

Appendix 8A

Aquafact Marine Survey Report 2016



AQUAFACT

Marine Assessment at Rossaveal Harbour

Produced by

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On behalf of

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1. Introduction

In order to address the absence of a deep water quay facility at the existing harbour, the Department of Agriculture, Food and the Marine (DAFM) is proposing to develop a quay comprising a vertical faced structure constructed using concrete caissons and providing 200m of outside berthing frontage, with a minimum alongside depth of -12m CD (Chart Datum). A vessel approach channel to the quay (approximately 600m) will be dredged to a depth of -8.0m CD with a turning circle of 200m diameter to be provided. A 30m x 200m dredged pocket, of depth to -12m CD will be provided alongside the quay structure. It is anticipated that all of the dredged material will be used to fill the caissons and to construct a reclaimed area that will link the quay to the shore.

The spatial dimensions of the proposed development, such as the quay length, dredge depth, and dredge layout (*i.e.* size of turning area and shape/extent of dredge channel) have been established by the preliminary engineering design work for the project. These spatial dimensions are considered appropriate for facilitating modern day fishing vessels, such as deep sea trawlers and reefer vessels, up to the following size:

- Length Overall (LOA): 118m;
- Beam: 17.5m; and
- Draught: 6.5m.

In addition, the provision of a deeper berthing pocket in front of quay will facilitate the tidal arrival and departure of deeper draught vessels.

The outside berthing line is planned to be suitable for vessels berthing directly alongside, though double banking of vessels is foreseen.

Fendering on the outside berth if provided would be arch fenders at an appropriate spacing. If necessary, fendering on the outside berthing line could be supplemented with removable floating fenders for occasional calls by larger vessels.

The onshore reclamation areas will be left unfinished as rolled rock hardcore. Fencing of an initial

secure area is proposed. The reclaimed area will be protected by a rock armour revetment, and hardstanding and parking areas and a paved access road to the deep water quay will be provided.

Appendix 1 details the construction methodologies proposed for this project.

A baseline characterisation survey was required to document the benthic community at the proposed development site (see Figure 1.1). A sediment characterisation was also required from the harbour area in line with Cronin *et al.* (2006) '*Guidelines for the assessment of dredge material for disposal in Irish waters*'. This report documents both of these assessments.

Figures 1.1 to 1.4 show the layout of the proposed deep water quay.



Figure 1.2: Proposed quay layout.

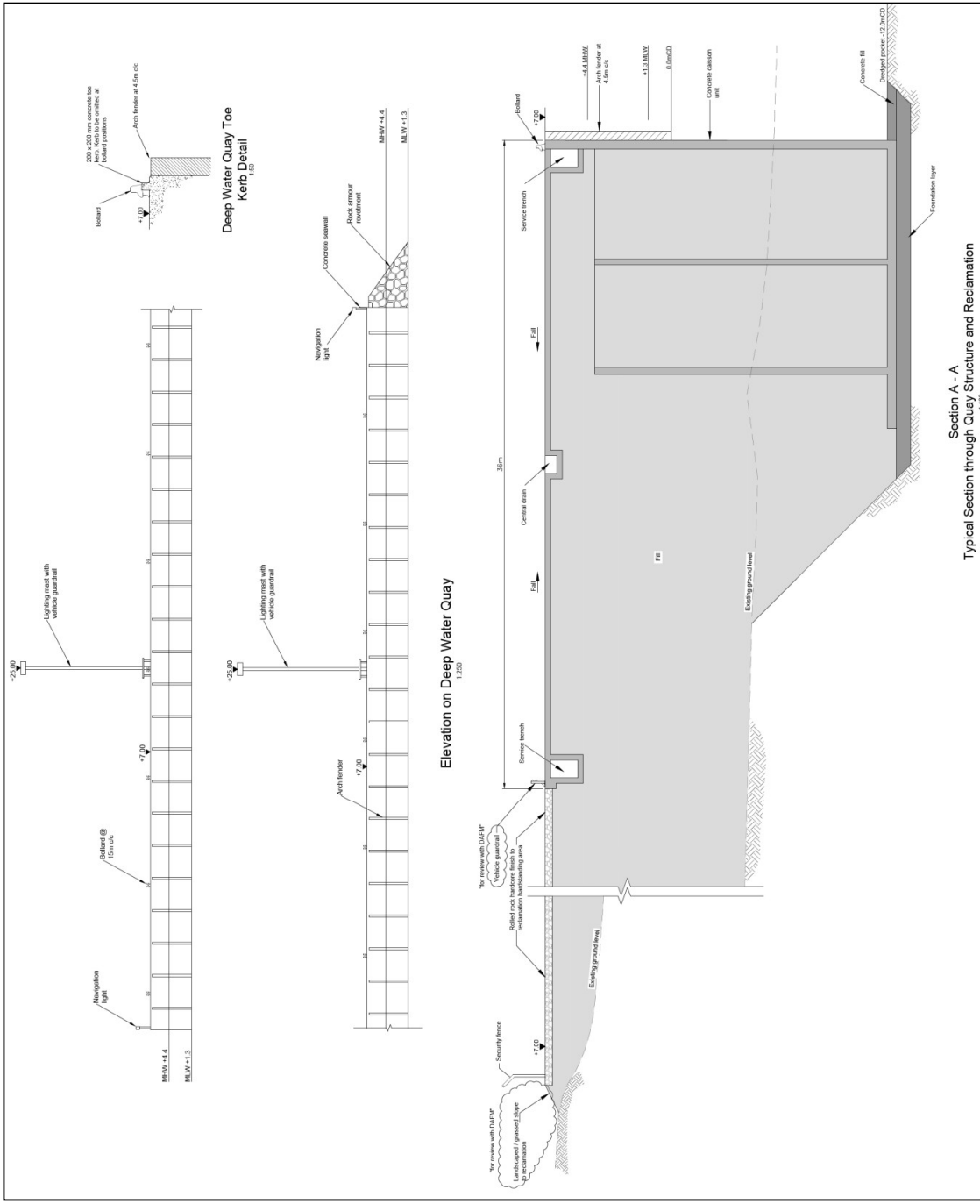
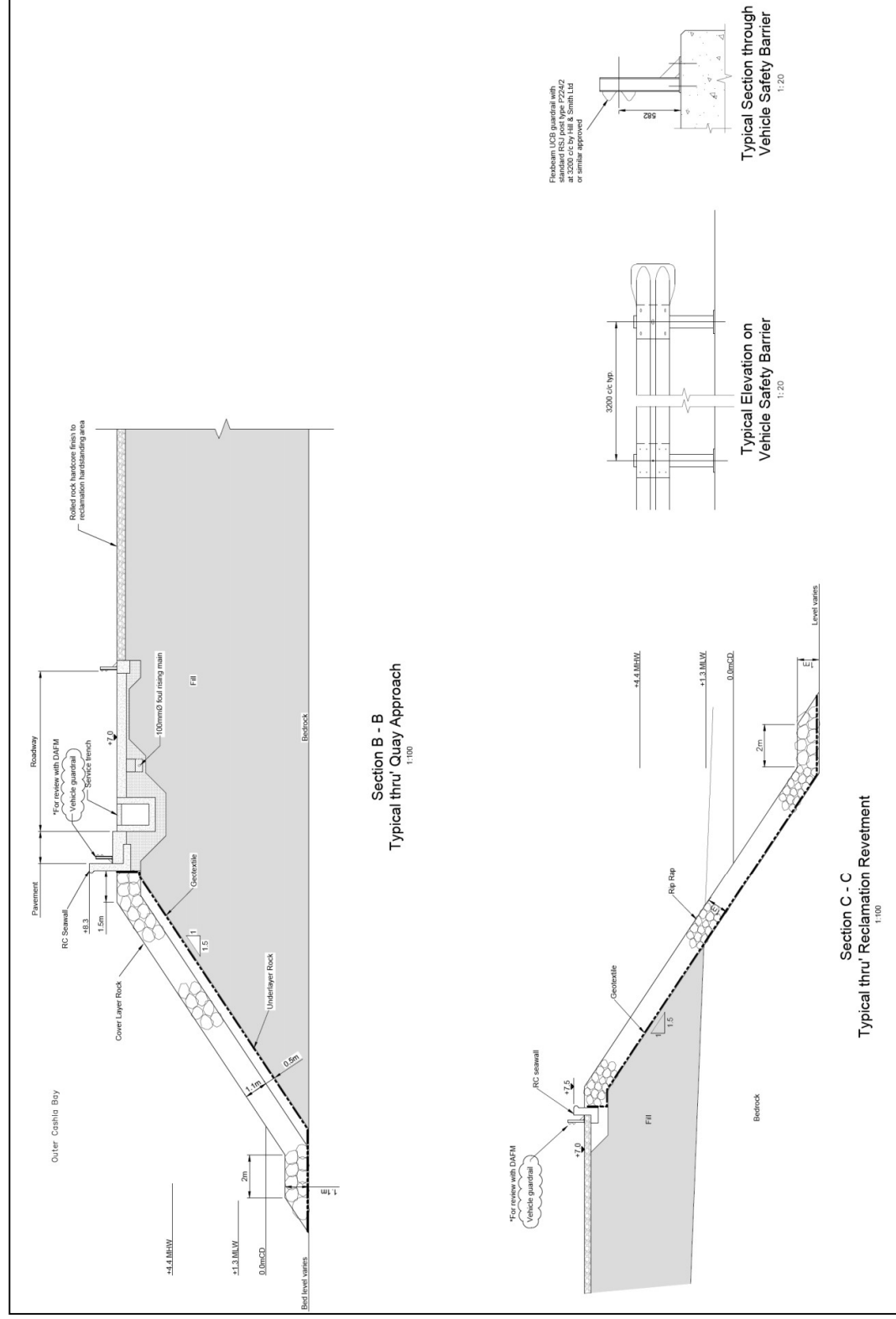


Figure 1.4:



2. Benthic Grab Survey

2.1. Background

Figure 2.1 shows the distribution of biotopes in the area of the proposed deep water quay that were surveyed as part of the Environmental Impact Statement (RPS, 2002). The littoral zone in the area of the proposed deep water quay comprises of boulders and is relatively sheltered to wave action. The upper shore consists of a narrow band of *Pelvetia canaliculata* (SLR.Pel), with the spiral wrack *Fucus spiralis* (SLR.Fspi) below it. In parts, barren rock or yellow and grey lichens dominate the upper shore. The midshore is dominated by dense knotted wrack *Ascophyllum nodosum* (SLR.AscAsc), which supports the epiphytic algae *Vertebrata lanosa*. The green algae *Cladophora rupestris* is present on the rocks below the *A. nodosum* zone. Within the *A. nodosum* zone, raised areas of bedrock are colonised by barnacles and limpets (ELR.BPat). A narrow band of the serrated wrack *Fucus serratus* is present below the *A. nodosum* zone and below that kelp *Laminaria digitata* (MIR.Ldig) is present in the sublittoral fringe. Intertidal surveys carried out by AQUAFACT in 2013 provided very similar results (AQUAFACT, 2015a).

Beyond the *L. digitata* zone, a band of sheltered infralittoral rock (SIR) is present which is dominated by sugar kelp *L. saccharina*. The main channel is predominantly coarse gravel and sand with decaying red and green seaweeds with tunicates on them and anemones buried in the sand (IMX.An) and the starfish *Asterias rubens* on the substrata. The pinnate sea pen *Virgularia mirabilis* was also recorded from the area. *V. mirabilis* is a characteristic species of the sea pen and burrowing megafaunal communities habitat which is listed on the OSPAR List of threatened and/or declining species and habitats (OSPAR 2008). There is also a patch of circalittoral muds in the centre of the channel. The western margin of the channel is mainly dominated by a mixed substratum with *L. saccharina* and mixed filamentous algae (IMX.KSwMx). There are also patches of sandy gravel dominated by seagrass *Zostera marina* along this western margin (IMS.Zmar). The *Zostera* beds in the southern part of the western margin are extensive where as the beds in the northern part are quite sparse.

AQUAFACT re-surveyed the area in October 2016 (grab survey) and February 2017 (drop-down video) to reconfirm the habitats and communities present and the results of this are outlined below.

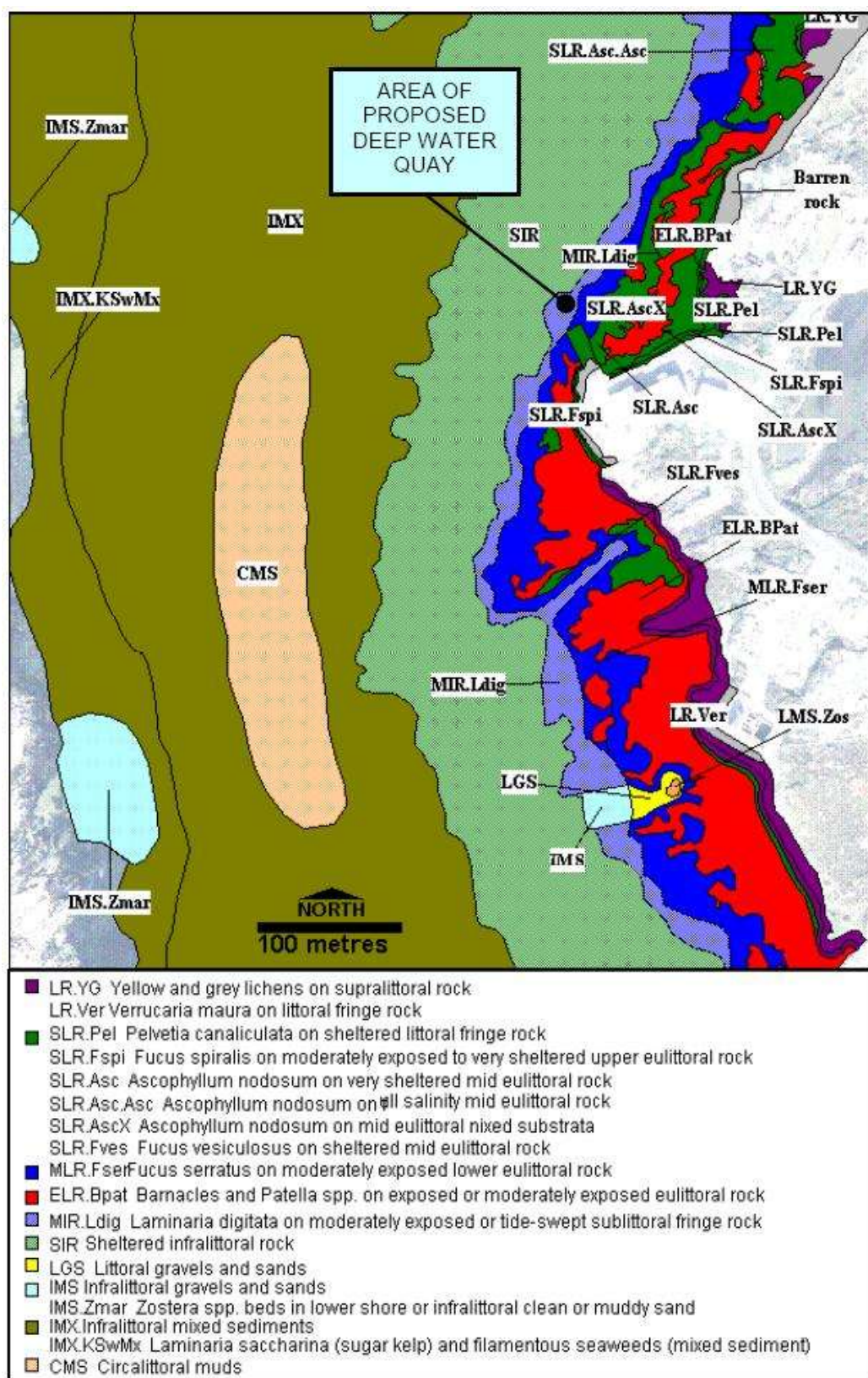


Figure 2.1: Biotopes recorded from the littoral and sublittoral surveys in the vicinity of the proposed deep water quay at Rossaveal (RPS, 2002).

2.2. Materials & Methods

2.2.1. Sampling Procedure

To carry out the subtidal benthic assessment of the proposed development area, AQUAFACT sampled a total of 7 stations. Sampling took place on the 11th October 2016 from RPS Marine's *Puffin*.

There was an easterly force 5-6 breeze blowing but conditions in the sheltered survey area were calm. Figure 2.2 shows the stations sampled in the dredge area and Table 2.1 shows the associated station coordinates and water depths.

AQUAFACT has in-house standard operational procedures for benthic sampling and these were followed for this project. Additionally, the recently published MESH report on "Recommended Standard methods and procedures" was adhered to.

A 0.1m² Day grab was used to sample the dredge site. On arrival at each sampling station, the vessel location was recorded using DGPS (latitude/longitude). Additional information such as date, time, site name, sample code and depth were recorded in a data sheet.

Two replicate grab samples were taken at each of the stations for faunal analysis and a third sample was collected for sediment grain size and organic carbon analysis. The grab deployment and recovery rates did not exceed 1 metre/sec. This was to ensure minimal interference with the sediment surface as the grab descended. Upon retrieval of the grab a description of the sediment type was noted in the sample data sheet. Notes were also made on colour, texture, smell and presence of animals.

A digital image of each sample (including sample label) was taken and these images can be seen in Appendix 2. The grab sampler was cleaned between stations to prevent cross contamination.

The samples collected for faunal analysis were carefully and gently sieved on a 1mm mesh sieve as a sediment water suspension for the retention of fauna. Great care was taken during the sieving process in order to minimise damage to taxa such as spionids, scale worms, phyllodocids and amphipods. The sample residue was carefully flushed into a pre-labelled (internally and externally)

container from below. Each label contained the sample code and date. The samples were stained with Eosin-briebrich scarlet and fixed in 4% w/v buffered formaldehyde solution upon returning to the laboratory. These samples were ultimately preserved in 70% alcohol prior to processing.

Table 2.1: Station coordinates and depths as recorded on the day at the dredge site (not tidally corrected).

Station	Longitude	Latitude	Depth (m)
S1	-9.56983	53.26405	9.4
S2	-9.5714	53.26415	9.7
S3	-9.56993	53.26419	9.2
S4	-9.56915	53.26551	8.2
S5	-9.57104	53.26578	8.9
S6	-9.56846	53.26733	6.8
S7	-9.57043	53.26172	9.1

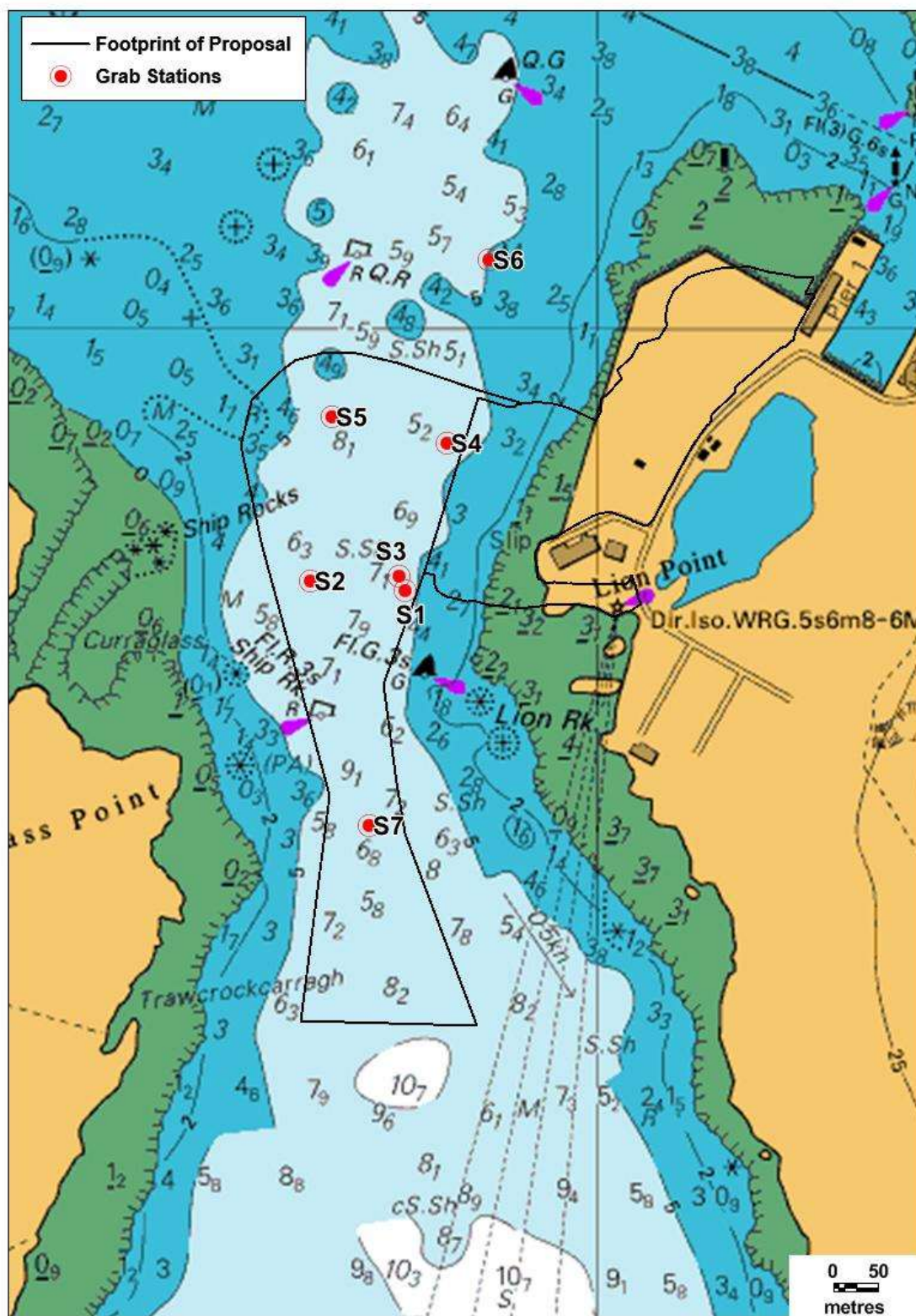


Figure 2.2: Location of the stations sampled at the dredge site on the 11th October 2016.

2.2.2. Sample Processing

All faunal samples were placed in an illuminated shallow white tray and sorted first by eye to remove large specimens and then sorted under a stereo microscope (x 10 magnification). Following the removal of larger specimens, the samples were placed into Petri dishes, approximately one half teaspoon at a time and sorted using a binocular microscope at x25 magnification.

The fauna was sorted into four main groups: Polychaeta, Mollusca, Crustacea and others. The 'others' group consisted of echinoderms, nematodes, nemerteans, cnidarians and other lesser phyla. The fauna were maintained in stabilised 70% industrial methylated spirit (IMS) following retrieval and identified to species level where practical using a binocular microscope, a compound microscope and all relevant taxonomic keys. After identification and enumeration, specimens were separated and stored to species level.

The sediment granulometric analysis was carried out by AQUAFACTM using the traditional granulometric approach. Traditional analysis involved the dry sieving of approximately 100g of sediment using a series of Wentworth graded sieves. The process involved the separation of the sediment fractions by passing them through a series of sieves. Each sieve retained a fraction of the sediment, which were later weighed and a percentage of the total was calculated. Table 2.3 shows the classification of sediment particle size ranges into size classes. Sieves, which corresponded to the range of particle sizes (Table 2.2), were used in the analysis. Appendix 3 provides the detailed granulometric methodology.

Table 2.2: The classification of sediment particle size ranges into size classes (adapted from Buchanan, 1984)

Range of Particle Size	Classification	Phi Unit
<63µm	Silt/Clay	>4 Ø
63-125 µm	Very Fine Sand	4 Ø, 3.5 Ø
125-250 µm	Fine Sand	3 Ø, 2.5 Ø
250-500 µm	Medium Sand	2 Ø, 1.5 Ø
500-1000 µm	Coarse Sand	1 Ø, 1.5 Ø
1000-2000 µm (1 – 2mm)	Very Coarse Sand	0 Ø, -0.5 Ø
2000 – 4000 µm (2 – 4mm)	Very Fine Gravel	-1 Ø, -1.5 Ø
4000 -8000 µm (4 – 8mm)	Fine Gravel	-2 Ø, -2.5 Ø

Range of Particle Size	Classification	Phi Unit
8 -64 mm	Medium, Coarse & Very Coarse Gravel	-3 Ø to -5.5 Ø
64 – 256 mm	Cobble	-6 Ø to -7.5 Ø
>256 mm	Boulder	< -8 Ø

The additional sediment samples collected from the faunal stations had their organic carbon analysis performed by ALS Laboratories in Loughrea using the Loss on Ignition method. Appendix 3 provides the methodology.

2.2.3. Data Analysis

Statistical evaluation of the faunal data was undertaken using PRIMER v.6 (Plymouth Routines in Ecological Research). Univariate statistics in the form of diversity indices are calculated. Numbers of species and numbers of individuals per sample will be calculated and the following diversity indices will be utilised:

- 1) Margalef's species richness index (D) (Margalef, 1958),

$$D = \frac{S-1}{\log_2 N}$$

where: N is the number of individuals

S is the number of species

- 2) Pielou's Evenness index (J) (Pielou, 1977)

$$J = \frac{H'(\text{observed})}{H'_{\max}}$$

where: $H'_{\max}$ is the maximum possible diversity, which could be achieved if all species were equally abundant ($= \log_2 S$)

- 3) Shannon-Wiener diversity index (H') (Pielou, 1977)

$$H' = - \sum_{i=1}^S p_i (\log_2 p_i)$$

where: p_i is the proportion of the total count accounted for by the i^{th} taxa

- 4) Simpson's Diversity Index (Simpson, 1949)

$$1-\lambda' = 1 - \{\sum_i N_i(N_i-1)\} / \{N(N-1)\}$$

where N is the number of individuals of species i.

Species richness is a measure of the total number of species present for a given number of individuals. Evenness is a measure of how evenly the individuals are distributed among different species. The Shannon-Wiener index incorporates both species richness and the evenness component of diversity (Shannon & Weaver, 1949) and Simpson's index is a more explicit measure of the latter, *i.e.* the proportional numerical dominance of species in the sample (Simpson, 1949).

The PRIMER programme (Clarke & Warwick, 2001) was used to carry out multivariate analyses on the station-by-station faunal data. All species/abundance data from the grab surveys was square root transformed and used to prepare a Bray-Curtis similarity matrix in PRIMER[®]. The square root transformation was used in order to allow the intermediate abundant species to play a part in the similarity calculation. All species/abundance data from the samples was used to prepare a Bray-Curtis similarity matrix. The similarity matrix was then be used in classification/cluster analysis. The aim of this analysis was to find “natural groupings” of samples, *i.e.* samples within a group that are more similar to each other, than they are similar to samples in different groups (Clarke & Warwick, *loc. cit.*). The PRIMER programme CLUSTER carried out this analysis by successively fusing the samples into groups and the groups into larger clusters, beginning with the highest mutual similarities then gradually reducing the similarity level at which groups are formed. The result was represented graphically in a dendrogram, the x-axis representing the full set of samples and the y-axis representing similarity levels at which two samples/groups are said to have fused. SIMPROF (Similarity Profile) permutation tests were incorporated into the CLUSTER analysis to identify statistically significant evidence of genuine clusters in samples which are *a priori* unstructured.

The Bray-Curtis similarity matrix was also be subjected to a non-metric multi-dimensional scaling (MDS) algorithm (Kruskal & Wish, 1978), using the PRIMER programme MDS. This programme produced an ordination, which is a map of the samples in two- or three-dimensions, whereby the placement of samples reflects the similarity of their biological communities, rather than their simple geographical location (Clarke & Warwick, 2001). With regard to stress values, they give an indication of how well the multi-dimensional similarity matrix is represented by the two-dimensional plot. They are calculated by comparing the interpoint distances in the similarity matrix with the corresponding interpoint distances on the 2-d plot. Perfect or near perfect matches are rare in field data, especially in the absence of a single overriding forcing factor such as an organic enrichment gradient. Stress values increase, not only with the reducing dimensionality (lack of clear forcing structure), but also with increasing quantity of data (it is a sum of the squares type regression coefficient). Clarke & Warwick (*loc. cit.*) have provided a classification of the reliability of MDS plots based on stress

values, having compiled simulation studies of stress value behaviour and archived empirical data. This classification generally holds well for 2-d ordinations of the type used in this study. Their classification is given below:

- Stress value < 0.05: Excellent representation of the data with no prospect of misinterpretation.
- Stress value < 0.10: Good representation, no real prospect of misinterpretation of overall structure, but very fine detail may be misleading in compact subgroups.
- Stress value < 0.20: This provides a useful 2-d picture, but detail may be misinterpreted particularly nearing 0.20.
- Stress value 0.20 to 0.30: This should be viewed with scepticism, particularly in the upper part of the range, and discarded for a small to moderate number of points such as < 50.
- Stress values > 0.30: The data points are close to being randomly distributed in the 2-d ordination and not representative of the underlying similarity matrix.

Each stress value must be interpreted both in terms of its absolute value and the number of data points. In the case of this study, the moderate number of data points indicates that the stress value can be interpreted more or less directly. While the above classification is arbitrary, it does provide a framework that has proved effective in this type of analysis.

The species, which are responsible for the grouping of samples in cluster and ordination analyses, were identified using the PRIMER programme SIMPER (Clarke & Warwick, 1994). This programme determined the percentage contribution of each species to the dissimilarity/similarity within and between each sample group.

2.3. Results

2.3.1. Fauna

The taxonomic identification of the benthic infauna across all 7 stations sampled at the dredge site yielded a total count of 236 taxa and 6,648 individuals ascribed to 10 phyla. Of the 236 taxa recorded, 179 were identified to species level. The remaining 57 could not be identified to species level as they were either juveniles, partial, damaged or indeterminate. Appendix 4 shows the faunal abundance matrix.

Of the 236 taxa present, 1 was a foraminiferan (hole bearer), 4 were cnidarians (corals, anemones, jellyfish etc), 1 was a nematode (roundworm), 1 was a nemertean (ribbon worms), 106 were annelids (segmented worms including sipunculids), 1 was a chelicerate (sea spider), 77 were crustaceans (crabs, shrimps, prawns), 35 were molluscs (mussels, cockles, snails etc.), 2 were phoronids (horseshoe worm) and 8 was an echinoderm (brittlestars, starfish, sea cucumbers).

2.3.1.1. Univariate Analysis

Univariate statistical analyses were carried out on the combined station-by-station faunal data. The following parameters were calculated and can be seen in Table 2.3: taxon numbers, number of individuals, richness, evenness, Shannon-Weiner diversity and Simpson's Diversity. Taxon numbers ranged from 52 (S6) to 118 (S2 and S3). Number of individuals ranged from 344 (S6) to 1,350 (S2). Richness ranged from 8.73 (S6) to 16.85 (S3). Evenness ranged from 0.77 (S4) to 0.85 (S3, S6 and S7). Shannon-Weiner diversity ranged from 3.18 (S4) to 4.07 (S7). Simpson's diversity ranged from 0.93 (S4) to 0.97 (S3 and S7). Figure 2.3 shows these community indices in graphical form.

Table 2.3: Univariate measures of community structure.

Station	No. Taxa	No. Individuals	Richness	Evenness	Shannon-Weiner Diversity	Simpson's Diversity
S1	102	1283	14.11	0.80	3.68	0.95
S2	118	1350	16.23	0.80	3.83	0.96
S3	118	1036	16.85	0.85	4.06	0.97
S4	64	577	9.91	0.77	3.18	0.93
S5	89	801	13.16	0.79	3.55	0.95
S6	52	344	8.73	0.85	3.37	0.95
S7	117	1257	16.25	0.85	4.07	0.97

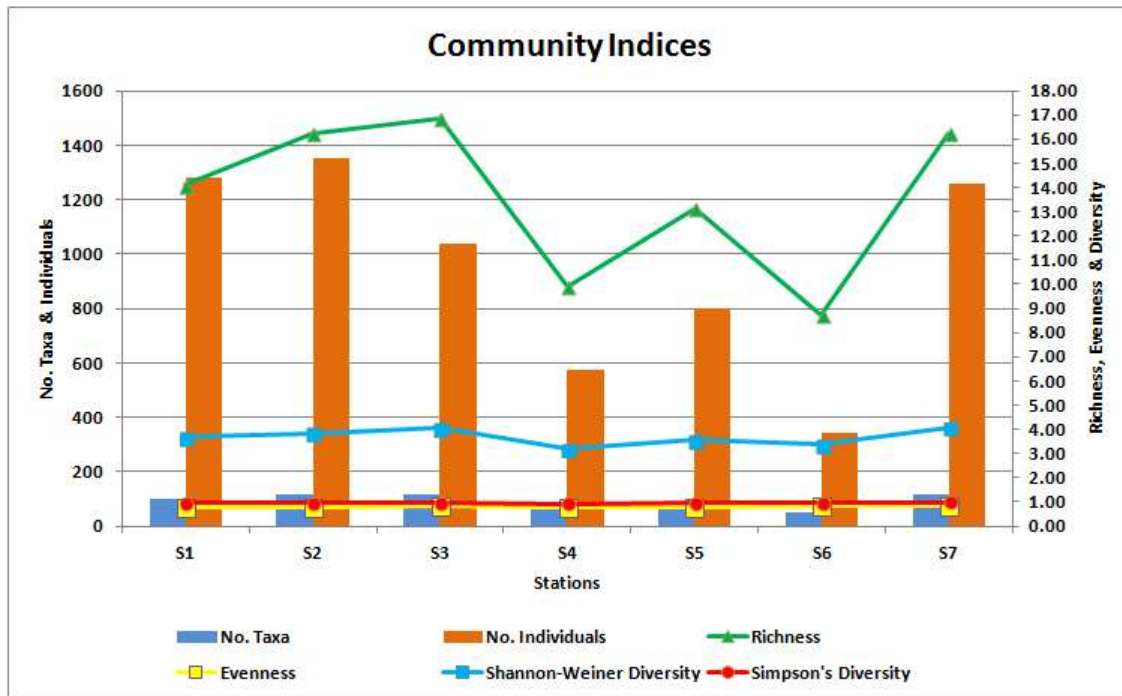


Figure 2.3: Community diversity indices.

2.3.1.2. Multivariate Analysis

The same data set used above for the univariate analyses was also used for the multivariate analyses. The dendrogram and the MDS plot can be seen in Figures 2.4 and 2.5 respectively. SIMPROF analysis revealed 2 statistically significant groupings between the 7 stations (the samples connected by red lines cannot be significantly differentiated). The stress level on the MDS plot indicates an excellent representation of the data with no real prospect of misinterpretation.

Groups a and b separated from each other at a 46.47% similarity level. **Group a** contained stations S1, S2, S3 and S7 and this group had an average similarity level of 59.26%. This group contained 216 taxa comprising 4,926 individuals. Of the 216 species, 75 were present twice or less. Fourteen species accounted for just over 50% of the combined faunal abundance of this group; the crustaceans *Metaphoxus simplex* (565 individuals; 11.5% abundance) and *Tanaopsis graciloides* (284 individuals; 5.8% abundance), the polychaetes *Mediomastus fragilis* (232 individuals; 4.7% abundance), *Euclymene lombricoides* (162 individuals; 3.3 % abundance), *Pholoe inornata* (150 individuals; 3.1% abundance), *Aponuphis bilineata* (147 individuals; 3.0% abundance), the crustacean *Euphilomedes sinister* (147 individuals; 3.0% abundance), the polychaete *Galathowenia oculata* (135 individuals; 2.7% abundance), the crustacean *Microdeutopus versiculatus* (124 individuals; 2.5% abundance), the polychaete *Melinna palmata* (115 individuals; 2.3% abundance), the bivalves

Thyasira flexuosa (111 individuals; 2.3% abundance) and *Kurtiella bidentata* (106 individuals; 2.2% abundance) and the crustaceans *Cheirocratus* sp. (105 individuals; 2.1% abundance) and *Macrochaeta clavicornis* (88 individuals; 1.8% abundance).

SIMPER analysis revealed that *Cheirocratus* sp., *Kurtiella bidentata*, *Pholoe inornata*, *Thyasira flexuosa* and *Tanaopsis graciloides* were the main characterising species of the group. Table 2.4 provides the SIMPER results showing the top 50% of the similarity.

Group b contained stations S4, S5 and S6. This group contained 125 taxa comprising 1,722 individuals. Of the 125 taxa, 55 were present twice or less. Eight species accounted for just over 50% of the faunal abundance of this group; the crustacean *Metaphoxus simplex* (222 individuals; 12.9% abundance), the polychaetes *Melinna palmata* (148 individuals; 8.6% abundance), *Euclymene lombricoides* (112 individuals; 6.5% abundance), the bivalve *Thyasira flexuosa* (112 individuals; 6.5% abundance), the polychaete *Pholoe inornata* (91 individuals; 5.3% abundance), the crustacean *Tanaopsis graciloides* (71 individuals; 4.1% abundance) and the polychaetes *Mediomastus fragilis* (68 individuals; 3.9% abundance) and *Galathowenia oculata* (66 individuals; 3.8% abundance).

SIMPER analysis revealed that *Euclymene lombricoides*, *Thyasira flexuosa*, *Mediomastus fragilis*, *Pholoe inornata* and *Melinna palmata* were the main characterising species of the group. Table 2.4 provides the SIMPER results showing the top 50% of the similarity.

While Groups a and b grouped separately, they did share quite a number of species (the majority listed above). They did differ as the result of a number of other species, namely the bivalve *Kurtiella bidentata* and the polychaetes *Paradoneis lyra*, *Scalibregma inflatum*, *Sphaerosyllis bulbosa*, *Paranaitis kosteriensis* and *Syllidia armata*.

Neither grouping could be attributed to any EUNIS assemblage. The group of species was however similar to what is typically found in an *Amphiura* community but as none of this ophiuroid were recorded, it did not fit any such assemblage.

The habitat type of the dredge site and can be classified by Fossitt (2000) as SS4 *Infralittoral mixed sediments*.

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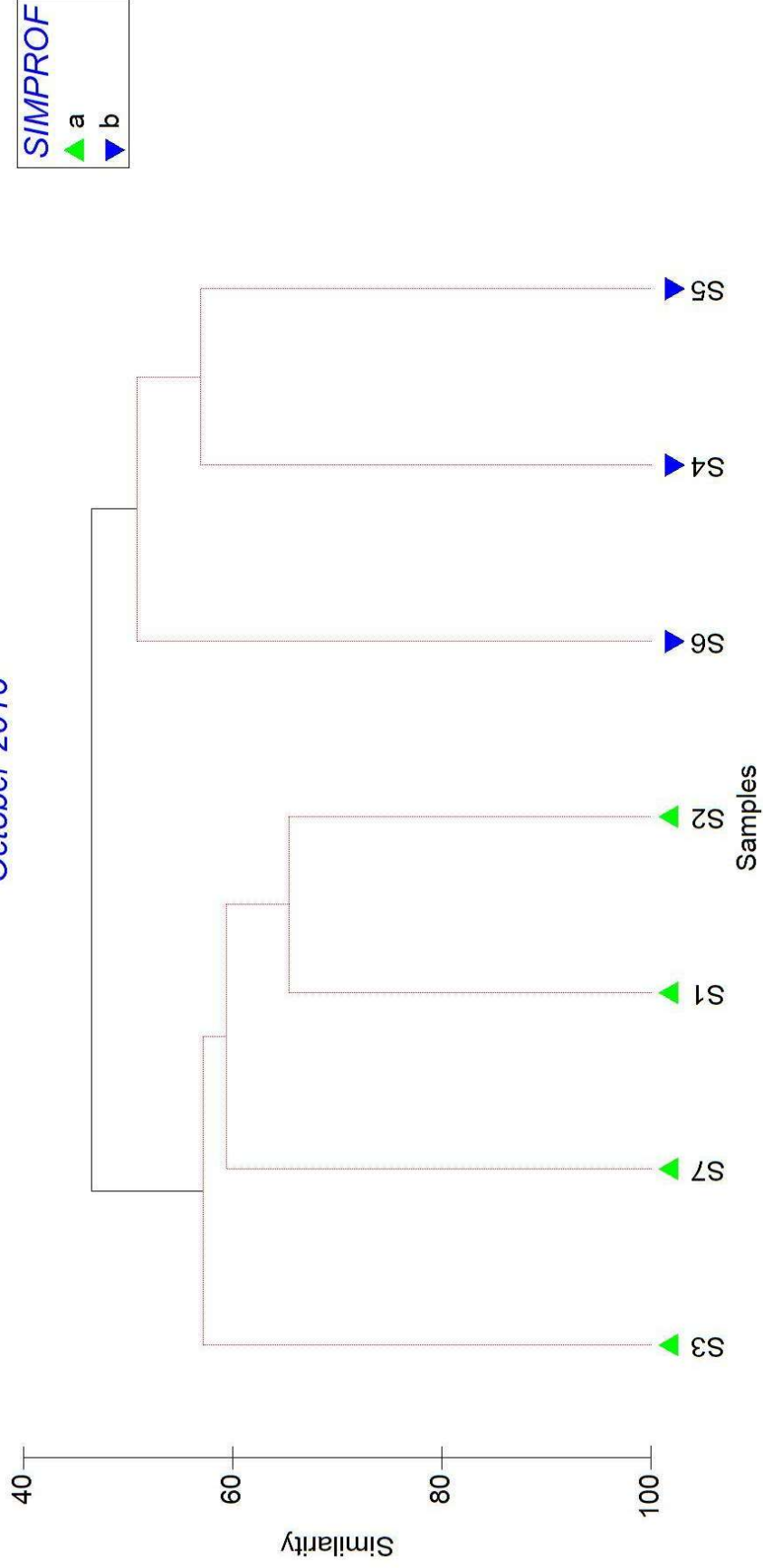


Figure 2.4: Dendrogram produced from Cluster analysis.

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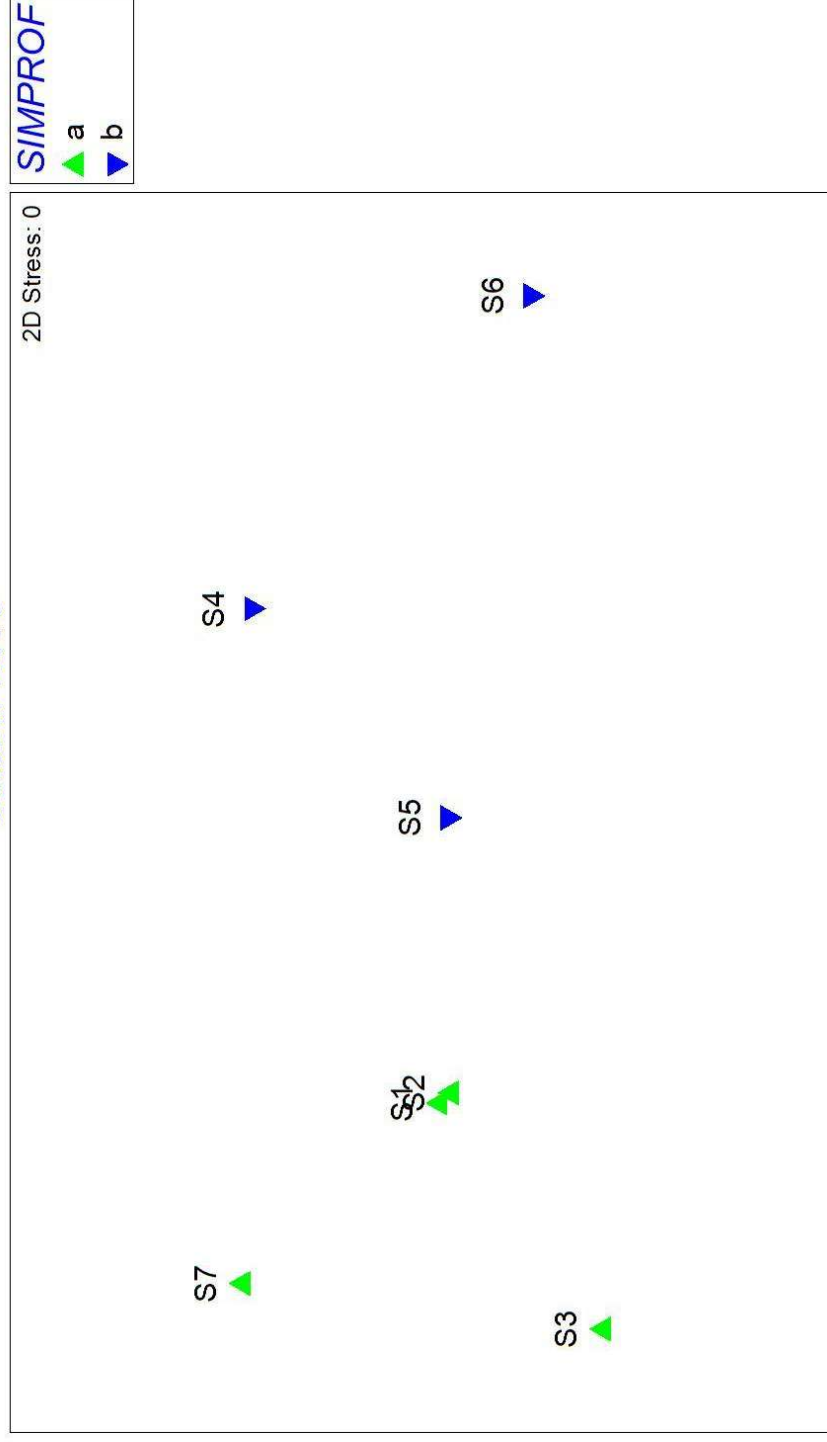


Figure 2.5: MDS plot.

Table 2.4: SIMPER Results

Group a: Average similarity: 59.26					
Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
<i>Metaphoxus simplex</i>	3.39	1.79	8.02	3.02	3.02
<i>Tanaopsis graciloides</i>	2.83	1.47	10.45	2.48	5.49
<i>Mediomastus fragilis</i>	2.72	1.44	15	2.43	7.93
<i>Pholoe inornata</i>	2.44	1.29	19.62	2.18	10.1
<i>Microdeutopus versiculatus</i>	2.35	1.29	13.02	2.17	12.28
<i>Cheirocratus</i> sp.	2.26	1.25	28.16	2.11	14.39
<i>Kurtiella bidentata</i>	2.26	1.25	26.68	2.1	16.49
<i>Thyasira flexuosa</i>	2.27	1.22	15.13	2.06	18.55
<i>Euphilomedes sinister</i>	2.36	1.19	8.11	2.01	20.55
<i>Galathowenia oculata</i>	2.33	1.18	6.27	1.99	22.54
<i>Macrochaeta clavicornis</i>	2.13	1.12	8.1	1.88	24.43
<i>Aponuphis bilineata</i>	2.29	1.09	4.13	1.83	26.26
<i>Lumbrineris cingulata/aniara</i>	2.01	1.08	45.79	1.82	28.08
<i>Ampelisca typica</i>	1.97	1.03	11.88	1.74	29.82
Nemertea	2.01	1.03	6.34	1.74	31.57
<i>Scalibregma celticum</i>	1.87	1.02	12.92	1.72	33.29
<i>Chondrochelia savignyi</i>	2.04	1	7.75	1.69	34.97
<i>Aonides oxycephala</i>	1.88	0.99	13.27	1.67	36.65
<i>Cirrophorus branchiatus</i>	1.94	0.97	15.72	1.64	38.29
<i>Scalibregma inflatum</i>	1.77	0.97	19.07	1.63	39.92
Nematoda	1.98	0.96	6.57	1.63	41.55
<i>Parametaphoxus fultoni</i>	1.84	0.96	16.38	1.63	43.18
<i>Ampelisca</i> sp.	1.85	0.96	6.95	1.63	44.8
<i>Longipedia minor</i>	1.76	0.92	7.9	1.56	46.36
<i>Paradoneis lyra</i>	1.84	0.9	5.08	1.51	47.87
<i>Eteone longa/flava</i>	1.77	0.88	17.68	1.48	49.35
<i>Nephtys</i> sp.	1.74	0.87	8.61	1.47	50.82
Group b: Average similarity: 52.87					
Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
<i>Thyasira flexuosa</i>	2.43	2.27	9.84	4.3	4.3
<i>Melinna palmata</i>	2.55	2.25	7.25	4.25	8.55
<i>Pholoe inornata</i>	2.3	2.16	7.54	4.08	12.62
<i>Metaphoxus simplex</i>	2.67	2.1	3.05	3.97	16.59
<i>Euclymene lombricoides</i>	2.37	2.08	9.87	3.93	20.52
<i>Mediomastus fragilis</i>	2.15	2.01	9.51	3.8	24.32
<i>Tanaopsis graciloides</i>	2.14	1.94	5.1	3.66	27.98
<i>Terebellides stroemii</i>	1.98	1.86	6.35	3.51	31.5
<i>Chondrochelia savignyi</i>	1.8	1.81	6.92	3.43	34.93
Nemertea	1.79	1.81	7.54	3.43	38.36
Aoridae	1.79	1.73	6.59	3.28	41.63

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
<i>Euphilomedes sinister</i>	1.77	1.72	8.35	3.26	44.89
<i>Microdeutopus versiculatus</i>	1.81	1.61	8.29	3.05	47.95
<i>Nephtys</i> sp.	1.79	1.6	3.41	3.03	50.98

2.3.2. Sediment

Table 2.6 shows the sediment characteristics of the faunal stations at the dredge site. Station S5 contained the highest percentage of fine gravel (3.9%) and very fine gravel (10.0%). Station S7 contained the highest proportion of very coarse sand (24.5%) and coarse sand (28.7%). Station S3 contained the highest proportion of medium sand (30.5%). Station S4 had the highest percentage of fine sand (23.7%). Station S6 had the highest percentage of very fine sand (26.7%) and silt-clay. (35.1%). The sediment sampled from the area was classified according to Folk (1954) as a mix of gravelly sand, muddy sand and gravelly muddy sand. The substrata type at all stations can be seen graphically in Figure 2.6 below. Figure 2.7 shows the sediment type according to Folk, 1954). Organic matter values ranged from 5.52 (S3) to 22.5 (S6).

Table 2.5: Sediment characteristics of the dredge site faunal stations.

Station	Fine Gravel (>4mm)	Very Fine Gravel (2- 4mm)	Very Coarse Sand (1- 2mm)	Coarse Sand (0.5- 1mm)	Medium Sand (0.25- 0.5mm)	Fine Sand (125- 250mm)	Very Fine Sand (62.5- 125mm)	Silt-Clay (<63mm)	Folk (1954)	LOI
S1	1.7	7.4	20.5	22.9	27.6	12.8	3.6	3.6	Gravelly sand	6.66
S2	3.5	6.2	11.7	17.5	26.2	15.7	9.4	9.7	Gravelly muddy sand	7.36
S3	1.3	5.0	16.8	28.4	30.5	12.3	2.6	3.2	Gravelly sand	5.52
S4	2.2	6.3	10.7	13.0	19.9	23.7	11.8	12.4	Gravelly muddy sand	6.71
S5	3.9	10.0	20.6	24.6	22.2	9.3	4.5	4.8	Gravelly sand	7.72
S6	0.0	0.0	0.0	0.6	16.4	21.2	26.7	35.1	Muddy sand	22.5
S7	3.7	9.5	24.5	28.7	19.9	6.4	3.6	3.7	Gravelly sand	8.61

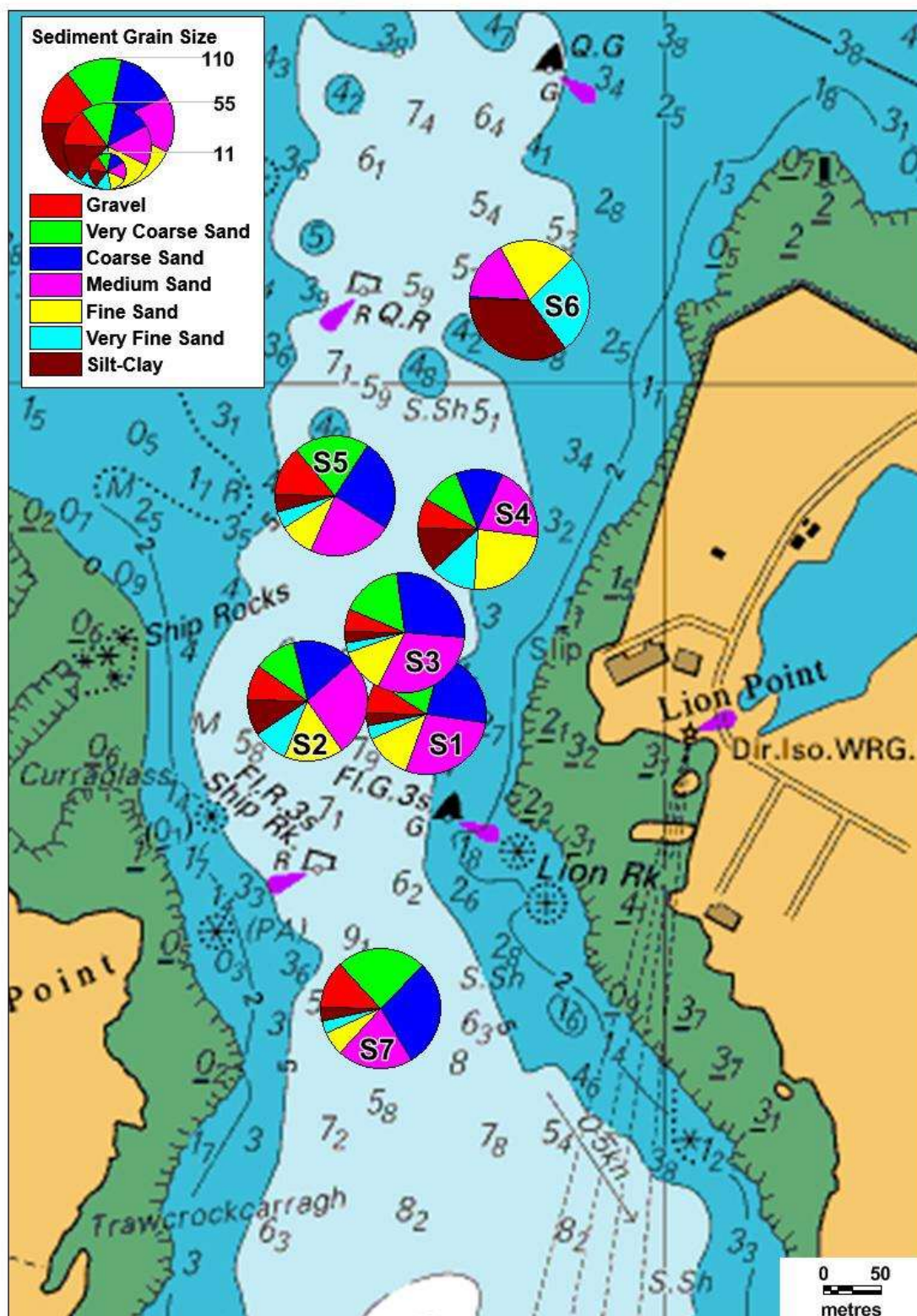


Figure 2.6: A breakdown of sediment type at each station in the dredge site.

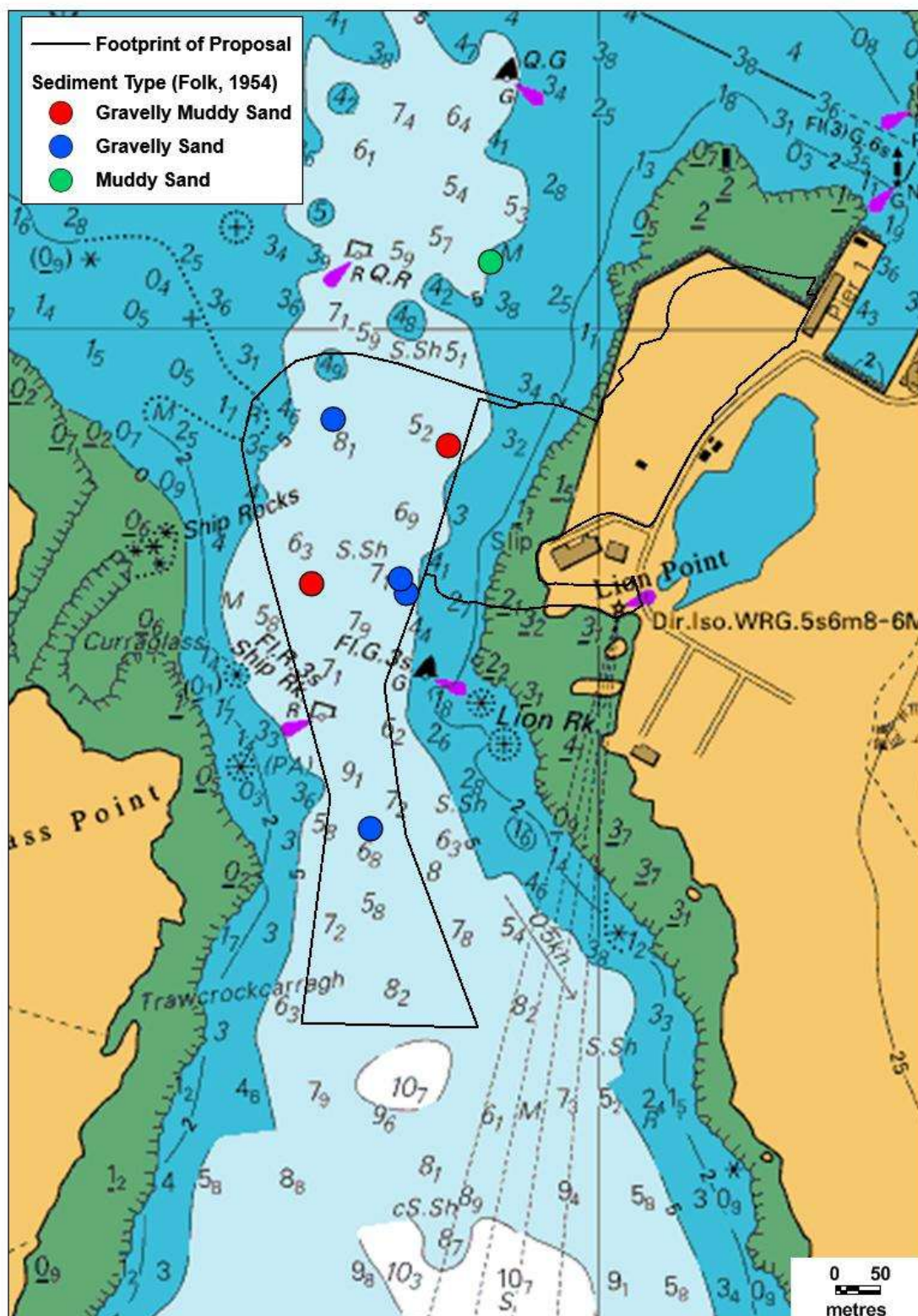


Figure 2.7: Sediment type according to Folk (1954) at each station in the dredge site.

3. Drop-down Video Survey

3.1. Sampling Procedure

The drop-down video survey of the area was carried out by AQUAFAC on the 22nd February 2017 from AQUAFAC's 6.8m Lencraft RIB. A total of 11 locations were surveyed and the location of these transects can be seen in Figure 3.1. The majority of these stations were located along the western shoreline as this was the area *Zostera* was encountered in a 2002 study (RPS, 2002). *Zostera* bed habitats are included on the OSPAR List of threatened and/or declining species and habitats (OSPAR agreement 2008-6). In addition, two sites were located within the proposed dredge area. Table 3.1 presents the coordinates of each site. A drop down camera (manufactured by LH-Camera) was used for this survey. This is an upgraded version of their standard unit. Its specification include a high resolution, 560 line colour PAL camera with 0.1 lux sensitivity. Footage was digitized and captured using a Getac B300 rugged notebook and backed up to writeable DVD media. A video overlay unit allows position (dGPS) to be inserted and recorded continually on screen, streamlining the incorporation of footage into GIS for ground truthing and mapping purposes.

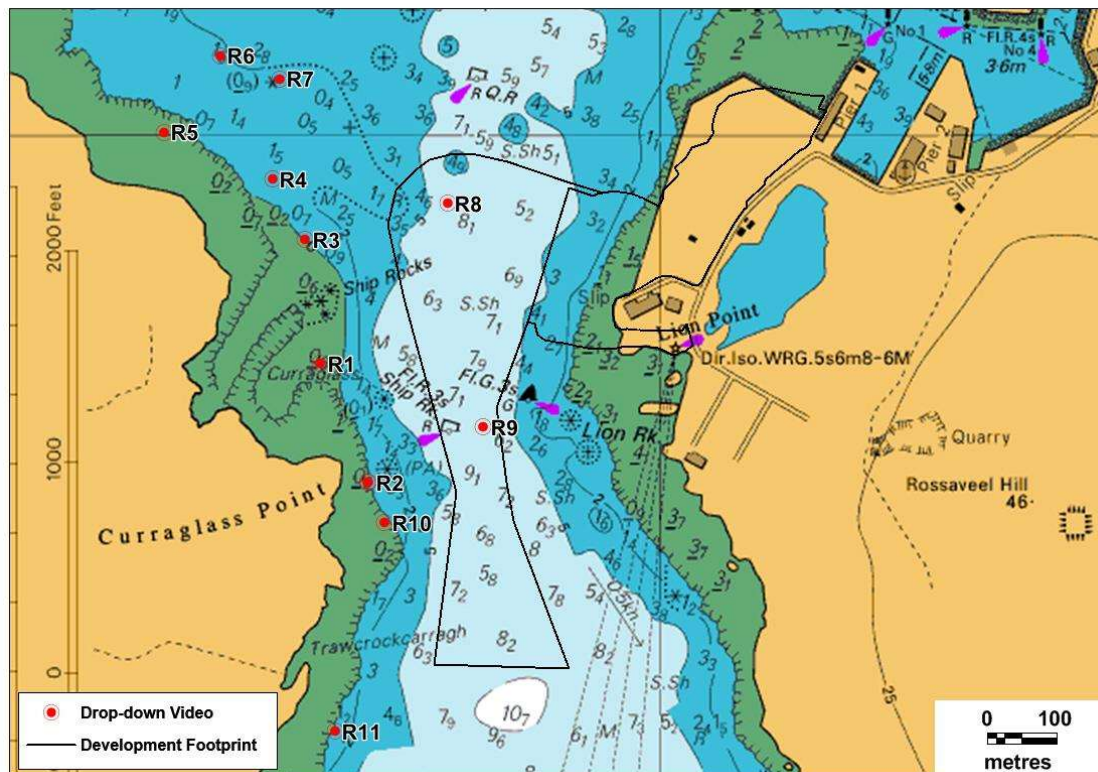


Figure 3.1: Location of the drop-down video sites surveyed February 22nd 2017.

Table 3.1: Video transect coordinates

Station	Longitude	Latitude
R1	-9.57401	53.26368
R2	-9.57296	53.26213
R3	-9.57434	53.26529
R4	-9.57505	53.26607
R5	-9.5774	53.26668
R6	-9.57619	53.26768
R7	-9.57489	53.26737
R8	-9.57125	53.26576
R9	-9.57048	53.26286
R10	-9.57261	53.26161
R11	-9.57369	53.2589

3.2. Results

Zostera (eel grass), a terrestrial plant that has migrated into shallow, sandy subtidal environments was present at sites R1, R2, R3 and R10. It had a patchy occurrence on a medium to fine clean sandy bottom (see Figure 3.2). It occurred in shallow waters close to the shore and disappeared beyond the 0m contour line where it was replaced by a clean sandy bottom. *Zostera* beds can be found all around the coast line of Ireland.

North of R3, the seabed became muddier with a mixture of diatoms, lugworm *Arenicola marina*, dillisk, *Palmaria palmata* and flocculent brown algae cover in R6 (Figure 3.3). Coarse gravelly sand dominated in the centre of the channel, with the hydroid *Nemertesia* present in R8 and the common starfish *Asterias rubens* in R9 (Figure 3.4). None of these habitats or species are considered rare or sensitive.

Just south of R10, *Laminaria* dominated and can be seen in Figure 3.5 (R11). *Laminaria* is common large brown seaweed that is found at and below low water on rocky substrates all around the Irish coastline.

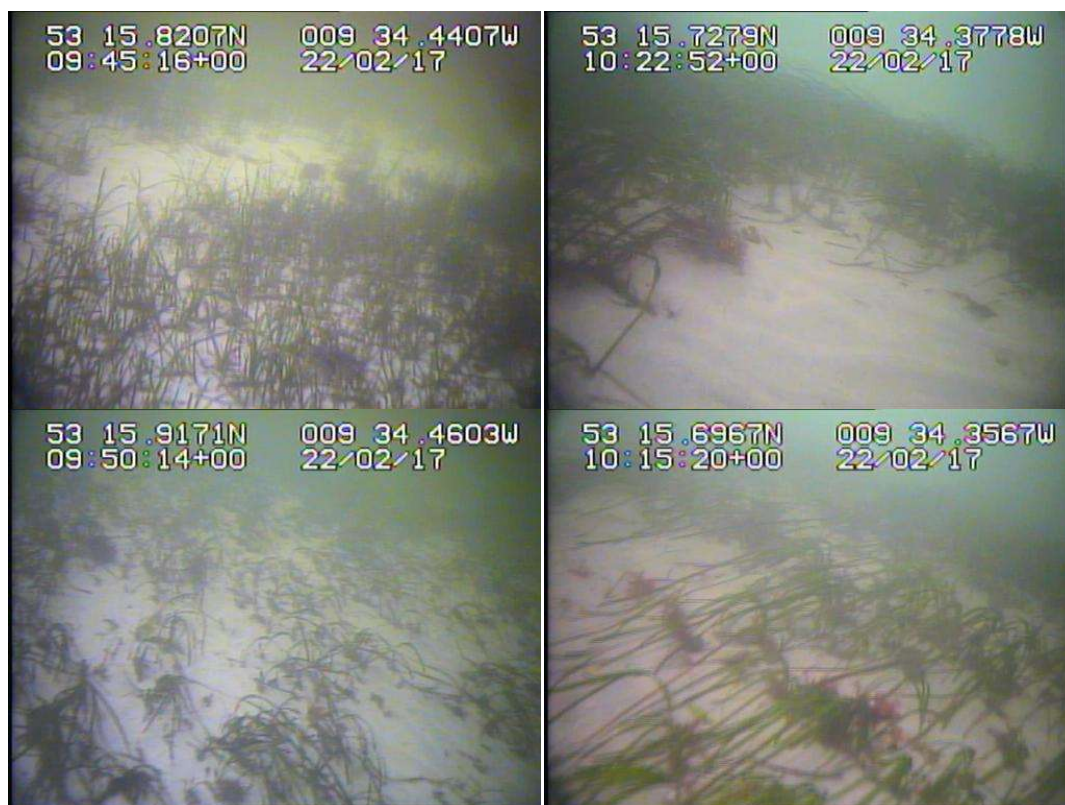


Figure 3.2: Sparse *Zostera* at R1, R2, R3 and R10 on medium to fine clean sandy seafloor.

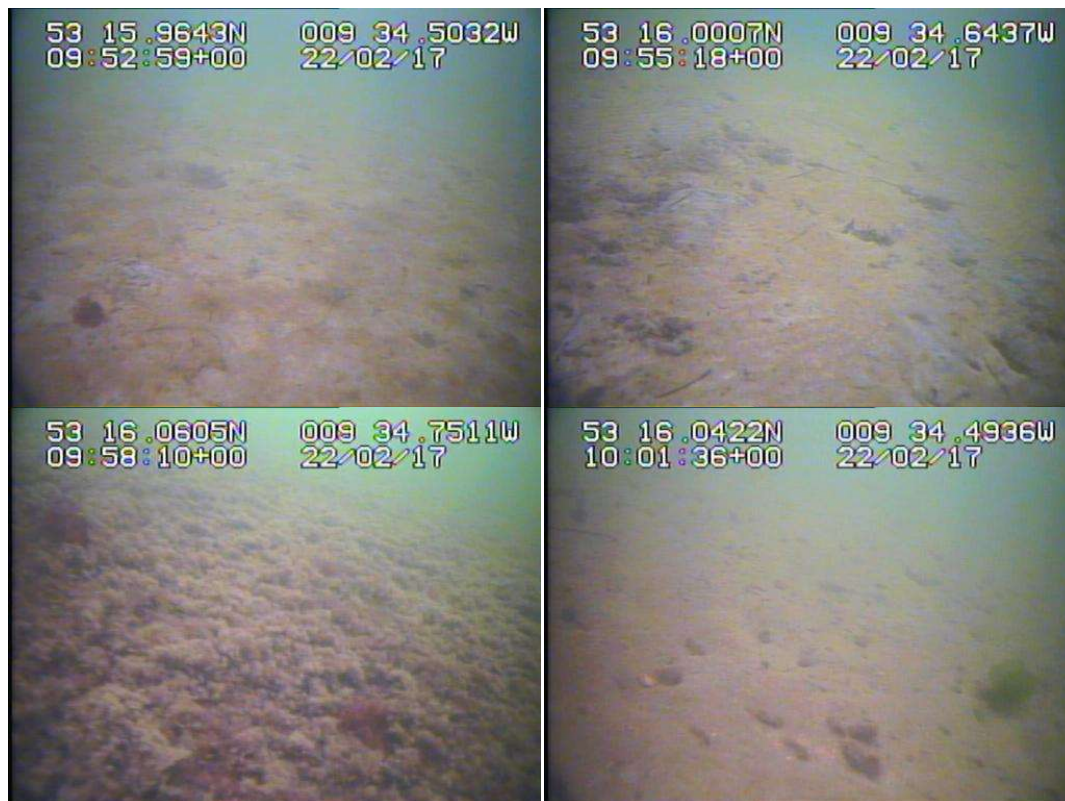


Figure 3.3: Muddy sediments recorded from the north of the site (R4, R5, R6 and R7).



Figure 3.4: Coarse gravelly sandy seabed in the centre of the channel (R8 and R9).



Figure 3.5: *Laminaria* community observed in the southern part of the site at R11.

4. Marine Mammals

Harbour seals *Phoca vitulina* are known to haul out in Cashla Bay (Cronin *et al.*, 2004) and these haul out locations can be seen in Figure 4.1. Numbers ranged from 1 to 12 in 2003 (Cronin *et al.*, 2004). More recent monitoring surveys recorded maximum counts in inner Cashla Bay of 108, 77 and 77 in 2009, 2010 and 2011 respectively (NPWS, 2012). Harbour seals haul out and moult between August and September. Harbour seals are a qualifying interest of the nearby Kilkieran Bay & Islands cSAC. Grey seals *Halichoerus grypus* have the potential to occur within Cashla Bay; however, this species prefers offshore islands as haul out and breeding sites and there are no known haul out of breeding sites in Cashla Bay (O’Cadhla *et al.*, 2005; O’Cadhla & Strong, 2007).

A number of small cetaceans have the potential to occur in the vicinity of the proposed development. Berrow *et al.* (2002) reported that Harbour porpoises *Phocoena phocoena* were the most frequently recorded species in Galway Bay, with most records reported between June and August with fewer sightings in the winter and spring. Berrow *et al.* (2002) also reported concentrations of sightings of Bottlenose dolphins *Tursiops truncatus* in Galway Bay, with sightings increasing rapidly from April to June, suggesting an inshore movement, which peaked in August (O’Brien, 2013). However, in more recent years O’Brien (2009) found that this was not the case. Harbour porpoises were the most regularly recorded species with dolphin sightings of any species being very rare. Berrow *et al.* (2008) showed an overall density of porpoises of 0.73 per km² with an abundance of 402 ± 84. In addition to these more common species, an additional 14 species have been recorded from Galway Bay and these include common dolphin *Delphinus delphis*, killer whale *Orcinus orca*, minke whale *Balaenoptera acutorostrata*, pilot whale *Globicephala macrorhynchus*, Risso’s dolphin *Grampus griseus*, sperm whale *Physeter macrocephalus* and false killer whale *Pseudorca crassidens* (O’Brien, 2013). All cetaceans are protected under Annex IV of the EU Habitats Directive while Bottle-nosed dolphin and Harbour Porpoise are also listed under Annex II.

Otter *Lutra lutra*, an Annex II species which is a qualifying interests of the Kilkieran Bay and Islands cSAC and the Connemara Bog Complex cSAC does have the potential to forage within the coastal strip of Cashla Bay and this includes the area of the proposed deep water quay.

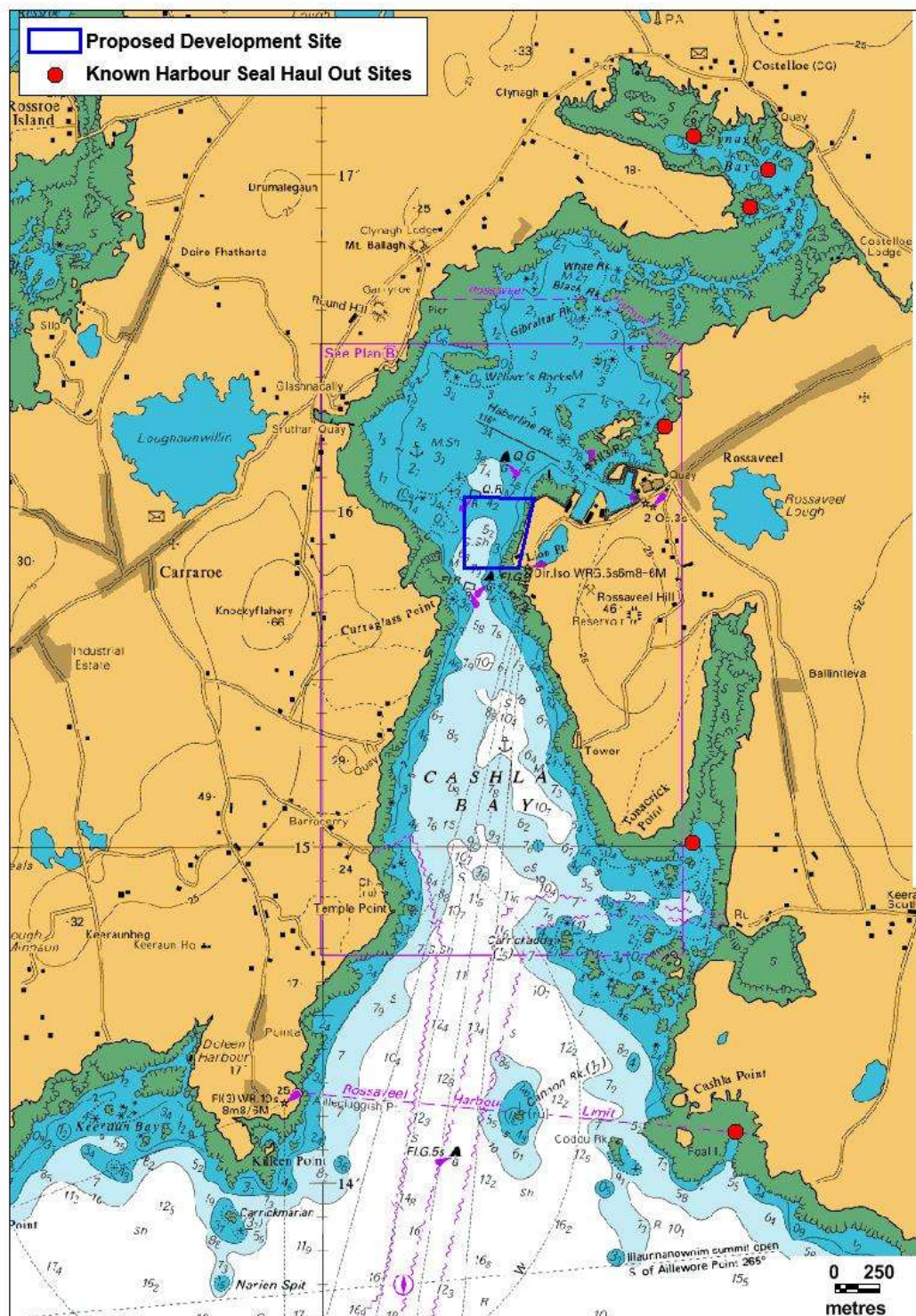


Figure 4.1: Known Harbour seal haul out sites in the vicinity of the proposed development.

5. Sediment Chemistry Assessment

The Marine Institute's requirements for chemistry sampling and analysis for dredging operations at Rossaveal can be seen in Appendix 5.

5.1. Materials & Methods

5.1.1. Sampling Procedure & Processing

To carry out the sediment chemistry assessment of the dredge area in line with Cronin *et al.* (2006), AQUAFACt sampled a total of 5 stations. Sampling took place on the 11th October 2016 from RPS Marine's *Puffin*. This survey was carried out in conjunction with the benthic grab survey. Figure 5.1 shows the stations sampled in the dredge area and Table 5.1 shows the associated station coordinates and water depths. All samples were collected and stored, according to the OSPAR JAMP Guidelines for Monitoring Contaminants in Sediments (2011 edition, OSPAR Reference No: 2002-16).

A 0.1m² Day grab was used to collect the sediment samples at each station. The sediment samples were divided up for contaminant analysis, radiological analysis (stations S1 and S2 only), sediment granulometry, sediment density and moisture content (the granulometry element was carried out as part of the faunal survey but the results are applicable here also). All sampling jars were marked externally with date, station number, sample number and survey reference number and placed in a cooler box.

Samples were couriered to the National Laboratory Service in the UK for the analysis of the parameters listed in Table 5.2 (except radiological analysis).

The following methodologies were employed by NLS:

- Total Organic Carbon analysis: combustion with oxygen; thermal conductivity detection.
- Carbonate content analysis: Gravimetric analysis of a dry portion of the sediment following carbonate removal with hydrochloric acid.
- Total Hydrocarbons: by fluorescence.
- Organotins: GCMS analysis following acetic acid/methanol extraction and subsequent derivatisation.
- Metal analysis (As, Cd, Cr, Cu, Pb, Li, Ni, Zn): ICP-MS analysis following microwave aqua regia

digested.

- Metal analysis (Al): ICPOES analysis following microwave aqua regia digested.
- Metal analysis (Hg): CV-AFS analysis following microwave aqua regia digested, acidic SnCl₂ reduced.
- Organochlorines, PAH & PCB analysis: GCMS analysis following solvent extraction.

All tests were carried out on the <2mm fraction. The Limits of detection which NLS performed the analyses to can be seen in Table 5.3.

Samples for radiological analysis were sent to the Radiological Protection Institute of Ireland where analysis was carried out by high resolution gamma spectrometry.

The sediment granulometric analysis, moisture content and density were carried out by AQUAFAC. Appendix 2 provides details on these analyses.

Table 5.1: Station coordinates and depths at the dredge site (not tidally corrected).

Station	Longitude	Latitude	Depth (m)
S1	-9.56983	53.26405	9.4
S2	-9.5714	53.26415	9.7
S3	-9.56993	53.26419	9.2
S4	-9.56915	53.26551	8.2
S5	-9.57104	53.26578	8.9

Table 5.2: Parameters analysed at each station.

Station	Parameters for analysis
S1	Visual inspection, Water content, Granulometry, Total organic carbon, Carbonate, Metals, Organochlorines, PCBs, Hydrocarbons, TBT, DBT and PAHs, Radiological analysis
S2	Visual inspection, Water content, Granulometry, Total organic carbon, Carbonate, Metals, Organochlorines, PCBs, Hydrocarbons, TBT, DBT and PAHs, Radiological analysis
S3	Visual inspection, Water content, Granulometry, Total organic carbon, Carbonate, Metals, TBT and DBT
S4	Visual inspection, Water content, Granulometry, Total organic carbon, Carbonate, Metals, TBT and DBT
S5	Visual inspection, Water content, Granulometry, Total organic carbon, Carbonate, Metals, TBT and DBT

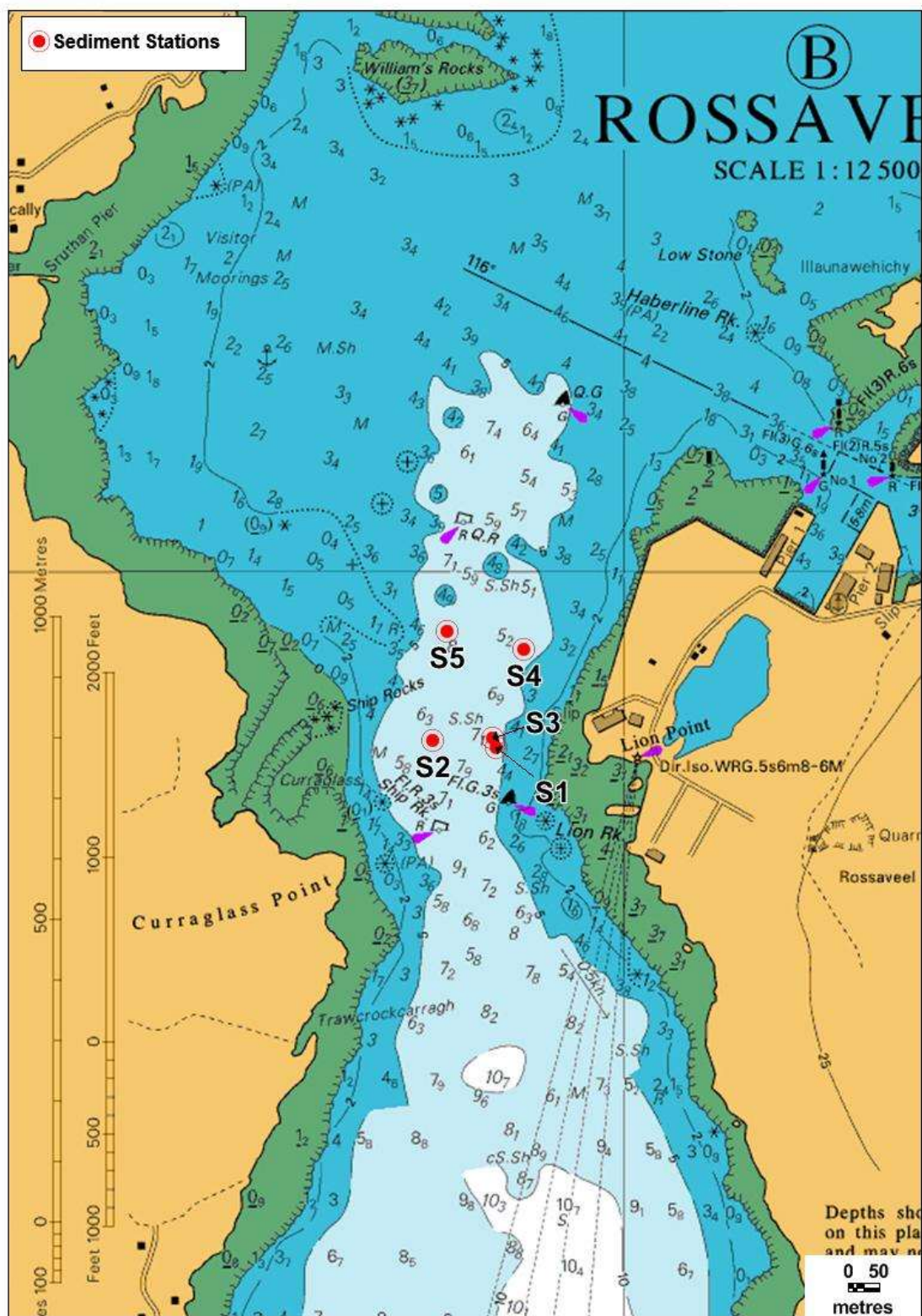


Figure 5.1: Location of the sediment stations sampled at the dredge site on the 11th October 2016.

Table 5.3: Limits of Detection for analyses performed by NLS

Parameter	Unit	LOD
Hydrocarbons	mg/kg	0.9
Mercury	mg/kg	0.01
Aluminium	mg/kg	20
Arsenic	mg/kg	1
Cadmium	mg/kg	0.04
Chromium	mg/kg	2
Copper	mg/kg	1
Lead	mg/kg	2
Lithium	mg/kg	0.3
Nickel	mg/kg	1
Zinc	mg/kg	2.5
OCP	µg/kg	0.1-0.5
PAH	µg/kg	1-5
PCBs	µg/kg	0.1
DBT/TBT	mg/kg	0.003

5.2. Results

5.2.1. Physical Properties

Table 5.4 shows the particle size analysis results. Gravel content ranged from 6.3% (Station S3) to 13.9% (Station S5). Sand content ranged from 79.1% (Station S4) to 90.6% (Station S3). Silt-clay content ranged from 3.2% (Station S3) to 12.4% (Station S4). Moisture content ranged from 28.79% (Station S3) to 37.99% (Station S4). Density ranged from 1.56 g/ml (Station S1) to 1.86 g/ml (Station S4).

Table 5.4: Physical properties of sediment.

Station	Visual	% Gravel (>2mm)	% Sand (<2mm)	% Silt-Clay (<63µm)	Moisture %	Density (g/ml)
S1	Brown clay sediment	9.1	87.4	3.6	31.26	1.56
S2	Brown clay sediment	9.7	80.5	9.7	35.95	1.81
S3	Brown sandy clay sediment	6.3	90.6	3.2	28.79	1.64
S4	Brown clay sediment	8.5	79.1	12.4	37.99	1.86
S5	Brown sandy clay sediment	13.9	81.2	4.8	30.61	1.57

5.2.2. Chemical Properties

Table 5.5 shows the results from the chemical analysis. Appendix 6 contains the laboratory report. All parameters were below the lower Irish Action Limit at all stations (see Table 5.6).

Table 5.5: Chemical properties of sediment

Analyte	Units	S1	S2	S3	S4	S5
Carbonate as C : Dry Wt	%	60	55	72	53	59
Carbon, Organic : Dry Wt as C	%	1.59	2.3	3	2.03	1.66
Hydrocarbons : Total : Dry Wt as Ekofisk	mg/kg	20.7	25.7			
Mercury : Dry Wt	mg/kg	0.0208	0.0264	<0.01	0.0278	0.0168
Aluminium, Dry Wt	mg/kg	6180	11500	3200	10200	4960
Arsenic, Dry Wt	mg/kg	4.76	5.96	3.16	6.64	5.35
Cadmium, Dry Wt	mg/kg	0.113	0.159	0.069	0.194	0.087
Chromium, Dry Wt	mg/kg	12.8	22.2	17.2	20.2	11.6
Copper, Dry Wt	mg/kg	4.5	6.93	2.65	7.27	3.32
Lead, Dry Wt	mg/kg	7.85	11.1	5	12.3	7.15
Lithium, Dry Wt	mg/kg	10.6	14.3	6.03	14	9.59
Nickel, Dry Wt	mg/kg	7.5	19.4	7.33	13.6	8.36
Zinc : Dry Wt	mg/kg	20.7	30.2	11	33.5	17.3
Aldrin : Dry Wt	ug/kg	<0.5	<0.5	-	-	-
DDE -pp : Dry Wt	ug/kg	<0.1	<0.1	-	-	-
DDT -op : Dry Wt	ug/kg	<0.1	<0.1	-	-	-
DDT -pp : Dry Wt	ug/kg	<0.1	<0.1	-	-	-
Dieldrin : Dry Wt	ug/kg	<0.5	<0.5	-	-	-
Endrin : Dry Wt	ug/kg	<0.5	<0.5	-	-	-
HCH -alpha : Dry Wt	ug/kg	<0.1	<0.1	-	-	-
HCH -beta : Dry Wt	ug/kg	<0.1	<0.1	-	-	-
HCH -delta : Dry Wt	ug/kg	<0.1	<0.1	-	-	-
HCH -gamma : Dry Wt :- {Lindane}	ug/kg	<0.1	<0.1	-	-	-
Hexachlorobenzene : Dry Wt	ug/kg	<0.1	<0.1	-	-	-
Hexachlorobutadiene : Dry Wt	ug/kg	<0.1	<0.1	-	-	-
Isodrin : Dry Wt	ug/kg	<0.5	<0.5	-	-	-
TDE - pp : Dry Wt	ug/kg	<0.1	<0.1	-	-	-
Acenaphthene : Dry Wt	ug/kg	<1	<1	-	-	-
Acenaphthylene : Dry Wt	ug/kg	<1	<1	-	-	-
Anthracene : Dry Wt	ug/kg	2.41	1.82	-	-	-
Benzo(a)anthracene : Dry Wt	ug/kg	3.8	4.93	-	-	-
Benzo(a)pyrene : Dry Wt	ug/kg	4.55	5.38	-	-	-
Benzo(b)fluoranthene : Dry Wt	ug/kg	4.8	7.8	-	-	-
Benzo(ghi)perylene : Dry Wt	ug/kg	5.82	5.56	-	-	-
Benzo(k)fluoranthene : Dry Wt	ug/kg	3.32	4.39	-	-	-
Chrysene : Dry Wt	ug/kg	4.12	4.56	-	-	-
Dibenzo(ah)anthracene : Dry Wt	ug/kg	<1	1.5	-	-	-
Fluoranthene : Dry Wt	ug/kg	9.35	9.92	-	-	-
Fluorene : Dry Wt	ug/kg	<5	<5	-	-	-
Indeno(1,2,3-c,d)pyrene : Dry Wt	ug/kg	3.65	5.93	-	-	-
Naphthalene : Dry Wt	ug/kg	<5	<5	-	-	-
Phenanthrene : Dry Wt	ug/kg	6.13	5.08	-	-	-

Analyte	Units	S1	S2	S3	S4	S5
Pyrene : Dry Wt	ug/kg	7.69	7.45	-	-	-
PCB - 028 : Dry Wt	ug/kg	<0.1	<0.1	-	-	-
PCB - 052 : Dry Wt	ug/kg	<0.1	<0.1	-	-	-
PCB - 101 : Dry Wt	ug/kg	<0.1	<0.1	-	-	-
PCB - 118 : Dry Wt	ug/kg	<0.1	<0.1	-	-	-
PCB - 138 : Dry Wt	ug/kg	<0.1	<0.1	-	-	-
PCB - 153 : Dry Wt	ug/kg	<0.1	<0.1	-	-	-
PCB - 180 : Dry Wt	ug/kg	<0.1	<0.1	-	-	-
Dibutyl Tin : Dry Wt as Cation	ug/kg	<5	7.57	<4	<5	<5
Tributyl Tin : Dry Wt as Cation	ug/kg	<5	<5	<4	<5	<5

Table 5.6: Results with reference to Irish Action Limits.

Parameter	Units (dry wt) Note 2	Lower Action Limit	Upper Action Limit	Sampling points				
				S1	S2	S3	S4	S5
Arsenic	mg kg ⁻¹	9.0	70	4.76	5.96	3.16	6.64	5.35
Cadmium	mg kg ⁻¹	0.7	4.2	0.113	0.159	0.069	0.194	0.087
Chromium	mg kg ⁻¹	120	370	12.8	22.2	17.2	20.2	11.6
Copper	mg kg ⁻¹	40	110	4.5	6.93	2.65	7.27	3.32
Lead	mg kg ⁻¹	60	218	7.85	11.1	5.0	12.3	7.15
Mercury	mg kg ⁻¹	0.2	0.7	0.0208	0.0264	<0.01	0.0278	0.0168
Nickel	mg kg ⁻¹	21	60	7.5	19.4	7.33	13.6	8.36
Zinc	mg kg ⁻¹	160	410	20.7	30.2	11.0	33.5	17.3
Σ TBT & DBT Note 3 *	mg kg ⁻¹	0.1	0.5	0.01	0.01257	0.008	0.01	0.01
γ-HCH (Lindane) Note 4	µg kg ⁻¹	0.3	1	<0.1	<0.1	-	-	-
HCB Note 5	µg kg ⁻¹	0.3	1	<0.1	<0.1	-	-	-
PCB (individual congeners of ICES 7) Note 6	µg kg ⁻¹							
PCB 028	µg kg ⁻¹			<0.1	<0.1	-	-	-
PCB 052	µg kg ⁻¹			<0.1	<0.1	-	-	-
PCB 101	µg kg ⁻¹			<0.1	<0.1	-	-	-
PCB 138	µg kg ⁻¹			<0.1	<0.1	-	-	-
PCB 153	µg kg ⁻¹			<0.1	<0.1	-	-	-
PCB 180	µg kg ⁻¹			<0.1	<0.1	-	-	-
PCB 118	µg kg ⁻¹			<0.1	<0.1	-	-	-
PCB (Σ ICES 7) Note 6 *	µg kg ⁻¹	7	1260	0.7	0.7	-	-	-
PAH (Σ 16) Note 7 *	µg kg ⁻¹	4000		68.64	76.32			
Total Extractable Hydrocarbons	g kg ⁻¹	1.0		0.0207	0.0257	-	-	-

Exceed Lower Irish Action Limit
Exceed Upper Irish Action Limit

Note 1: Applicants should highlight in Table B.1 any results which exceed either the upper or lower Irish action levels. Action levels are published in: Cronin et al. 2006.

Guidelines for the Assessment of Dredge Material for Disposal in Irish Waters. Marine Environment & Health Series, No. 24. Marine Institute.

Note 2: Total sediment <2 mm

Note 3: Sum of tributyl tin and dibutyl tin

Note 4: 1α, 2α, 3β, 4α, 5α, and 6β-hexachlorocyclohexane

Note 5: Hexachlorobenzene

Note 6: ICES 7 polychlorinated biphenyls: PCB 28, 52, 101, 118, 138, 153, 180.

Note 7: Polyaromatic hydrocarbons (measured as individual compounds): Naphthalene, Acenaphthylene, Fluorene, Phenanthrene, Anthracene, Fluoranthene, Pyrene, Benzo(a)anthracene, Chrysene, Benzo(b)fluoranthene, Benzo(a)pyrene, Dibenzo(ah)anthracene, Benzo(ghi)perylene, Indeno(123-cd)pyrene.

* Total calculated is worst-case scenario, i.e. sum of the < value

5.2.3. Radiological analysis.

Table 5.7 shows the results of the radiological analysis. Appendix 7 contains the full report from the analysing laboratory.

Table 5.7: Radiological analysis results

Station	K-40	I-131	Cs-134	Cs-137	Ra-226	Ra-228
S1	172 ± 19	Nd	Nd	1.1 ± 0.1	6.7 ± 1.2	6.1 ± 0.9
S2	208 ± 23	Nd	Nd	1.7 ± 0.2	9.7 ± 1.7	10.1 ± 1.5

6. Impact Assessment

The impacts associated with this project include:

- Loss/disturbance of habitat and species during dredging and quay construction ;
- Noise associated with blasting, drilling, dredging, vessel and marine and terrestrial traffic noise
- Suspended solid increases due to dredging activities
- Impacts arising from the construction phase of the project
- Impacts arising from the operational phase

Appendix 1 contains details on construction and operational phases of the project.

6.1. Impact on Habitat and Species

The area where the new structure will be built is c. 8,000m² and the habitats and species that occur in this intertidal and subtidal habitat will be permanently lost. There is no possible mitigation for the loss of the subtidal area but if eco-engineered materials (see Firth *et al.*, 2016) are used for the quay wall and the revetment, some mitigation for the loss of intertidal habitat can be achieved. Uniformly flat concrete surfaces of quay walls and coastal protection works are more difficult for marine organisms such as sea weeds, barnacles, limpets and periwinkles to colonise and eco-engineering involves creating pits, holes, indentations and pools on the surfaces of the construction materials. A Method Statement will be prepared in consultation with the NPWS prior to the construction phase of the development.

The spatial extent of seabed habitat that is to be dredged is c. 140,000m² and there will be a temporal loss of these habitats and the species that occur within them. However, marine invertebrates quickly re-colonise the sea bed after a disturbance such as a dredging campaign and it is anticipated that the same species that were recorded by the two AQUAFACt surveys presented in this report will have re-established themselves within 3 years post-dredging.

There will be some impact from smothering by sediments suspended during the dredging operations. Particle sizes of <125µ will settle out with c 30m of the dredger. This gives an area of c 22,000m² that will be affected by sediments settling out on the sea bed. *Zostera* (eel grass) does not occur in this area. As for dredging activities, marine invertebrates quickly re-colonise the sea bed after a disturbance such as sediment settling out on top of them and it is anticipated that the same species that were recorded in previous AQUAFACt surveys will have re-established themselves within 3 years after the dredging activity.

Particles that are finer than 125µm will stay in suspension of a long enough period of time to be dispersed and settle out in volumes/depths that are too low to have any effect on benthic communities.

6.2. Noise

Noise generated during the construction of the proposed development will come from blasting, drilling, dredging and vessel noise and marine and terrestrial traffic. The descriptions of these activities are taken from the NPWS guidance document on the risk of man-made sound to marine mammals (NPWS, 2014a).

6.2.1. Blasting

The use of explosives or other blasting methods to blast and break sections of coastal bedrock is relatively common (NPWS, 2014a). Man-made explosions mainly produce pulsed sounds at low frequencies (several Hz to several kHz), which are detectable by a wide range of marine mammal species. Active blasting normally occurs intermittently in a fixed area for a prolonged period of hours, days or weeks depending on the required operation, with intervening periods of preparation, substrate removal, evaluation and often drilling. Preparation for underwater blasting usually takes place from fixed platforms (*i.e.* rig, platform or barge) which are normally moved a safe distance away for the time of explosion. A jack-up pontoon will be used for the proposed works at Rossaveal.

Pulsed sounds created by coastal or underwater explosions have been reported to contain significantly high SPLs, high SELs and very rapid rise times (Richardson *et al.*, 1995) and they are acknowledged to be among the highest energy, man-made sounds introduced into the sea. While the duration and extent of underwater sound transmission from an individual explosion is variable depending on the type of plan or project, blast location features and the mass of explosive charges used, source sound pressure levels may be significantly higher than from many other anthropogenic sources, commonly ranging between 250-300 dB re: 1 μ Pa (Hildebrand, 2005; Richardson *et al.*, 1995; OSPAR, 2009a; 2009b). Such plans or projects can incur the highest known level of risk to marine mammals from an anthropogenic sound source, with energy introduced at sufficient magnitude and velocity to cause immediate PTS in a receiving marine mammal. Explosions also produce a physical shock wave at close distances that propagates differently through the environment than does the acoustic energy and can result in direct traumatic or lethal injury to marine mammal (Richardson *et al.*, 1995; Ketten, 1995). Blasting activity in the marine environment therefore has the potential in most, if not all, circumstances to introduce pulsed sounds at levels that may impact very significantly upon marine mammal individuals and/or populations. Therefore, it commonly requires the operation of very stringent mitigation measures for the protection of these species.

In order to mitigate for this source on impact on salmon, blasting will not be carried out between 1st April and 31st July as this is the time of year when adult fish will be passing through Cashla Bay on their way up to the Cashla River to spawn and juveniles (smolts) will be passing southwards on their way to sea. This restriction of when blasting can be carried out will also mitigate impacts on seals in the area.

In order to mitigate for this source of impact on marine mammals, standard mitigation measures such as adherence to protocols to minimise the effects of blasting on such species, the presence of marine mammal observers (MMO's) on the work vessel during blasting events, daily reports by the MMO being submitted to the NPWS *etc* will be strictly adhered to.

6.2.2. Drilling

Drilling activity is common in coastal and marine construction and infrastructure works and will be required for the creation of boreholes for explosive blasting. Conventional drilling operations take

place from both fixed and moveable platforms (*i.e.* drill rigs, semi-submersible platforms, barges and ships) but the scale of drilling activity and associated acoustic output can be very variable depending on the type of development, drill depth and substrates involved, for example. The use of fixed or dynamically-positioned platforms and associated vessel activity can combine further to make drilling operations a potentially significant source of anthropogenic sound.

Drilling is generally acknowledged to produce moderate levels of continuous omnidirectional sound at low frequency (several tens of Hz to several thousand Hz and up to c.10 kHz). Source sound pressure levels have generally been reported to lie within the 145-190 dB re: 1 μ Pa range (Richardson *et al.*, 1995; OSPAR, 2009a; 2009b). While sound exposure levels from such operations are thought to be below that expected to cause injury to a marine mammal, they have the potential to cause lower level disturbance, masking or behavioural impacts, for example.

Drilling operations comprise a static activity that tends to take place in a fixed area for a prolonged or intermittent period of days, weeks or several months depending on the required operation. This activity therefore has the potential in most circumstances to introduce continuous sounds at levels that may impact upon marine mammal individuals and/or populations, the degree of which will also depend on operational features such as the location, water depth, time-scale, etc. An evaluation of risk to marine mammals from such plans or projects either in coastal situations or further offshore is essential in all cases.

In order to mitigate for this source of impact, standard mitigation measures such as adherence to protocols to minimise the effects of drilling on marine mammals, the presence of marine mammal observers (MMO's) on the work vessel during blasting events, daily reports by the MMO being submitted to the NPWS *etc* will be strictly adhered to.

6.2.3. Dredging

The excavation of sand, gravel, loose rock and other material from the seabed during dredging operations is common, particularly in coastal waters where harbour works and channel maintenance commonly require such activity. Many different types of dredging device are in operation worldwide ranging from hopper dredges to suction, bucket, grab-type arrangements or backhoe dredger with a bucket. It is the latter type of dredging device that will be used for the Rossaveal project.

In addition to the sound from attendant vessels, dredging operations have been reported to produce low frequency omnidirectional sound of several tens of Hz to several thousand Hz (and up to approximately 20 kHz) at sound pressure levels of 135-186 dB re: 1 μ Pa (Richardson *et al.*, 1995; OSPAR, 2009a; 2009b). Therefore some coastal dredging operations can be detected at received levels (RL) exceeding ambient sound more than 10km from shore (Richardson *et al.*, 1995). While sound exposure levels from such operations are thought to be below that expected to cause injury to a marine mammal, they have the potential to cause lower level disturbance, masking or behavioural impacts, for example.

Dredging activity tends to occur in a fixed area for a prolonged period of days or weeks which for the Rossaveal project is estimated at 18 weeks. Therefore, it has the potential to introduce continuous anthropogenic sound at levels that may impact upon marine mammal individuals and/or local populations and the risk of acoustic impacts associated with this activity should be considered to ensure good environmental management.

In order to mitigate for this source of impact, standard mitigation measures such as adherence to protocols to minimise the effects of dredging activities on marine mammals, the presence of marine mammal observers (MMO's) on the work vessel during blasting events, daily reports by the MMO being submitted to the NPWS *etc* will be strictly adhered to.

It should be noted however, that during a recent dredging operation in Rosslare where an AQUAFAC MMO was present, observations were made of both Harbour porpoises and Common dolphins coming within 20m of the dredger. It is therefore evident that neither the vessel nor the dredging activity had any kind of “disturbance” effect on either of these species and indicates a low level of significance.

6.2.4. Vessel and Other Traffic Noise

Dredging vessels are typically less than 100m in length. Typical broadband source levels for these mid-size vessels are generally in the 165 - 180 dB (re: 1 μ Pa) range (Richardson *et al.*, 1995; Kipple & Gabriel, 2003; 2004; Heitmeyer *et al.*, 2004). There is considerable variability in the associated frequency spectra, although medium-sized ships tend to be more similar to large vessels in that the vast majority of sound energy is in the low-frequency band (below 1 kHz) (OSPAR Commission, 2009a). Noise generated from vessels during the construction phase will be significantly lower than

that generated from blasting.

As noted above for impacts of dredging, during a recent dredging operation in Rosslare where an AQUAFAC MMO was present, observations were made of both Harbour porpoises and Common dolphins coming within 20m of the dredger. It is therefore evident that neither the noise generated by the vessel had any kind of “disturbance” effect on either of these species, indicating a low level of significance.

In terms of construction, there will be the normal disturbance effects arising from activities such as marine and road traffic, noise from both these sources, emissions from trucks, machinery and boats *etc.* None of these are considered to be of sufficient intensity to be significant.

6.3. *Suspended Sediments*

Blasting and drilling of the rock bedrock and dredging of the softer sediments in the turning circle will result in the release of small amounts of fine material into the water column which will result in very localised increases in suspended sediment concentrations. It is anticipated that c. 150,000m³ of dredged material will be removed from the site. This will comprise c. 120,000m³ of rock and 30,000m³ other material mostly sand and gravel.

It is assumed that the backhoe dredger will use a large excavator arm fitted with a clamshell closed bucket. The excavator will lift material in the bucket and deliver it to a waiting hopper barge which will transport the material to the quayside where this material will be used to fill the concrete box caisson units and to construct the deep water quay. Research and past experience have shown that material is suspended from the seabed due to the initial grab. Further suspension is generated as sediment overflows from the bucket as the bucket is lifted throughout the water column. Overflow also occurs as the bucket breaks free of the water surface and drains freely. Only fine sediment (<63µm) are considered “lost” (*i.e.* suspended into the water column), coarser sediment will fall straight to the bottom and be recovered by subsequent dredge operations. Loss rates from similar operations are known to vary based on such factors as the size and type of bucket (*i.e.* open or closed), nature of the bed material, presence of debris, current speed and depth of water, as well as the care of the operator. Reported rates vary from 0.1% to 10%, with a mean of 2.1%. For this assessment it is assumed that 2% will be lost (c. 600m³).

Localised temporary increases in suspended sediments will not be of the concentrations or duration that would be detrimental to the seagrass beds. Furthermore, *Zostera* beds that are present in Cashla bay occur along the western side of the bay and as current flows are north/south in the bay, sediments suspended by the dredging activities cannot be transported in that direction.

The sea pen *Virgularia mirabilis* is not sensitive to increases in suspended sediments and smothering (Hill & Watson, 2000). This species is insensitive to light (Hoare & Wilson, 1977) therefore an increase or decrease in light levels caused by changing turbidity levels will have little or no effect on the sea pen population.

Water quality monitoring was carried out by DAFM at three locations during an historical dredging and disposal campaign in Rossaveal Harbour in 2004. During these dredging works, the water quality was monitored at three monitoring locations and at an offshore dredged material disposal site by Mott MacDonald (2005). The monitoring found that dredging and disposal activities could not be correlated to any significant changes in water quality, either in terms of an improvement or deterioration in water quality across the range of parameters measured (EirEco, 2015). Monitoring adjacent to Rossaveal Harbour indicated a turbidity spike during a period when dredging of soft material was taking place but otherwise there was no significant correlation between dredging activities and the fluctuation in water quality.

The impacts of suspended sediments on the benthic habitat have been discussed above in Section 5.1.

6.4. *Impacts arising from the construction phase*

As the planned construction method is the use of caissons (see Section 1.2.1, Appendix I), the putting in place of these and infilling them with stone will also have a very minimal impact on the receiving environment. This is because dropping caissons onto the sea bed will cause a spatially small extent of impact and will also will only take a temporally short period of time.

6.5. *Impacts arising from the operational phase*

Rossaveal Harbour already has a significant level of shipping movements arising from fishing vessels and passenger ferries, especially in summer months. As the projected increase in deep sea fishing

vessels (see Section 2.2, Appendix I) is forecasted to be slow and steady up to 2045, it is anticipated that this rate of increase will not have any significant impact on the receiving environment.

7. Discussion

The sediment sampled from the area was classified according to Folk (1954) as a mix of gravelly sand, muddy sand and gravelly muddy sand.

The habitat type of the dredge site and can be classified by Fossitt (2000) as SS4 *Infralittoral mixed sediments*. Variations in the community type and dominating species between the stations was evident. These local variations are common in the natural environment.

The faunal results revealed a diverse and species-rich community characterised by the crustaceans *Metaphoxus simplex*, *Euphilomedes sinister*, *Microdeutopus versiculatus*, *Cheirocratus* sp., *Macrochaeta clavicornis* and *Tanaopsis graciloides*, the polychaetes *Mediomastus fragilis*, *Euclymene lombricoides*, *Pholoe inornata*, *Aponuphis bilineata*, *Galathowenia oculata*, *Melinna palmata* and the bivalves *Thyasira flexuosa* and *Kurtiella bidentata*.

All species observed are typically of the gravelly/sandy/muddy sandy habitat in the area. None of the species recorded are rare or unusual as all are common in Irish inshore sediments.

The results of the univariate analyses on the species data returned some quite high values. For example 118 were recorded at Stations 2 and 3 and 1,350 were recorded at S2. The highest richness value recorded (16.85) was at S3.

Multivariate analyses returned to grouping of infaunal species although these groups contained the same suite of taxa though in different levels of density. Neither grouping could be attributed to any EUNIS assemblage. The group of species was however similar to what is typically found in an *Amphiura* community but as none of this ophiuroid were recorded, it did not fit any such assemblage.

The drop down video survey showed that eel grass, *Zostera marina*, was present at sites along the western side of Cashla Bay where it occurred on a medium to fine clean sandy bottom. North of the eel grass bed, the seabed became muddier with a mixture of diatoms, lugworm, dillisk and flocculent brown algae. Coarse gravelly sand was the dominant sediment type in the central channel.

Results from the chemical analysis showed that levels of all analytes were below the lower Irish Action Limit at all stations.

Regarding impacts of the receiving environment, there will be an unavoidable and immitigable loss of 8,000m² of sea bed. With regard to the remaining aspects of the construction phase, it has been concluded that if all standard mitigation measures are followed there will be minimal impact on the receiving environment.

The predicted rate of increase in marine traffic during the operational phase will not have any significant impact on the receiving environment.

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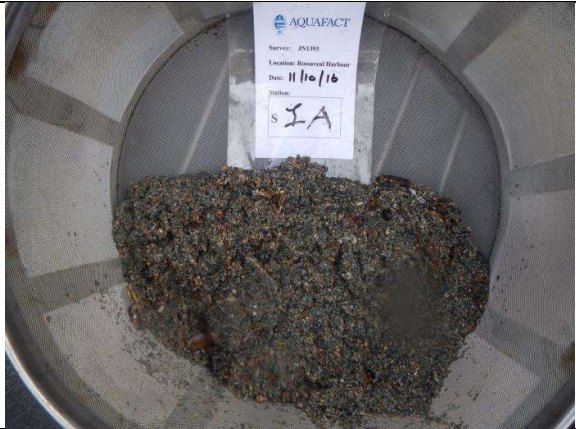
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Appendix 1
Construction and Operational Phases of proposed
Deep Water Quay Development

(refer Chapter 4 of EIS)

Appendix 2

Photographic Log

Station	Photo
S1	 AquaFact Survey: JN1303 Location: Rosarivul Harbour Date: 11/16/16 Station: S1A
S2	 AquaFact Survey: JN1303 Location: Rosarivul Harbour Date: Station: S2B
S3	 AquaFact Survey: JN1303 Location: Rosarivul Harbour Date: Station: S3B
S4	 AquaFact Survey: JN1303 Location: Rosarivul Harbour Date: Station: S4B

Station	Photo
S5	
S6	
S7	

Appendix 3

Sediment Analysis Methodologies

Granulometry

1. Approximately 25g of dried sediment is weighed out and placed in a labelled 1L glass beaker to which 100 ml of a 6 percent hydrogen peroxide solution was then added. This was allowed to stand overnight in a fume hood.
2. The beaker is placed on a hot plate and heated gently. Small quantities of hydrogen peroxide are added to the beaker until there is no further reaction. This peroxide treatment removes any organic material from the sediment which can interfere with grain size determination.
3. The beaker is then emptied of sediment and rinsed into a 63 μ m sieve. This is then washed with distilled water to remove any residual hydrogen peroxide. The sample retained on the sieve is then carefully washed back into the glass beaker up to a volume of approximately 250ml of distilled water.
4. 10ml of sodium hexametaphosphate solution is added to the beaker and this solution is stirred for ten minutes and then allowed to stand overnight. This treatment helps to dissociate the clay particles from one another.
5. The beaker with the sediment and sodium hexametaphosphate solution is washed and rinsed into a 63 μ m sieve. The retained sample is carefully washed from the sieve into a labelled aluminium tray and placed in an oven for drying at 100°C for 24 hours.
6. When dry this sediment is sieved through a series of graduated sieves ranging from 4 mm down to 63 μ m for 10 minutes using an automated column shaker. The fraction of sediment retained in each of the different sized sieves is weighed and recorded.
7. The silt/clay fraction is determined by subtracting all weighed fractions from the initial starting weight of sediment as the less than 63 μ m fraction was lost during the various washing stages.

Organic Content

1. The collected sediments should be transferred to aluminium trays, homogenised by hand and dried in an oven at 100°C for 24 hours.
2. A sample of dried sediment should be placed in a mortar and pestle and ground down to a fine powder.
3. 1g of this ground sediment should be weighed into a pre-weighed crucible and placed in a muffle furnace at 450°C for a period of 6 hours.
4. The sediment samples should be then allowed to cool in a desiccator for 1 hour before being weighed again.
5. The organic content of the sample is determined by expressing as a percentage the weight of the sediment after ignition over the initial weight of the sediment.

Moisture Content & Density

Moisture content was taken as the percentage weight difference between the wet and dried sediment. Sediment density was calculated by placing a fixed volume (100 ml) of sediment in a volumetric cylinder and weighing the contents.

Appendix 4

Faunal Abundance

[illegible]

[illegible]

Station	AphiaID	S1 A	S1 B	S2 A	S2 B	S3 A	S3 B	S4 A	S4 B	S5 A	S5 B	S6 A	S6 B	S7 A	S7 B
Orbiniidae	902														
Orbinia sertulata	130523				1									2	
Scoloplos (Scoloplos) armiger	334772					3									
Paraonidae	903														
Paraonidae	903						1								
Cirrophorus branchiatus	130576	7		11	24	8				2					16
Paradoneis lyra	130585	6	24	3			9							15	
Aricidea (Acmira) cerrutii	525497			1											
SPIONIDA	889														
Spionidae	913														
Spionidae	913	1			1	4									
Aonides oxycephala	131106	4	7	13		3	4			2			7	16	6
Laonice bahusiensis	131127													1	
Prionospio fallax	131157			13			2								3
Prionospio steenstrupi	131164											1			
Prionospio cirrifera	131153	7	4		12	1	1		5	3					
Pseudopolydora antennata	131166			1							1				
Spio sp.	129625													5	
Spiophanes bombyx	131187	3				3			1						
Magelonidae	914														
Magelona alleni	130266				1	2			1						
Chaetopteridae	918														
Spiochaetopterus sp.	129233					1					4	1			
Spiochaetopterus typicus	129924				7				3						
CAPITELLIDA	890														
Capitellidae	921														
Capitella sp. complex	129211						1								
Mediomastus fragilis	129892	34	22		44	14	20	16	18	8	14	1	11	60	38
Notomastus latericeus	129898	5		2	2	3	3	5		3	8	2	6	4	
Maldanidae	923														
Leiochone sp.	146991						6								
Euclymene lombricoides	130293	36	37	24	32			20	8	39	32		13	33	

Station	AphiaID	S1 A	S1 B	S2 A	S2 B	S3 A	S3 B	S4 A	S4 B	S5 A	S5 B	S6 A	S6 B	S7 A	S7 B
Euclymene sp.	129347						17								
OPHELIIDA	891														
Opheliidae	924														
Ophelina acuminata	130500	2	3											3	
Polyophthalmus pictus	130510					1	1			1				1	
Scalibregmatidae	925														
Scalibregma celticum	130979	4	8	4	4		16				3			5	9
Scalibregma inflatum	130980	1	5	4	7	8	4							3	8
TEREBELLIDA	900														
Cirratulidae	919														
Cirratulidae	919	1				7									
Caulierella sp.	129241	1								2	2				17
Chaetozone setosa	129955	3		7						4					
Tharyx killariensis	152269			17	2										
Fiabelligeridae	976														
Diplocirrus glaucus	130100			8					1						
Diplocirrus sp.	129290											1			3
Diplocirrus stopowitzi	532139					1									
Acrocirridae	920														
Macrochaeta clavicornis	129745	18	11		17	6	4	1		2		12		23	9
Pectinariidae	980														
Amphictene auricoma	152448				4	4	1		1						
Ampharetidae	981														
Ampharetidae	981		1								2				
Melinna palmata	129808	3		28	53	12	17	22	37	34	41	5	9		2
Ampharete sp.	129155				1	4									
Ampharete acutifrons	129775			1									4		
Trichobranchidae	983														
Terebellides stroemii	131573	4	2	9	5	4	6	7	1	9	14	7	11		4
Terebellidae	982														
Amphitrite cirrata	131474							1					1		1
Janice conchilega	131495								2		1				

Station	AphiaID	S1 A	S1 B	S2 A	S2 B	S3 A	S3 B	S4 A	S4 B	S5 A	S5 B	S6 A	S6 B	S7 A	S7 B
Nicolea venustula	131507			1										1	
Pista cristata	131516	3													
Polycirrus sp.	129710													3	
Polycirrus cf medusa	131531	1	1												
SABELLIDA	901														
Oweniidae	975														
Galathowenia oculata	146950	23	23	1	16	23	36		13	37	16				13
Owenia fusiformis	130544														
Owenia borealis	329882			1		9							43		
Sabellidae	985														
Sabellidae	985				3					1					
Sabellinae	154917													7	
Branchiomma bombyx	130878				1										
Serpulidae	988														
Spirobranchus sp.	129582			1			3			1					
Spirobranchus triqueter	555935	5	6		6			2	8					1	
OLIGOCHAETA	2036														
Oligochaeta	2036					8	13						18		
ARTHROPODA	1065														
CHELICERATA	1274														
PYCNOGONIDA	1302														
Phoxichilidae	14469														
Anoplodactylus petiolatus	134723								1						
CRUSTACEA	1066														
COPEPODA	1080														
HARPACTICOIDA	1102														
Longipediidae	115160														
Longipedia sp.	115403								1		1				
Longipedia minor	116371	4	11	1	13	2	5					3	1	1	4
Longipedia scotti	116375														4
Canuellidae	115141														
Sunaristes paguri	115732								2						

Station	AphiaID	S1 A	S1 B	S2 A	S2 B	S3 A	S3 B	S4 A	S4 B	S5 A	S5 B	S6 A	S6 B	S7 A	S7 B
Thalestridae	115181														
Phyllothalestris mysis	116607			4			2								
OSTRACODA	1078														
Ostracoda	1078	2					1					2		2	2
MYODOCOPIDA	2104														
Philomedidae	127483														
Euphilomedes sinister	127866	8	30	18	58	13	6		10	12	1	6	1	8	6
Cylindroleberididae	196139														
Asterope mariae	127700				1	1	1								4
MALACOSTRACA	1071														
LEPTOSTRACA	146996														
Nebaliidae	147029														
Nebalia sp.	147031					1									
Nebalia kocatasi	459304	1		1										1	
Sarsinebalia urgorrii	388224			2	2	1									
AMPHIPODA	1135														
Amphipoda	1135														1
Oedicerotidae	101400														
Periculodes longimanus	102915	1										1			
Synchelidium maculatum	102928						1								
Amphilochidae	101365														
Apolochus neapolitanus	236495				1									1	
Leucothoidae	101393														
Leucothoe liljeborgi	102462			4	1			1		1	4	1	2	1	
Urothoidae	101412														
Urothoe elegans	103228	9			1	39	4								24
Phoxocephalidae	101403														
Harpinia sp.	101716			1					1		4				
Harpinia antennaria	102960				1				32		10				
Harpinia crenulata	102963			2	2			2	1	1					
Metaphoxus simplex	102983	45	153	109	90	28	68	49	66	63	38	6		42	30
Parametaphoxus fultoni	102985	6	4	5	2	5	4	3	2	7	1	1	1	16	8

Station	AphialID	S1 A	S1 B	S2 A	S2 B	S3 A	S3 B	S4 A	S4 B	S5 A	S5 B	S6 A	S6 B	S7 A	S7 B
Lysianassidae	101395														
Lysianassa ceratina	102605		1											5	
Tryphosa crenata	761800		19	1										1	
Argissidae	101369														
Argissa hamatipes	102064				1										
Atylidae	146525														
Atylidae	146525				1		1								
Nototropis vedlomensis	488968	1			8	1	2			3	1			2	7
Dexaminidae	101378														
Dexamine spinosa	102135	1					2	1						1	
Ampeliscidae	101364														
Ampelisca sp.	101445	7	14	3	9	4	9		3	4	9		1	2	3
Ampelisca brevicornis	101891											2			
Ampelisca diadema	101896	3	2	3	4					2	1				
Ampelisca spinipes	101928	2		3	3	5	2			2					
Ampelisca tenuicornis	101930							3	2						2
Ampelisca typica	101933	5	11	1	10	17	12			4	5		3	3	6
Melphidippidae	101398														
Megaluropus agilis	102783													1	
Melitidae	101397														
Melitidae	101397					3								13	
Abludomelita obtusata	102788	1				2			1					1	
Animoceradocus semiserratus	531364													36	
Cheirocratus sp.	101669	9	26	9	15	13	9		7	5			1	3	21
Cheirocratus intermedius	102795												1		
Cheirocratus sundevalli	102798	2	3	2	4	3	4				1				4
Othomaera othonis	534781		6											20	1
Photidae	148558														
Photis longicaudata	102383		26	1	3		20	2	3	5	5	1		1	
Aoridae	101368														
Aoridae	101368	10	29	2	6	3	6	1	7	15	1	7	1		3
Leptocheirus hirsutimanus	102036						1							1	2

Station	AphiaID	S1 A	S1 B	S2 A	S2 B	S3 A	S3 B	S4 A	S4 B	S5 A	S5 B	S6 A	S6 B	S7 A	S7 B
Microdeutopus anomalus	102043		3		1					5					
Microdeutopus versiculatus	102053	17	23	17	16	16	14	3	16	14		4		6	15
Corophiidae	101376														
Corophiidae	101376	1	6												
Crassirophium crassicorne	397383	5	4	3	4					2				1	
Siphonocetes kroyeranus	102111					1									
Caprellidae	101361														
Pariambus typicus	101857			2		2	1								
Phthisica marina	101864		1	1		2	6		1	1	1				
ISOPODA	1131														
Gnathiidae	118278														
Gnathia sp.	118437	2	3	1	2				1	1					1
Gnathia oxyuraea	118995		1												
Anthuridae	118244														
Anthura gracilis	118467	1													
Sphaeromatidae	118277														
Lekanesphaera rugicauda	118958					1								1	7
Arcturidae	118280														
Astacilla dilatata	295579			1											
TANAIDACEA	1133														
Paratanaidae	136162														
Chondrochelia savignyi	880874	3	3	36	6	3	7	2	7	10	2	5	6	25	2
Leptognathiidae	237596														
Tanaopsis graciloides	136458	80	51	41	34	22	20	4	4	29	6	5	23	13	23
CUMACEA	1137														
Bodotriidae	110378														
Vaunthompsonia cristata	110467		1	1										7	
Leuconidae	110382														
Eudorella truncatula	110535		1		1				2	6	9	1	2		
Nannastacidae	110383														
Cumella (Cumella) pygmaea	110567					1									1
Nannastacus unguiculatus	110574	1		2		1	1								

[illegible]

Station	AphiaID	S1 A	S1 B	S2 A	S2 B	S3 A	S3 B	S4 A	S4 B	S5 A	S5 B	S6 A	S6 B	S7 A	S7 B
Thyasiridae	219														
Thyasira sp.	138552											1			
Thyasira flexuosa	141662	12	6	29	9	13	23	4	47	22	21	14	4	19	
Kelliidae	224														
Kellia suborbicularis	140161				2										
IMPARIDENTIA	869600														
Montacutidae	225														
Kurtiella bidentata	345281	15	9	14	11	9	12				1			23	13
CARDITIDA	382256														
Astartidae	228														
Goodallia triangularis	138831					16									
CARDIIDA	869602														
Cardiidae	229														
Acanthocardia tuberculata	381057	8			17										
Parvicardium sp.	137739									2					1
Parvicardium pinnulatum	181343		8			3	5								
Tellinidae	235														
Moerella donacina	147021						1								
Psammobiidae	237														
Gari fervensis	140870					2								1	
Semelidae	1781														
Abra alba	141433			9		4					4	3			2
ADAPEDONTA	869601														
Pharidae	23091														
Ensis ensis	140733					1					2				
Phaxas pellucidus	140737	3	1			1	1			2	1				11
VENERIDA	217														
Veneridae	243														
Chamelea striatula	141908	1	1								1				
Clausinella fasciata	141909					1	2							3	
Timoclea ovata	141929		3												
Dosinia exoleta	141911		2	2				1				1		8	1

Station	AphiaID	S1 A	S1 B	S2 A	S2 B	S3 A	S3 B	S4 A	S4 B	S5 A	S5 B	S6 A	S6 B	S7 A	S7 B
MYIDA	245														
Corbulidae	248														
Corbula gibba	139410	2		3	3	3	4				3				3
ANOMALODESMATA	254														
Thraciidae	256														
Thracia sp.	138549			1											1
Thracia phaseolina	152378									4					
PHORONIDA	1789														
Phoronidae	148378														
Phoronis sp.	128545						1								
Phoronis hipocrepia	128548					1	1								
ECHINODERMATA	1806														
OPHIUROIDEA	123084														
OPHIURIDA	123117														
Amphiuridae	123206														
Amphiura sp.	123613									3					3
Amphipholis squamata	125064			1	3	4	1				1			5	
Ophiuridae	123200														
Ophiura sp.	123574									1					2
ECHINOIDEA	123082														
Echinoidea	123082					1									
Echinidae	123160														
Echinocyamus pusillus	124273		1											6	
HOLOTHUROIDEA	123083														
DENDROCHIROTIDA	123111														
Cucumariidae	123187														
Leptopentacta elongata	124635							1		2					
APODIDA	123108														
Synaptidae	123182														
Leptosynapta sp.	123449			1											
Leptosynapta bergensis	124462						1							4	

Appendix 5

MI Chemistry Requirements



Marine Institute
Foras na Mara

Rinville
Oranmore
Co Galway
Tel: +353 91 387200

Dr Caroline Roche
Aquafact International
Liosbaun Industrial Estate
Galway

04 October 2016

Dear Caroline,

Details are given below of the recommended chemistry sampling and analysis for dredging operations at Rossaveal. The plan is based on your email that confirms maximum quantities to be dumped as being 20,000m³. Sample locations are indicated in Figure 1 (below) and listed in Table 1 (below).

Samples should be taken and appropriately stored, according to the OSPAR JAMP Guidelines for Monitoring Contaminants in Sediments (2011 edition, OSPAR Reference No: 2002-16).

Please supply your analysing lab with a copy of this plan as it is important that they can meet the quality requirements set out in sections 3 and 4, below.

If you need clarification on anything, please don't hesitate to contact me.

Best regards,

Margot Cronin
Marine Environment Chemist

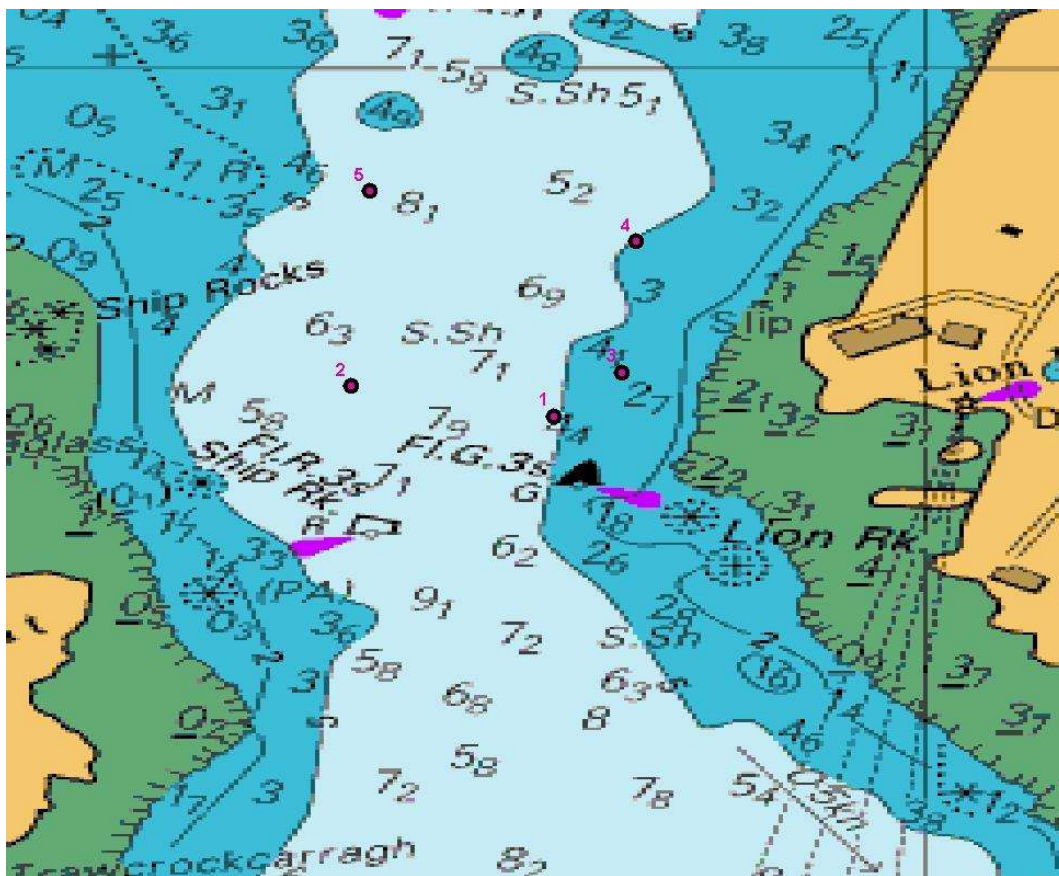


Figure 1. Sample locations for sediment chemistry, Rossaveal

Table 1. Sample location and analyses required:

Sample No.	Latitude o N	Longitude E	Depth of sediment	Parameters for analysis
1	53.26378	-9.56972	Surface	1, 2, 3, 4a, 4b, 4c, 4d, 4e, 4f, 4g
2	53.26403	-9.57139	Surface	1, 2, 3, 4a, 4b, 4c, 4d, 4e, 4f, 4g
3	53.26414	-9.56916	Surface	1, 2, 3, 4a, 4b, 4c, 4f
4	53.26522	-9.56904	Surface	1, 2, 3, 4a, 4b, 4c, 4f
5	53.26564	-9.57124	Surface	1, 2, 3, 4a, 4b, 4c, 4f

* Coordinates in WGS84

2.0 Parameter Code:

1. Visual inspection, to include colour, texture, odour, presence of animals etc
2. Water content, density (taking into account sample collection and handling)
3. Granulometry including % gravel (> 2mm fraction), % sand (< 2mm fraction) and % mud (< 63µm fraction).
4. The following determinants in the sand-mud (< 2mm) fraction * :
 - a) total organic carbon

- b) carbonate
- c) mercury, arsenic, cadmium, copper, lead, zinc, chromium, nickel, lithium, aluminium.
- d) organochlorines including γ -HCH (Lindane) and PCBs (to be reported as the 7 individual CB congeners: 28, 52, 101, 118, 138, 153, and 180).
- e) total extractable hydrocarbons.
- f) tributyltin (TBT) and dibutyltin (DBT)
- g) Polycyclic aromatic hydrocarbons (PAH) - Acenaphthene, Acenaphthylene, Anthracene, Benzo (a) anthracene, Benzo (a) pyrene, Benzo (b) fluoranthene, Benzo (ghi) perylene, Benzo (k) fluoranthene, Chrysene, Dibenzo (a,h) anthracene, Flourene, Fluoranthene, Indeno 1,2,3 – cd pyrene, Naphthalene, Phenanthrene, Pyrene.
- h) Toxicity tests (Microtox or whole sediment bioassay) using appropriate representative aquatic species. (This requirement will depend on the results of the chemical analyses.)

**where the gravel fraction (> 2mm) constitutes a significant part of the total sediment, this should be taken into account in the calculation of the concentrations.*

3.0 Important notes:

- 3.1 Details of the methodologies used must be furnished with the results. This should include sampling, sub sampling and analytical methods used for each determinant
- 3.2 Appropriate marine CRM are to be analysed during each batch of analyses and the results to be reported along with sample results.
- 3.3 The required detection limits for the various determinants are given in Table 2 (below).

Table 2. Limits of detection required

Contaminant	Concentration	Units (dry wt)
Mercury	0.05	mg kg ⁻¹
Arsenic	1.0	mg kg ⁻¹
Cadmium	0.1	mg kg ⁻¹
Copper	5.0	mg kg ⁻¹
Lead	5.0	mg kg ⁻¹
Zinc	10	mg kg ⁻¹
Chromium	5.0	mg kg ⁻¹
Nickel	15	mg kg ⁻¹
Total extractable hydrocarbons	10.0	mg kg ⁻¹
TBT and DBT (not organotin)	0.01	mg kg ⁻¹
PCB – individual congener	1.0	µg kg ⁻¹
OCP – individual compound	1.0	µg kg ⁻¹
PAH – individual compound	20	µg kg ⁻¹

4.0 Reporting requirements

Reports should include the following information

- 4.1 Date of sampling
- 4.2 Location of samples in WGS84.

- 4.3 Treatment of samples and indication of sub sampling, compositing etc.
- 4.4 Tabulated geophysical and chemical test results
- 4.5 Completed excel spreadsheet for results (from EPA Dumping at Sea website)
- 4.6 Summary method details
- 4.7 Method performance specifications: Limit of detection, Precision, Bias
- 4.8 Clear expression of units and indication of wet weight or dry weight basis
- 4.9 Blanks & in-house references to be run with each sample batch, and reported with sample results.
- 4.10 Appropriate Certified Reference Materials (CRM) to be run with each sample batch, and reported in full with sample results.
- 4.11 If determinant is not detected, report less than values, and indicate LoD/ LoQ used.
Other quality assurance information (e.g. accreditation status)

Appendix 6
Chemical Analysis
Lab Report

Caroline Roche
AQUAFACT International Services Ltd
12 Kilkierrin Park
Liosbaun
Galway

Dear Caroline

Please find attached the results for the batch of 6 samples described below.

Samples Registered on:	18-Oct-2016
Analysis Started on:	18-Oct-2016
Analysis Completed on:	08-Dec-2016
Results for Batch Number	20100536
Your Purchase Order Number:	None Supplied

You will be invoiced shortly by our accounts department.

If we can be of further assistance then please do not hesitate to contact us.

Yours sincerely



Vici Morgan
Customer Services Team Leader
Tel: (0113) 231 2177
nls@environment-agency.gov.uk

Opinions and interpretations expressed herein are outside the scope of UKAS Accreditation. Details of analytical procedures and performance data are available on request. The date of sample analysis is available on request.

The Environment Agency carries out analytical work to high standards and within the scope of its UKAS accreditation, but has no knowledge of whether the circumstances or the validity of the procedures used to obtain the samples provided to the laboratory were representative of the need for which the information was required.

The Environment Agency and/or its staff does not therefore accept any liability for the consequences of any acts or omissions made on the basis of the analysis or advice or interpretation provided.

Client: AQUAFAC International Services Ltd Project: 13736 Sediment Analysis
Quote Description: 4a 4b 4c 4d 4e 4f 4g
Folder No: 003686107 Sampled on: 11-Oct-16 @ 11:40
Comments: S1
Quote No: 13736 Matrix: Sediment

Analyte	Result	Units	Flag	MRV	Accred	Lab ID	Testcode
Hydrocarbons : Total : Dry Wt as Ekofisk	20.7	mg/kg	QB	0.9	UKAS	LE	402
Carbon, Organic : Dry Wt as C	1.59	%		0.1	UKAS	LE	535
Mercury : Dry Wt	0.0208	mg/kg		0.01	UKAS	LE	1042
Aluminium : Dry Wt	6180	mg/kg		20	UKAS	LE	1043
Arsenic : Dry Wt	4.76	mg/kg		1	UKAS	LE	1041
Cadmium : Dry Wt	0.113	mg/kg		0.04	UKAS	LE	1041
Chromium : Dry Wt	12.8	mg/kg		2	UKAS	LE	1041
Copper : Dry Wt	4.50	mg/kg		1	UKAS	LE	1041
Lead : Dry Wt	7.85	mg/kg		2	UKAS	LE	1041
Lithium : Dry Wt	10.6	mg/kg		0.3	None	LE	1041
Nickel : Dry Wt	7.50	mg/kg		1	UKAS	LE	1041
Zinc : Dry Wt	20.7	mg/kg		2.5	UKAS	LE	1041
Aldrin : Dry Wt	<0.5	ug/kg		0.5	None	LE	672
DDE -pp : Dry Wt	<0.1	ug/kg		0.1	None	LE	672
DDT -op : Dry Wt	<0.1	ug/kg		0.1	None	LE	672
DDT -pp : Dry Wt	<0.1	ug/kg		0.1	None	LE	672
Dieldrin : Dry Wt	<0.5	ug/kg		0.5	None	LE	672
Endrin : Dry Wt	<0.5	ug/kg		0.5	None	LE	672
HCH -alpha : Dry Wt	<0.1	ug/kg		0.1	None	LE	672
HCH -beta : Dry Wt	<0.1	ug/kg		0.1	None	LE	672
HCH -delta : Dry Wt	<0.1	ug/kg		0.1	None	LE	672
HCH -gamma : Dry Wt :- {Lindane}	<0.1	ug/kg		0.1	None	LE	672
Hexachlorobenzene : Dry Wt	<0.1	ug/kg		0.1	None	LE	672
Hexachlorobutadiene : Dry Wt	<0.1	ug/kg		0.1	None	LE	672
Isodrin : Dry Wt	<0.5	ug/kg		0.5	None	LE	672
TDE - pp : Dry Wt	<0.1	ug/kg		0.1	None	LE	672
Acenaphthene : Dry Wt	<1	ug/kg		1	UKAS	LE	1051
Acenaphthylene : Dry Wt	<1	ug/kg		1	None	LE	1051
Anthracene : Dry Wt	2.41	ug/kg		1	UKAS	LE	1051
Benzo(a)anthracene : Dry Wt	3.80	ug/kg		1	UKAS	LE	1051
Benzo(a)pyrene : Dry Wt	4.55	ug/kg		1	UKAS	LE	1051
Benzo(b)fluoranthene : Dry Wt	4.80	ug/kg		1	UKAS	LE	1051
Benzo(ghi)perylene : Dry Wt	5.82	ug/kg		1	UKAS	LE	1051
Benzo(k)fluoranthene : Dry Wt	3.32	ug/kg		1	UKAS	LE	1051
Chrysene : Dry Wt	4.12	ug/kg		3	UKAS	LE	1051
Dibenzo(ah)anthracene : Dry Wt	<1	ug/kg		1	UKAS	LE	1051

Fluoranthene : Dry Wt	9.35	ug/kg	1	UKAS	LE	1051
Fluorene : Dry Wt	<5	ug/kg	5	UKAS	LE	1051
Indeno(1,2,3-c,d)pyrene : Dry Wt	3.65	ug/kg	1	UKAS	LE	1051
Naphthalene : Dry Wt	<5	ug/kg	5	UKAS	LE	1051
Phenanthrene : Dry Wt	6.13	ug/kg	5	UKAS	LE	1051
Pyrene : Dry Wt	7.69	ug/kg	1	UKAS	LE	1051
PCB - 028 : Dry Wt	<0.1	ug/kg	0.1	UKAS	LE	685
PCB - 052 : Dry Wt	<0.1	ug/kg	0.1	UKAS	LE	685
PCB - 101 : Dry Wt	<0.1	ug/kg	0.1	UKAS	LE	685
PCB - 118 : Dry Wt	<0.1	ug/kg	0.1	UKAS	LE	685
PCB - 138 : Dry Wt	<0.1	ug/kg	0.1	UKAS	LE	685
PCB - 153 : Dry Wt	<0.1	ug/kg	0.1	UKAS	LE	685
PCB - 180 : Dry Wt	<0.1	ug/kg	0.1	UKAS	LE	685
Dibutyl Tin : Dry Wt as Cation	<5	ug/kg	3	UKAS	LE	897
ELEVATED_MRV : Dry weight calculation						
Tributyl Tin : Dry Wt as Cation	<5	ug/kg	3	UKAS	LE	897
ELEVATED_MRV : Dry weight calculation						
Dry Solids @ 30°C	61.1	%	0.5	None	LE	1130
Accreditation Assessment	2	No.	1	None	LE	924
Additional Material Present	Report	Text			LE	924
Plant and Stones						
Drying Method	Report	Text			LE	924
Air dried at 30°C						
Rejected Matter Description	Report	Text			LE	924
No material removed						
Sample Colour	Report	Text			LE	924
Brown						
Sample Matrix	Report	Text			LE	924
Clay Sediment						
Sample Preparation	Report	Text			LE	924
Homogenised, Jaw Crushed & Sieved to <2mm						
Calcium Carbonate Equivalent : Dry Weight	60	%	DC	0.1	None	SC 1096

Client: AQUAFAC International Services Ltd Project: 13736 Sediment Analysis
Quote Description: 4a 4b 4c 4d 4e 4f 4g
Folder No: 003686108 Sampled on: 11-Oct-16 @ 11:00
Comments: S2
Quote No: 13736 Matrix: Sediment

Analyte	Result	Units	Flag	MRV	Accred	Lab ID	Testcode
Hydrocarbons : Total : Dry Wt as Ekofisk	25.7	mg/kg	QB	0.9	UKAS	LE	402
Carbon, Organic : Dry Wt as C	2.30	%		0.1	UKAS	LE	535
Mercury : Dry Wt	0.0264	mg/kg		0.01	UKAS	LE	1042
Aluminium : Dry Wt	11500	mg/kg		20	UKAS	LE	1043
Arsenic : Dry Wt	5.96	mg/kg		1	UKAS	LE	1041
Cadmium : Dry Wt	0.159	mg/kg		0.04	UKAS	LE	1041
Chromium : Dry Wt	22.2	mg/kg		2	UKAS	LE	1041
Copper : Dry Wt	6.93	mg/kg		1	UKAS	LE	1041
Lead : Dry Wt	11.1	mg/kg		2	UKAS	LE	1041
Lithium : Dry Wt	14.3	mg/kg		0.3	None	LE	1041
Nickel : Dry Wt	19.4	mg/kg		1	UKAS	LE	1041
Zinc : Dry Wt	30.2	mg/kg		2.5	UKAS	LE	1041
Aldrin : Dry Wt	<0.5	ug/kg		0.5	None	LE	672
DDE -pp : Dry Wt	<0.1	ug/kg		0.1	None	LE	672
DDT -op : Dry Wt	<0.1	ug/kg		0.1	None	LE	672
DDT -pp : Dry Wt	<0.1	ug/kg		0.1	None	LE	672
Dieldrin : Dry Wt	<0.5	ug/kg		0.5	None	LE	672
Endrin : Dry Wt	<0.5	ug/kg		0.5	None	LE	672
HCH -alpha : Dry Wt	<0.1	ug/kg		0.1	None	LE	672
HCH -beta : Dry Wt	<0.1	ug/kg		0.1	None	LE	672
HCH -delta : Dry Wt	<0.1	ug/kg		0.1	None	LE	672
HCH -gamma : Dry Wt :- {Lindane}	<0.1	ug/kg		0.1	None	LE	672
Hexachlorobenzene : Dry Wt	<0.1	ug/kg		0.1	None	LE	672
Hexachlorobutadiene : Dry Wt	<0.1	ug/kg		0.1	None	LE	672
Isodrin : Dry Wt	<0.5	ug/kg		0.5	None	LE	672
TDE - pp : Dry Wt	<0.1	ug/kg		0.1	None	LE	672
Acenaphthene : Dry Wt	<1	ug/kg		1	UKAS	LE	1051
Acenaphthylene : Dry Wt	<1	ug/kg		1	None	LE	1051
Anthracene : Dry Wt	1.82	ug/kg		1	UKAS	LE	1051
Benzo(a)anthracene : Dry Wt	4.93	ug/kg		1	UKAS	LE	1051
Benzo(a)pyrene : Dry Wt	5.38	ug/kg		1	UKAS	LE	1051
Benzo(b)fluoranthene : Dry Wt	7.80	ug/kg		1	UKAS	LE	1051
Benzo(ghi)perylene : Dry Wt	5.56	ug/kg		1	UKAS	LE	1051
Benzo(k)fluoranthene : Dry Wt	4.39	ug/kg		1	UKAS	LE	1051
Chrysene : Dry Wt	4.56	ug/kg		3	UKAS	LE	1051
Dibenzo(ah)anthracene : Dry Wt	1.50	ug/kg		1	UKAS	LE	1051

Fluoranthene : Dry Wt	9.92	ug/kg	1	UKAS	LE	1051
Fluorene : Dry Wt	<5	ug/kg	5	UKAS	LE	1051
Indeno(1,2,3-c,d)pyrene : Dry Wt	5.93	ug/kg	1	UKAS	LE	1051
Naphthalene : Dry Wt	<5	ug/kg	5	UKAS	LE	1051
Phenanthrene : Dry Wt	5.08	ug/kg	5	UKAS	LE	1051
Pyrene : Dry Wt	7.45	ug/kg	1	UKAS	LE	1051
PCB - 028 : Dry Wt	<0.1	ug/kg	0.1	UKAS	LE	685
PCB - 052 : Dry Wt	<0.1	ug/kg	0.1	UKAS	LE	685
PCB - 101 : Dry Wt	<0.1	ug/kg	0.1	UKAS	LE	685
PCB - 118 : Dry Wt	<0.1	ug/kg	0.1	UKAS	LE	685
PCB - 138 : Dry Wt	<0.1	ug/kg	0.1	UKAS	LE	685
PCB - 153 : Dry Wt	<0.1	ug/kg	0.1	UKAS	LE	685
PCB - 180 : Dry Wt	<0.1	ug/kg	0.1	UKAS	LE	685
Dibutyl Tin : Dry Wt as Cation	7.57	ug/kg	3	UKAS	LE	897
Tributyl Tin : Dry Wt as Cation	<5	ug/kg	3	UKAS	LE	897
ELEVATED_MRV : Dry weight calculation						
Dry Solids @ 30°C	55.4	%	0.5	None	LE	1130
Accreditation Assessment	2	No.	1	None	LE	924
Additional Material Present	Report	Text			LE	924
Plant and Stones						
Drying Method	Report	Text			LE	924
Air dried at 30°C						
Rejected Matter Description	Report	Text			LE	924
No material removed						
Sample Colour	Report	Text			LE	924
Brown						
Sample Matrix	Report	Text			LE	924
Clay Sediment						
Sample Preparation	Report	Text			LE	924
Homogenised, Jaw Crushed & Sieved to <2mm						
Calcium Carbonate Equivalent : Dry Weight	55	%	DC	0.1	None	SC 1096

Client: AQUAFAC International Services Ltd Project: 13736 Sediment Analysis
 Quote Description: 4a 4b 4c 4f
 Folder No: 003686109 Sampled on: 11-Oct-16 @ 11:20
 Comments: S3
 Quote No: 13736 Matrix: Sediment

Analyte	Result	Units	Flag	MRV	Accred	Lab ID	Testcode
Carbon, Organic : Dry Wt as C	3.00	%		0.1	UKAS	LE	535
Mercury : Dry Wt	<0.01	mg/kg		0.01	UKAS	LE	1042
Aluminium : Dry Wt	3200	mg/kg		20	UKAS	LE	1043
Arsenic : Dry Wt	3.16	mg/kg		1	UKAS	LE	1041
Cadmium : Dry Wt	0.0690	mg/kg		0.04	UKAS	LE	1041
Chromium : Dry Wt	17.2	mg/kg		2	UKAS	LE	1041
Copper : Dry Wt	2.65	mg/kg		1	UKAS	LE	1041
Lead : Dry Wt	5.00	mg/kg		2	UKAS	LE	1041
Lithium : Dry Wt	6.03	mg/kg		0.3	None	LE	1041
Nickel : Dry Wt	7.33	mg/kg		1	UKAS	LE	1041
Zinc : Dry Wt	11.0	mg/kg		2.5	UKAS	LE	1041
Dibutyl Tin : Dry Wt as Cation	<4	ug/kg		3	UKAS	LE	897
ELEVATED_MRV : Dry weight calculation							
Tributyl Tin : Dry Wt as Cation	<4	ug/kg		3	UKAS	LE	897
ELEVATED_MRV : Dry weight calculation							
Dry Solids @ 30°C	67.2	%		0.5	None	LE	1130
Accreditation Assessment	2	No.		1	None	LE	924
Additional Material Present	Report	Text				LE	924
Plant and Stones							
Drying Method	Report	Text				LE	924
Air dried at 30°C							
Rejected Matter Description	Report	Text				LE	924
No material removed							
Sample Colour	Report	Text				LE	924
Brown							
Sample Matrix	Report	Text				LE	924
Sandy Clay Sediment							
Sample Preparation	Report	Text				LE	924
Homogenised, Jaw Crushed & Sieved to <2mm							
Calcium Carbonate Equivalent : Dry Weight	72	%	DC	0.1	None	SC	1096

Client: AQUAFAC International Services Ltd Project: 13736 Sediment Analysis
Quote Description: 4a 4b 4c 4f
Folder No: 003686110 Sampled on: 11-Oct-16 @ 10:20
Comments: S4
Quote No: 13736 Matrix: Sediment

Analyte	Result	Units	Flag	MRV	Accred	Lab ID	Testcode
Carbon, Organic : Dry Wt as C	2.03	%		0.1	UKAS	LE	535
Mercury : Dry Wt	0.0278	mg/kg		0.01	UKAS	LE	1042
Aluminium : Dry Wt	10200	mg/kg		20	UKAS	LE	1043
Arsenic : Dry Wt	6.64	mg/kg		1	UKAS	LE	1041
Cadmium : Dry Wt	0.194	mg/kg		0.04	UKAS	LE	1041
Chromium : Dry Wt	20.2	mg/kg		2	UKAS	LE	1041
Copper : Dry Wt	7.27	mg/kg		1	UKAS	LE	1041
Lead : Dry Wt	12.3	mg/kg		2	UKAS	LE	1041
Lithium : Dry Wt	14.0	mg/kg		0.3	None	LE	1041
Nickel : Dry Wt	13.6	mg/kg		1	UKAS	LE	1041
Zinc : Dry Wt	33.5	mg/kg		2.5	UKAS	LE	1041
Dibutyl Tin : Dry Wt as Cation	<5	ug/kg		3	UKAS	LE	897
ELEVATED_MRV : Dry weight calculation							
Tributyl Tin : Dry Wt as Cation	<5	ug/kg		3	UKAS	LE	897
ELEVATED_MRV : Dry weight calculation							
Dry Solids @ 30°C	58.2	%		0.5	None	LE	1130
Accreditation Assessment	2	No.		1	None	LE	924
Additional Material Present	Report	Text				LE	924
Plant and Stones							
Drying Method	Report	Text				LE	924
Air dried at 30°C							
Rejected Matter Description	Report	Text				LE	924
No material removed							
Sample Colour	Report	Text				LE	924
Brown							
Sample Matrix	Report	Text				LE	924
Clay Sediment							
Sample Preparation	Report	Text				LE	924
Homogenised, Jaw Crushed & Sieved to <2mm							
Calcium Carbonate Equivalent : Dry Weight	53	%	DC	0.1	None	SC	1096

Client: AQUAFAC International Services Ltd Project: 13736 Sediment Analysis
Quote Description: 4a 4b 4c 4f
Folder No: 003686111 Sampled on: 11-Oct-16 @ 10:35
Comments: S5
Quote No: 13736 Matrix: Sediment

Analyte	Result	Units	Flag	MRV	Accred	Lab ID	Testcode
Carbon, Organic : Dry Wt as C	1.66	%		0.1	UKAS	LE	535
Mercury : Dry Wt	0.0168	mg/kg		0.01	UKAS	LE	1042
Aluminium : Dry Wt	4960	mg/kg		20	UKAS	LE	1043
Arsenic : Dry Wt	5.35	mg/kg		1	UKAS	LE	1041
Cadmium : Dry Wt	0.0870	mg/kg		0.04	UKAS	LE	1041
Chromium : Dry Wt	11.6	mg/kg		2	UKAS	LE	1041
Copper : Dry Wt	3.32	mg/kg		1	UKAS	LE	1041
Lead : Dry Wt	7.15	mg/kg		2	UKAS	LE	1041
Lithium : Dry Wt	9.59	mg/kg		0.3	None	LE	1041
Nickel : Dry Wt	8.36	mg/kg		1	UKAS	LE	1041
Zinc : Dry Wt	17.3	mg/kg		2.5	UKAS	LE	1041
Dibutyl Tin : Dry Wt as Cation	<5	ug/kg		3	UKAS	LE	897
ELEVATED_MRV : Dry weight calculation							
Tributyl Tin : Dry Wt as Cation	<5	ug/kg		3	UKAS	LE	897
ELEVATED_MRV : Dry weight calculation							
Dry Solids @ 30°C	61.4	%		0.5	None	LE	1130
Accreditation Assessment	2	No.		1	None	LE	924
Additional Material Present	Report	Text				LE	924
Plant and Stones							
Drying Method	Report	Text				LE	924
Air dried at 30°C							
Rejected Matter Description	Report	Text				LE	924
No material removed							
Sample Colour	Report	Text				LE	924
Brown							
Sample Matrix	Report	Text				LE	924
Sandy Clay Sediment							
Sample Preparation	Report	Text				LE	924
Homogenised, Jaw Crushed & Sieved to <2mm							
Calcium Carbonate Equivalent : Dry Weight	59	%	DC	0.1	None	SC	1096

Client: AQUAFAC International Services Ltd Project: 13736 Sediment Analysis
Quote Description: 4a 4b 4c 4d 4e 4f 4g
Folder No: 003730071 Sampled on: 30-Oct-16 @ 15:17
Comments: Certified Reference Material
Quote No: 13736 Matrix: Sediment

Analyte	Result	Units	Flag	MRV	Accred	Lab ID	Testcode
Hydrocarbons : Total : Dry Wt as Ekofisk	NoResult	mg/kg	DC, QB	0.9	UKAS	LE	402
Carbon, Organic : Dry Wt as C	NoResult	%		0.1	UKAS	LE	535
Mercury : Dry Wt	0.0754	mg/kg		0.01	UKAS	LE	1042
Aluminium : Dry Wt	60600	mg/kg	DC	20	UKAS	LE	1043
Arsenic : Dry Wt	20.8	mg/kg		1	UKAS	LE	1041
Cadmium : Dry Wt	0.216	mg/kg		0.04	UKAS	LE	1041
Chromium : Dry Wt	89.6	mg/kg		2	UKAS	LE	1041
Copper : Dry Wt	32.4	mg/kg		1	UKAS	LE	1041
Lead : Dry Wt	19.0	mg/kg		2	UKAS	LE	1041
Lithium : Dry Wt	72.2	mg/kg		0.3	None	LE	1041
Nickel : Dry Wt	44.9	mg/kg		1	UKAS	LE	1041
Zinc : Dry Wt	150	mg/kg		2.5	UKAS	LE	1041
Aldrin : Dry Wt	<0.5	ug/kg		0.5	None	LE	672
DDE -pp : Dry Wt	3.11	ug/kg		0.1	None	LE	672
DDT -op : Dry Wt	<0.1	ug/kg		0.1	None	LE	672
DDT -pp : Dry Wt	0.311	ug/kg		0.1	None	LE	672
Dieldrin : Dry Wt	<0.5	ug/kg		0.5	None	LE	672
Endrin : Dry Wt	<0.5	ug/kg		0.5	None	LE	672
HCH -alpha : Dry Wt	<0.3	ug/kg		0.1	None	LE	672
	ELEVATED_MRV : Matrix interference						
HCH -beta : Dry Wt	<0.3	ug/kg		0.1	None	LE	672
	ELEVATED_MRV : Matrix interference						
HCH -delta : Dry Wt	<0.1	ug/kg		0.1	None	LE	672
HCH -gamma : Dry Wt :- {Lindane}	<0.1	ug/kg		0.1	None	LE	672
Hexachlorobenzene : Dry Wt	10.6	ug/kg		0.1	None	LE	672
Hexachlorobutadiene : Dry Wt	<0.3	ug/kg		0.1	None	LE	672
	ELEVATED_MRV : Matrix interference						
Isodrin : Dry Wt	<0.5	ug/kg		0.5	None	LE	672
TDE - pp : Dry Wt	1.94	ug/kg		0.1	None	LE	672
Acenaphthene : Dry Wt	36.5	ug/kg		1	UKAS	LE	1051
Acenaphthylene : Dry Wt	48.8	ug/kg		1	None	LE	1051
Anthracene : Dry Wt	140	ug/kg		1	UKAS	LE	1051
Benzo(a)anthracene : Dry Wt	250	ug/kg		1	UKAS	LE	1051
Benzo(a)pyrene : Dry Wt	240	ug/kg		1	UKAS	LE	1051
Benzo(b)fluoranthene : Dry Wt	421	ug/kg		1	UKAS	LE	1051
Benzo(ghi)perylene : Dry Wt	269	ug/kg		1	UKAS	LE	1051

Benzo(k)fluoranthene : Dry Wt	213	ug/kg	1	UKAS	LE	1051
Chrysene : Dry Wt	270	ug/kg	3	UKAS	LE	1051
Dibenzo(ah)anthracene : Dry Wt	77.0	ug/kg	1	UKAS	LE	1051
Fluoranthene : Dry Wt	533	ug/kg	1	UKAS	LE	1051
Fluorene : Dry Wt	41.2	ug/kg	5	UKAS	LE	1051
Indeno(1,2,3-c,d)pyrene : Dry Wt	255	ug/kg	1	UKAS	LE	1051
Naphthalene : Dry Wt	714	ug/kg	5	UKAS	LE	1051
Phenanthrene : Dry Wt	354	ug/kg	5	UKAS	LE	1051
Pyrene : Dry Wt	432	ug/kg	1	UKAS	LE	1051
PCB - 028 : Dry Wt	3.78	ug/kg	0.1	UKAS	LE	685
PCB - 052 : Dry Wt	4.54	ug/kg	0.1	UKAS	LE	685
PCB - 101 : Dry Wt	4.41	ug/kg	0.1	UKAS	LE	685
PCB - 118 : Dry Wt	3.53	ug/kg	0.1	UKAS	LE	685
PCB - 138 : Dry Wt	3.12	ug/kg	0.1	UKAS	LE	685
PCB - 153 : Dry Wt	4.47	ug/kg	0.1	UKAS	LE	685
PCB - 180 : Dry Wt	2.90	ug/kg	0.1	UKAS	LE	685
Dibutyl Tin : Dry Wt as Cation	791	ug/kg	3	UKAS	LE	897
Tributyl Tin : Dry Wt as Cation	514	ug/kg	3	UKAS	LE	897
Dry Solids @ 30°C	NoResult	%	0.5	None	LE	1130
Accreditation Assessment	NoResult	No.	1	None	LE	924
Additional Material Present	Report	Text	0	None	LE	924
Drying Method	Report	Text	0	None	LE	924
Rejected Matter Description	Report	Text	0	None	LE	924
Sample Colour	Report	Text	0	None	LE	924
Sample Matrix	Report	Text	0	None	LE	924
Sample Preparation	Report	Text	0	None	LE	924

Method Description Summary for all samples in batch Number 20100536

- 402 LE I Hydrocarbons by fluorescence
- 535 LE I TOC 01 - combusted with oxygen; thermal conductivity detection
- 672 LE O OCP_PAH_PCB in Marine Biota and Sediment - solvent extracted, determined by GCMS QQQ
- 685 LE O OCP_PAH_PCB in Marine Biota and Sediment - solvent extracted, determined by GCMS QQQ
- 897 LE O Organotins (GCMS) 01 - acetic acid/methanol extracted; derivatised; determined GCMS (SIM); from "as received" sample
- 924 Sample Preparation; Dry Solids (30°C); from "as received" sample
- 1041 LE M Metals ICP-MS Sediment - microwave aqua regia digested, determined by ICPMS, samples are sieved to <2000µm.
- 1042 LE M Mercury CSEMP - microwave aqua regia digested, acidic SnCl₂ reduced, determined by CV-AFS. Samples are sieved to <2000µm.
- 1043 LE M Metals Marine (ICPOES) - microwave aqua regia digested, determined by ICPOES, samples are sieved to <2000µm.
- 1051 LE O OCP_PAH_PCB in Marine Biota and Sediment - solvent extracted, determined by GCMS QQQ
- 1096 Sub-contract
- 1130 LE P Soil Preparation 01: The sample is air-dried at <30°C in a controlled environment until a constant weight it achieved.

S.M.

Steve Moss
Laboratory Site Manager

Any additional accompanying reports received should be used in conjunction with the formal PDF and not as a standalone report. The formal PDF report provides full details of the accreditation status, sample deviation information and any other relevant related information.

All reporting limits quoted are those achievable for clean samples of the relevant matrix. No allowance is made for instances when dilutions are necessary owing to the nature of the sample or insufficient volume of the sample being available. In these cases higher reporting limits may be quoted and will be above the MRV.

Minimum Reporting Value (MRV). A minimum concentration selected for reporting purposes (i.e. the less than value), which is higher than the statistically derived method limit of detection.

Solid sample results are determined on a "dried" sample fraction except for parameters where the method description identifies that "as received" sample was used.

Uncertainty of Measurement information relating to sample results is supplied upon request. Uncertainty is estimated from the performance of routine quality control standards, using the calculation 2 X Relative Standard Deviation + Bias. This is based on the guidance issued by the UKTAG Chemistry task team - Guidance on the implementation of the Quality Assurance/Quality Control requirements' associated with Commission Directive 2009/90/EC, Article 4 (UoM = 2 X %RSD), with a contribution added for the bias.

Key to Results Flags:

DC Analysis started outside of specified stability time. It is possible that the results may be compromised.

QB QC Flag. Result accepted against QC breach

The analysis start date specified is the date of the first test, dates for other analysis are available on request.

Please note all samples will be retained for 10 working days for aqueous samples and 30 working days for solid samples after reporting unless otherwise agreed with Customer Services

Key to Accreditation: UKAS = Methodology accredited to ISO/IEC 17025:2005, MCertS = Methodology accredited to MCertS Performance Standard for testing of soils, none = Methodology not accredited

Key to Lab ID: LE = Leeds, NM = Nottingham, SX = Starcross, SC = Sub-Contracted outside NLS, FI = Field Data - outside NLS, NLS = Calculated

Any subsequent version of this report denoted with a higher version number will supersede this and any previous versions

END OF TEST REPORT

Appendix 7
Radiological Analysis
Lab Report

Laboratory Test Report

Report Date: 19th December 2016

Samples Tested on Behalf of: Aquafact,
Environmental Consultants
12 Kilkerrin Park
Liosbaun Industrial Estate
Galway

Laboratory Analysis: High Resolution Gamma Spectrometry with
appropriate density correction

Sample Type: Marine Sediment ex Rossaveal Harbour

Date of Receipt: October 2016

Date of Analysis: October - December 2016

Results:

ORP Reference	Client Reference	Coordinates	Nuclide	Activity Concentration (Bq/kg, dry) ¹
ES1600434	Rossaveal S1		K-40	172 ± 19
			I-131	nd
			Cs-134	nd
			Cs-137	1.1 ± 0.1
			Ra-226	6.7 ± 1.2
			Ra-228	6.1 ± 0.9

ES1600435	Rossaveal S2	K-40	208 ± 23
		I-131	nd
		Cs-134	nd
		Cs-137	1.7 ± 0.2
		Ra-226	9.7 ± 1.7
		Ra-228	10.1 ± 1.5

Note:

- (1) Quoted uncertainties are ±1 SD counting statistics
- (2) nd = not detected

The Office of Radiological Protection received two grab sediment samples from the Aquafact. These samples were taken at the Rossaveal Harbour in October 2016 in support of application for a Maintenance Dredging Permit. The sample was prepared by placing an aliquot in a well-defined counting geometry and then measured on a high-resolution gamma spectrometer. Appropriate density corrections were applied to the resultant spectra to take account of the differences in sample density. Dry to wet weight ratio was determined for the sample. Results are quoted on a dry weight basis.

The results indicate that dumping of these materials at sea will not result in a radiological hazard.

Lorraine Currivan
Laboratory Manager

Notes:

- This report relates only to the samples tested.
- This report shall not be reproduced except in full, without the approval of the Institute
- The following scientific officers may sign test reports on behalf of the lab manager: Dr Ciara Mc Mahon, Dr Kevin Kelleher.
- Where applicable, the number following the symbol ± is the combined standard uncertainty and not a confidence interval.