-5.088301	370489.602	6231887.275

2.2 Laboratory and Data Analysis

2.2.1 Macrofaunal Analysis

Macrobenthic analysis was undertaken by Ocean Ecology Limited (OEL) in line with the NMBAQC (North East Atlantic Marine Biological Quality Control) Processing Requirement Protocol (PRP) (Worsfold and Hall, 2010). Faunal samples were sieved over a 1 mm mesh and all fauna retained identified to species level where possible. The biota were identified and counted by trained benthic taxonomists using the most up to date taxonomic literature and checked against existing reference collections and the World Register of Marine Species (WoRMS) for the latest taxonomic nomenclature. Colonial taxa (e.g. hydroids, bryozoans, and eggs) were identified to species level where possible and recorded as present (P).

Biomass was pooled into major taxonomic groups (Annelida, Crustacea, Mollusca, Echinodermata and Miscellaneous taxa) and measured to the nearest 0.0001 g blotted wet weight. As a standard, the conventional conversion factors as defined by Eleftheriou and Basford (1989) were then applied to provide equivalent dry weight biomass (Ash Free Dry Weight). A single reference collection preserved in 70% IDA of all taxa identified was retained for Quality Assurance (QA) purposes.

2.2.2 Particle Size Analysis (PSA)

PSA was undertaken by OEL in line with NMBAQC protocols (Mason, 2016), using dry sieving for the >1 mm fraction and laser diffraction for the fine fraction residue (<1 mm).

The dry sieve and laser data were merged for each sample with the results expressed as a percentage of the whole sample. Once the data were merged, PSA statistics and sediment classifications were generated from the percentages of the sediment determined for each sediment fraction using the Gradistat v8 software (Blott and Pye, 2001).

Sediment descriptions were defined by their size class based on the Wentworth sediment size classification system (Wentworth, 1922). Statistics such as mean and median grain size, sorting coefficient, skewness and bulk sediment classes (percentage silt, sand and gravel) were also derived in accordance with the Folk classification (Folk, 1954).

Table 2-2: Classification used for defining sediment type based on the Wentworth Classification System (Wentworth 1922).

Wentworth Scale	Phi Units (φ)	Sediment Types
>64000 µm	<-6	Cobble and boulders
32000 – 64000 µm	-5 to -6	Pebble
16000 – 32000 µm	-4 to -5	Pebble
8000 – 16000 µm	-3 to -4	Pebble
4000 - 8000 µm	-3 to -2	Pebble
2000 - 4000 µm	-2 to -1	Granule
1000 - 2000 µm	-1 to 0	Very coarse sand
500 - 1000 µm	0-1	Coarse sand
250 - 500 µm	1-2	Medium sand
125 - 250 µm	2-3	Fine sand
63 - 125 µm	3-4	Very fine sand
31.25 – 63 µm	4-5	Very coarse silt
15.63 – 31.25 µm	5-6	Coarse silt
7.813 – 15.63 µm	6-7	Medium silt
3.91 – 7.81 µm	7–8	Fine silt
1.95 – 3.91 µm	8-9	Very fine silt
<1.95 µm	<9	Clay

2.2.3 Statistical Analysis

To assess macrofaunal community structure and assemblage patterns, multivariate statistical analysis, including site similarity assessment using cluster analysis, similarity percentage (SIMPER), and similarity profile (SIMPEROF) in PRIMER v7 (Clarke and Gorley, 2015).

To remove the weighting of common or rare species within a sample, data were square-root transformed and a similarity matrix was constructed (Bray-Curtis similarity), which groups samples based on their community assemblage. Following this, the cluster analysis was performed which provides ‘natural groupings’ of samples, the results of which were visualised using a non-metric multi-dimensional scaling (nMDS) plot. The SIMPROF test was then used to find statistically similar cluster groupings, with a SIMPER test run to identify the species contributing to similarity within the cluster groupings.

2.2.4 Habitat Classification

Macrofaunal community and PSA data obtained during the surveys were used to classify the habitats present in accordance with the European Union Nature Information System (EUNIS) habitat classification system shown in Table 2-3 (EEA, 2012). This classification system uses standard descriptions (‘biotopes’), which categorises habitats based on the marine zone, physical nature of the habitat, and the biological communities observed. For example, marine habitats can be divided into littoral (also known as intertidal) and subtidal zones, and then classified according to the physical nature of the substratum, either rock or sediment, and the biological community found. Habitats observed were recorded to the lowest (i.e. most detailed) level possible.

Table 2-3: Example of the five-level EUNIS classification system (EEA 2012).

Level	Habitat Detail
1. Environment	Marine (A)
2. General Habitats	Littoral sediment (A2)
3. Broad Scale Habitat	Littoral mud (A2.3)
4. Biotope Complexes	Polychaete/oligochaete-dominated upper estuarine mud shores (A2.32)
5. Biotopes	*A2.323 : Tubificoides benedii* and other oligochaetes in littoral mud (A2.323)

3. Results

3.1 Macrofauna

A total of 142 taxa were recorded across the ten sites. The macrobenthic community had a mean species richness of 14.8 (SD ± 9.3) and a mean abundance of 398.3 individuals m^{-2} (SD ± 379.1; *Figure 3-2*) per sample.

Grab sampling stations G001, G003, G004, G005, and G010 exhibited the greatest abundances of infauna, with mean abundances ranging from 583 (SD ± 425) to 763 (SD ± 139) individuals m^{-2}. Sites G002, G006, G007, and G009 had the next greatest abundances, with means ranging from 117 (SD ± 49) to 170 (SD ± 125) individuals m^{-2}. Station G008, had the lowest mean abundance with 77 (SD ± 49) individuals m^{-2}. The number of taxa recorded was also greatest at the sites that exhibited the greatest abundances, with the mean number of taxa ranging from 15 (SD ± 6.2) to 21 (SD ± 5.6) per site. The mean number of taxa at the remaining sites (G002, G006, G007, G008, G009) ranged from 5 (SD ± 1.5) to 9 (SD ± 3.0).

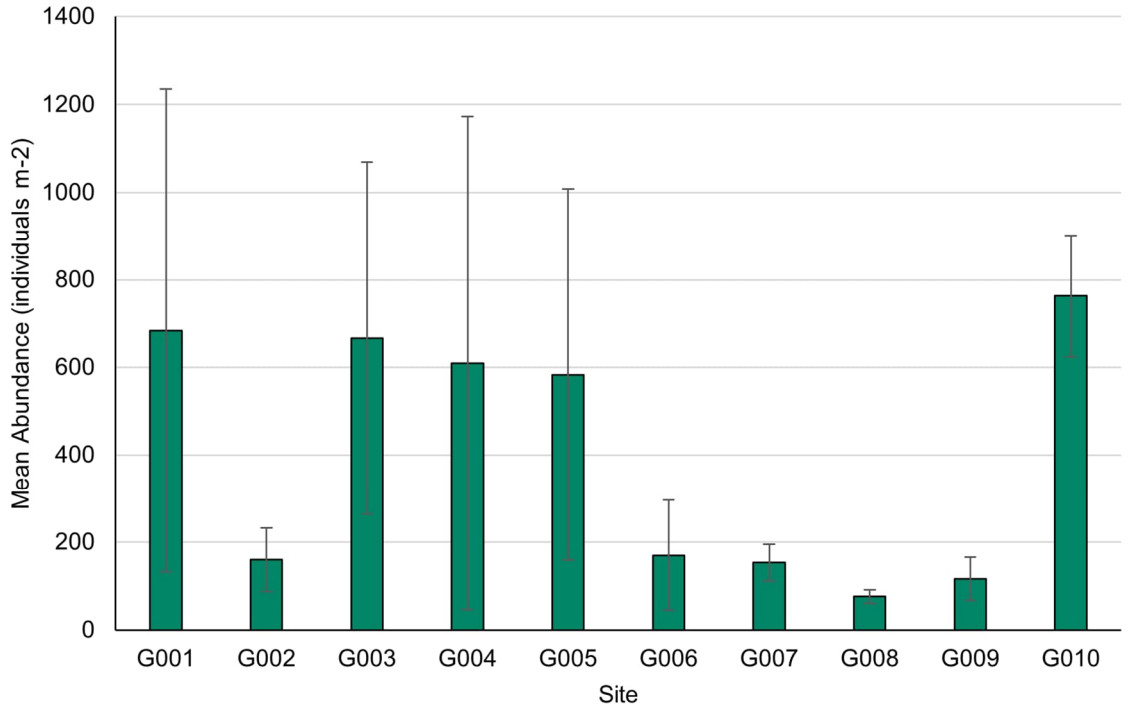

Figure 3-1: Mean abundance (individuals m^{-2}) recorded at each site

Polychaeta was the most abundant taxon recorded (n = 5,660), comprising 47% of the total infaunal composition. A total of 73 species of polychaetes were recorded, with *Leitoscoloplos mammosus* and *Scoloplos armiger* comprising the greatest proportion, each at 15% of the overall polychaete abundance. The remaining species were each present

at <9% of the overall abundance. *Leitoscoloplos mammosus* was observed at four stations and *S. armiger* was observed at eight. Of the remaining species, 52 comprised <1% of the overall abundance. Polychaetes were the most abundant taxa at sites G001, G004, G005, G007, G009, and G010, comprising 49-71% of the mean site abundances (Figure 3-2). At sites G002, G003, and G008, polychaetes comprised 21-30% of the meant site abundance, whilst G006 exhibited the lowest proportion of polychaetes at 14% of the mean site abundance.

The second most abundant taxon was Bivalvia (n = 3,590) (the bivalve molluscs), with individuals observed at all sites. Twenty-six species of bivalves were recorded. Unidentified bivalves comprised the greatest proportion of overall abundance (30%), with *Nucula nucleus* and *Kurtiella bidentata* constituting the next greatest proportions at 16% an 14% respectively. A further 11 species each comprised 1-10% of the overall abundance, with the remaining 12 each responsible for <1%. *Nucula nucleus* was found at all but one site, while *K. bidentata* was found at eight sites. At these sites, abundances ranged from 20-200 individuals m^{-2} and 20-160 individuals m^{-2} respectively. Bivalves comprised the greatest proportion of mean total site abundances at G002, G003, G006, and G008, ranging from 35-51%. At the remaining sites (G001, G004, G005, G007, G009, and G010, the proportion of bivalves ranged from 21-41% of the mean total site abundances.

The remaining taxa were each responsible for <5% of the overall macroinfaunal composition. Sea cucumbers (the Holothuroidea) (n = 550) and other molluscs comprised the next greatest proportions of overall composition (n = 440), followed by Crustacea (including amphipods, cumaceans, isopods, decapods, and tanaidaceans; n = 280). Holothuroidea were observed at all sites except G004, G007, and G010 and were most abundant at site G003, where they comprised 20% of the mean site abundance. Site G002 had the next greatest proportion at 13% of the mean site abundance. At all remaining sites, Holothuroidea comprised <10% of the mean site abundance. Other molluscs were recorded at all sites and were most abundant at sites G006-G008, where they comprised 16%, 11%, and 13% of the mean site abundances respectively. All other sites exhibited mean abundances <10%. Crustacea were observed at sites G001-G005 and G010, where they comprised the greatest proportion of mean site abundance at site G004 (9%). Remaining taxa were pooled due their low abundances and included Cnidaria (n = 150), Hemichordata (n = 20), Nemertea (n = 150), Ophiuroidea (n = 190), Priapulida (n = 10), and remaining Annelida (n = 130).

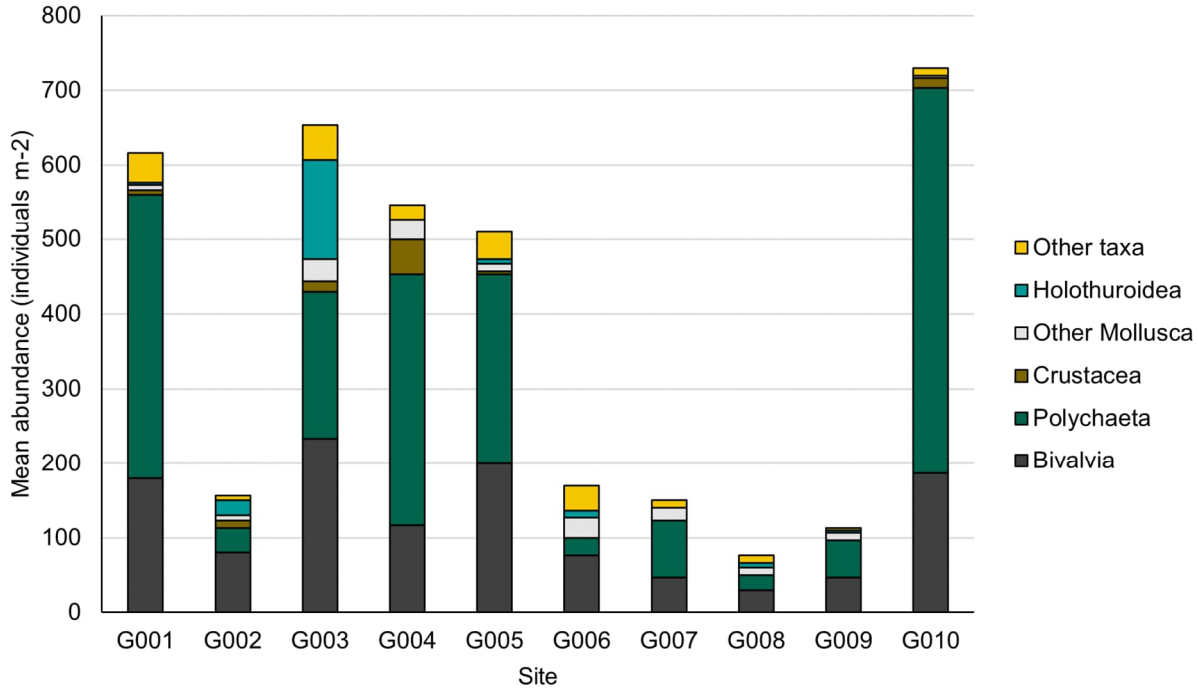

Figure 3-2: Mean site abundance by taxa (individuals m^{-2})

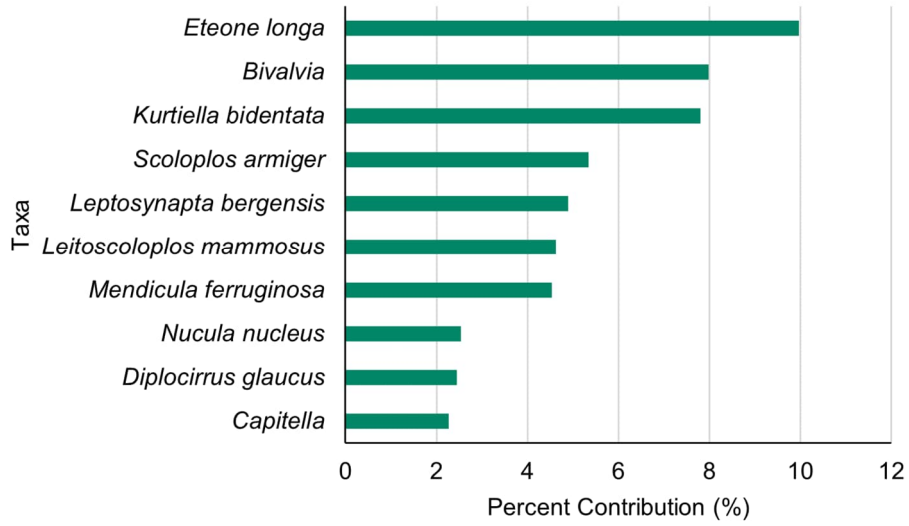

Figure 3-3: Percent contribution of top 10 taxa to total abundance

The SIMPROF test indicated four distinct groupings of sites (*Figure 3-4*). The largest clustering of samples (Group C) included sites G002, G003, and G005, as well as samples G001B, G001C, G004B, G004C, G007B, G007C, G009A, and G010C. Another cluster of samples included sampled G001A, G010A, and G010B (Group B). The third cluster (Group D) was more dissimilar and included sites G006 and G008, and samples G007A, G009B, G009C. The remaining sample (Group A), G004A, was the most dissimilar to the other clusters.

The SIMPER analysis indicated key taxa which contributed most to within group similarities, which is presented in Table 3-1 with average group similarities and percent contribution of each species to within group similarity. As group A only contained one sample, within group similarity and species contribution could not be determined; however, *Capitella* sp. Constituted 22% of the sample abundance, with *Aonides oxychephala* and *Kurtiella bidentata* comprising 9.6% and 7.9% respectively. All other species were present at $\leq$ 5% of the total sample abundance.

The samples from group B are from some of the sites which are closest to the shore: G001 and G010. The polychaete *Leitoscoloplos mammosus* contributed most to within group similarity, which exhibited its greatest abundances in the samples from this group (210-340 individuals m^{-2}). All other samples exhibited abundances $\leq$ 40 individuals m^{-2}. Bivalvia were the only other taxa to contributed >50 individuals m^{-2} to the total abundance across all three samples, with total abundance ranging from 90-250 individuals m^{-2}. They differ from the other samples at their respective sites in that the abundance of both taxa were 0-20 individuals m^{-2}.

Group C contained most of the samples, including the entirety of sites G002, G003, and G005. These sites are further offshore than G001 and G010, and occur adjacent to one another, primarily in the south-west region of the study area. The remaining samples from this group occur at all other sites, except for sites G006 and G008, which occur the furthest offshore and deepest (19-23 m). Overall abundance varied greatly within these samples, ranging from 100-1,030 individuals $m^{-2.}$ Bivalvia contributed most to similarity among these samples, with abundances ranging from 20-80 individuals m^{-2}.

Group D included the entirety of the deepest sites (G006 and G008), as well as samples from G007 and G009, which occur adjacent to site G008 in the north-east region of the study area, although do not occur as deep (13-16 m). *Cylichna cylindracea* contributed most to within group similarity, with sample abundances ranging from 0-30 individuals m^{-2}).

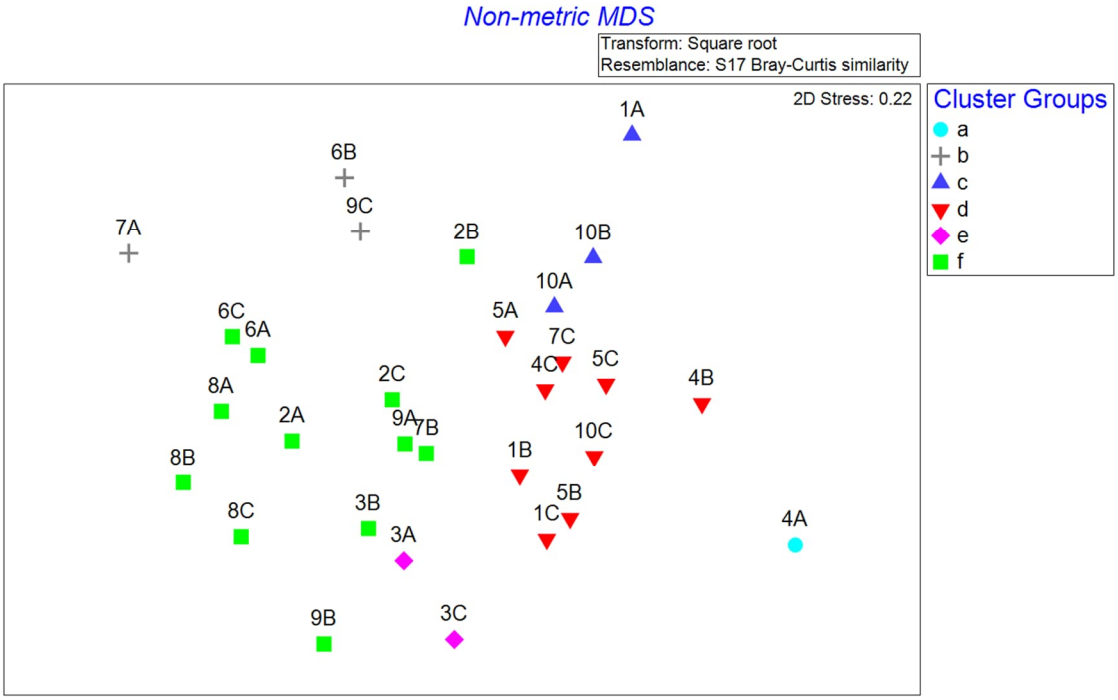

Figure 3-4: nMDS plot of community composition data (square root transformed), with results of SIMPROF cluster analysis overlaid (grab sample letters labelled)

Table 3-1: SIMPER analysis results, comparing within cluster similarity (average similarity and percent contribution of species shown in brackets)

Group A*	Group B (38.41)	Group C (28.71)	Group D (27.53)
Capitella sp. *Aonides oxychephala* *Kurtiella bidentata* *Onoba semicostata*	*Leitoscoloplos mammosus* (34.06%) Bivalvia (23.3%) *Nephtys hombergii* (7.2%) *Melinna palmata* (5.7%)	Bivalvia (22.4%) *Diplocirrus glaucus* (15.6%) *Scoloplos armiger* (14.9%) *Nucula nucleus* (10.5%) *Kurtiella bidentata* (9.1%)	*Cylichna cylindracea* (34.0%) *Nucula nucleus* (25.0%) Bivalvia (11.2%)

** Fewer than two samples present in group and therefore no SIMPER results were produced. The species shown signify those that dominated the total abundance for that sample.*

3.2 Particle Size Analysis (PSA)

The major sediment fractions at each site are presented in *Figure 3-5*. The Particle Size Analysis (PSA) data has been classified as per the Folk (1954) classification system, as described in Figure 3-2.

Sand and mud was the dominant sediment type in the majority of sediment samples at each site, with mean percent contributions ranging from 38.1-73.6% for sand, 17.8-61.6% for mud, and 0.3-14.0% for gravel. Sites G001, G004, G005 and G010 occurred at depths <15 m, and exhibited greater proportions of sand than mud. G001 and G004 hadthe greatest proportions of sand, with 63% sand, 35% mud, and 2% gravel at G001 and 74% sand, 18% mud, and 9% gravel at G004, whilst G005 and G010 exhibited 53% sand, 41% mud, and 6% gravel and 50% sand, 36% mud, and 14% gravel respectively. Site G008 was further offshore, occurring at 20 m depth, and exhibited the greatest percentage of mud, with 38% sand, 62% mud, and 0% gravel. G002, G003, G006, G007, and G009 all exhibited greater proportions of mud, with sediment contributions of 47% sand, 49% mud, and 4% gravel at G002, 43% sand, 51% mud, and 6% gravel at G003, 42% sand, 58% mud, and 0% gravel at G006, 46% sand, 52% mud, and 1% gravel at G007, and 44%

sand, 55% mud, and 0% gravel at G009. Of these sites, G003, G006, and G009 occurred at depths of 16-23 m and had the greatest differences in percent contribution between mud and sand, while G002 and G007 occurred at depths of 12-13 m, with sand and mud contributions only differing by 2% and 6% respectively. The greatest proportions of gravel were observed at G003 (6%), G004 (9%), G005 (6%), and G010 (14%).

As such, sites G001, G004, G005, and G010 each had a greater proportion of sand than mud, and were classified as 'gravelly sand,' 'muddy sand,' or 'gravelly muddy sand' (*Table 3-2*) Conversely, sites G002, G003, G006, G007, G008, and G009 exhibited a greater proportion of mud and were classified as 'sandy mud' or 'gravelly mud' (*Table 3-2*).

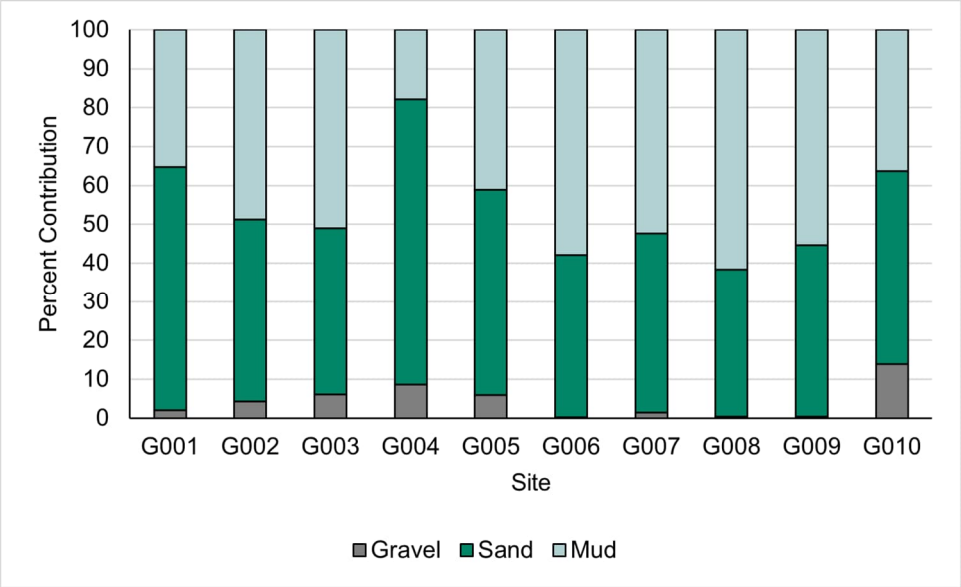

Figure 3-5: Major sediment fractions (mean percentage contribution) at each sampling site

Table 3-2: PSA data as classified by Folk (1954)

Station	Folk and Ward Description	Folk and Ward Sorting	Mean µm	Mean phi	Sediment Classification	Modified Folk
G001A	Medium Sand	Poorly Sorted	399.9	1.322	Slightly Gravelly Sand	(g)S
G001B	Very Coarse Silt	Poorly Sorted	56.51	4.145	Slightly Gravelly Muddy Sand	(g)mS
G001C	Very Coarse Silt	Poorly Sorted	52.43	4.253	Slightly Gravelly Sandy Mud	(g)sM
G002A	Very Coarse Silt	Very Poorly Sorted	56.74	4.140	Gravelly Mud	gM
G002B	Very Coarse Silt	Poorly Sorted	49.92	4.324	Slightly Gravelly Sandy Mud	(g)sM
G002C	Very Coarse Silt	Poorly Sorted	53.83	4.215	Slightly Gravelly Muddy Sand	(g)mS
G003A	Very Coarse Silt	Poorly Sorted	51.16	4.289	Slightly Gravelly Sandy Mud	(g)sM
G003B	Very Coarse Silt	Poorly Sorted	48.27	4.373	Slightly Gravelly Sandy Mud	(g)sM
G003C	Very Fine Sand	Very Poorly Sorted	63.53	3.976	Gravelly Mud	gM
G004A	Coarse Sand	Very Poorly Sorted	587.3	0.768	Gravelly Sand	gS
G004B	Medium Sand	Poorly Sorted	398.9	1.326	Gravelly Sand	gS
G004C	Very Fine Sand	Poorly Sorted	65.35	3.936	Slightly Gravelly Muddy Sand	(g)mS
G005A	Very Fine Sand	Poorly Sorted	67.09	3.898	Slightly Gravelly Muddy Sand	(g)mS
G005B	Fine Sand	Very Poorly Sorted	133.9	2.901	Gravelly Muddy Sand	gmS
G005C	Very Coarse Silt	Poorly Sorted	53.43	4.226	Slightly Gravelly Muddy Sand	(g)mS

G006A	Very Coarse Silt	Poorly Sorted	48.26	4.373	Slightly Gravelly Sandy Mud	(g)sM
G006B	Very Coarse Silt	Poorly Sorted	43.64	4.518	Slightly Gravelly Sandy Mud	(g)sM
G006C	Very Coarse Silt	Poorly Sorted	42.00	4.573	Sandy Mud	sM
G007A	Very Coarse Silt	Poorly Sorted	46.29	4.433	Slightly Gravelly Sandy Mud	(g)sM
G007B	Very Coarse Silt	Poorly Sorted	54.71	4.192	Slightly Gravelly Sandy Mud	(g)sM
G007C	Very Coarse Silt	Poorly Sorted	50.11	4.319	Slightly Gravelly Sandy Mud	(g)sM
G008A	Very Coarse Silt	Poorly Sorted	42.29	4.564	Slightly Gravelly Sandy Mud	(g)sM
G008B	Very Coarse Silt	Poorly Sorted	40.95	4.610	Slightly Gravelly Sandy Mud	(g)sM
G008C	Very Coarse Silt	Poorly Sorted	41.79	4.581	Slightly Gravelly Sandy Mud	(g)sM
G009A	Very Coarse Silt	Poorly Sorted	46.65	4.422	Slightly Gravelly Sandy Mud	(g)sM
G009B	Very Coarse Silt	Poorly Sorted	47.51	4.396	Slightly Gravelly Sandy Mud	(g)sM
G009C	Very Coarse Silt	Poorly Sorted	46.33	4.432	Sandy Mud	sM
G010A	Fine Sand	Very Poorly Sorted	189.6	2.399	Gravelly Muddy Sand	gmS
G010B	Fine Sand	Very Poorly Sorted	213.7	2.227	Gravelly Muddy Sand	gmS
G010C	Very Fine Sand	Very Poorly Sorted	63.65	3.974	Gravelly Muddy Sand	gmS

The non-metric MDS plot for sediment data, presented in *Figure 3-6*, shows the Folk (1954) classifications of each sample overlaid on the faunal nMDS plot. This gives a description of the sediment characteristics at each station.

Group A (G004A) was composed of ‘gravelly sand’ (gS) and was one of the shallowest samples (4.2 m) nearest the shoreline. Group B (G001A, G010A, and G010B) was primarily sand with sediment types ‘gravelly sand’ and ‘gravelly muddy sand’ (gmS). These were also some of the sites nearest the shoreline (depth 8-10 m). Group C (G002, G003, G005, G001B, G001C, G004B, G004C, G007B, G007C, G009A, G010C) consisted of a range of sediment types: ‘gravelly mud’ (gM), ‘gravelly sand’, ‘slightly gravelly sandy mud’ ((g)sM), ‘slightly gravelly muddy sand’ ((g)mS) and ‘gravelly muddy sand’. This group encompasses nearly all sites, which occur at varying depths (4.2-18.6 m) and distances to shore. Group D (G006, G008, G007A, G009B, G009C) was comprised of only the muddy sediment types, ‘sandy mud’ and ‘slightly gravelly sandy mud’ ((g)sM). This grouping included the deepest (20-23 m) and furthest from shore sites, as well as some samples from adjacent sites.

At the majority of sites, the proportion of sand to mud was similar, with comparatively low proportions of gravel. Most sites exhibited sediment compositions that existed along the borderline of the sand: mud ratio under the Folk classifications, indicating similar proportions of sand and mud throughout the study area.

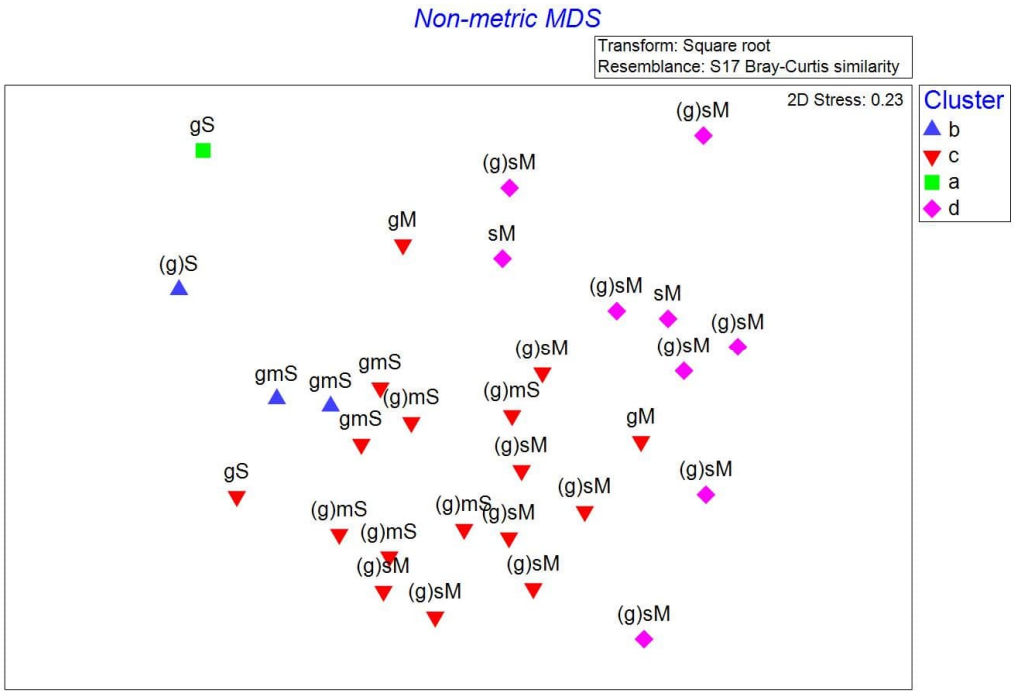

Figure 3-6: nMDS plot of cluster groups with respect to Folk (1954) classification for each sample

se

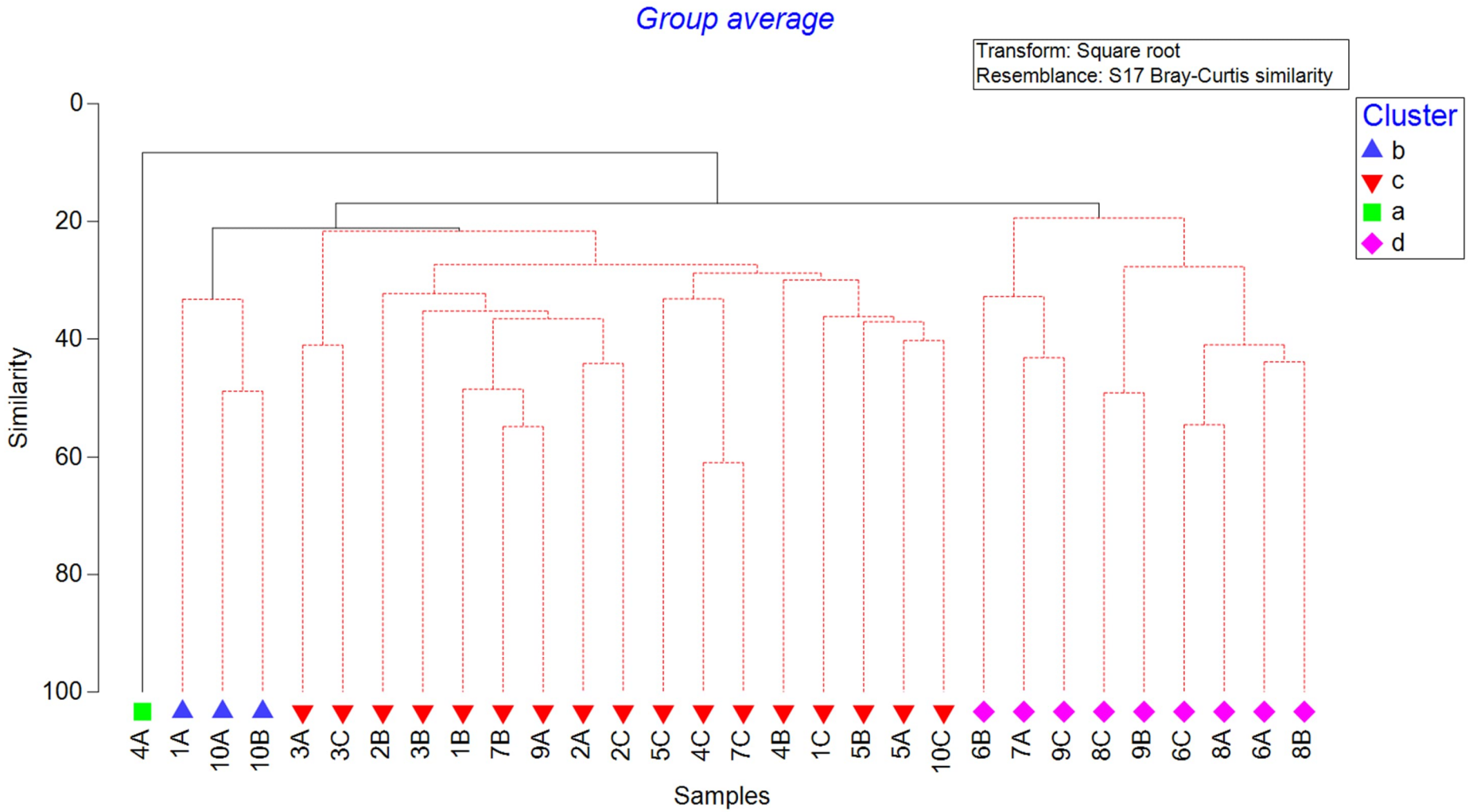

Figure 3-7: Cluster dendrogram of community composition (square root transformed), with results of SIMPROF cluster analysis overlaid

3.3 Biotope Descriptions

The following biotopes and their descriptions were sampled at each station and are based upon the descriptions outlined within the EUNIS habitat classification system (EEA, 2012). All habitats are classified under 'sublittoral sediment,' (A5) which refers to the sediments in the nearshore (i.e. infralittoral, circalittoral) zone down to ~200 m.

The broadscale habitats identified in the study area ranged from 'sublittoral coarse sediment' (A5.1) and 'sublittoral sand' (A5.2) to 'sublittoral mud,' (A5.3) and 'sublittoral mixed sediment' (A5.4). The habitats were further classified as infralittoral or circalittoral, depending on water depth (circalittoral $\geq$ 20 m).

3.3.1 Infralittoral Coarse Sediment (A5.13)

'Infralittoral coarse sediment' (A5.13) was identified during the Phase II surveys within Loch Fyne, where the sediment was composed of predominantly sand with moderate levels of gravel and small amounts of mud.

Stations: G004A and G004B

This biotope is typically found along moderately exposed coasts, such as open coastlines or tide-swept inlets, at depths <10 m. It is typically characterised by coarse sand, gravelly sand, shingle, and gravel, and supports robust communities of polychaetes and cumacean crustaceans.

3.3.2 Infralittoral Muddy Sand (A5.24)

'Infralittoral muddy sand' was (A5.24) was identified during the Phase II surveys within Loch Fyne, where the sediment was composed of predominantly sand with low amounts of mud. This biotope is typically characterised by muddy sand with a 5-20% silt/clay content, up to 15-20 m depth, with communities dominated by polychaetes, bivalves, and the urchin *Echinocardium cordatum*.

Sample: G001A

This station was further classified as '*Fabulina fabula* and *Magelona mirabilis* with venerid bivalves and amphipods in infralittoral compacted fine muddy sand (A5.242). It occurs in stable, fine, compacted sands with slightly muddy contents. Communities are dominated by venerid bivalves, with a prevalence of *Fabulina fabula* and *Magelona mirabilis*. Other taxa may include polychaetes and amphipods.

3.3.3 Infralittoral Sandy Mud (A5.33)

'Infralittoral sandy mud' (A5.35) was identified during the Phase II surveys within Loch Fyne, where the sediment was composed of >20% mud with moderate amounts of sand. This habitat is often found around sheltered bays, inlets, or coasts, with rich communities of polychaetes and tube-building amphipods.

Samples: G001B, G001C, G004C, G005A, G005C

These stations were further classified as '*Nephtys hombergii* and *Macoma balthica* in infralittoral sandy mud' (A5.331; G001B, G001C, G005A, G005C) and '*Capitella capitata* in enriched sublittoral muddy sediments' (A5.336; G004C). A5.331 typically occur in nearshore shallow areas and are characterised by the presence of the polychaete *Nephtys hombergii* and the bivalve *Macoma balhica*. Other prevalent taxa may include *Abra alba, Nucula nitidosa, Spiophane bombyx, Lagis korenia, Echinocardium cordatum*, *Scolopos armiger*, and *Crangon crangon.* A5.336 typically occurs in inlets, embayments, or estuaries, but may also occur in enriched muddy coastal sediments or offshore where there is high organic input. The community is charactarised by *Capitella capitata*, a widely-occurring opportunistic species associated with enriched and polluted sediments. In widely polluted areas it may occur in large numbers, but in less polluted areas, other species may be present such as *Tubificoides, Cirriformia tentaculate, Pygospio elegans,* and *Polydora ciliata*.

3.3.4 Circalittoral Sandy Mud (A5.35)

'Circalittoral sandy mud' (A5.44) was identified during the Phase II surveys within Loch Fyne, where the sediment was composed of >20% mud in water depths >10 m. It typically occurs in deeper areas of bays and inlets and the community

is typically characterised by seapens and brittlestars, with infaunal assemblages including tube-building polychaetes and deposit feeding bivalves.

Samples: G002A, G003C, G005B, G010A, G010B, G010C

These samples were further classified as '*Amphiura filiformis, Mysella bidentata* and *Abra nitida* in circalittoral sandy mud' (A5.351; G003A, G003B, G006, G007, G009C) and '*Thyasira spp*. and *Nuculoma tenuis* in circalittoral sandy mud' (A5.352; G008, G009A, G009B). A5.351 typically occurs off exposed coasts and with weak tidal streams in moderately deep waters, and is characterised by super abundant assemblages *Amphiura filiformis, Mysella bidentata* and *Abra nitida.* A5.352 typically exhibits small quantities of gravel and occur of sheltered and moderately exposed coasts, charactarised by *Thyasira spp., Nuculoma tenuis*, and *Goniada maculate,* as well as *Rhodine gracilior, Mysella bidentata, Abra alba, Harpinia antennaria,* and *Amphiura filiformis* in some areas.

3.3.5 Infralittoral Mixed Sediment (A5.43)

'Infralittoral mixed sediment' (A5.43) was identified during the Phase II surveys within Loch Fyne, where the sediment types are mixed, possibly including muddy gravelly sands or mosaics of shells, cobbles, and pebbles. The wide ranging sediment types indicate that a wide range of communities may be present.

Samples: G002, G005B, G010

These samples were further classified as '*Venerupis senegalensis*, *Amphipholis squamata* and *Apseudes latreilli* in infralittoral mixed sediment' (A5.433). This biotope typically exhibits a mixture of muddy, sandy, gravelly, and pebbly sediments, and occurs in sheltered marine inlets, estuaries or embayments, at a range of depths from 5-30 m. It supports large populations of the pullet carpet shell Venerupis senegalensis with the brittlestar Amphipholis squamata and the tanaid Apseudes latreilli.

3.3.6 Circalittoral Mixed Sediment (A5.44)

'Circalittoral mixed sediment' (A5.44) was identified during the Phase II surveys within Loch Fyne, where the sediment types are mixed, possibly including muddy gravelly sands or mosaics of shells, cobbles, and pebbles, occurring at depths >15-20 m. Due to the variable nature of the seabed, a variety of diverse communities can develop.

Samples: G003C

This sample was further classified as 'sparse *Modiolus modiolus*, dense *Cerianthus lloydii* and burrowing holothurians on sheltered circalittoral stones and mixed sediment' (A5.442). It is characterised by pebbles and cobbles on mud or muddy gravel, often occurring in sea lochs. It supports large numbers of burrowing holothurians, the species of which vary. This biotope is well established in the Clyde and southwest Scottish sea lochs.

3.4 Priority Habitat, Species and INNS

Whilst the biotopes mentioned above all may occur as part of the Annex I habitat, 'sandbanks which are slightly covered by sea water all the time,' they are conditional upon the presence of sandbanks. No sandbanks were identified during these surveys and thus do not fall under this designation. However, the drop-down camera (DDC) survey identified most of the survey area to be 'burrowed mud,' a Priority Marine Feature (PMF). This was largely expected as the upper Loch Fyne is a Marine Protected Area (MPA) designated for the presence of burrowed mud habitats. Another PMF 'Kelp and Seaweed Communities on Sublittoral Sediment' was also identified along seven transects of the DDC survey. No species considered to be PMFs were identified in the grab samples though this sampling was targeted to areas where sensitive species were not observed.

The firework anemone *Pachycerianthus multiplicatus* was the only PMF species observed during the DDC survey. It was seen in images along transects T_005, T_008, T_009, T_010 and T_011. A total of eight individuals were observed, with mean densities ranging from 0.16 to 0.44 individuals m^{-2} at the stations in which they were observed. No individuals were recorded in the grab samples.

Annex I stony reefs were observed along transects T_002, T_003, T_005, T_009, T_010 and T_011, which is largely accounted for by an area of reef in the centre of the survey area.

No invasive non-native species (INNS) were observed in the DDC or the grab samples.

4. Discussion

The results of the subtidal survey indicate that the study area can be divided into four different broadscale habitat types. The majority of the study area was classified as 'mud and sandy mud' (A5.3), which was observed at all sites except G002, nor was it observed at the samples closest to shore. Much of the remaining samples were comprised of 'mixed sediments' (A5.4), which also occurred at some of the nearshore, mid-depth sites. The remaining samples were classified as 'sand and sandy mud' (A5.2) and 'coarse sediment' (A5.1), which occurred in the samples closest to shore, with the coarse sediments occurring at the shallowest depth.

These broadscale habitats were further classified into different biotopes, generally determined by slight differences in sediment composition and differences in the diversity and abundance of three main faunal groups: polychaetes, bivalve molluscs and brittlestars. These biotopes are as follows:

- Bivalve mollusc and/or polychaete dominated communities:
    - '*Fabulina fabula* and *Magelona mirabilis* with venerid bivalves and amphipods in infralittoral compacted fine muddy sand' (A5.242);
    - '*Nephtys hombergii* and *Macoma balthica* in infralittoral sandy mud' (A5.331);
    - '*Thyasira spp.* and *Nuculoma tenuis* in circalittoral sandy mud' (A5.352);
    - *Venerupis senegalensis, Amphipholis squamata* and *Apseudes latreilli* in infralittoral mixed sediment' (A5.433)
- Polychaete dominated communities:
    - '*Capitella capitata* in enriched sublittoral muddy sediments' (A5.336)
- Communities with high abundance of brittle stars:
    - '*Amphiura filiformis, Mysella bidentata* and *Abra nitida* in circalittoral sandy mud' (A5.351); and
- A mixed community with a high abundance of burrowing holothurians:
    - 'sparse *Modiolus modiolus*, dense *Cerianthus lloydii* and burrowing holothurians on sheltered circalittoral stones and mixed sediment' (A5.442).

The grab sample biotopes largely matched the biotopes identified by the DDC survey, with the only discrepancy observed for the biotope 'infralittoral course sediment' (A5.13). DDC surveys at these sites observed 'kelp and seaweed communities on sublittoral sediment' (A5.52).

Of the above biotopes identified, several have also been classed as Habitats of Principal Importance (HPI) under Section 41 of the NERC Act 2006. 'infralittoral course sediment' (A5.13) and 'infralittoral compacted fine muddy sand' (A5.242) are included under 'subtidal sands and gravels,' '*Amphiura filiformis*, *Mysella bidentata* and *Abra nitida* in circalittoral sandy mud' (A5.351) and '*Thyasira* spp. and *Nuculoma tenuis* in circalittoral sandy mud' (A5.352) are included as 'mud habitats in deep water,' and '*Venerupis senegalensis*, *Amphipholis squamata* and *Apseudes latreilli* in infralittoral mixed sediment' (A5.433) may occur as part of the HPI 'sheltered muddy gravels.' Furthermore, all broadscale habitats which these biotopes represent, may occur as part of the Annex I habitats (as per the EU Habitats Directive) 'sandbanks which are slightly covered by sea water all the time,' although this is dependent on the presence of a sandbank feature.

In addition to the grab sampling, DDC surveys were conducted along transects in the study area, and observed the PMFs 'burrowed mud' and 'kelp and seaweed communities on sublittoral sediment.' Low and medium stony Annex I reefs were also observed. DDC surveys also observed low numbers of another PMF, the fireworks anemone *Pachycerianthus multiplicatus,* although this species was not recorded in any of the grab samples.

Multivariate analysis determined that the grouping of the benthic communities within the study area can be explained in part by the sediment classification of the samples, in particular the percent sediment content of gravel and mud. Physical environmental factors, such as general circulation, tidal currents and wave exposure play an important part in determining the local nature of sediments via the processes of siltation and erosion, though biotic

factors such as inhabiting species which stabilise the sediment are also important (Thrush, 1991). There appears to be some zonation in the samples, with the deepest and furthest sites from shore exhibiting the greatest proportions of mud and sites closest to shore exhibiting the greatest proportions of gravel.

The sediment particle distribution can also determine the favourability of a particular environment to certain species (Dauvin *et al.,* 2004). Therefore, to a certain extent, the differences seen in the faunal community at sites G006, G008, and G009 can be attributed to the higher content of mud and sample G004A can be attributed to the higher content of gravel. Much of the remaining sites had a range of sediment classification that did not align with the macrofaunal clusters.

5. Conclusion

The subtidal benthic survey was undertaken as part of the Balliemeanoch PSH Scheme in December 2021, sampling the area adjacent to the proposed jetty construction in Loch Fyne to highlight key benthic receptors that may be affected by the Development. Within this area is a range of biotopes and habitats, a summary of the findings of this survey is provided below:

- The subtidal survey revealed that the study area can be divided into four broad-scale habitats: coarse sediment (A5.1), sand and muddy sand (A5.2), mud and sandy mud (A5.3), and mixed sediment (A5.4).
- Some zonation in the sediment composition was observed, with the greatest percentages of gravel occurring at sites nearest the shore, and sites with the greatest percentages of mud occurring deepest and furthest from shore.
- The primary biotope observed was '*Amphiura filiformis, Mysella bidentata* and *Abra nitida* in circalittoral sandy mud' (A5.351).
- Several biotopes classify as Habitats of Principal Importance (HPI) under Section 41 of the NERC Act 2006, and are included under 'subtidal sands and gravels, 'mud habitats in deep water,' and 'sheltered muddy gravels.'
- All biotopes are also included as Annex I habitats and may occur under the classification 'sandbanks which are slightly covered by sea water all the time,' however, this is dependent on the presence of sandbanks which were not assessed in the scope of this study.
- No PMFs or INNS were observed in the grab sampling, but supplementary DDC surveys observed the PMFs 'burrowed mud' and 'kelp and seaweed communities on sublittoral sediment,' as well as fireworks anemones. Annex I reef habitats (low and medium rocky reefs) were also observed in the DDC surveys.

6. References

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