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# Benthic Ecology Validation Survey Report

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**Table of Contents**

## Acronyms

| Acronym | Definition |
|---|---|
| BIIGLE | Bio-Image Indexing and Graphical Labelling Environment |
| DDV | Drop Down Video |
| EIA | Environmental Impact Assessment |
| EUNIS | European University Information Systems |
| HD | High Definition |
| HRA | Habitats Regulations Appraisal |
| JNCC | Joint Nature Conservation Committee |
| MCA | Maritime and Coastguard Agency |
| MDS | Multi-dimensional scaling |
| MP | Mega Pixel |
| MPA | Marine Protected Area |
| MS-LOT | Marine Scotland Licensing Operations Team |
| NMBAQC | North Atlantic Marine Biological Analytical Quality Control |
| NMPI | National Marine Plan Interactive Maps |
| OSP | Offshore Substation Platforms |
| OSPAR | Convention for the Protection of the Marine Environment of the North-East Atlantic |
| OTA | Offshore Transmission Assets |
| OWF | Offshore Wind Farm |
| PMF | Priority Marine Feature |
| PSA | Particle Size Analysis |
| RSMP | Regional Seabed Monitoring Programme |
| SIMPER | Similarity Percentage |
| SIMPROF | Similarity Profile |

| | |
|---|---|
| SWEL | Seagreen Wind Energy Limited |
| UKBAP | United Kingdom Biodiversity Action Plan |
| WTG | Wind Turbine Generators |

# 1. Introduction

## 1.1 Project Background

Seagreen Alpha and Seagreen Bravo Offshore Wind Farms (OWFs) and the associated Offshore Transmission Assets (OTA) are being constructed together as one development (collectively referred to as 'the Seagreen Project'). The consented Seagreen Project consists of 150 wind turbine generators (WTG) and associated array cables, two offshore substations platforms (OSPs) and three export cables which will transport energy generated from the consented project to the landfall at Carnoustie on the Angus coast. To maximise energy generation and facilitate full export capacity for the Seagreen Project, Seagreen Wind Energy Limited (SWEL) is proposing to construct an additional export cable corridor from the consented Seagreen Project Area to an identified landfall location. In February 2020, SWEL received a grid offer from National Grid for the Cockenzie substation in East Lothian and this was accepted by Seagreen in June 2020. This infrastructure comprises the Seagreen 1A project.

A Marine Licence application for the Seagreen 1A project was submitted to Marine Scotland Licensing Operations Team (MS-LOT) on 05 March 2021 with an accompanying Environmental Appraisal and Habitats Regulations Appraisal (HRA) Report. The Environmental Appraisal included a description of the existing benthic ecology baseline from existing desktop data sources in the vicinity of the Seagreen 1A export cable corridor. SWEL has since undertaken a benthic validation survey of the Seagreen 1A export cable corridor in order to validate the benthic ecology baseline characterisation which is presented within the Environmental Appraisal document for Seagreen 1A. The results of this survey are presented within this Benthic Validation Survey Report which presents the validation of the baseline characterisation and is structured as follows:

- Section 1: Introduction
- Section 2: Methods
- Section 3: Summary of Desktop Review
- Section 4: Results
- Section 5: Final Biotopes
- Section 6: Discussion

**Project Location**

The Seagreen 1A export cable corridor route runs from the south western boundary of the Seagreen 1A array area, approximately 27 km from the Angus coastline, along the eastern boundary of the Inch Cape OWF, along the western boundary and slightly overlapping with Seagreen Berwick and Marr Bank OWF then broadly follows the Inch Cape export cable route, around the western boundary of Neart Na Gaoithe OWF, before making landfall at Cockenzie, on the East Lothian coast (Figure 1.1).

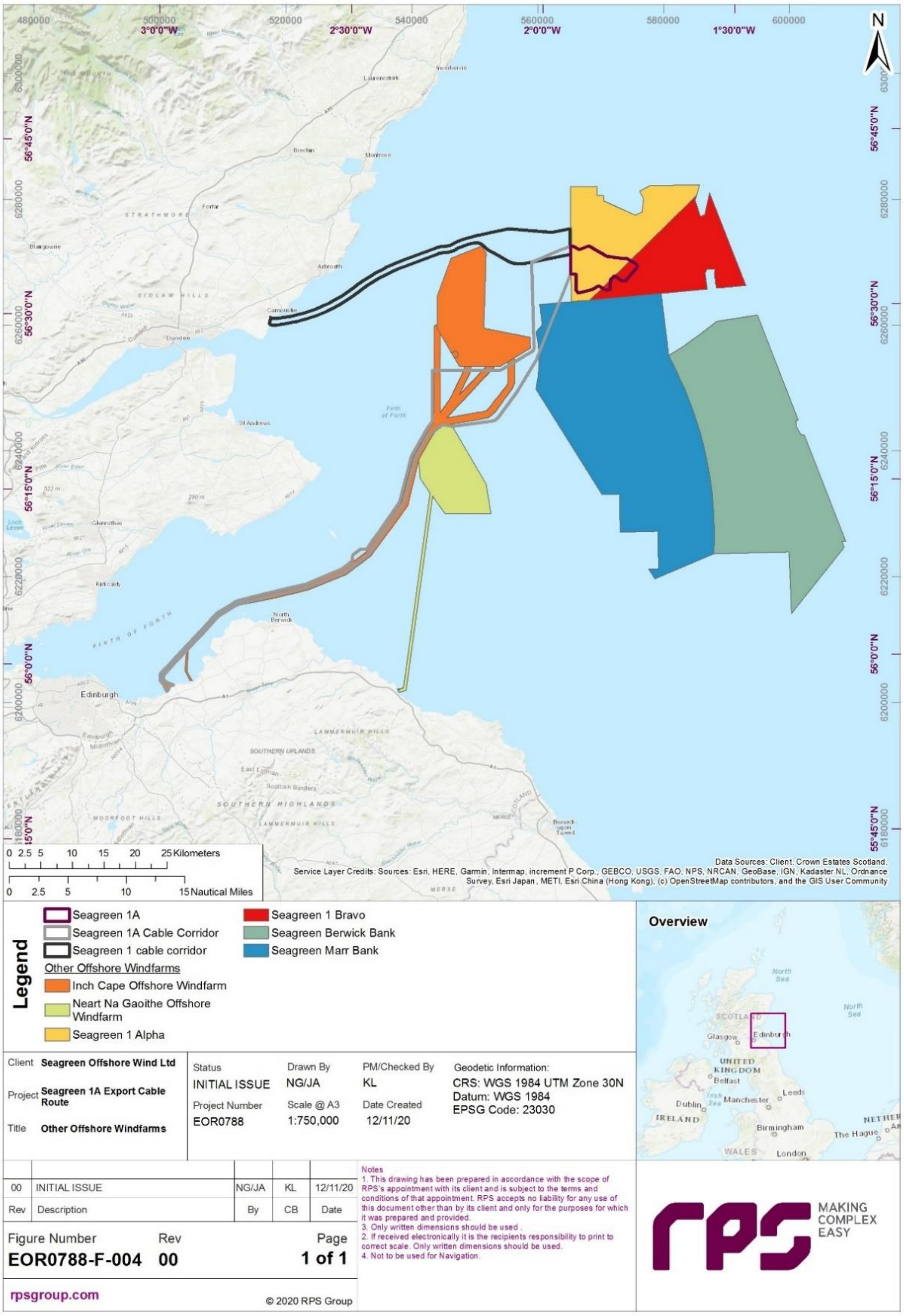



Figure 1.1: Seagreen 1A site boundaries

## 1.2 Aims and Objectives

The Seagreen 1A export cable corridor survey data has been analysed within this Benthic Validation Survey Report in order to:

- Validate the existing baseline by confirming habitats and biotopes along the export cable corridor;
- Determine whether the benthic communities have changed since the historical desk top baseline data was collected; and
- Provide up-to-date data to increase confidence in predictions made within the Environmental Appraisal.

# 2. Methodology

## 2.1 Desktop Review

There are considerable desktop benthic ecology data sources available for the Seagreen 1A export cable corridor, from a variety of site specific surveys and broadscale habitat mapping (Figure 2.1). These desktop data sources and reports provide the basis of the baseline characterisation presented within the Environmental Appraisal that accompany the Marine Licence application for the Seagreen 1A project. The results of the site specific survey, as detailed in this Benthic Validation Survey Report will be used to validate the existing baseline presented using these desk top data and sources.

The key sources (i.e. data and reports) used to inform the baseline characterisation of the Seagreen 1A export cable corridor are summarised in Table 2.1 below. The key datasets are summarised in section 3, and this summary was used to inform the survey specification which is described in the following sections.

Table 2.1: Summary of key data sources.

| Title | Author | Year | Source |
|---|---|---|---|
| The Marine Scotland National Marine Plan Interactive (NMPI) maps | N/A | 2021 | NMPI |
| Predicted European University Information Systems (EUNIS) habitats from the EUSeaMap 2019 | N/A | 2019 | EUNIS |
| A big data approach to macrofaunal baseline assessment, monitoring and sustainable exploitation of the seabed. | K.M. Cooper and J. Barry | 2017 | Scientific Journal- Science Report vol 7 article no. 12431. |
| Biotope Assignment of Grab Samples from Four Surveys Undertaken in 2011 Across Scotland's Seas | Pearce, B., Grubb, L., Earnshaw, S., Pitts, J. and Goodchild, R. | 2014 | JNCC |
| Inch Cape Benthic Ecology Baseline Offshore Export Cable Corridor Technical Report, Volume 2D, Appendix 12C | Inch Cape Offshore Limited | 2013 | Inch Cape Offshore Limited |

| Title | Author | Year | Source |
|---|---|---|---|
| Seagreen Environmental Impact Statement. Volume 1, Chapter 11 Benthic Ecology and Intertidal Ecology | Seagreen | 2012 | SWEL |
| Inch Cape Offshore Environmental Statement, Volume 1B: Biological Environment, Chapter 12 Benthic Ecology | Inch Cape Offshore Limited | 2011 | Inch Cape Offshore Limited |
| Neart na Gaoithe Proposed Offshore Wind Farm Benthic Ecology Characterisation Survey. A Report for: Neart na Gaoithe Offshore Wind Ltd. Report No: 09/J/1/03/1483/0943 | EMU | 2010 | Neart na Gaoithe Offshore Limited |

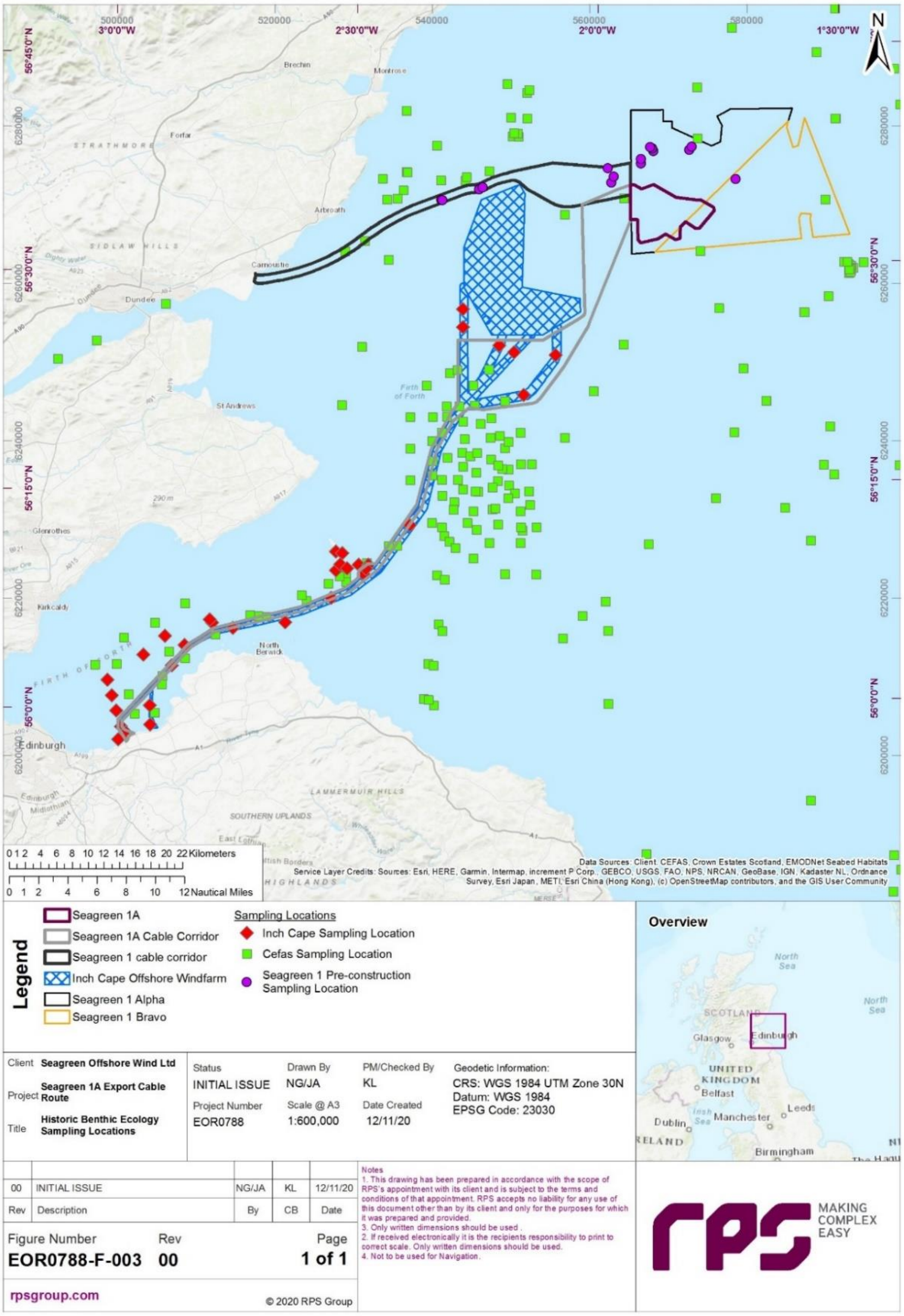



Figure 2.1: Historic benthic sampling locations relevant to Seagreen 1A

## 2.2 Site-Specific Survey

### 2.2.1 Benthic Validation Survey Design

Following initial review of the existing datasets, the Seagreen 1A export cable corridor was subdivided into three section for the purposes of the benthic validation survey: offshore section, mid-section and inshore section. The proposed sampling strategy was designed to adequately sample each of these areas to validate the baseline characterisation and to provide up-to-date data to increase confidence in the assessment conclusions within the Environmental Appraisal for Seagreen 1A. The broad principles behind the benthic validation survey were:

- Ensure adequate coverage across the Seagreen 1A export cable corridor, and subdivisions as outlined above;
- Ensure representative sampling across the broadscale sediment types as indicated by the desktop data sources; and
- Ensure sampling of any potential geogenic or biogenic reef features to allow for assessment according to relevant guidelines.

Based on the principles outlined above, the benthic subtidal sampling strategy for Seagreen 1A comprised 35 combined drop down video (DDV) and 0.1 $m^2$ Hamon grab sampling locations to ensure adequate data coverage for both infaunal and epifaunal communities at each location. A total of 12 combined DDV/grab locations were proposed in the offshore section, 10 in the mid-section and 13 in the inshore section of the Seagreen 1A export cable corridor. Ten of the combined grab/DDV sampling locations were proposed within the boundaries of the Firth of Forth Banks Complex Marine Protected Area (MPA) (Figure 2.2).

This survey design was discussed and agreed with MS-LOT, Marine Scotland Science and NatureScot during a meeting (18 November 2020) and subsequent email correspondence (2 December 2020).

The Seagreen 1A benthic validation survey was undertaken by Ocean Ecology Ltd in December 2020. All sampling was conducted aboard the 26 m Maritime and Coastguard Agency (MCA) category 1 coded survey vessel '*DVS Curtis Marshall*'. The vessel mobilised from Hartlepool, on the east coast of England, and operated on a 24-hour operations basis. It also operated from Montrose in the latter stages of the survey owing adverse weather conditions.

### 2.2.2 Grab Sampling

A single 0.1 $m^2$ grab sample was collected from 23 of the 35 sample stations (Figure 2.2 and Table 2.2; see section 2.2.4 for survey limitations, including unsuccessful sampling) using a mini-Hamon grab for macrofaunal analysis and for characterisation of the physical nature of the substrate (particle size analysis (PSA)). The collection and processing of all grab samples was undertaken in consideration of version 8 of the Regional Seabed Monitoring Programme (RSMP) protocol (Cooper and Mason, 2019). Initial processing of all mini-Hamon grab samples was undertaken aboard the survey vessel in line with the following methodology:

- Assessment of sample size and acceptability made upon retrieval of the grab;

- Photograph of sample with station details and scale bar taken;
- 10% of sample removed for subsequent PSA analysis and transferred to labelled container;
- Sample emptied onto 1 mm sieve net laid over 4 mm sieve table and washed through using gentle rinsing with seawater hose;
- Remaining sample for sorting and identification backwashed into a suitably sized sample container using seawater and diluted 10% formalin solution added to fix sample prior to laboratory analysis; and
- Sample containers clearly labelled internally and externally with date, sample identification and project name.

#### 2.2.3 Drop Down Video

DDV was undertaken at 24 of the 35 sample stations, this included DDV completed at station 3 where grab sampling was not carried out (Figure 2.2). Seabed imagery (simultaneous video and stills) was collected using two high-definition optical camera systems. The majority of the nearshore and some of the offshore imagery was collected using Ocean Ecology Limited's ROVTech subsea camera system providing 1080p High Definition (HD) video and 20 Megapixel (MP) stills imagery. Lighting from two LED strip lamps and two lasers separated by 10 cm were projected into the field of view for illumination and scaling. Seabed imagery at the deeper water stations in the mid-section of the Seagreen 1A export cable corridor were collected using a Subsea Technology and Rentals Seaspyder-HD Drop Camera System, providing 1080p HD video and 18 MP stills imagery.

All DDV stations were sampled in line with the Joint Nature Conservation Committee (JNCC) epibiota remote monitoring operational guidelines (Hitchin *et al.*, 2015). DDV sampling were undertaken at each location prior to any proposed grab sampling. This is in line with relevant guidance notes (Limpenny *et al.*, 2010) that state that grab samples are to be avoided in areas where Annex I habitat features, (e.g. biogenic reefs such as *Sabellaria* reef, mussel beds/reef and/or geogenic reefs), might be present in order to avoid unnecessary damage to such features.

A minimum of five images were taken from each DDV station along with approximately five minutes of video. Between images, the camera was moved several metres to ensure a good overview of the station was obtained and any heterogeneity in the substrate was identified. All video footage was reviewed *in situ* by the lead marine ecologist.

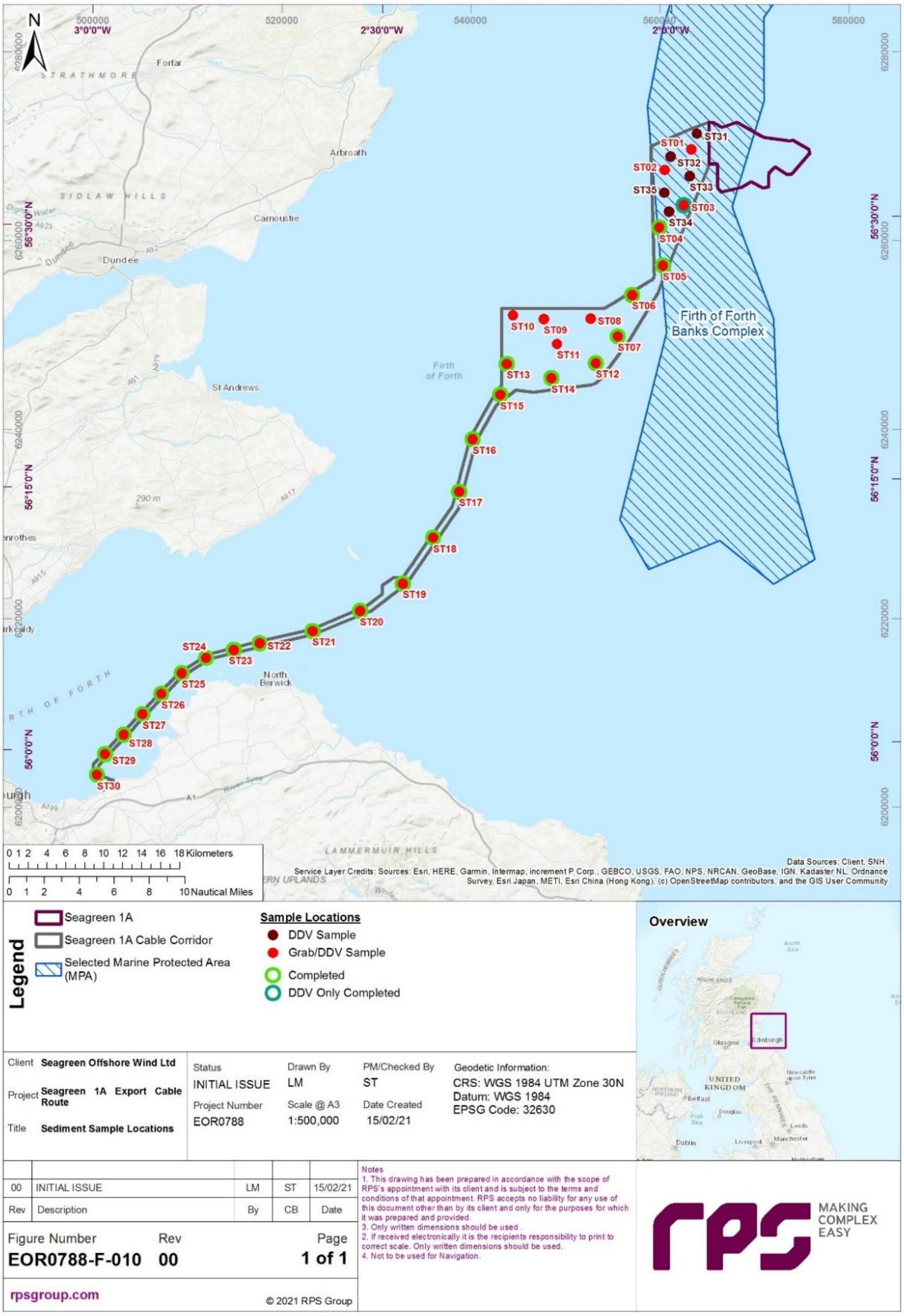



Figure 2.2: Proposed and completed sample locations for the Seagreen 1A export cable corridor benthic validation survey.

Table 2.2: Table of target and actual sample station locations.

| Sampling station | Export Cable Corridor Section | Firth of Forth Banks MPA | Target sample location | | Actual sample location | |
|---|---|---|---|---|---|---|
| | | | Lat_WGS84 | Long_WGS84 | Lat_WGS84 | Long_WGS84 |
| ST01 | Offshore | Y | 56° 34' 2.362" N | 1° 58' 9.345" W | Not sampled | Not sampled |
| ST02 | Offshore | Y | 56° 32' 38.395" N | 2° 1' 29.144" W | Not sampled | Not sampled |
| ST03 | Offshore | Y | 56° 30' 51.303" N | 1° 59' 0.971" W | 56° 30' 51.303152" N<br>DDV only | 1° 59' 0.970813" W<br>DDV only |
| ST04 | Offshore | Y | 56° 29' 35.521" N | 2° 1' 35.772" W | 56° 29' 35.287081" N | 2° 1' 35.893301" W |
| ST05 | Offshore | Y | 56° 27' 24.856" N | 2° 1' 15.931" W | 56° 27' 25.080041" N | 2° 1' 16.362483" W |
| ST06 | Offshore | N | 56° 25' 46.195" N | 2° 4' 28.219" W | 56° 25' 46.124868" N | 2° 4' 27.615950" W |
| ST07 | Offshore | N | 56° 23' 24.613" N | 2° 6' 1.746" W | 56° 23' 24.443524" N | 2° 6' 1.686802" W |
| ST08 | Offshore | N | 56° 24' 27.409" N | 2° 8' 48.516" W | Not sampled | Not sampled |
| ST09 | Offshore | N | 56° 24' 26.998" N | 2° 13' 35.766" W | Not sampled | Not sampled |
| ST10 | Offshore | N | 56° 24' 40.821" N | 2° 16' 44.811" W | Not sampled | Not sampled |
| ST11 | Offshore | N | 56° 23' 1.137" N | 2° 12' 16.287" W | Not sampled | Not sampled |
| ST12 | Offshore | N | 56° 21' 54.020" N | 2° 8' 19.564" W | 56° 21' 53.726131" N | 2° 8' 19.370553" W |
| ST13 | Mid-section | N | 56° 21' 54.072" N | 2° 17' 28.462" W | 56° 21' 54.620193" N | 2° 17' 28.158790" W |
| ST14 | Mid-section | N | 56° 21' 3.626" N | 2° 12' 51.967" W | 56° 21' 3.930250" N | 2° 12' 52.646963" W |
| ST15 | Mid-section | N | 56° 20' 8.184" N | 2° 18' 8.942" W | 56° 20' 8.359958" N | 2° 18' 8.841500" W |
| ST16 | Mid-section | N | 56° 17' 37.759" N | 2° 21' 2.756" W | 56° 17' 37.671959" N | 2° 21' 2.982385" W |
| ST17 | Mid-section | N | 56° 14' 38.616" N | 2° 22' 30.532" W | 56° 14' 38.364882" N | 2° 22' 29.930598" W |
| ST18 | Mid-section | N | 56° 12' 1.191" N | 2° 25' 11.397" W | 56° 12' 1.030417" N | 2° 25' 11.720646" W |
| ST19 | Mid-section | N | 56° 9' 25.746" N | 2° 28' 18.703" W | 56° 9' 25.522109" N | 2° 28' 19.205706" W |
| ST20 | Mid-section | N | 56° 7' 53.005" N | 2° 32' 42.667" W | 56° 7' 53.012029" N | 2° 32' 43.589534" W |

| Sampling station | Export Cable Corridor Section | Firth of Forth Banks MPA | Target sample location | | Actual sample location | |
|---|---|---|---|---|---|---|
| | | | Lat_WGS84 | Long_WGS84 | Lat_WGS84 | Long_WGS84 |
| ST21 | Mid-section | N | 56° 6' 45.107" N | 2° 37' 34.562" W | 56° 6' 44.483226" N | 2° 37' 34.718932" W |
| ST22 | Mid-section | N | 56° 6' 4.009" N | 2° 42' 59.237" W | 56° 6' 4.002781" N | 2° 42' 59.333137" W |
| ST23 | Inshore | N | 56° 5' 41.399" N | 2° 45' 37.957" W | 56° 5' 41.536681" N | 2° 45' 37.764685" W |
| ST24 | Inshore | N | 56° 5' 14.065" N | 2° 48' 25.461" W | 56° 5' 14.460077" N | 2° 48' 25.798788" W |
| ST25 | Inshore | N | 56° 4' 22.336" N | 2° 50' 54.985" W | 56° 4' 22.138307" N | 2° 50' 55.327840" W |
| ST26 | Inshore | N | 56° 3' 10.943" N | 2° 53' 0.351" W | 56° 3' 10.723144" N | 2° 53' 0.756346" W |
| ST27 | Inshore | N | 56° 2' 1.432" N | 2° 54' 56.623" W | 56° 2' 1.270873" N | 2° 54' 56.827808" W |
| ST28 | Inshore | N | 56° 0' 52.801" N | 2° 56' 51.314" W | 56° 0' 52.380981" N | 2° 56' 51.799284" W |
| ST29 | Inshore | N | 55° 59' 44.350" N | 2° 58' 45.637" W | 55° 59' 44.319189" N | 2° 58' 45.318335" W |
| ST30 | Inshore | N | 55° 58' 33.716" N | 2° 59' 35.105" W | 55° 58' 33.736724" N | 2° 59' 34.542360" W |
| ST31 | Offshore (DDV only) | N | 56° 34' 55.228558" N | 1° 57' 34.125573" W | Not sampled | Not sampled |
| ST32 | Offshore (DDV only) | N | 56° 33' 38.393999" N | 2° 0' 19.152001" W | Not sampled | Not sampled |
| ST33 | Offshore (DDV only) | N | 56° 32' 30.692401" N | 1° 58' 22.421999" W | Not sampled | Not sampled |
| ST34 | Offshore (DDV only) | N | 56° 30' 29.808001" N | 2° 0' 33.379203" W | Not sampled | Not sampled |
| ST35 | Offshore (DDV only) | N | 56° 31' 34.111914" N | 2° 1' 1.252559" W | Not sampled | Not sampled |

### 2.2.4 Survey Limitations

As discussed in section 2.2, 24 of the 35 combined grab/DDV stations were successfully sampled during the Seagreen 1A benthic validation survey and one station was sampled using DDV only (ST03). The survey was terminated early due to unsafe weather conditions creating a large amount of downtime. A total of 6 combined DDV/grab sample stations and 5 DDV sample stations across the Seagreen 1A export cable corridor were not sampled, and a grab sample was not collected at station ST03 (see Table 2.2). SWEL are proposing to undertake a further infill survey to sample the stations missed in this survey.

### 2.2.5 Sample Analysis

**Benthic Infaunal Analysis**

Sediment samples for benthic infaunal analysis were processed through a 1 mm sieve and the retained material transferred to an appropriate container and preserved immediately in 4% buffered saline formalin solution. The samples were analysed at Ocean Ecology's benthic laboratory which participates in the North Atlantic Marine Biological Analytical Quality Control Scheme (NMBAQC scheme) for identification (to species level), enumeration and biomass determination. Biomass of the infaunal component was recorded from the blotted wet weights, in grams (g). The retained infauna was separated into the following phyla: *Polychaeta*; *Crustacea*; *Echinodermata*; *Mollusca*; and Others.

The epifaunal component of each sample was analysed separately with identification to species level. Where possible each component was enumerated and presented as discrete counts or in the case of colonies, recorded as present and given a P (present) value.

**PSA Analysis**

Sediment samples were analysed for particle size distribution at Ocean Ecology's benthic laboratory. Representative sub-samples of each sediment sample were oven dried to a constant weight and sieved through a series of mesh apertures over the range 64 mm to 63 µm (0.063 mm) on the Wentworth scale. The weight of the sediment fraction retained on each mesh was measured and recorded. This method was in accordance with NMBAQC Best Practice Guidelines (Mason, 2016). Laser diffraction techniques were also used for samples where sediments of less than 63 µm accounted for more than 5% by weight of the sample.

**DDV Analysis**

All images were reviewed by Ocean Ecology's Environmental Scientists *in situ* to ensure there was a minimum of 10 representative images per station. Any stations that did not fit these criteria were revisited to obtain more imagery. Digital photographic stills and video footage were successfully obtained along all transects and subsequently analysed to aid in the identification and delineation of EUNIS habitats and potential Annex I habitats. Seabed images were enhanced prior to analysis using the open-source image editing software GNU Image Manipulation Program (www.gimp.org). All seabed imagery analysis was undertaken using the Bio-Image Indexing and Graphical Labelling Environment (BIIGLE[1]) annotation platform (Langenkämper *et al*., 2017) and in line with JNCC epibiota remote monitoring interpretation guidelines (Turner *et al*., 2016).

[1] https://www.biigle.de/

Analysis of still images was undertaken in two stages. The first stage, “Tier 1”, consisted of labels that referred to the whole image being assigned, providing appropriate metadata for the image. The second stage, “Tier 2”, was used to assign percentage cover of ‘reef’ types by drawing polygons to inform the habitat assessment process. This analysis produced a list of discrete taxa identified and their abundance (number of individuals), or percentage cover for colonial organisms, within each image at each sample station. It also identified burrows, grouping them into size categories to give number and size of burrows per image at each sample station, this is discussed further in section 2.3.2.4.

## 2.3 Data Analysis

### 2.3.1 Sediment Characteristics Analysis

The PSA data were categorised using the Modified Folk classification which groups particles into mud, sand and gravel (mud <63 µm = mud; sand <2 mm; gravel >2 mm) and the relative proportion of each used to ascribe the sediment to one of 15 classes (e.g. slightly gravelly sand, muddy sand etc.) (Long, 2006). These classifications were then used to describe the data in the analysis. Proportions of mud, sand and gravel, as well as the Folk and Ward sorting coefficient, were also used to describe the sediment data. The Folk and Ward sorting coefficient describes the extent of deviation from lognormality of the particle size distribution (i.e. the variation in particle size with a sample).

### 2.3.2 Macrofaunal Analysis

#### Summary and Univariate Analysis

The benthic infaunal data were summarised to highlight the number of individuals and number of taxa recorded. Analysis was also undertaken to identify the dominance of the major taxonomic groups, the percentage contribution of each taxa group to the total number of taxa and to the total number of individuals. The discussion and analysis of the faunal community was made using the adult only dataset to avoid skewing the results with the abundant but largely ephemeral juvenile taxa.

A number of univariate indices were calculated to further describe the infaunal data, including: S = number of species; N = abundance; B = Biomass (wet weight in grams); d = Margalef’s index of Richness; J’ = Pielou’s Evenness index; H’ = Shannon-Wiener Diversity index; $\lambda$ = Simpson’s Dominance index for each Faunal group.

#### 2.3.2.1 Multivariate Community Analysis

The adult only benthic infaunal community structure was analysed using the PRIMER v6 software (Clarke and Gorley, 2006). However, the multivariate analysis was also run on the data which included the juvenile data to check for any differences in patterns or groupings. The benthic adult only infaunal dataset was initially square root transformed to down-weight the species with the highest abundances for multivariate community analysis. To determine the relative similarities between stations, the benthic infaunal community structure was investigated using CLUSTER analysis (hierarchical agglomerative clustering). This uses the Bray Curtis similarity coefficient to assess the similarity of sites based on the faunal components. The procedure produces a dendrogram indicating the relationships between sites based on the similarity matrix and uses a Similarity Profile (SIMPROF) test (at a 5% significance level) to test whether the differences between the clusters are significant.

Similarity Percentages (SIMPER) analyses were subsequently undertaken on the infaunal dataset to identify which species best explained the similarity within groups and the dissimilarity between groups identified in the cluster analysis. The similarity matrix was also used to produce a multi-dimensional scaling (MDS) ordination plot which shows, on a two or three-dimensional representation, the relatedness of the communities (at each site) to one another. Full methods for the application of both the hierarchical clustering and the MDS analysis are given in Clarke and Warwick (2001).

The results of the cluster analyses and associated SIMPER were reviewed alongside the raw, untransformed data to assign preliminary biotopes (Connor *et al*., 2004). Using the clusters identified, several sites within a cluster and, where appropriate, several clusters were assigned to a single biotope, where possible, based on relatedness and presence/absence of key indicator species for a particular biotope. Based on the infaunal data the sample stations were assigned a preliminary biotope classification.

#### 2.3.2.2 Seabed Imagery Analysis

The DDV data was analysed to produce average number of individuals or percentage cover for each taxa identified for each sample station. This was then reviewed to describe the species that were of the highest abundance, found at the greatest number of stations and those that were recorded rarely. These species were described alongside the sample station locations to identify any patterns associated with location.

#### 2.3.2.3 Annex I Reef Assessment

As discussed in section 2.2, DDV was deployed prior to the deployment of the grab at every combined grab/DDV sample location in order to determine whether Annex I reef was present and if Annex I reef was present, grab sampling should be avoided. Should Annex I reef have been observed during the DDV sampling then a full Annex I reef assessment would have been undertaken. However, potential Annex I reef was not recorded during any of the DDV sampling and therefore no reef assessment was required.

#### 2.3.2.4 Sea Pen and Burrowing Megafauna Communities Assessment

At stations where burrows sufficiently large enough to indicate the presence of burrowing megafauna were present, an assessment was undertaken to determine whether the OSPAR Sea Pens and Burrowing Megafauna communities habitat was present. As detailed in the JNCC (2014b) clarification document for defining this habitat, the following data is required for this assessment:

- Video and still imagery to confirm burrows and /or mounds and, where present, sea pens;
- Infaunal grab samples to confirm relevant fauna; and
- PSA data to confirm a find mud habitat.

The PSA data from the grab samples were initially analysed to determine if fine mud sediments were present. The DDV data were then analysed to determine which images showed burrows and/or mounds and their locations. The number of burrows within each image were counted, along with the size of the burrows to produce a matrix of burrow density at each location where burrows where identified. This was used to classify the abundance of burrows using the SACFOR scale[2]; burrows are required to be classified as at least frequent on the SACFOR scale for this habitat to be assigned (JNCC, 2014b; Hiscock, 1996). The number of sea pens were also counted within each image to produce a matrix of sea pen density at each location where burrows where identified. This was used to classify the abundance of sea pens using the SACFOR scale. However, the presence of sea pens is not a prerequisite for the classification of this habitat (JNCC, 2014b). Based on the results of the analysis, the of imagery data and PSA data for the presence of sea pens, burrows and fine mud habitat, a conclusion was made as to the presence of the Sea Pens and Burrowing Megafauna communities habitat for each sample station. Based on this and the overall epifaunal data the sample stations were assigned a preliminary biotope classification.

#### 2.3.2.5 Final Biotope Allocations

Preliminary biotopes allocated from the infaunal and epifaunal data were analysed and combined to present a final biotope classification for each sample station. Biotopes were plotted out over the Seagreen 1A export cable corridor to produce a biotope map.

## 3. Desktop Review

There are considerable desktop benthic ecology data sources available for the Seagreen 1A export cable corridor, from a variety of site specific surveys and broadscale habitat mapping (Table 2.1). This section provides a brief overview of the existing datasets that have been used to inform the baseline for the Marine Licence application.

### 3.1 EUSeaMap

The EUSeaMap 2019 data is shown in Figure 3.1 for the Seagreen 1A array area and export cable corridor.

Within the Seagreen 1A array area, the EUSeaMap data indicate that the sediments are dominated by deep circalittoral coarse sediments, with smaller areas of deep circalittoral sand and deep circalittoral mud along the southern boundary. The offshore sections of the export cable corridor (i.e. those sections around the Inch Cape array area) are characterised almost entirely by deep circalittoral coarse sediments and deep circalittoral sand, with sand becoming more dominant further south along the export cable corridor, grading into circalittoral mud in the mid sections (i.e. south of the Inch Cape array). The mid sections of the

[2] SACFOR classification scale, S=Superabundant, A=Abundant, C=Common, F=Frequent, O=Ocasional and R=Rare.

export cable corridor are dominated by deep circalittoral mud, with the exception of the areas close to the Isle of May, where rocky areas (Faunal communities on deep, low energy circalittoral rock) are present. According to the EUSeaMap data, the inshore areas of the export cable corridor are characterised by circalittoral sandy mud and circalittoral mixed sediment (Figure 3.1).

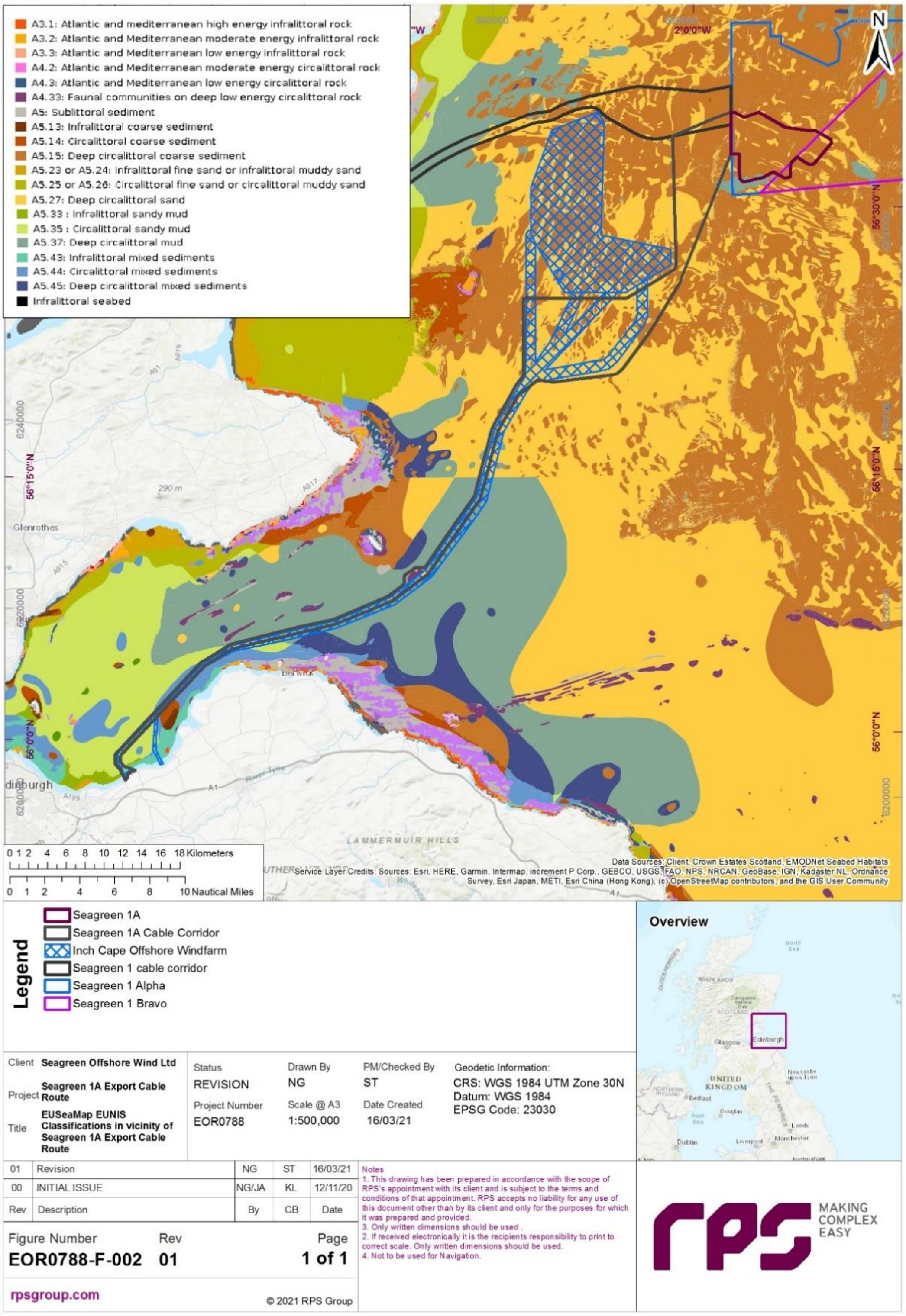



Figure 3.1 Predicted EUNIS Habitats from the EUSeaMap 2019 for the Seagreen 1A export cable corridor.

### 3.2 Seagreen Alpha and Bravo OWF Survey Data

The Environmental Impact Assessment (EIA) benthic characterisation for Seagreen Alpha and Seagreen Bravo offshore find farms (located immediately to the north-east of Seagreen 1A export cable (Figure 1.1) was based on the results of site-specific surveys undertaken by Seagreen in 2011. These comprised infaunal grab sampling, beam trawl sampling and DDV sampling. The sediments present across the Seagreen Alpha OWF site ranged from cobbles with sand and gravelly sand in the west, to sandy gravel in the east. There was a greater predominance of fine sediments recorded across Seagreen Bravo OWF compared with Seagreen Alpha OWF with sediments ranging from slightly gravelly sand in the west, sandy gravel in the central section and gravelly sand in the east of the Seagreen Bravo OWF (Seagreen, 2012).

The biological habitats mapped for the EIA characterisation can be divided into the following benthic community classes for each site:

- Seagreen Alpha OWF:
    - – Western area: '*Sabellaria*', 'sparse polychaetes and bivalves' and 'faunal turf'; and
    - – Central and eastern areas: dominated by the sabellid polychaete classes 'dense Chone' and 'sparse Chone'.
- Seagreen Bravo OWF:
    - – Western half: '*Sabellaria*', 'rich polychaetes and bivalves' and 'epifauna with polychaetes'; and
    - – Eastern half: 'dense Chone' and 'rich polychaetes'.

High species richness was recorded in association with areas of the *Sabellaria* habitat, although there was no evidence from the DDV surveys of extensive or well developed aggregations of *Sabellaria* at the Seagreen Alpha or Seagreen Bravo OWF sites.

Pre-construction surveys within the Seagreen Alpha and Bravo OWFs and export cable corridor were undertaken in 2020. The focus of these were to assess the potential for reef habitats (i.e. biogenic or geogenic reefs) to occur. The sampling locations are shown in Figure 2.1, based on the areas where reef habitats had the greatest potential to be present. While the pre-construction monitoring report has yet to be finalised, initial indications are that biogenic reefs were not present at any locations and patches of medium resemblance stony reef were recorded among larger areas of cobble and sand, in line with the habitats mapped in the baseline characterisation presented in the Environmental Statement (Seagreen, 2012).

### 3.3 Inch Cape OWF Survey Data

The baseline characterisation surveys for the Inch Cape array area (Inch Cape Offshore Limited, 2011) showed the sediments to be characterised primarily by circalittoral sands and gravelly sands, with smaller areas of muddy mixed sediment. The dominating biotopes within the array were SS.SMx.CMx.MysThyMx

(*Mysella bidentata* and *Thyasira* spp. in circalittoral muddy mixed sediment[3]) covering 65% of the area, offshore circalittoral coarse sediment (SS.SCS.OCS) covering 31% of the area and SS.SCS.CCS.MedLumVen (*Mediomastus fragilis*, *Lumbrineris* spp. and venerid bivalves in circalittoral coarse sand or gravel) covering 4% of the area (Inch Cape Offshore Limited, 2011, 2013).

Along the Inch Cape export cable corridor (Inch Cape Offshore Limited, 2013), the sediments were primarily characterised by sands, muddy sands and sandy muds, which aligns with those habitats mapped by EUSeaMap 2019 data (Figure 3.1). The most offshore section of the Inch Cape export cable route was characterised by sandy sediments (i.e. slightly gravelly sand habitat, grading into slightly gravelly muddy sand, with patches of sandy mud). Coarser mixed sediment with boulders and cobbles was also recorded in proximity to Isle of May. The inshore area was found to be characterised by a mix of sandy and mixed sediments of gravel and sand.

The dominant biotope/communities recorded along the Inch Cape cable route was associated with the SS.SMu.CSaMu.SpnMeg (Sea pens and burrowing megafauna in circalittoral sandy mud) biotope, as identified from seabed imagery data and grab sample data. This included burrowing species such as the Norway lobster *Nephrops norvegicus*, together with sea pens *Pennatula phosphorea* and *Virgularia mirabilis* and sediment mounds produced by other burrowing species. The SS.SMu.CSaMu.SpnMeg biotope is a component of the United Kingdom Biodiversity Action Plan (UKBAP) 'mud habitat in deep water' and the Scottish Priority Marine Feature (PMF) "burrowed mud". The Inch Cape offshore export cable corridor Benthic Ecology Baseline Report (Inch Cape Offshore Limited, 2013) also described the epifaunal communities present at the Neart na Gaoithe wind farm and found these to be also characterised by the SS.SMu.CSaMu.SpnMeg biotope. The Neart na Gaoithe sampling locations coincide with the sampling locations presented in Figure 3.2 and as presented for Cooper and Barry.

The inshore area of the Inch Cape cable route was also characterised by sandy mud sediments and communities (e.g. SS.SMu.CSaMu.SpnMeg), although areas of sublittoral mixed sediments were also recorded close to the landfall locations, including the SS.SMx.CMx.FluHyd (*Flustra foliacea* and *Hydrallmania falcata* on tide-swept circalittoral mixed sediment) and SS.SMx.CMx (Circalittoral mixed sediment) biotopes.

### 3.4 Cooper and Barry (2017) Data

Cooper and Barry (2017) describe the results of a baseline assessment of the UK's macrobenthic infauna, with a particular focus around sites and regions of marine aggregate dredging as part of the implementation of the RSMP. Although aggregates were the focus of the study, a "big data" approach was taken, collating data from across UK waters from various industries including OWFs, oil and gas, nuclear and port and harbour sectors. This also included samples from the Neart Na Gaoithe OWF, in close proximity to the Seagreen 1A cable route. The Cooper and Barry (2017) paper describes the infaunal communities as characterised by grab sample data, while the Inch Cape data discussed above, provided

[3] *Mysella Bidentata* has been updated to *Kurtiella Bidentata* therefore this hatbait is now SS.SMx.CMx.KurThyM *Kurtiella bidentata* and *Thyasira* spp. in circalittoral muddy mixed sediment

information on the epifaunal communities in this part of the Seagreen 1A export cable route (see Figure 3.2).

The majority of data points coinciding with the Seagreen 1A export cable corridor were characterised by slightly muddy sands with a small gravel component, and associated benthic infaunal communities of polychaetes (*Spionidae, Nephtyidae, Lumbrineridae, Oweniidae, Cirratulidae, Capitellidae* and *Ampharetidae*), echinoderms (*Amphiuridae*) and *nemerteans* (i.e. D2b faunal group in Figure 3.2). The other main community type recorded along the Seagreen 1A export cable corridor was characterised by slightly gravelly slightly muddy sand and species rich communities of polychaetes (*Spionidae, Nephtyidae, Capitellidae, Cirratulidae, Oweniidae* and *Pholoidae*), bivalve molluscs (*Montacutidae, Semelidae* and *Nuculidae*) and *nemerteans* (i.e. D1 faunal group in Figure 3.2). This was recorded sporadically in the middle section of the offshore cable corridor and in inshore areas.

### 3.5 Data from the Firth of Forth Banks Complex MPA

Surveys of the Firth of Forth Banks Complex MPA were undertaken by JNCC in 2012, with sediments and biotopes identified in Pearce *et al*. (2014). These sampling locations were also included in the Cooper and Barry (2017) dataset, with the majority of the sampling locations located to the east of the Seagreen 1A boundaries shown in Figure 2.1 and Figure 3.2. A small number of sampling stations (i.e. 5 locations) were positioned within 5 km of the offshore section of the Seagreen 1A export cable corridor. Pearce *et al*. (2014) identified the sediments in this area as comprising circalittoral coarse sediments (i.e. sands and gravels), with the following biotope classifications:

- SS.SMx.OMx: Offshore circalittoral mixed sediments;
- SS.SBR.PoR.SspiMx: *Sabellaria spinulosa* on stable circalittoral mixed sediment; and
- SS.SSa.Osa.[Sbom]: *Spiophanes bombyx* aggregations in offshore sands.

This is in line with other historic datasets coinciding with the offshore part of the Seagreen 1A cable corridor (i.e. Inch Cape and Seagreen Alpha and Bravo), as outlined above.

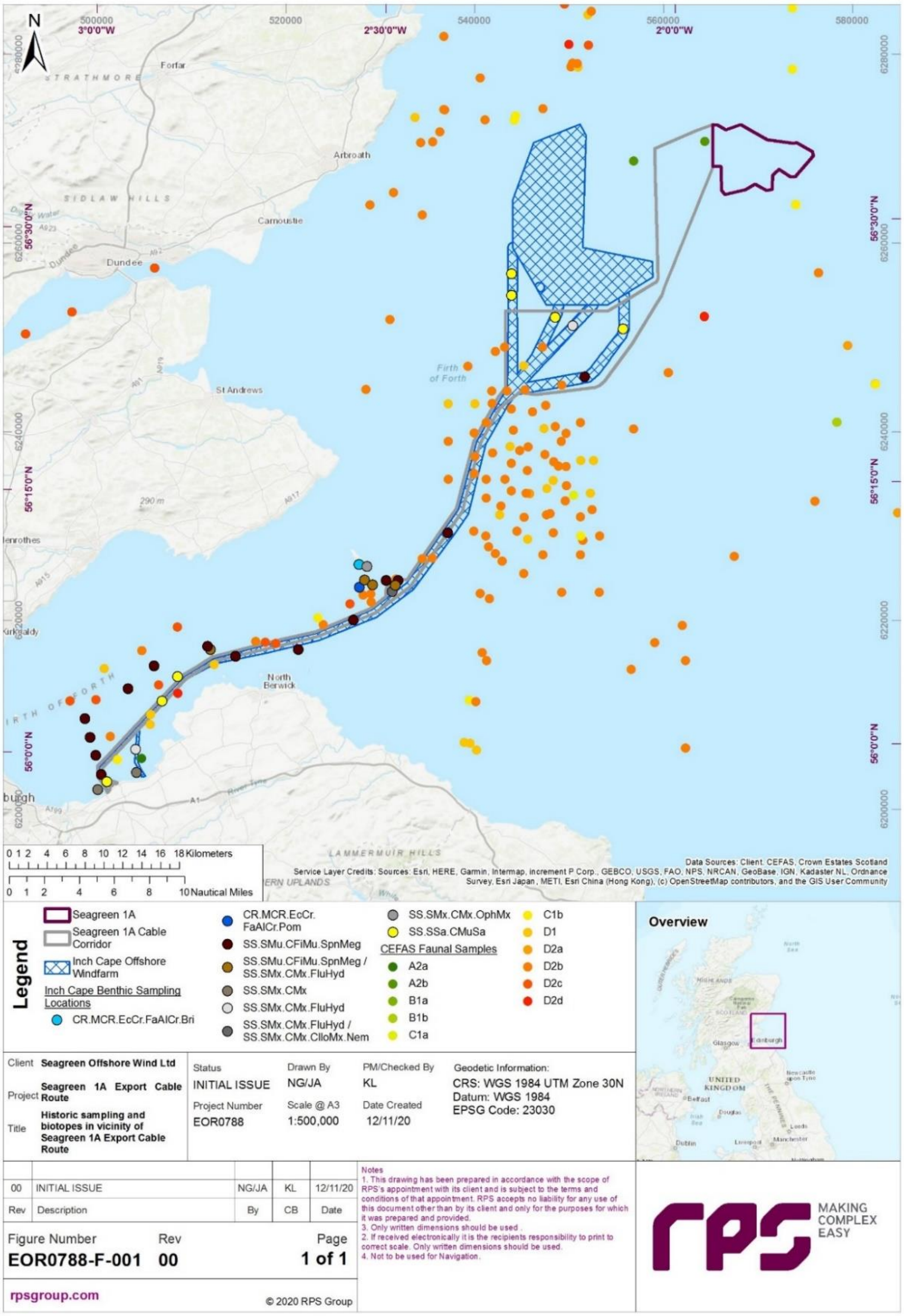



Figure 3.2: Historic Sampling and biotopes for Seagreen 1A export cable corridor .

# 4. Results of the Benthic Validation Survey

## 4.1 Physical Sediment Characteristics

The subtidal benthic sediments across the Seagreen 1A export cable corridor were classified into main sediment types according to the Modified Folk Classification as described in section 2.3.1 (Table 4.1, Figure 4.1). Sediments recorded ranged from sand to gravelly muddy sand (Plate 4.1, Plate 4.2) with 40% of the sample stations classified as muddy sand (Figure 4.2). The only station characterised as mud sediment was the station closest to the landfall in the inshore section of the export cable corridor with other inshore stations characterised by sandy mud, slightly gravelly sandy mud, slightly gravelly sand and slightly gravelly muddy sand with some degree of variability in sediment classifications in this area. The mid-section was characterised primarily by muddy sand and sandy mud, with small areas with an increased gravel proportion (slightly gravelly muddy sand). The offshore section was characterised by muddy sand, slightly gravelly sand, gravelly muddy sand, with more sandy sediments characterising the area coinciding with the MPA (Figure 4.1). According to the simplified Folk Classification (Long, 2006), most stations were classified as 'mud and sandy mud' with a few stations classified as 'sand and muddy sand'.

Plate 4.1: Representative image of Gravelly Muddy Sand sediment (ST07).

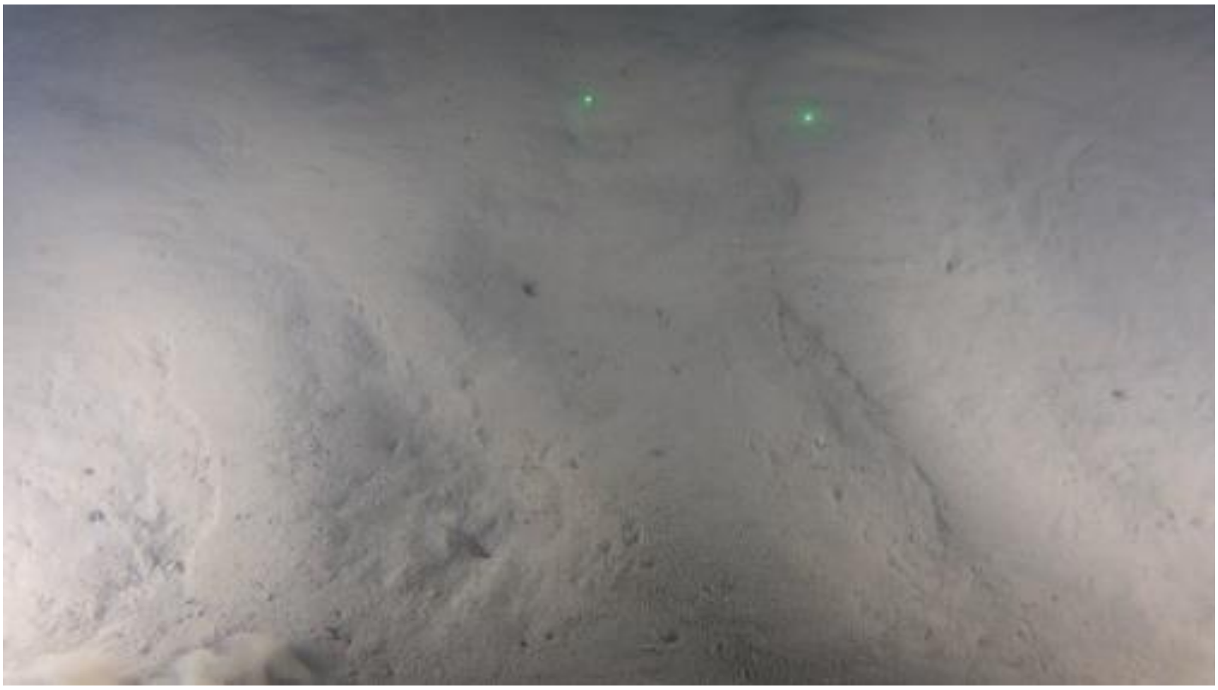


Plate 4.2: Representative image of Mud sediment (station 30).

The percentage sediment composition at each grab location is presented in Table 4.1 and Figure 4.3 (i.e. mud ≤0.63 mm; sand <2 mm; gravel ≥2 mm). Across all samples, the average percentage sediment composition was 0.8% gravel, 64.2% sand and 35% mud. The stations with the highest percentage composition of mud were generally found closest to the coast with sand forming the highest percentage composition of sediments at the offshore stations. Very small proportions of gravel were found at some stations along the inshore, mid and offshore sections of the export cable corridor. ST07 had a larger proportion of gravel (8.2%; Table 4.1) and was classified as gravelly muddy sands (Table 4.1; Figure 4.3). The two stations sampled within the Firth of Forth Banks Complex MPA (ST04 and ST05; Table 4.1) were furthest offshore and contained the highest percentage of sand. These stations were classified as slightly gravelly sand and sand sediments.

Sediments from all stations across the Seagreen 1A export cable corridor were generally poorly sorted with only the samples from the two stations within the MPA characterised as moderately sorted sediments.

Table 4.1: Results of the Particle Size Analysis

| Sample station | Modified Folk Classification | Folk and Ward Sorting | Major sediment Fractions | | |
|---|---|---|---|---|---|
| | | | % Gravel | % Sand | % Mud |
| ST04 | Slightly Gravelly Sand | Moderately Sorted | 0.2% | 93.6% | 6.2% |
| ST05 | Sand | Moderately Sorted | 0.0% | 92.4% | 7.6% |

| Sample station | Modified Folk Classification | Folk and Ward Sorting | Major sediment Fractions | | |
|---|---|---|---|---|---|
| | | | % Gravel | % Sand | % Mud |
| ST06 | Muddy Sand | Poorly Sorted | 0.0% | 89.1% | 10.9% |
| ST07 | Gravelly Muddy Sand | Very Poorly Sorted | 8.2% | 75.5% | 16.4% |
| ST12 | Muddy Sand | Poorly Sorted | 0.0% | 86.6% | 13.4% |
| ST13 | Muddy Sand | Very Poorly Sorted | 0.0% | 72.0% | 28.0% |
| ST14 | Muddy Sand | Poorly Sorted | 0.0% | 76.4% | 23.6% |
| ST15 | Muddy Sand | Poorly Sorted | 0.0% | 72.2% | 27.8% |
| ST16 | Slightly Gravelly Muddy Sand | Poorly Sorted | 0.1% | 72.6% | 27.3% |
| ST17 | Muddy Sand | Poorly Sorted | 0.0% | 64.0% | 36.0% |
| ST18 | Sandy Mud | Poorly Sorted | 0.0% | 45.5% | 54.5% |
| ST19 | Slightly Gravelly Muddy Sand | Very Poorly Sorted | 2.3% | 56.7% | 41.0% |
| ST20 | Muddy Sand | Poorly Sorted | 0.0% | 62.3% | 37.7% |
| ST21 | Sandy Mud | Very Poorly Sorted | 0.0% | 46.7% | 53.3% |
| ST22 | Muddy Sand | Very Poorly Sorted | 0.0% | 50.8% | 49.2% |
| ST23 | Muddy Sand | Very Poorly Sorted | 0.0% | 50.5% | 49.5% |
| ST24 | Sandy Mud | Very Poorly Sorted | 0.0% | 42.8% | 57.2% |
| ST25 | Slightly Gravelly Muddy Sand | Poorly Sorted | 1.2% | 71.0% | 27.7% |
| ST26 | Slightly Gravelly Muddy Sand | Poorly Sorted | 1.2% | 82.9% | 15.8% |
| ST27 | Slightly Gravelly Sand | Poorly Sorted | 1.4% | 90.6% | 8.0% |
| ST28 | Slightly Gravelly Sandy Mud | Very Poorly Sorted | 3.7% | 46.9% | 49.4% |
| ST29 | Sandy Mud | Very Poorly Sorted | 0.0% | 27.6% | 72.4% |

| Sample station | Modified Folk Classification | Folk and Ward Sorting | Major sediment Fractions | | |
|---|---|---|---|---|---|
| | | | % Gravel | % Sand | % Mud |
| ST30 | Mud | Poorly Sorted | 0.0% | 8.5% | 91.5% |

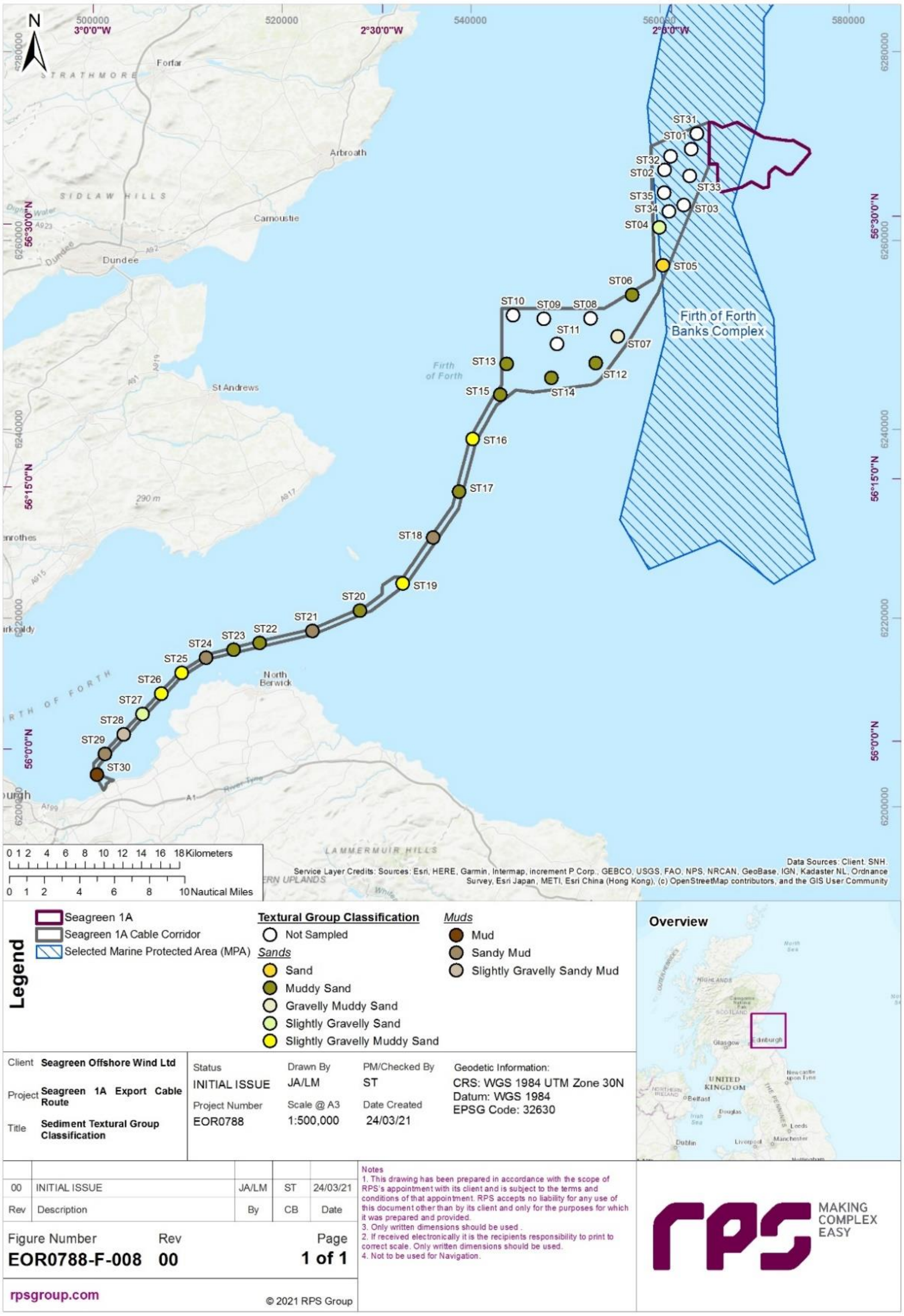



Figure 4.1: Modified Folk Sediment Classifications for each benthic grab sample location within the Seagreen 1A export cable corridor

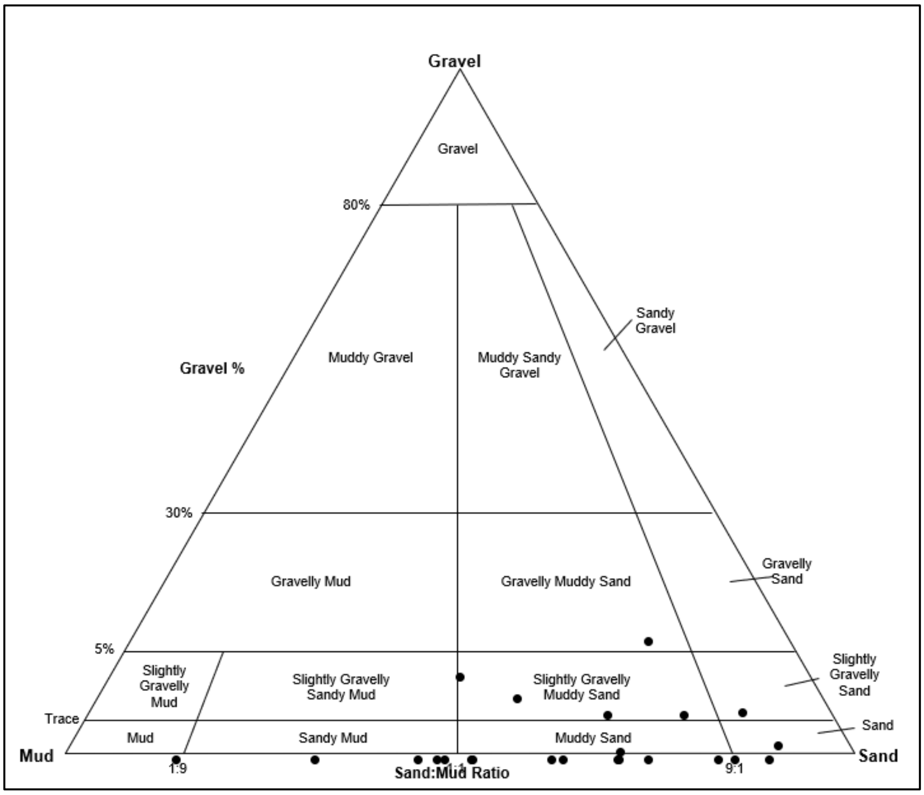



Figure 4.2: Trigon presenting the range of Modified Folk Classifications across the Seagreen 1A export cable corridor.

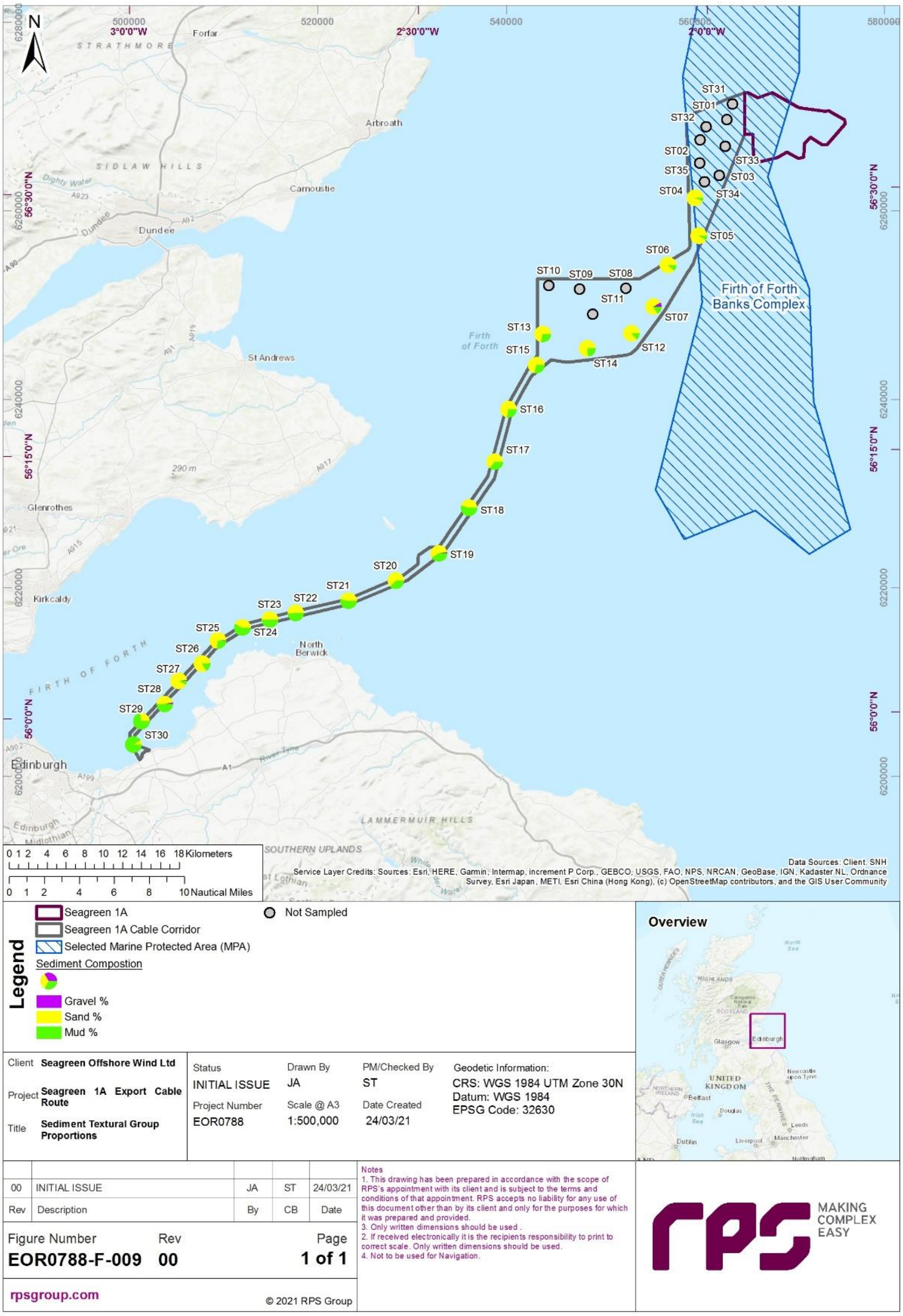



Figure 4.3: Sediment composition (from PSA) at each benthic grab sampling location within the Seagreen 1A export cable corridor.

### 4.1.1 Macrofaunal Analysis

#### 4.1.1.1 Summary

A total of 191 taxa were recorded from the 23 macrofaunal samples collected across the Seagreen 1A export cable corridor. Of these, 27 taxa were colonial or taxa whose abundance cannot be enumerated, and were therefore recorded as present (P). These taxa were removed from the numerical analysis but are discussed below. A total of 1,662 individuals representing 164 taxa were recorded across the Seagreen 1A export cable corridor. Of these, juveniles accounted for 127 individuals from 19 taxa (the four most abundant taxa were *Amphiuridae*, *Ophiuridae*, *Ampelisca* and *Abra*) representing 7.5% of the total number of individuals and 10% of the total number of taxa recorded.

Of the 164 total taxa enumerated throughout the Seagreen 1A export cable corridor, none were observed at all stations. A total of 91 taxa (c.50%) were present at a single location (ST28) and 10% of the individuals recorded across the export cable corridor were represented by the polychaete *Euclymene oerstedii*. A total of 70 taxa (38%) were represented by one individual across the export cable corridor. It is generally accepted that ecological communities which are frequently subjected to local disturbance or contamination events will be dominated by a limited number of tolerant taxa, which will be represented in high individual abundances (Clarke and Warwick, 2006). The relatively high numbers of single and low abundance species recorded in this survey could suggest a reasonably diverse community that has been subjected to relatively limited disturbance or contamination.

Juvenile species were recorded from all sections of the Seagreen 1A export cable corridor; taxa recorded included *Mollusca, Crustacea, Echinodermata, Annelida* and *Tunicata*. Juvenile echinoderms (*Amphiuridae* and *Ophiuridae*) were particularly abundant at station ST05. Juveniles, although a valid part of the community, are ephemeral in their nature due to high levels of mortality and usually have little impact on faunal communities. Therefore, the discussion of the faunal community analysis has been made using the adult only dataset to avoid skewing the results with the abundant but largely ephemeral juvenile taxa. However the SIMPER analysis was run on the data which included the juvenile data to check for any differences in patterns or groupings.

As mentioned above, 27 taxa were recorded only as present; these taxa were dominated by *Bryozoa* and *Hydrozoa*. Taxa also recorded as present across the export cable corridor included: *Enteroprocta, Porifera* and *Heterotrichida*. A total of 19 of the 27 'present' taxa were recorded at ST28.

Initially, the adult dataset was divided into the five major taxonomic groups: *Annelida* (*Polychaeta*), *Crustacea*, *Mollusca*, *Echinodermata* and 'Others'. The 'Other' group comprised two taxa of *Anthozoa* (*Edwardsiidae, V. mirabilis*), three taxa of *Pycnigonida* (*Achelia echinata, Anoplodactylus petiolatus* and *Callipallene brevirostris*), three taxa of *Sipunculidae* (*Golfingia (golfingia) vulgaris, Phascolion (phascolion) strombus strombus* and *Thysanocardia procera*), four taxa of *Tunicata* (*Actinaria, Ascidiacea, Ciona intestinalis* and *Dendrodoa grossularia*) and a single taxon of each of the following: *Cnideria* (*Actinaria*), *Astorohizda*, *Enteropneusta*, *Nematoda*, *Nemertea*, *Tentaculata* (*Owenia*), *Phoronis* and *Priapulomorpha* (*Priapulus caudatus*). The absolute and proportional contributions of these five taxonomic groups to the overall community structure is summarised in Table 4.2 whilst biomass values by gross taxonomic groups, are presented in Appendix C.

Table 4.2: Contribution of Gross Taxonomic Groups-Adult only dataset

| Group | Individuals | | Taxa | |
|---|---|---|---|---|
| | Abundance | Proportional Contribution % | Abundance | Proportional Contribution % |
| Annelida (Polychaeta) | 864 | 56 | 70 | 43 |
| Crustacea | 112 | 7 | 31 | 19 |
| Mollusca | 333 | 22 | 35 | 21 |
| Echinodermata | 99 | 7 | 9 | 6 |
| Others | 127 | 8 | 19 | 11 |
| **Total** | **1,535** | **100** | **164** | **100** |

Across the export cable corridor, the adult faunal community were generally dominated by *Annelida* (n=864) and *Mollusca* (n=333) which contributed 56% and 22% of the total number of adult individuals respectively. At individual stations, gross taxonomic group dominance also reflected this with 10 stations dominated by *Mollusca* with abundance ranging from 37-60% of total individuals, and 11 stations dominated by *Annelida* with abundance ranging from 36-75% of total individuals. One station (ST07) was dominated by *Echinodermata* and another station (ST29) was dominated by other taxa (*Phoronis* and *V. mirabilis*).

Biomass data also reflected this dominance with 10 stations dominated by *Mollusca* and eight stations dominated by *Annelida*. Three stations (ST07, ST26, ST27) were dominated by *Echinodermata*, one station (ST23) was dominated by *Crustacea* and one station (ST29) was dominated by other taxa.

The most abundant taxa included *Annelida* (*E. oerstedii*, *Galathowenia oculata, Melinna palmata* and *S. spinulosa*) and *Mollusca* (*Musculus subpictus* and *Nucula nitidosa*). A total of 74 individuals of *S. spinulosa* were recorded across four stations (ST25, ST26, ST27 and ST28) with the majority at station ST28. While *S. spinulosa* themselves are not a species of conservation importance, they can build biogenic reefs through forming tubes in the sand. Within the UK, these biogenic reefs are afforded protection under Annex I of the Habitats Directive. The benthic characterisation for Seagreen Alpha and Seagreen Bravo offshore find farms and sampling for the Firth of Forth Banks Complex MPA also recorded *Sabellaria* in the area but no biogenic reefs. The Firth of Forth Banks Complex MPA is not designated for biogenic reefs. Among other features, the MPA is designated for the bivalve Ocean Quahog *Arctica islandica* aggregations. *Arctica islandica* is a species listed on the OSPAR list of threatened and/or declining species and habitats (OSPAR, 2008). In addition, *A. islandica* is species listed as a Scottish Priority Marine Feature (PMF) (Tyler-Walters *et al*., 2016). No *A. islandica* were recorded within the Seagreen 1A benthic validation survey.

#### 4.1.1.2 Multivariate Community Analysis

The results of the cluster analyses, SIMPROF tests and SIMPER analyses were used, together with the raw untransformed data, to assign biotopes to each sample location. In several instances, clusters that were identified as significantly different from each other in the SIMPROF tests were assigned the same biotope code. This was based on a review of the SIMPER results which indicated that the differences between the groups could be explained by differences in abundances of characterising species rather than the presence/absence of key species.

The results of the hierarchical clusters analysis of the square root transformed infaunal dataset together with the SIMPROF test identified five groups that were statistically dissimilar, based on the SIMPROF test, and one station that was statistically distinct (ST28) from all other stations (Figure 4.4). The 3-D MDS plot, is presented in Figure 4.5 and the low stress value (0.1) indicates that this is a good representation of the data. The 2-D MDS plot has not been presented as the 3-D MDS plot presents a clearer representation of the data. The sample stations within Faunal group A (SIMPROF a; ST21, ST22 , ST29 and ST30) showed good clustering away from the other stations at a Bray-Curtis similarity of 42.5%. The single site (Faunal group B- SIMPROF b; ST28) was distinct from all of the other sites with the Bray-Curtis dissimilarity of 94.21% (Figure 4.4 and Figure 4.5). However, Faunal group C (SIMPROF c) and B (SIMPROF b) showed clustering with more similarity to each other than to the other groups with a Bray-Curtis dissimilarity of 79.66%. Faunal groups E (SIMPROF e) and F (SIMPROF f) also show a higher similarity with each other than with the other Faunal groups with a Bray-Curtis dissimilarity of 77.99% (Figure 4.4, Figure 4.5). Faunal group D (SIMPROF d) showed a higher similarity with Faunal groups E and F than with any other Faunal groups. The Bray-Curtis similarity for Faunal groups D and F were lower than for any of the other Faunal groups with Bray-Curtis similarity of 31.35% and 29.45% respectively.

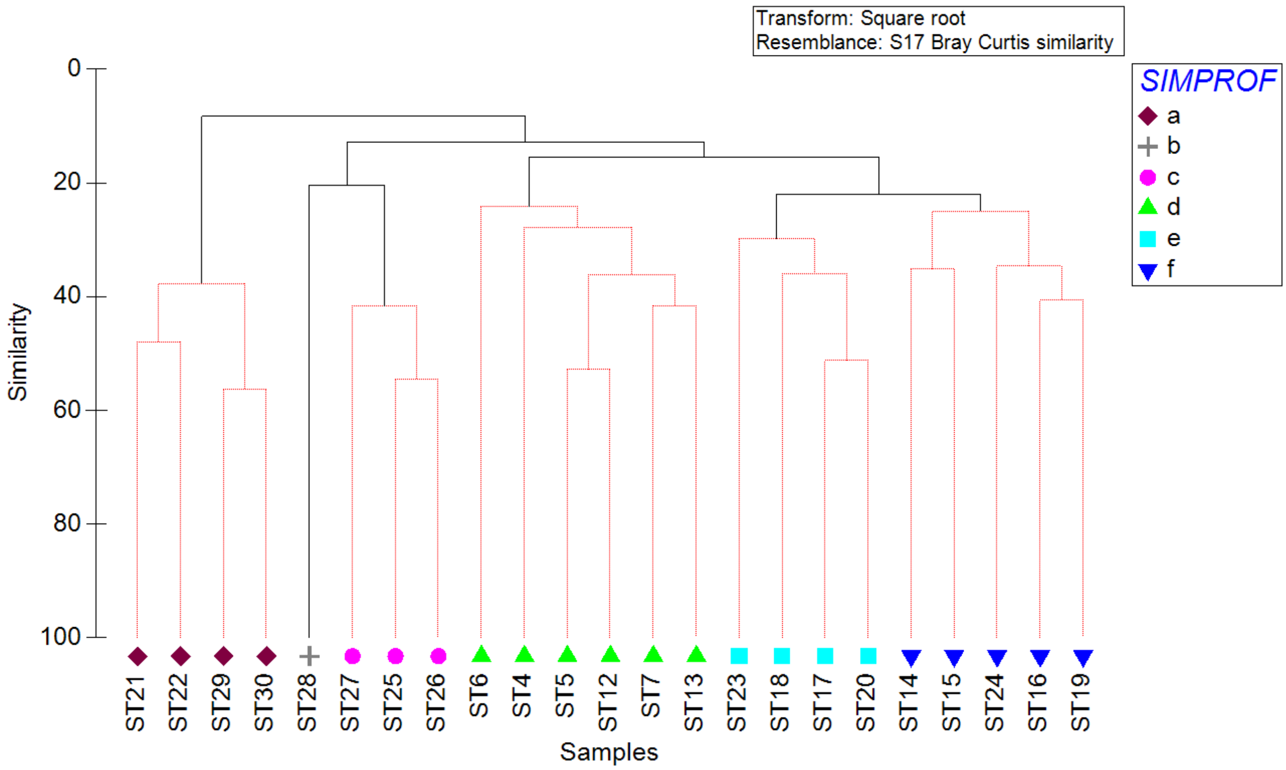



Figure 4.4: Cluster analysis for benthic infaunal samples within the Seagreen 1A export cable corridor.

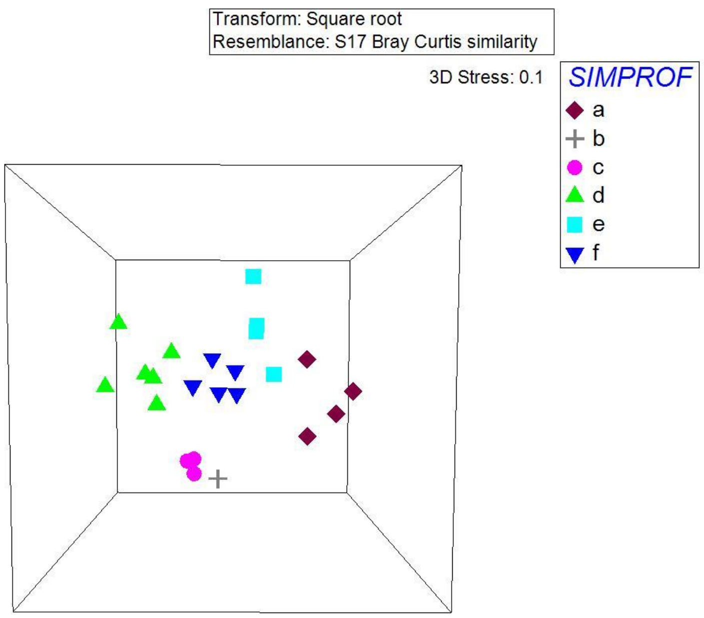



Figure 4.5: 3-D MDS plot for benthic infaunal samples (with SIMPROF groupings) within the Seagreen 1A export cable corridor.

Faunal group A corresponded to four sites in the inshore section of the Seagreen 1A export cable corridor. This group was associated with muddy sand, sandy mud and muddy sediments. The community at these stations was characterised by *N. incisa, A. nitida* and *M. palmata;* these species made up 94.64% of the similarity of stations within Faunal group A according to the SIMPER analysis. Faunal group A is distinct from the other Faunal groups due to the presence and abundance of the charactering species as well as the low abundance of *G. oculata* and high abundance of *V. mirabilis* compared to other Faunal groups (Table 4.3). When a SIMPER analysis was run on the data which included the juvenile data, SIMPROF group a was split into two separate groups of ST21 and ST22 and ST29 and ST30 due to the presence of *V. mirabilias, M. palmata* and *Phoronis* at sample stations ST29 and ST30. However, the raw data were analysed and due to the low species richness at these sample stations and the same dominating species (*Nephtys incisa*) these sample stations can all be grouped as one. Faunal group A was allocated a preliminary biotopes based on the infaunal data of *Melinna palmata* with *Magelona* spp. and *Thyasira* spp. in infralittoral sandy mud (SS.SMu.ISaMu.MelMagThy) (Table 4.3).

Faunal group B (ST28) comprised a single site in the shallow inshore section of the export cable corridor and was associated with slightly gravelly sandy mud sediments. It was characterised by *E. oerstedii*, *M. palmata* and *S. spinulosa* which were all recorded in their highest abundances at ST28 (Table 4.3). Faunal group B is distinct from the other Faunal groups due to the presence and abundance of the characterising species as well as *M. subpictus*, *Rhodine gracilior*, *Dipolydora saintjosephi* and *Paradoneis lyra* which were only found at ST28. ST28 recorded a higher number of taxa and individuals than any other sample station. Faunal group B was allocated a preliminary biotopes based on the infaunal data of *Melinna palmata* with *Magelona* spp. and *Thyasira* spp. in infralittoral sandy mud (SS.SMu.ISaMu.MelMagThy) (Table 4.3).

Faunal group C comprised three sites at the inshore section of the export cable corridor. This group was associated with slightly gravelly sandy mud and slightly gravelly sand sediments. This community was characterised by *G. oculata, E. oerstedii* and *Amphiura filiformis* due to the high abundance of these species. *A. filiformis* was recorded in its highest abundance at a station within this Faunal group (Table 4.3). It is distinct from the other Faunal groups due to the presence and abundance of the characterising species as well as *Owenia*, *K. bidentata* and *N. nitidosa* which were recorded at high abundances. Faunal group C was allocated a preliminary biotope based on the infaunal data of *Melinna palmata* with *Magelona* spp. and *Thyasira* spp. in infralittoral sandy mud (SS.SMu.ISaMu.MelMagThy) (Table 4.3).

Faunal group D comprised six sites in offshore section of the export cable corridor, including the two sample stations within the Firth of Forth Banks Complex MPA. This faunal group was associated with slightly gravelly sand to muddy sand. This community was characterised by *A. filiformis, C. striatula* and *K. bidentata* due to the high abundance of these species (Table 4.3). It is distinct from the other faunal groups due to the presence and abundance of the characterising species as well as due to the low abundance of *Thyasira flexuosa, Glycera unicornis* and *N. nitidosa*, along with the presence of *Abra prismatica* which was only found in this Faunal group. Faunal group D was allocated a preliminary biotope based on the infaunal data of *Amphiura filiformis*, *Mysella bidentata* and *Abra nitida* in circalittoral sandy mud (SS.SMu.CSaMu.AfilMysAnit) (Table 4.3).

Faunal group E comprised four sites at the mid-section of the export cable corridor. This faunal group was associated with muddy sand and sandy mud sediments. This community was characterised by *Cylichna cylindracea, G. unicornis* and *A. nitida* due to the high abundance of these species (Table 4.3). It is distinct from the other Faunal groups due to the presence and abundance of the characterising species as well due to the low abundance of *A. auricoma* and differences in abundance of *T. flexuosa, Notomastus,* and *N. incisa* compared to other Faunal groups. Faunal group E was allocated a preliminary biotope based on the infaunal data of Sea pens and burrowing megafauna in circalittoral fine mud (SS.SMu.CFiMu.SpnMeg) (Table 4.3).

Faunal group F was identified at five sites at mid-section of the export cable corridor. This faunal group was associated with muddy sand and sandy mud sediments. This community was characterised by *T. flexuosa, Phaxas pellucidus* and *A. nitida* due to the high abundance of these species (Table 4.3). It is distinct from the other Faunal groups due to the presence and abundance of the characterising species as well due to the high abundance of *Amphictene auricoma* and low abundances of *A. filiformis* and *G. oculata*. Faunal group F was allocated a preliminary biotopes based on the infaunal data of Sea pens and burrowing megafauna in circalittoral fine mud (SS.SMu.CFiMu.SpnMeg) (Table 4.3).

Table 4.3: Benthic infauna groups identified in the Seagreen 1A export cable corridor through the cluster analysis, including a summary of the SIMPER results and geographic locations.

| Faunal / SIMPROF Group | Grab station number | Water Depth range (m) | Sediment classification | Characterising species accounting for up to 75% of cumulative simper similarity (SIMPER) | Geographic location | Preliminary Infaunal Biotope |
|---|---|---|---|---|---|---|
| A | ST21, ST22, ST29, ST30 | 41-8 | Muddy Sand- Mud | *Nephtys incisa, Abra nitida, Melinna palmata* | Inshore | *Melinna palmata* with *Magelona* spp. and *Thyasira* spp. in infralittoral sandy mud (SS.SMu.ISaMu.MelMagThy) |
| B | ST28 | 7 | Slightly gravelly sandy mud | *Euclymene oerstedii, Melinna palmata, Sabellaria spinulosa* | Inshore | *Melinna palmata* with *Magelona* spp. and *Thyasira* spp. in infralittoral sandy mud (SS.SMu.ISaMu.MelMagThy) |
| C | ST25, ST26, ST27 | 14-8 | Slightly gravelly sandy mud – slightly gravelly sand | *Galathowenia oculata, Euclymene oerstedii, Amphiura filiformis, Nucula nitidosa, Owenia, Thracioidea, Lumbrineris cingulate, Phaxas pellucidus, Harpinia antennaria, Sabellaria spinulosa, Kurtiella bidentata* | Inshore | *Melinna palmata* with *Magelona* spp. and *Thyasira* spp. in infralittoral sandy mud (SS.SMu.ISaMu.MelMagThy) |
| D | ST04, ST05, ST06, ST07, ST12, ST13 | 63-45 | Slightly gravelly sand muddy sand | *Amphiura filiformis, Chamelea striatula, Kurtiella bidentata, Abra prismatica, Antalis entalis* | offshore | *Amphiura filiformis*, *Mysella bidentata*[4] and *Abra nitida* in circalittoral sandy mud (SS.SMu.CSaMu.AfilMysAnit) |

[4] *Mysella Bidentata* is no longer the accepted species name, this has been updated to *Kurtiella bidentata* http://www.marinespecies.org/aphia.php?p=taxdetails&id=345281

| Faunal / SIMPROF Group | Grab station number | Water Depth range (m) | Sediment classification | Characterising species accounting for up to 75% of cumulative simper similarity (SIMPER) | Geographic location | Preliminary Infaunal Biotope |
|---|---|---|---|---|---|---|
| E | ST17, ST18, ST20, ST23 | 55-36 | Muddy sand- Sandy mud | *Cylichna cylindracea, Glycera unicornis, Abra nitida, Thyasira flexuosa* | Mid-section | Sea pens and burrowing megafauna in circalittoral fine mud (SS.SMu.CFiMu.SpnMeg) |
| F | ST14, ST15, ST16, ST19, ST24 | 55-25 | Muddy sand- Sandy mud | *Thyasira flexuosa, Phaxas pellucidus, Abra nitida, Amphictene auricoma, Amphiura filiformis, Galathowenia oculata, Cylichna cylindracea, Polycirrus* | Mid-section | Sea pens and burrowing megafauna in circalittoral fine mud (SS.SMu.CFiMu.SpnMeg) |

A review of the results of the SIMPER analysis shows that Faunal groups E and F were distinguished from each other by differences in abundances of characterising species (*T. flexuosa*, *A. nitida* and *A. auricoma*) rather than presence/absence of key species. Faunal groups B (ST28) and C were also distinguished from each other by differences in abundances of characterising species (*E. oerstedii* and *M. palmata*) rather than presence/absence of key species. These groups were therefore considered to be representative of variation of the same habitat. The Faunal groups presented in the SIMPER analysis and the raw data were used to assign three preliminary biotopes within the Seagreen 1A export cable corridor (Table 4.3). Although *S. spinulosa* was a characterising species at Faunal group B, no reef forming structure were recorded and other abiotic factors were considered to assign SS.SMu.ISaMu.MelMagThy as a best fit. The full SIMPER analysis results are presented in Appendix A.

#### 4.1.1.3 Univariate Analysis

The following univariate statistics were calculated for each benthic grab sample: number of species (S), abundance (N), blotted wet weight biomass in grams (g), Margalef's index of Richness (d), Pielou's Evenness index (J'), Shannon-Wiener Diversity index (H') and Simpson's index of Dominance (λ). The mean of each of these indices was then calculated for each of the Faunal groups identified in the study area and these are summarised in Table 4.4 with univariate statistics for individual sites presented in Appendix B.

The univariate statistics indicated that Faunal group B had the highest number of species (81), this was identified earlier in the raw data summary (section 4.1.1.1). Faunal group A sample stations dominated by sandy mud and mud, had a particularly low number of species (5.25± 2.21). The highest mean number of individuals was recorded at Faunal group B (743) which is expected due to the higher number of taxa present. This was mostly due to the high abundance of *E. oerstedii*, *M. palmata* and *S. spinulosa.* The lowest mean number of individuals was recorded at Faunal group A (14.75± 10.14) although Faunal Groups D and E also had low number of individuals (Table 4.4).

The highest mean diversity score of all identified communities was at Faunal Group B (d=12.10 and H'=3.15) which is expected as this group has the highest number of species and individuals. The slightly gravelly communities at Faunal Groups C and F had the next highest mean diversity score (d=6.31± 1.20 , H'=2.90± 0.11 and d= 5.57± 2.20, H' = 2.70± 0.49 respectively). The lowest diversity was found at Faunal group A (d=1.62± 0.48 and H'=1.39± 0.25) which was expected as this group had the lowest number of species and individuals. The stations that make up Faunal group A are the furthest inshore samples as such are likely to be exposed to greater disturbance from wave action than those communities in the deeper waters, potentially explaining the reduced diversity in these communities.

Pielou's evenness scores (J') and the Simpson's index of Dominance scores varied across the Faunal groups. J' was highest at Faunal group F (0.92± 0.03) which also had the lowest λ (0.09± 0.03) indicating an even distribution of abundances among species and that this community is not dominated by a small number of species. Faunal group D also has a low J' (0.92± 0.07) with a slightly higher λ than Faunal group F (0.13± 0.07). Faunal group A, C and E also have a high J' with Faunal group C having a very low λ (0.08± 0.01).

Faunal group B had a low J' (0.71) but a low λ (0.08) indicating that some dominance by a small number of species, from the raw data they can be identified as *E. oerstedii*, *M. palmata* and *S. spinulosa*.

Table 4.4: Mean (± standard deviation) univariate statistics for benthic faunal groups recorded within the Seagreen 1A export cable corridor. S = number of species; N = abundance; B= Biomass (wet weight in grams); d = Margalef's index of Richness; J' = Pielou's Evenness index; H' = Shannon-Wiener Diversity index; λ = Simpson's index of Dominance.

| Faunal/ SIMPROF Group | Grab station number | S | N | Biomass (g) | d | J' | H' | λ |
|---|---|---|---|---|---|---|---|---|
| A | ST21, ST22, ST29, ST30 | 5.25± 2.21 | 14.75± 10.14 | 0.46± 0.27 | 1.62± 0.48 | 0.89± 0.08 | 1.39± 0.25 | 0.28± 0.05 |
| B | ST28 | 81 | 743 | 7.94 | 12.10 | 0.71 | 3.15 | 0.08 |
| C | ST25, ST26, ST27 | 30.33± 9.71 | 111.33± 67.60 | 5.01± 2.85 | 6.31± 1.20 | 0.86± 0.05 | 2.90± 0.11 | 0.08± 0.01 |
| D | ST04, ST05, ST06, ST07, ST12, ST13 | 11.5± 2.58 | 17.5± 5.39 | 1.42± 1.82 | 3.69± 0.58 | 0.92± 0.07 | 2.24± 0.30 | 0.13± 0.07 |
| E | ST17, ST18, ST20, ST23 | 10± 3.91 | 18± 9.83 | 0.51± 0.29 | 3.19± 0.64 | 0.89± 0.07 | 1.97± 0.28 | 0.17± 0.02 |
| F | ST14, ST15, ST16, ST19, ST24 | 22± 12.86 | 44.4± 35.35 | 2.29± 2.19 | 5.57± 2.20 | 0.92± 0.03 | 2.70± 0.49 | 0.09± 0.03 |

Figure 4.6 to Figure 4.8 show the mean number of species, abundance and biomass for each of the major taxa groups (*Annelida, Crustacea, Mollusca, Echinodermata* and Other) in each of the Faunal groups identified in the Seagreen 1A export cable corridor. As previously discussed, the single station comprising Faunal group B has the highest number of species, abundance and biomass, the majority of which were made up of *Annelida*. *Annelida* also dominated the total species numbers, making up 43% of the taxa present (Table 4.2). *Echinodermata* in general were poorly represented across all of the Faunal groups, with a total of nine difference species recorded across all the samples, the majority of which were from grab sites within Faunal groups B and C.

Figure 4.7 shows that *Annelida* dominated the mean abundances of individuals within Faunal groups A, B and C, accounting for at least 40% of all individuals within each of these Faunal groups. As expected, Faunal group B had a disproportionally high abundance of *Annelida*. *Mollusca* dominated within Faunal groups D, E and F, accounting for at least 35% of all individuals within each of these Faunal groups. *Echinodermata* also contributed to the abundance, especially within Faunal group C.

The major taxa groups biomass data for the Faunal groups show that the dominant taxa group varied between Faunal groups. *Annelida* dominated at the majority of Faunal groups (A, B an E) making up over 45% of the biomass at each of the groups. *Mollusca* dominated at Faunal groups D and F, making up over 45% of the biomass at each of the groups. *Echinodermata* dominated the biomass at Faunal group C, making up 63% of the biomass. This is be due to the higher abundances of the brittlestars *Acrocnida brachiata* and *A. filiformis*.

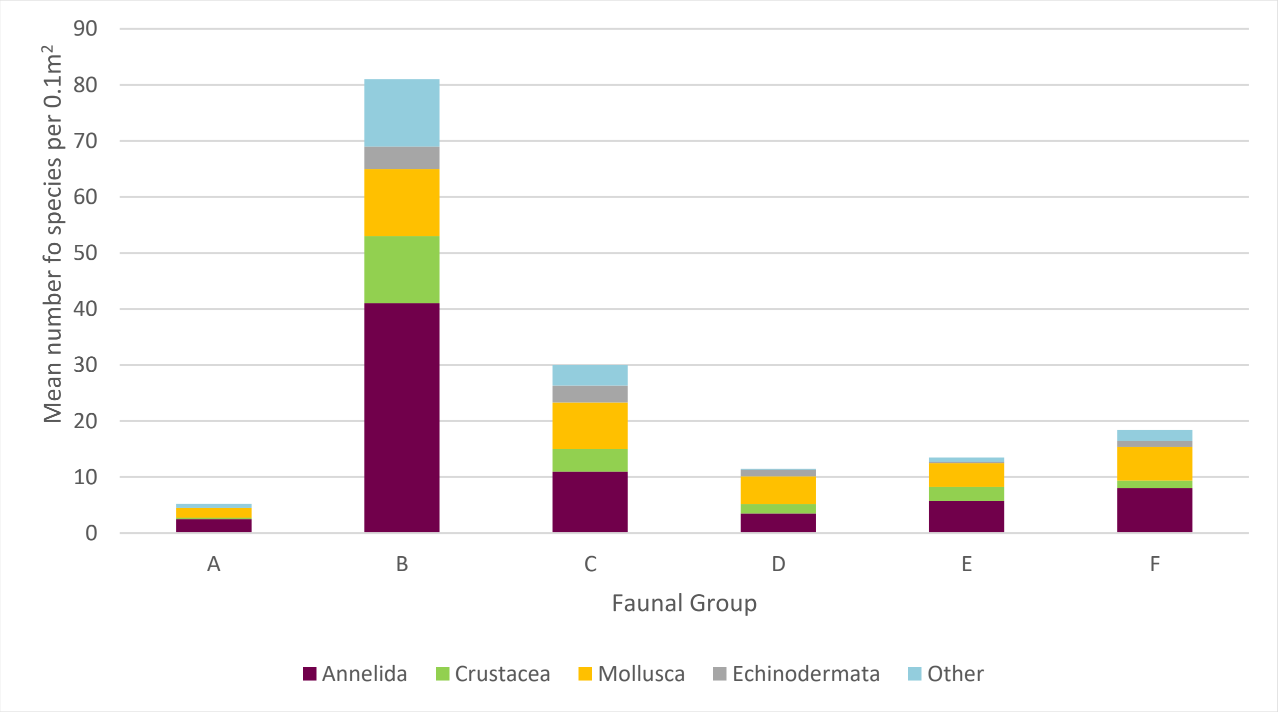



Figure 4.6: Mean number of species (per 0.1 $m^2$) per taxonomic group identified for each Faunal group in the export cable corridor

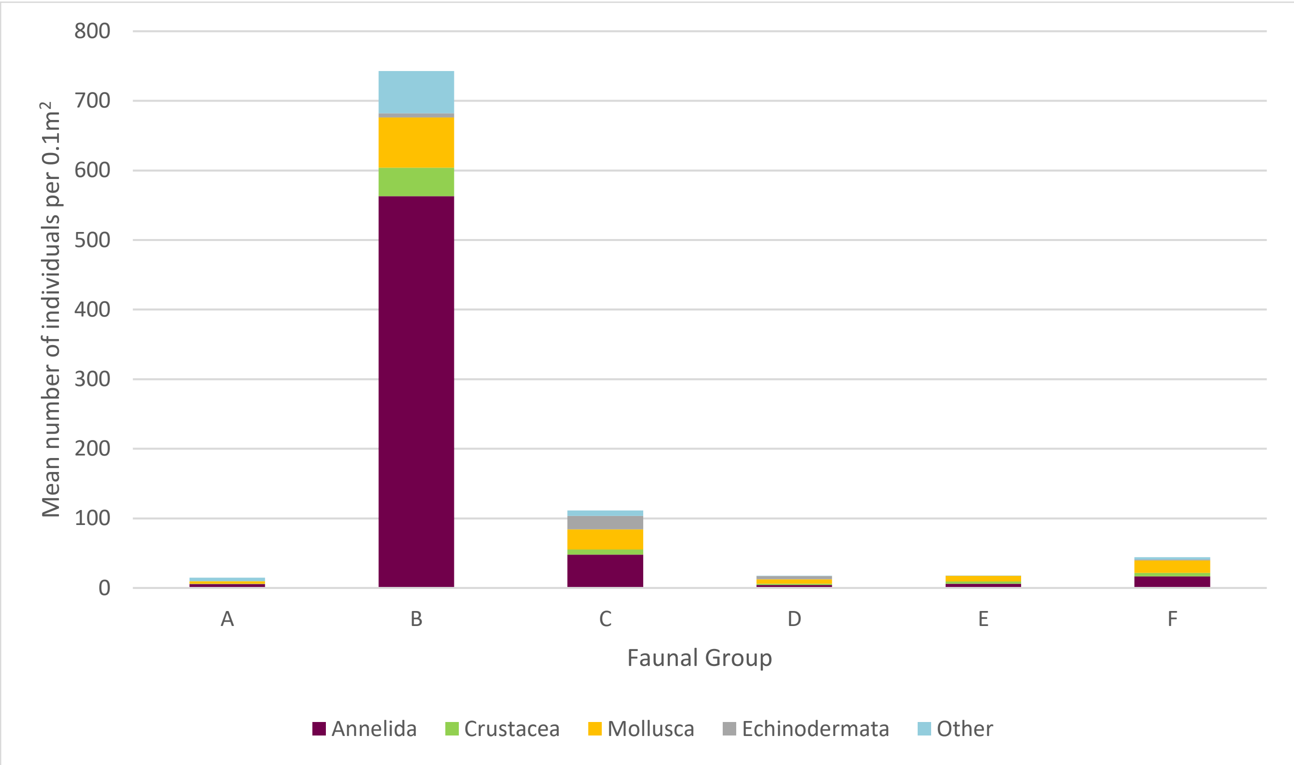



Figure 4.7: Mean abundance of individuals (per 0.1 $m^2$) per taxonomic group identified for each Faunal group in the export cable corridor

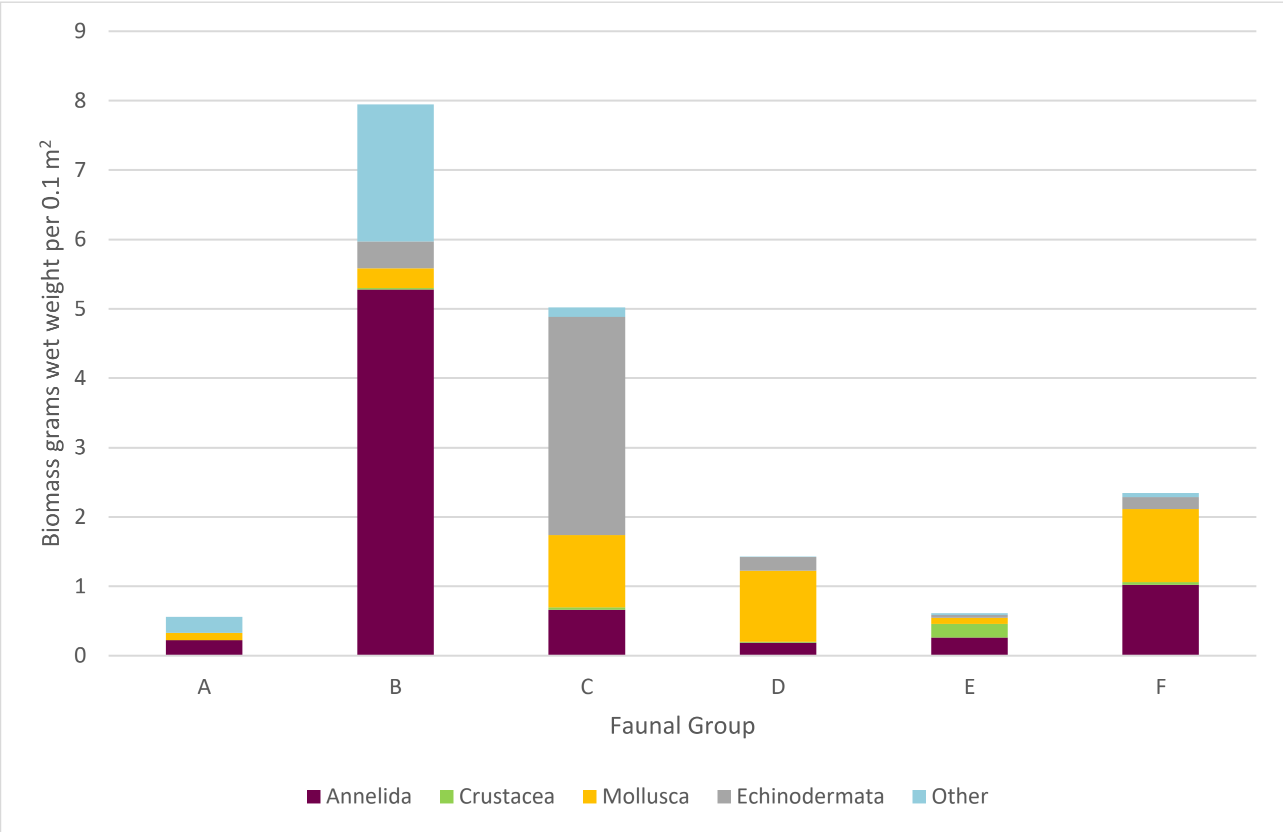


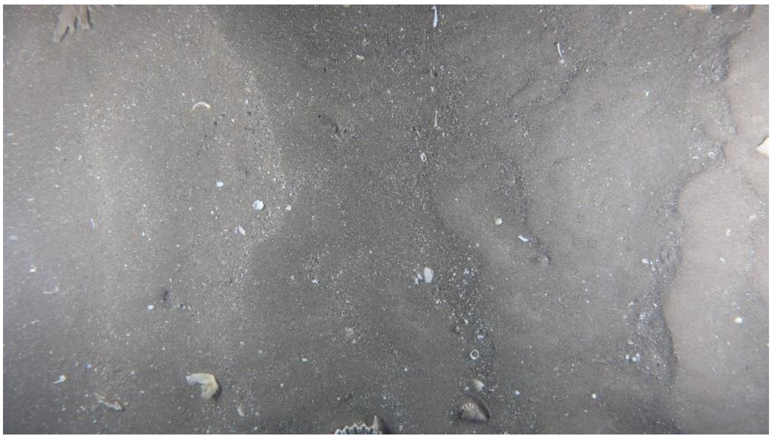

Figure 4.8: Mean biomass (per 0.1 m$^2$) per taxonomic group identified for each Faunal group in the export cable corridor

### 4.1.2 Seabed Imagery Analysis

The sediments recorded in the seabed imagery largely comprised of soft sediments, primarily sands and muds, and therefore showed limited epifaunal communities. A relatively small number of taxa were recorded with burrows (<1-10cm) recorded at almost every sample station. In general, high numbers of epifaunal species were recorded in association with the coarser sediments (sands and coarse sediments). Stations with subtidal sands were associated with the presence of the bryozoan hornwrack *Flustra foliacea*, bushy hydroids, hermit crabs, mysids, bivalves, *Turritella* sp., *Scaphopoda*, and tube worms. Subtidal muds were generally reported from the seabed imagery at stations within the inshore half of the export cable corridor (Table 4.5). Stations with subtidal muds were associated with the presence of *F. foliacea*, sea pens *P. phospoherea* and *V. mirabilis*, *N. norvegicus*, *Turritella* sp. and tube worms in the seabed imagery (Table 4.5). *F. foliacea*, bivalves and *N. novegicus* were the taxa found across most stations. Burrows of 1 cm were found at almost all stations with large burrows found at stations 16-24.

Taxa that were recorded in only a very small number of instances included the common star fish *Asterias rubens,* dead man's fingers *Alcyonium digitatum,* erect and branching hydroids which were only found at ST03 (classified as Subtidal Coarse Sediment, within the Firth of Forth MPA). True crabs *Brachyura* were only found at ST22 (inshore half of the export cable corridor) as well as *Sertularidae* and brittle stars *Ophiuroidea* were only found at ST26 (inshore half of the export cable corridor). The number of different species found at ST03 and ST26 that weren't found at any other sample station is likely due to the different sediment types found at those stations. ST03 was classified as subtidal coarse sediment and ST26 was classified as slightly gravelly muddy sand from the seabed imagery. As discussed in section 2.3.1, coarse sediments and gravels were rarely recorded within the export cable corridor therefore these stations present a rarely recorded habitat. Bony fish were recorded at several stations; two were recorded at ST05, one at ST12 and one at ST21. One pogge *Agonus cataphractus* was identified at ST03.

Table 4.5: Sample stations classified by sediment type with key species recorded during DDV.

| Sediment description | Sample Stations | Species recorded during DDV | Photographic example |
|---|---|---|---|
| Sand and Muddy Sand | ST4, ST5, ST6, ST7, ST12, ST27 | Bushy hydroids<br>Hermit crabs<br>Mysids<br>Bivalves<br>Tube worms<br>*F. foliacea*<br>*Turritella* sp.<br>*Scaphopoda* |  |
| Mud and Sandy Mud | ST13, ST14, ST15, ST16, ST17, ST18, ST19, ST20, ST21, ST22, ST23, ST24, ST25, ST28, ST29, ST30 | Mysids<br>Tube worms<br>*F. foliacea*<br>*P. phospoherea*<br>*V. mirabilis*<br>*N. norvegicus*<br>*Turitella* sp. |  |

| Sediment description | Sample Stations | Species recorded during DDV | Photographic example |
|---|---|---|---|
| Coarse sediment | ST03 | *F. foliacea,*<br>*A. digitatum,*<br>*A. rubens,*<br>*A. cataphractus*,<br>*Spirobranchus* sp.<br>Tube worms |  |
| Mixed Sediment | ST26 | *Sertularidae*<br>*O. albida*<br>*O. ophiura*<br>*Spirobranchus* sp. |  |

#### 4.1.2.1 Annex I Reef Assessment

No images taken during the DDV survey showed any evidence of potential Annex I reef therefore no reef assessment was required.

#### 4.1.2.2 Sea Pen and Burrowing Megafauna Communities Assessment

The sea pen and burrowing megafauna communities assessment was conducted on those stations where DDV data indicated the habitat aligned with the OSPAR habitat. Other sample stations recorded sea pens and burrows however there was no indication of megafauna being present since all the burrows in the images from these sample stations were small in size (<1cm). Burrows were observed at 10 stations within the seabed stills and DDV footage and sea pens (*Pennatulacea*) were also observed at three of these stations (ST16, ST17 and ST29; Plate 4.4); *V. mirabilis* and *P. phosphorea* were both observed. The sediment type recorded along the central and coastal sections of the offshore cable corridor are consistent with the mud and sandy mud as typical for the 'sea pen and burrowing megafauna communities' habitat, as defined by OSPAR (2010). The densities of burrows and sea pens at all stations present were analysed and their abundance categorised using the JNCC's Marine Natural Conservation Review SACFOR classification to assess if the station habitat should be classified as a 'sea pen and burrowing megafauna communities' habitat. Table 4.6 presents the burrows and sea pen abundance data and analysis for each sample station where burrows were recorded.

The density of burrows was assessed to consider if their density was a prominent feature of the sediment surface and indicative of a sub-surface complex burrow system. Therefore, areas with burrows and sea pen species with densities considered 'frequent' or more under the SACFOR scale were considered likely to constitute a 'sea pen and burrowing megafauna communities' habitat. However, as recommended in the JNCC report (2014b), interpretation of the density of burrows should be treated with a degree of caution as it can be difficult to identify species based on burrow alone. Burrow density was calculated for each station using the total area covered by the photographs as calculated from laser scale lines (average image swathe x camera transect length).

Plate 4.3: *Virgularia mirabilis* at sample station 29.

Plate 4.4: Burrows at sample station 24.

Table 4.6: Analysis of sample stations where burrows and sea pens were recorded within the seabed imagery.

| Station | Number of images assessed | Estimated total area investigation ($m^2$) | Burrows | | | | Sea Pens | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Quantity | Size Range (diameter in cm) | Average Density (Burrows $m^2$) | SACFOR Abundance Range | Quantity | Average Density (Sea pens $m^2$) | SACFOR Abundance Range |
| ST16 | 7 | 7 | 168 | 1 to 10 | 24.0 | Abundant | 8 | 1.1 | Common |
| ST17 | 8 | 8 | 144 | 1 to 10 | 18.0 | Abundant | 8 | 1.0 | Common |
| ST18 | 11 | 11 | 236 | 1 to 10 | 21.5 | Abundant | 0 | 0.0 | n/a |
| ST19 | 2 | 2 | 20 | 1 to 10 | 10.0 | Abundant | 0 | 0.0 | n/a |
| ST20 | 2 | 2 | 4 | 2 to 10 | 2.0 | Common | 0 | 0.0 | n/a |
| ST21 | 7 | 7 | 128 | 1 to 10 | 18.3 | Abundant | 0 | 0.0 | n/a |
| ST22 | 4 | 4 | 36 | 1 to 10 | 9.0 | Common | 0 | 0.0 | n/a |
| ST23 | 6 | 6 | 84 | 1 to 10 | 14.0 | Abundant | 0 | 0.0 | n/a |
| ST24 | 2 | 2 | 32 | 1 to 10 | 16.0 | Abundant | 0 | 0.0 | n/a |
| ST29 | 7 | 7 | 12 | 3 to 10 | 1.7 | Common | 136 | 19.4 | Abundant |

Sea pens were also recorded in the grab sampling although only *V. mirablis* was recorded. *V. mirablis* was recorded in the grab samples at ST24, ST25, ST28, ST29 with highest abundance at ST28. This somewhat correlates with the DDV seabed imagery which also recorded *V. mirablis* at ST29 however in addition, it recorded *V. mirablis* at ST16, ST17 and ST30. *Pennatula phosphorea* was also recorded in the DDV seabed imagery at ST14, ST15, ST16 but not in the grab sampling.

For most of the stations where burrows are present, they were classified as abundant according to the SACFOR scale. As defined by JNCC (JNCC, 2014b) they therefore are classified as a prominent feature of the site (frequent on the SACFOR scale is required for burrows to be classified as a prominent feature). In addition, numerous DDV stations recorded *N. norvegicus* which is one of the species known to be responsible for creating the characteristic burrows of the 'sea pen and burrowing megafauna communities' habitat. The presence of sea pens is not a prerequisite for the classification of this habitat however where they were recorded, they were common or abundant. The PSA data also confirmed the presence of mud and sandy mud at these stations, as typical for the 'sea pen and burrowing megafauna communities' habitat. It is therefore concluded that all the stations in Table 4.6 above should be classified as 'sea pen and burrowing megafauna communities'. These stations are located throughout the mid-section of the export cable corridor.

Analysis of the DDV and sea pens and burrowing megafauna assessment were combined to provide a preliminary epifaunal biotope for each sample station across the Seagreen 1A export cable corridor. As stated above and shown in Table 4.7, all stations in Table 4.6 have been classified as 'sea pen and burrowing megafauna communities'. Stations ST13-ST15, ST25 and ST30 recorded subtidal mud, however ST25 and ST30 are from the inshore section of the export cable corridor therefore come from different water depths to ST13-ST15 therefore they have been assigned a separate biotope. Stations ST04, ST05, ST06, ST07, ST12 and ST27 recorded subtidal sand and were also split due to different water depths at the sample sites. Station ST03 recorded Subtidal Coarse Sediment and is located in the offshore section of the export cable corridor therefore assigned the biotope Circalittoral Coarse Sediment (SS.SCS.CCS). Sample stations ST26 and ST28 recorded Subtidal Mixed Sediments and are located in the offshore section of the export cable corridor therefore assigned the preliminary biotope Infralittoral Mixed sediments (SS.SMx.IMx) (Table 4.7).

Table 4.7: Benthic epifauna groups identified in the Seagreen 1A export cable corridor through DDV seabed imagery analysis

| Grab station number | Water Depth range (m) | Sediment classification | Key species recorded during DDV | Geographic location | Preliminary Epifaunal Biotope |
|---|---|---|---|---|---|
| ST16-ST24, ST29 | 8-55 | Subtidal Mud | *Pennatula phospohorea, Virgularia mirabilis, Nephrops norvegicus*, hermit crabs, *Turritella* sp. | Mid and Inshore section | Sea pens and burrowing megafauna in circalittoral fine mud (SS.SMu.CFiMu.SpnMeg) |
| ST13, ST14, ST15 | 52-54 | Subtidal Mud | *Pennatula phospohorea,* Mysids, Bivalves | Mid - section | Circalittoral fine mud (SS.SMu.CFiMu) |

| Grab station number | Water Depth range (m) | Sediment classification | Key species recorded during DDV | Geographic location | Preliminary Epifaunal Biotope |
|---|---|---|---|---|---|
| ST25, ST30 | 10-14 | Subtidal Mud | *Virgularia mirabilis,* Faunal turf | Inshore section | Infralittoral sandy mud (SS.SMu.ISaMu) |
| ST03 | c.65 | Subtidal Coarse Sediment | *Flustra foliacea*, *Alcyonium digitatum*, *Asterias rubens*, Branching and Erect Hyrodoids. | Offshore section | Circalittoral Coarse Sediment (SS.SCS.CCS) |
| ST04, ST05, ST06, ST07, ST12, | 45-63 | Subtidal Sand | *Flustra foliacea*, *Ophiura ophiura*, *Scaphopoda*, Hermit crabs, Mysids, Bony Fish, Bivalves, Tube worms | Offshore section | Circalittoral muddy sand (SS.SSa.CMuSa) |
| ST27 | 10 | Subtidal Sand | *Spirobranchus* sp | Inshore section | Infralittoral muddy sand (SS.SSa.IMuSa) |
| ST26, ST28 | 7-8 | Subtidal Mixed Sediments | *Ophiura albida, Ophiura ophiura*, *Sertularidae*, Ascidians | Inshore section | Infralittoral Mixed sediments (SS.SMx.IMx) |

## 5. Final biotopes

As presented in Table 4.3, three biotopes have been assigned to the six Faunal groups identified through the cluster analysis of the infaunal data: SS.SMu.ISaMu.MelMagThy, SS.SMu.CSaMu.AfilMysAnit and SS.SMu.CFiMu.SpnMeg. The infaunal and epifaunal biotopes were considered together to assign a final biotope for each sample station. Sample stations within Faunal group A: ST21, ST22 and ST29 were classified as SS.SMu.CFiMu.SpnMeg habitat in the sea pens and burrowing megafauna assessment. The SS.SMu.ISaMu.MelMagThy habitat assigned to stations ST21, ST22 and ST29 based on the infaunal data has characteristics similar to the SS.SMu.CFiMu.SpnMeg habitat; it is found on muddy sediment and at the sediment surface visible taxa may include occasional *V. mirabilis*, and mobile epifauna such as *Pagurus bernhardus*. No sea pens were recorded at stations ST21 and ST22 with common and abundant burrows on the SACFOR scale. Station ST29 recorded abundant sea pens but common abundance of burrows on the SACFOR scale, however still high enough to qualify as SS.SMu.CFiMu.SpnMeg habitat. Infaunal and epifaunal preliminary biotopes were combined to give a final biotope of a mosaic of the SS.SMu.CFiMu.SpnMeg and SS.SMu.ISaMu.MelMagThy habitat for ST21,ST22 and ST29.

Sample stations ST14 and ST15 were in Faunal group F which was been classified as SS.SMu.CFiMu.SpnMeg based on the infaunal data, however they were not included in the sea pens and burrowing megafauna assessment as there was no indication of megafauna being present, since all the burrows in the images from these stations were small in size (1cm or less). Stations ST14 and ST15 were assigned the biotope Circalittoral fine mud (SS.SMu.CFiMu) based on the epifaunal data. The raw epifaunal data was analysed and the seabed images from stations ST14 and ST15 show the sea pen *V. mirabilis,* muddy sediment and small burrows therefore the stations were classified as SS.SMu.CFiMu.SpnMeg. However, the burrows are were small in size (1cm or less) indicating that megafauna may not be present therefore these stations are a poor or impoverished example of the SS.SMu.CFiMu.SpnMeg habitat and do not qualify as the OSPAR habitat or as a Scottish PMF.

Stations ST04, ST05, ST06, ST07, ST12 were assigned the preliminary biotope Circalittoral muddy sand (SS.SSa.CMuSa) based on the epifaunal data (Table 4.7). In combination with the infaunal data, it was possible to assign the more detailed final biotope of *Amphiura filiformis, Mysella bidentata* and *Abra nitida* in circalittoral sandy mud (SS.SMu.CSaMu.AfilMysAnit).

Stations ST26 and ST27 were assigned the preliminary biotope Infralittoral Mixed sediments (SS.SMx.IMx) based on the epifaunal data (Table 4.7). The infaunal data split ST26 and ST28 into two Faunal groups however they were assigned the same preliminary biotope (Table 4.3). The combination of the epifaunal data with the infaunal data, it was possible to assign the more detailed final biotope of *Melinna palmata* with *Magelona* spp. and *Thyasira* spp. in infralittoral sandy mud (SS.SMu.ISaMu.MelMagThy).

The SS.SMu.CSaMu.AfilMysAnit habitat was recorded at the offshore section of the export cable corridor. SS.SCS.CCS was also recorded at the offshore section of the export cable corridor at the sample station where only DDV was undertaken. The SS.SMu.CFiMu.SpnMeg habitat was recorded in the mid-section of the export cable corridor and the SS.SMu.ISaMu.MelMagThy habitat was recorded at the inshore section of the export cable corridor (Figure 5.1). A map of the final biotopes identified across the Seagreen A1 export cable corridor is presented below in Figure 5.1.

The final benthic biotope extents and boundaries were mapped based on a mid-point between the sample stations with known biotopes. Where two different biotopes were present adjacent to each other it is likely that these biotopes grade into one another rather than a hard boundary as presented in Figure 5.1. It is therefore important to recognise that there is a degree of interpolation between sampling point data and the resulting biotopes mapped.

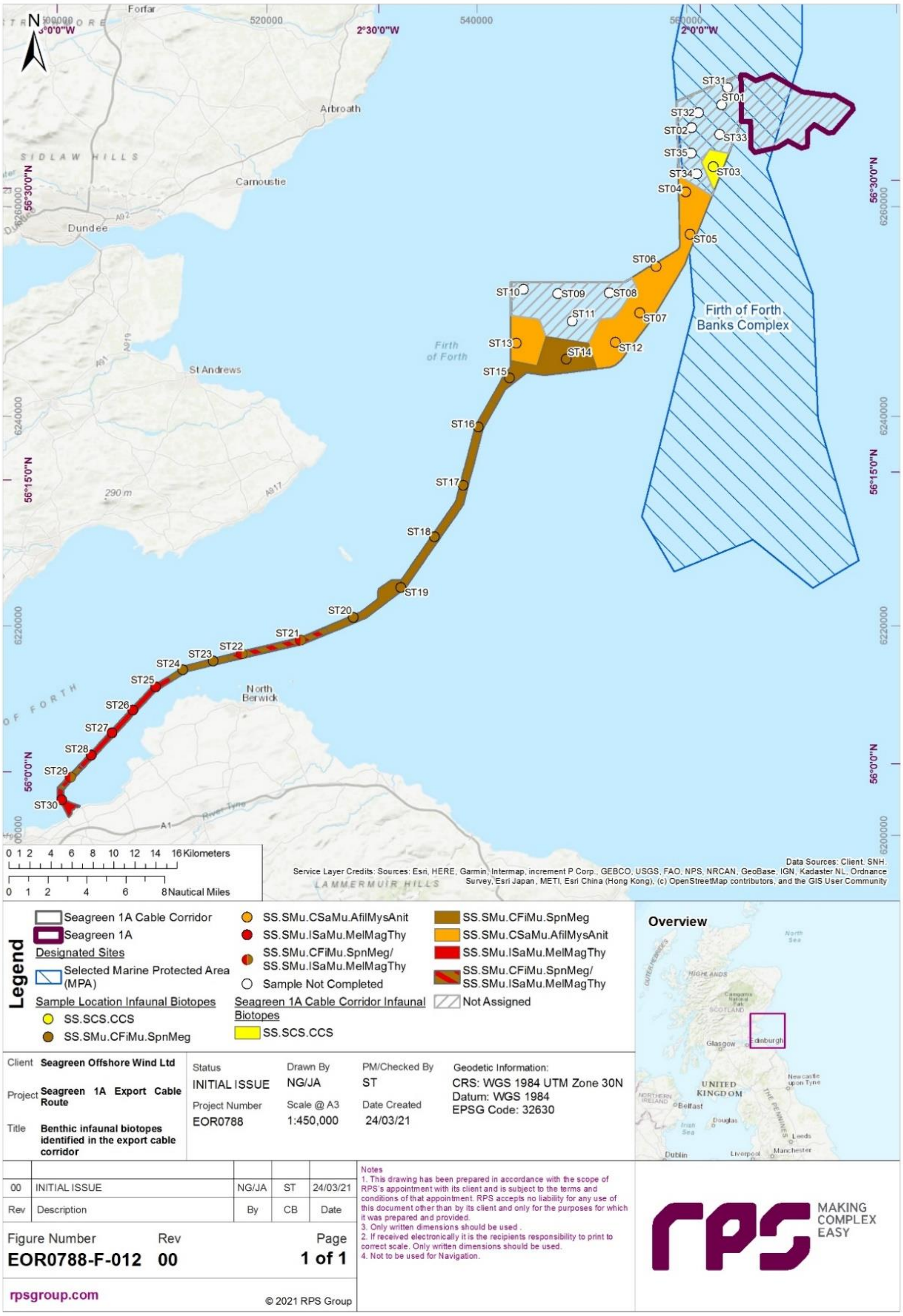



Figure 5.1: Biotopes recorded within the Seagreen 1A export cable corridor.

# 6. Discussion

### 6.1.1 Physical Sediment Characteristics Analysis

As discussed in section 4.1, the sediments recorded ranged from sand to gravelly muddy sand with the majority of the sample stations, particularly in the mid-section of the export cable corridor, characterised by muddy sand or sandy mud, in some cases with a very small proportion of gravel. Muddier sediments were recorded closest to the landfall of the inshore section of the export cable corridor with sediments grading to sandier sediments in the mid-section and offshore section of the export cable corridor. The two stations sampled within the Firth of Forth Banks Complex MPA were furthest offshore and reported the highest percentage of sand.

### 6.1.2 Benthic Ecology

As discussed in section 4.1.1.2, the multivariate analysis identified six Faunal groups however only three preliminary biotopes were identified: SS.SMu.ISaMu.MelMagThy, SS.SMu.CSaMu.AfilMysAnit and SS.SMu.CFiMu.SpnMeg. The univariate analysis highlighted that *Annelida* and *Mollusca* dominated the taxa and abundance data across all Faunal groups. The DDV identified that in the benthic epifauna data, *F. foliacea*, bivalves and *N. novegicus* were the taxa found across most stations. A sea pen and burrowing megafauna community assessment identified that this habitat was present across the majority of the mid-section of the export cable corridor. The epifauna and infaunal preliminary biotopes were reviewed and combined to provide a final biotope classification for each sample station. No Annex 1 reefs were recorded.

Nine sample stations across the export cable corridor were classified as the sea pen and burrowing megafauna OSPAR habitat. ST14 and ST15, although classified as the SS.SMu.CFiMu.SpnMeg biotope, did not contain burrows large enough to indicate the presence of megafauna therefore represents a poor example of this habitat and does not qualify as the OSPAR habitat or the Scottish PMR. Sea pen and burrowing megafauna communities (SS.SMu.CFiMu.SpnMeg) is a protected habitat, being listed as a Scottish PMF, an OSPAR threatened and declining habitat as well as being component of the Scottish PMF 'burrowed mud'. This habitat is typically found along the west coast of Scotland however it has previously been recorded in the Firth of Forth. The main threats to this habitat are activities that physically disturb the seabed, such as demersal fisheries, marine pollution through organic enrichment and increased bottom water temperature due to climate change (OSPAR, 2010).

### 6.1.3 Comparison to Desktop Data

The results of the survey are aligned with the desktop study results which also found that the sediments are dominated by muddy sands and sandy mud with a small proportion of coarse sediment. Muddier habitats become more prevalent in the mid-section of the export cable corridor and sand more prevalent in the offshore section.

Sampling for Seagreen Alpha and Bravo focused on the offshore habitats and also found sandy sediment dominating, in line with the findings of the validation survey. These surveys indicated the presence of *Sabellaria* in the same areas as those recorded in the current survey (i.e. Faunal group C) however in line with the findings of the current survey, Sabellaria was recorded at low abundance and did not indicate the presence of *Sabellaria* reef habitat in the offshore section of the Seagreen 1A export cable corridor. Sampling within the Forth of Firth Banks Complex MPA recorded sand and mud habitats with small areas of gravelly sediment which reflects the designated features of the MPA, offshore subtidal sands and gravels (JNCC, 2014a).

Sampling for the Inch Cape OWF cable route, which partially follows the same route as that for Seagreen 1A, indicated the prevalence of the SS.SMu.CSaMu.SpnMeg habitat throughout the cable corridor which is validated through the results of this survey. The Inch Cape sampling also recorded the SS.SMu.CSaMu.SpnMeg habitat in parts of the inshore area which is validated by this survey as ST29 in the inshore area is classified as a mosaic with the SS.SMu.CSaMu.SpnMeg habitat (see Figure 3.2 and Figure 5.1).

Desktop data (Cooper and Barry 2017) reported slightly muddy sand sediments with a small gravel component and slightly gravelly slightly muddy sand. This is validated by this survey which recorded muddy sands and sandy muds with a small proportion of gravel content. Cooper and Barry (2017) also reported a rich community of polychaetes (including *Spionidae, Pholoidae* and *Nephtyidae*) with some molluscs (including *Nuculidae*) and echinoderms (including *Amphuridae*) in the vicinity of the export cable corridor which is aligned with the annelid and mollusc dominated faunal groups recorded during this survey. Three species of the polychaete *Spionidae,* two species of *Pholoidae,* four species of *Nephtyidae* were found across the Seagreen 1A export cable corridor. The echinoderms *Amphiuridae* and the molluscs *Nuculidae* were also found across several sample stations in the Seagreen 1A export cable corridor.

In conclusion, the results of the Seagreen 1A survey, validate the desktop data used in the Environmental Appraisal for the Marine Licence application for the Seagreen 1A project.

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## Appendix A: Benthic Infaunal Data Multivariate Analysis Results

SIMPER
Similarity Percentages - species contributions

One-Way Analysis

Data worksheet
Name: Square root
Data type: Abundance
Sample selection: All
Variable selection: All

Parameters
Resemblance: S17 Bray Curtis similarity
Cut off for low contributions: 90.00%

Factor Groups

| Sample | SIMPROF |
|---|---|
| ST4 | d |
| ST5 | d |
| ST6 | d |
| ST7 | d |
| ST12 | d |
| ST13 | d |
| ST14 | f |
| ST15 | f |
| ST16 | f |
| ST19 | f |
| ST24 | f |
| ST17 | e |
| ST18 | e |
| ST20 | e |
| ST23 | e |
| ST21 | a |
| ST22 | a |
| ST29 | a |
| ST30 | a |
| ST25 | c |
| ST26 | c |
| ST27 | c |
| ST28 | b |

Group d
Average similarity: 31.35

| Species | Av.Abund | Av.Sim | Sim/SD | Contrib% | Cum.% |
|---|---|---|---|---|---|
| Amphiura filiformis | 2.02 | 12.63 | 7 | 40.28 | 40.28 |
| Chamelea striatula | 0.83 | 4.85 | 1.32 | 15.46 | 55.75 |
| Kurtiella bidentata | 0.8 | 2.82 | 0.78 | 9.01 | 64.75 |
| Abra prismatica | 0.69 | 1.69 | 0.48 | 5.38 | 70.14 |
| Antalis entalis | 0.57 | 1.64 | 0.48 | 5.22 | 75.35 |
| Nephtys hombergii | 0.57 | 1.44 | 0.48 | 4.59 | 79.94 |
| Galathowenia oculata | 0.62 | 1.38 | 0.48 | 4.4 | 84.34 |
| Ennucula tenuis | 0.5 | 1.3 | 0.48 | 4.14 | 88.48 |

| | | | | | |
|---|---|---|---|---|---|
| Thyasira flexuosa | 0.5 | 1.22 | 0.48 | 3.88 | 92.36 |

Group f
Average similarity: 29.45

| Species | Av.Abund | Av.Sim | Sim/SD | Contrib% | Cum.% |
|---|---|---|---|---|---|
| Thyasira flexuosa | 1.9 | 4.67 | 1.05 | 15.84 | 15.84 |
| Phaxas pellucidus | 1 | 4.02 | 2.36 | 13.67 | 29.51 |
| Abra nitida | 1.67 | 2.96 | 1.03 | 10.05 | 39.56 |
| Amphictene auricoma | 1.57 | 2.87 | 1.02 | 9.75 | 49.31 |
| Amphiura filiformis | 0.91 | 2.21 | 0.59 | 7.51 | 56.82 |
| Galathowenia oculata | 0.88 | 2.18 | 0.99 | 7.42 | 64.24 |
| Cylichna cylindracea | 0.97 | 2.06 | 1.03 | 6.99 | 71.23 |
| Polycirrus | 0.6 | 1.16 | 0.55 | 3.95 | 75.19 |
| Turritellinella tricarinata | 0.93 | 0.9 | 0.6 | 3.07 | 78.26 |
| Ampelisca tenuicornis | 1.01 | 0.89 | 0.61 | 3.03 | 81.29 |
| Goniada maculata | 0.6 | 0.85 | 0.6 | 2.88 | 84.16 |
| Phoronis | 0.68 | 0.8 | 0.6 | 2.73 | 86.89 |
| Lucinoma borealis | 0.4 | 0.48 | 0.32 | 1.63 | 88.51 |
| Chaetoderma nitidulum | 0.4 | 0.38 | 0.32 | 1.28 | 89.79 |
| Glycinde nordmanni | 0.4 | 0.38 | 0.32 | 1.28 | 91.07 |

Group e
Average similarity: 35.44

| Species | Av.Abund | Av.Sim | Sim/SD | Contrib% | Cum.% |
|---|---|---|---|---|---|
| Cylichna cylindracea | 1.1 | 8.52 | 3.74 | 24.05 | 24.05 |
| Glycera unicornis | 1 | 8.52 | 3.74 | 24.05 | 48.1 |
| Abra nitida | 1.47 | 5.05 | 0.76 | 14.25 | 62.35 |
| Thyasira flexuosa | 1.52 | 4.84 | 0.81 | 13.65 | 76.01 |
| Notomastus | 0.93 | 4.65 | 0.86 | 13.13 | 89.14 |
| Abyssoninoe hibernica | 0.5 | 1.46 | 0.41 | 4.12 | 93.26 |

Group a
Average similarity: 42.46

| Species | Av.Abund | Av.Sim | Sim/SD | Contrib% | Cum.% |
|---|---|---|---|---|---|
| Nephtys incisa | 1.79 | 20.72 | 5.05 | 48.8 | 48.8 |
| Abra nitida | 1.6 | 17.19 | 2.2 | 40.47 | 89.28 |
| Melinna palmata | 0.85 | 2.28 | 0.41 | 5.36 | 94.64 |

Group c
Average similarity: 45.89

| Species | Av.Abund | Av.Sim | Sim/SD | Contrib% | Cum.% |
|---|---|---|---|---|---|
| Galathowenia oculata | 3.94 | 6.9 | 7.18 | 15.04 | 15.04 |
| Euclymene oerstedii | 2.7 | 3.83 | 7.05 | 8.35 | 23.39 |
| Amphiura filiformis | 3.35 | 3.58 | 4.38 | 7.8 | 31.19 |
| Nucula nitidosa | 2.46 | 3.58 | 4.38 | 7.8 | 39 |
| Owenia | 1.82 | 3.55 | 4.46 | 7.74 | 46.74 |
| THRACIOIDEA | 1.76 | 2.9 | 4.46 | 6.32 | 53.06 |
| Lumbrineris cingulata | 1.66 | 2.52 | 2.96 | 5.5 | 58.56 |
| Phaxas pellucidus | 1.47 | 2.32 | 3.98 | 5.05 | 63.61 |

| | | | | | |
|---|---|---|---|---|---|
| Harpinia antennaria | 1.38 | 2.28 | 7.31 | 4.97 | 68.58 |
| Sabellaria spinulosa | 2.05 | 2.28 | 7.31 | 4.97 | 73.55 |
| Kurtiella bidentata | 2.43 | 1.75 | 0.58 | 3.8 | 77.35 |
| Ampelisca tenuicornis | 1.24 | 0.96 | 0.58 | 2.08 | 79.44 |
| NEMERTEA | 1.15 | 0.96 | 0.58 | 2.08 | 81.52 |
| Acrocnida brachiata | 1.22 | 0.85 | 0.58 | 1.86 | 83.38 |
| Chaetozone gibber | 0.67 | 0.85 | 0.58 | 1.86 | 85.23 |
| Melinna palmata | 1.05 | 0.78 | 0.58 | 1.7 | 86.93 |
| Abra alba | 0.91 | 0.65 | 0.58 | 1.41 | 88.34 |
| Ampelisca brevicornis | 0.8 | 0.65 | 0.58 | 1.41 | 89.76 |
| Magelona filiformis | 0.91 | 0.65 | 0.58 | 1.41 | 91.17 |

Group b
Less than 2 samples in group

| Species | Abundance |
|---|---|
| Euclymene oerstedii | 173 |
| Melinna palmata | 139 |
| Galathowenia oculata | 85 |
| Sabellaria spinulosa | 74 |
| Musculus subpictus | 52 |
| Lumbrineris cingulata | 41 |
| NEMERTEA | 28 |
| Rhodine gracilior | 25 |
| Dipolydora saintjosephi | 23 |
| Paradoneis lyra | 22 |
| Pholoe inornata | 17 |
| Tritaeta gibbosa | 16 |

## Appendix B: Benthic Infaunal Data Univariate Analysis Results

| | S | N | d | J' | H'(loge) | lambda |
|---|---|---|---|---|---|---|
| ST4 | 9 | 10 | 3.474356 | 0.984859 | 2.163956 | 0.12 |
| ST5 | 14 | 21 | 4.269964 | 0.950216 | 2.507675 | 0.092971 |
| ST6 | 10 | 13 | 3.508841 | 0.957526 | 2.204785 | 0.12426 |
| ST7 | 9 | 18 | 2.76781 | 0.780413 | 1.714743 | 0.283951 |
| ST12 | 12 | 18 | 3.805739 | 0.946216 | 2.351257 | 0.111111 |
| ST13 | 15 | 25 | 4.349345 | 0.93918 | 2.543348 | 0.0944 |
| ST14 | 8 | 10 | 3.040061 | 0.973976 | 2.025326 | 0.14 |
| ST15 | 17 | 22 | 5.176247 | 0.939657 | 2.662248 | 0.090909 |
| ST16 | 17 | 37 | 4.431006 | 0.880069 | 2.493424 | 0.113221 |
| ST17 | 14 | 27 | 3.94437 | 0.860574 | 2.271105 | 0.144033 |
| ST18 | 5 | 5 | 2.48534 | 1 | 1.609438 | 0.2 |
| ST19 | 42 | 101 | 8.883842 | 0.888405 | 3.320564 | 0.05421 |
| ST20 | 9 | 16 | 2.88539 | 0.877194 | 1.927392 | 0.195313 |
| ST21 | 3 | 5 | 1.24267 | 0.96023 | 1.05492 | 0.36 |
| ST22 | 6 | 12 | 2.012148 | 0.859298 | 1.539654 | 0.263889 |
| ST23 | 12 | 24 | 3.461238 | 0.847032 | 2.104795 | 0.170139 |
| ST24 | 26 | 52 | 6.327122 | 0.922292 | 3.004915 | 0.06287 |
| ST25 | 41 | 181 | 7.694532 | 0.816731 | 3.032991 | 0.079637 |
| ST26 | 28 | 107 | 5.778085 | 0.84268 | 2.80798 | 0.089527 |
| ST27 | 22 | 46 | 5.484974 | 0.928832 | 2.87106 | 0.074669 |
| ST28 | 81 | 743 | 12.1016 | 0.717991 | 3.155174 | 0.088469 |
| ST29 | 8 | 29 | 2.078819 | 0.791123 | 1.645094 | 0.248514 |
| ST30 | 4 | 13 | 1.169614 | 0.975032 | 1.351681 | 0.266272 |

## Appendix C: Benthic Infaunal Contribution of Biomass to Gross Taxonomic Groups (Adults only dataset)

| Sample | Sample Biomass (g) | | | | | Subtotal (g) |
|---|---|---|---|---|---|---|
| | Annelida | Crustacea | Mollusca | Echinodermata | Other | |
| ST4 | 0.08 | 0.0008 | 0.0624 | 0.0479 | | 0.1911 |
| ST5 | 0.2372 | 0.003 | 0.0631 | 0.0818 | | 0.3851 |
| ST6 | 0.3251 | 0.0011 | 0.5557 | 0.0697 | | 0.9516 |
| ST7 | 0.0238 | | 0.1866 | 0.5422 | 0.0037 | 0.7563 |
| ST12 | 0.091 | 0.0016 | 0.788 | 0.2826 | | 1.1632 |
| ST13 | 0.3613 | 0.062 | 4.5084 | 0.1514 | | 5.0831 |
| ST14 | 0.0648 | | 0.0255 | 0.0049 | | 0.0952 |
| ST15 | 0.0492 | 0.0837 | 0.8594 | 0.6586 | 0.1852 | 1.8361 |
| ST16 | 0.0931 | 0.0019 | 0.9095 | | 0.0058 | 1.0103 |
| ST17 | 0.3925 | 0.0726 | 0.1078 | | | 0.5729 |
| ST18 | 0.147 | | 0.0202 | | | 0.1672 |
| ST19 | 2.4268 | 0.0668 | 3.2605 | 0.0035 | 0.0469 | 5.8045 |
| ST20 | 0.2307 | 0.008 | 0.1515 | 0.0413 | | 0.4315 |
| ST21 | 0.0536 | 0.0003 | 0.0761 | | | 0.1300 |
| ST22 | 0.3614 | | 0.1061 | | | 0.4675 |
| ST23 | 0.2816 | 0.5112 | 0.0652 | | 0.0238 | 0.8818 |
| ST24 | 2.4706 | 0.0082 | 0.1963 | 0.0104 | 0.0238 | 2.7093 |
| ST25 | 0.9269 | 0.0661 | 2.4905 | 2.2624 | 0.1767 | 5.9226 |
| ST26 | 0.7661 | 0.0061 | 0.1595 | 6.3131 | 0.0725 | 7.3173 |
| ST27 | 0.2975 | 0.0235 | 0.4738 | 0.8733 | 0.1498 | 1.8179 |

| Sample | Sample Biomass (g) | | | | | Subtotal (g) |
|---|---|---|---|---|---|---|
| | Annelida | Crustacea | Mollusca | Echinodermata | Other | |
| ST28 | 5.2774 | 0.017 | 0.2886 | 0.3869 | 1.9775 | 7.9474 |
| ST29 | 0.1596 | 0.0004 | 0.1221 | | 0.4278 | 0.799 |
| ST30 | 0.327 | | 0.1207 | | 0.0292 | 0.4769 |