Shell E& P Ireland Ltd.

Corrib Offshore Baseline Environmental Surveys 2014 and 2016

Treated Surface Water Outfall (SW1) and Corrib Offshore Gas Field (SW3)

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Where field investigations have been carried out, these have been restricted to a level of detail required to achieve the stated objectives of the work.

This work has been undertaken in accordance with the quality management system of RSK Environment Ltd.

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1 INTRODUCTION

The Corrib Field lies in approximately 350m of water, approximately 65km off the coast of County Mayo. The gas in the field is transported ashore via a 20-inch-diameter subsea pipeline. The landfall is at Dooncarton in Broadhaven Bay; from there the gas is routed to the Terminal at Bellanaboy Bridge. The proposed outfall for surface water collected at the Terminal, is located approximately 2km north of Erris Head, and is also known as SW1. The outfall is piggy-backed onto the gas pipeline, and will receive and disperse water which has first been treated on site, prior to discharge.

Shell E&P Ireland Ltd (SEPIL) requested RSK to undertake a programme of offshore benthic and water quality sampling at the Corrib treated surface water outfall location (SW1) and at the Corrib Central Manifold (SW3 within the Corrib Offshore Gas Field) (hereafter referred to as the Corrib Field). This was undertaken in Autumn 2014. Subsequently the Environmental Protection Agency (EPA) requested that additional parameters be monitored at the two locations from a review of the Baseline Environmental Surveys – Survey Plan.

The scope of this survey report serves to combine the results of the surveys at the two offshore locations from 2014 and the seawater quality sampling in 2016, and meet the requirements of IE licence P0738-03 (condition 6.14).

1.1 Previous Surveys

A number of surveys have previously been undertaken in the vicinity of the Corrib SW1 Treated Surface Water Outfall, and Corrib Field (which includes the SW3 Corrib Central Manifold), and as such a good degree of representative baseline data is available for these areas.

1.1.1 SW1 Treated Surface Water Outfall

Initial surveys of seabed sediments date back to 2000 (Gardline, 2000), with subsequent monitoring of sediments and seawater quality taking place in 2005 (EcoServe, 2006). During 2007 and 2008 comprehensive programmes of seabed sediment and water quality were undertaken from the R/V *Prince Madog* (RSK, 2008) and M/V *Deepworker* (RSK, 2009). Also in 2008, additional sediment and water quality sampling took place immediately to the north of the sampling spread at the SW1 (Figure 2.1). The most recent campaign (prior to 2014) took place in 2013, when a programme of water quality sampling was undertaken in the vicinity of both the Corrib Manifold (SW3), and SW1 sites (RSK, 2014).

1.1.2 Corrib Field (SW3)

The most recent campaign (prior to 2014) took place in 2013, which included a programme of quality sampling (RSK, 2014). Prior to this, seabed sediment sampling took place in 2012, where samples were collected for physicochemical analysis from cores obtained by an ROV.

Surveys were also carried out during the summers of 2007 and 2008. These comprised comprehensive programmes of seabed sediment sampling undertaken from the *RV Prince Madog* (RSK, 2008) along the route of the offshore pipeline, and by the *MV Deepworker* (RSK, 2009) at the Corrib Field itself.

2 METHODS

2.1 2014 Survey Campaign

2.1.1 Survey Vessel

The surveys were carried out from the ILV *Granuaile*, an 80-metre dynamically positioned multi-purpose offshore aids-to-navigation support vessel. This vessel was chartered from the Commissioners of Irish Lights through Osiris Projects (who acted as charter agents), and was selected based on her suitability to provide a safe platform for the deployment and recovery of environmental survey equipment in challenging sea conditions.

The vessel was equipped with a USBL (ultra short baseline) system, which was provided and installed by Osiris projects, for the duration of the survey. The system is used for underwater acoustic positioning of the deployed sampling equipment and ensures that the position of the survey equipment relative to any seabed assets is known. The mobilisation report for the USBL and navigation equipment calibration carried out by Osiris projects can be referred to as Appendix 5.

2.1.2 Personnel

SEPIL commissioned RSK Environment Ltd (RSK) to manage the environmental survey. RSK in turn contracted Osiris Projects to act as vessel operators and to provide navigational services (equipment and surveyors) for the duration of the project. RSK also contracted Benthic Solutions Ltd. to supply environmental staff and specialist survey equipment.

During survey operations, the scientific crew worked according to two 12-hour shifts to enable sampling operations over 24 hours. Each watch comprised three scientists and one surveyor.

2.1.3 Survey Dates

Table 2-1 presents key dates of the survey.

Table 2-1: Dates of 2014 environmental survey

Date	Task	Location
24th – 25th September	Mobilisation	Cobh, Co. Cork
25th – 27th September	Transit to Corrib Field, Weather downtime on arrival	Transit / Standby
28th September – 1st October	Survey Operations and Weather Standby at the Corrib Field (SW3) and Erris Head Outfall(SW1)	Corrib Field and Erris Head Outfall
2nd October	Transit to Galway	Transit
3rd October	Demobilisation	Galway, Co. Galway

2.1.4 Sampling Locations

Sampling locations at SW1 were spread over eight sediment and two water stations, while sixteen sediment and two water sampling stations were proposed at the Corrib Field. Sediment sampling at both locations involved the use of a drop-down camera system (video and still imagery). Sampling stations at both locations were arranged in a pattern that corresponded roughly with the prevailing currents. The coordinates of the surveyed sampling stations at SW1 are listed in Table 2-2, and their locations are presented in Figure 2.1. The coordinates of the sampling stations at the Corrib Field (SW3) are listed in Table 2-3, and their locations are presented in Figure 2.2.

Table 2-2: Sample Stations at the SW1 – Corrib Treated Surface Water Outfall. Sediment. Water.

Analyte	Sampling station	Lat	Long	Easting	Northing
Sediment	S1	54.29470	10.18364	422963.57	6016956.69
	S2	54.32080	10.01754	433815.56	6019691.94
	S6	54.33250	9.99310	435423.64	6020971.49
	S6R	54.32660	9.99244	435457.18	6020313.99
	S9	54.33230	9.95224	438080.04	6020912.14
	S10	54.35650	9.98624	435906.91	6023635.06
	S11	54.33250	10.02704	433216.63	6021002.65
	S17	54.32070	9.95634	437795.95	6019625.11
Water	W1	Same location as S1			
	W12	54.32933	9.99091	435561.27	6020616.56

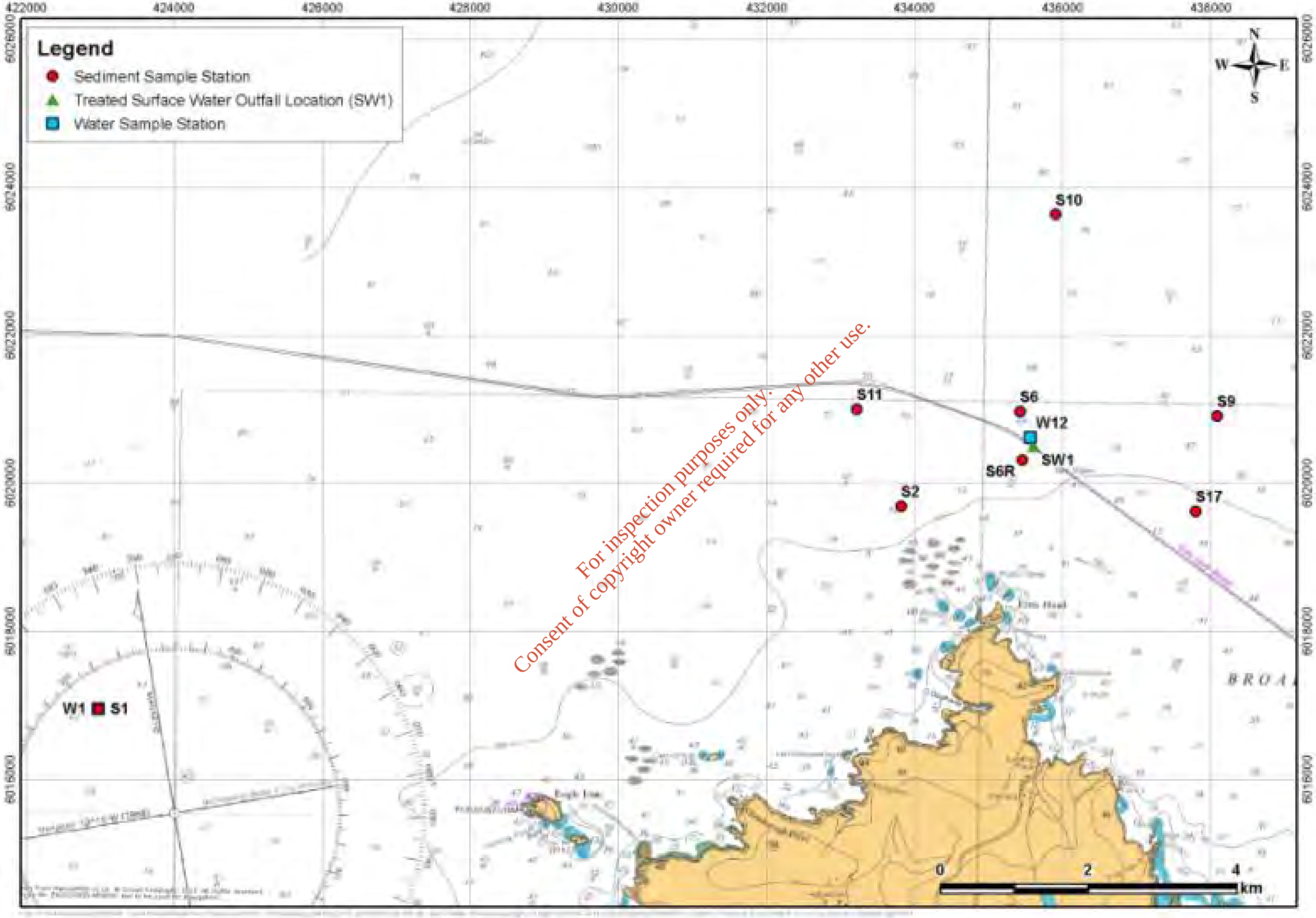

Figure 2.1: Plan of benthic and seawater sampling stations at the Corrib treated surface water outfall (SW1), Erris Head.

Table 2-3: Sample Stations at (SW3) within the Corrib Field. Sediment. Water.

Analyte	Sampling station	Lat	Long	Easting	Northing
Sediment	**C1**	54.349827028 N	011.037853955 W	367551.01	6024359.06
	C4	54.345607992 N	011.037476034 W	367562.00	6023889.00
	F3	54.332545605 N	011.071628478 W	365299.66	6022500.60
	F4	54.333413025 N	011.043149005 W	367153.98	6022543.06
	F5	54.319682426 N	011.047751178 W	366810.42	6021024.30
	F6	54.339335029 N	011.084195001 W	364505.01	6023279.96
	F8	54.345347425 N	011.047733879 W	366894.48	6023879.34
	Z3	54.341865894 N	011.057528262 W	366246.61	6023510.58
	Z4	54.340732733 N	011.057551590 W	366241.42	6023384.56
	Z5	54.337859488 N	011.057409577 W	366241.32	6023064.66
	Z6	54.336686015 N	011.057370951 W	366240.02	6022934.05
	Z9	54.338987023 N	011.053655011 W	366489.04	6023182.98
	Z10	54.338958989 N	011.055839058 W	366346.98	6023184.00
	Z11	54.338915975 N	011.060344501 W	366053.97	6023187.76
	Z12	54.338831354 N	011.062694370 W	365900.95	6023182.82
	A4	54.317955020 N	011.071274035 W	365275.02	6020876.82
Water	**Z11**	Same location as Z11			
	SW3	54.339006 N	011.058550 W	366171.01	6023194.02

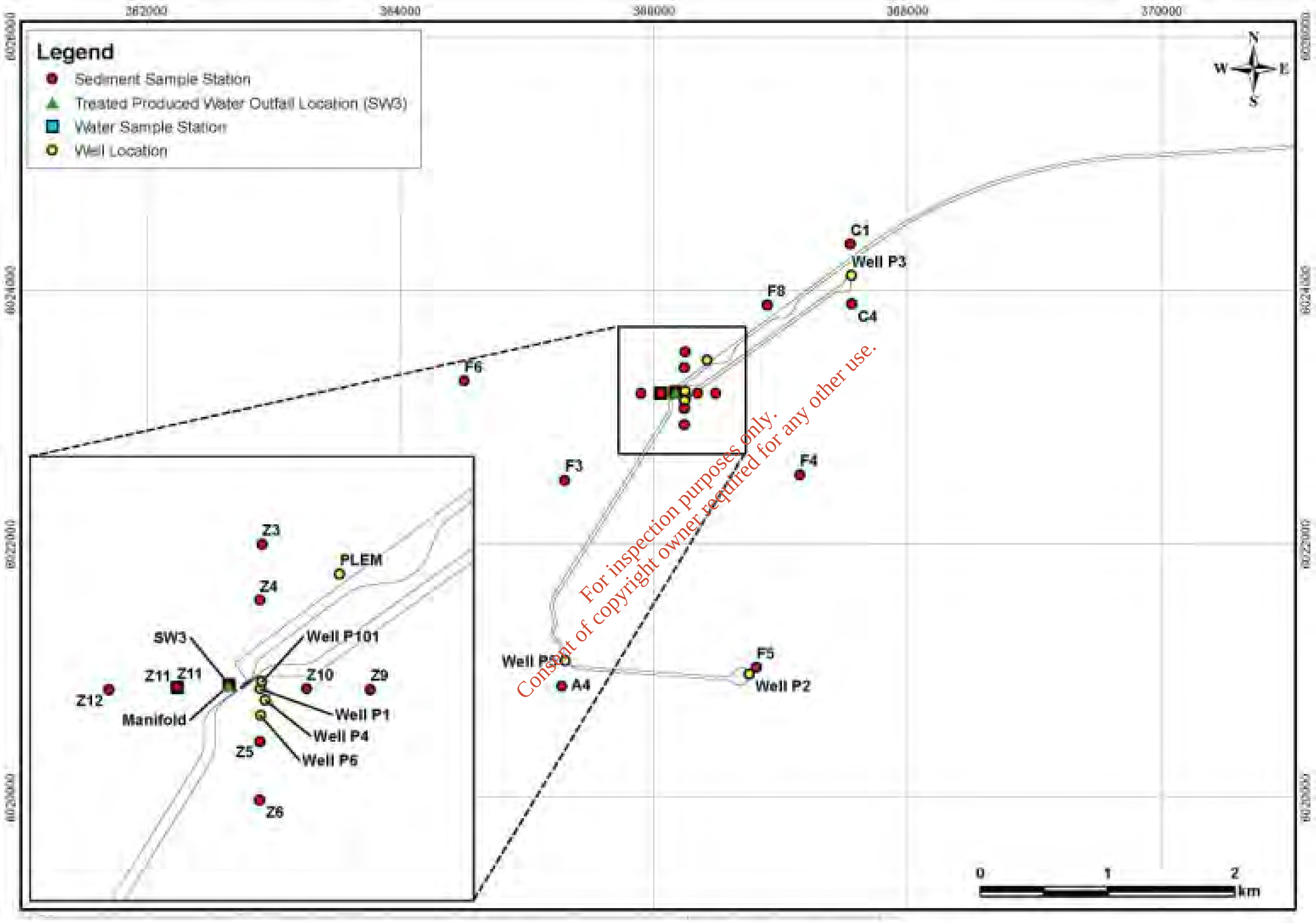

Figure 2.2: Plan of benthic and seawater sampling stations at SW3 within the Corrib Field.

2.1.5 Sampling Methods

Environmental survey operations at the SW1 and SW3 locations comprised seabed photography and video, sampling of seabed sediments using a benthic grab sampler, and sampling of water quality using a Niskin type water sampler at near surface and near seabed depths.

2.1.5.1 Seabed photography

Seabed photography and video operations were undertaken at all benthic sites to supplement data gathered from grab sampling, and to ground truth seabed conditions. The camera system was mounted in a Benthic Solutions Ltd. sled type frame configured to allow for operations over a range of sediment types and water depths. The camera frame was designed to be deployed in either a drop-down drift configuration to avoid contact with the seabed, or as a towed sled which remains in close proximity to the seabed at all times.

The camera system was deployed to visually record the localised benthic habitats, and qualitatively determine the community composition at the surface in the vicinity of each benthic sampling station. At each station, once the camera was in visual contact with the seabed, the vessel would commence moving along a 50m target transect using dynamic positioning. Typically 10-12 still photographs were taken on each transect at each benthic sampling station, along with a video record of seabed conditions obtained for the entire transect to supplement the still photographs.

2.1.5.2 Seabed Sediment

Seabed sediment samples were collected using a double Van-Veen benthic grab. The grab sampler is designed to retrieve two quantitative sediment samples from a single deployment. The grab comprises twin sampling buckets, with each bucket acquiring a surface area of 0.1 m^2. The grab was used in place of standard single-grab sampler to reduce the number of deployments necessary at each sampling station.

On sample recovery and prior to sub sampling a visual inspection of the samples was taken. Samples were subject to quality control and would be retained in the following circumstances:

- Supernatant water above the sample surface was undisturbed;
- Grab buckets were fully closed resulting in no washout of sample;
- Penetration of the grab was sufficient to maintain a seal at the base;
- The sampler was recovered upright, and cables were not fouled in any way;
- Sampler top doors were closed completely, enclosing the sample;
- No disruption of the sample had occurred through striking the side of the vessel;
- Sample was acquired within the acceptable target range, and
- The sample was acceptable to the Principal Scientist

Samples from each grab were photographed with a station ID card, visually inspected and described prior to processing. Key observations included sediment colour, classification (including any obvious layering and presence of REDOX Potential

Discontinuity (RPD) layers, smell (including the presence of Hydrogen Sulphide (H_2S)), conspicuous fauna, and evidence of bioturbation and anthropogenic debris.

Three replicates were sampled at each station for benthic macroinvertebrates. A fourth sample was acquired at each station to be sub-sampled for the analysis of various physico-chemical parameters. Samples were taken from the grab by an experienced surveyor wearing nitrile gloves (disposed of after each station) and using the necessary sampling utensils/receptacles for each sub-sample dependent on the analytical requirements.

Physico chemistry sub-samples were recovered from the grab with care taken to ensure sediment had not been in direct contact with the surface or sides of the grab. The grab was also scrubbed clean and rinsed with seawater between each deployment to avoid cross contamination of samples between deployments / stations.

2.1.5.3 Water quality

Both near surface and near seabed water samples were obtained by means of a Richter and Weise Niskin water sampler deployed from the deck of the survey vessel. For near surface water samples, the Niskin bottle was lowered into the water using 4 mm dyneema rope. Once at the required depth of around 1-2 m below the sea surface a metal 'messenger' was sent down the deployment line to trigger the sampler and obtain the water sample.

For near bottom surface samples the Niskin sampler was attached directly to the side of the sediment sampling grab. The water sampler was configured so that when the grab triggered at the seabed it would also simultaneously trigger the Niskin water sampler at the correct near seabed depth.

A Valeport Midas CTD profiler was deployed simultaneously with each water sample deployment. This was also fixed onto the grab sampler. Prior to sampling at near seabed water depths, the CTD was allowed to equilibrate in the surface waters for three minutes after being deployed from the vessel deck, before it was lowered through the water column to the seabed.

On retrieval of the sampling equipment from both near surface and near seabed depths, subsamples were taken directly from the Niskin sampler into the appropriate containers using the samplers release tap. Where appropriate, prior to sub sampling each subsample container was rinsed with a small volume of sample prior to filling. During all water quality sampling operations, care was taken to avoid any contamination from the survey vessel. Therefore, all vessel outlets (deck scupper, bilge pump, water maker outlets etc.) were identified and avoided as far as possible, during the water sampling operations.

2.1.5.4 Other equipment

As the standard vessel configuration of the ILV *Granuaile* did not readily provide for the launch and recovery of survey equipment in open water environments, a dedicated and self contained LARS (Launch and Recovery System) was provided (Figure 2.3). The LARS comprised an A-frame and 3t tugger winch, with a separate hydraulic power pack, which was then connected to the vessels electrical supply. The LARS was deployed approximately mid-ships (port side) to provide good operational capacity in marginal sea conditions (therefore with the vessel positioned head or stern to sea at each sampling location, the degree of surge/ heave during deployment was significantly less than if deployed over the vessel stern). All survey equipment (camera, benthic grab sampler, water sampler) were deployed and recovered using the LARS.

Figure 2.3: Deck LARS system used during the 2014 environmental survey

A 10 ft shipping container was fastened to the deck to provide a dedicated deck laboratory, providing shelter as well as housing electrical control systems (topside camera equipment), consumables and chemicals (via onboard COSHH locker).

A spare winch was also provided from which to deploy equipment (to be used in the event of a breakdown of the primary sampling winch on the LARS), in addition a dedicated winch for the deployment of the camera was also provided. The camera winch was electrically operated and used data cable rather than the dyneema rope used to deploy the grab sampler. This winch was operated using a remote control, so could be operated from inside the laboratory allowing the depth to be adjusted while reviewing the live video feed from the camera during deployments.

Samples retained for macrofaunal analysis were processed using a Wilson Autosiever connected to the vessels seawater deck supply.

2.1.6 Sample Processing

2.1.6.1 Seabed photography

During the survey, notes on conspicuous fauna and a description of the sediment type were taken from a preliminary review of the video and still photographs during acquisition. Following the survey the still photographs were reviewed in more detail and a qualitative description of the main marine biota present and sediment characteristics was made by an experienced marine scientist.

2.1.6.2 *Sediment processing and analysis*

Details of sediment samples collected are presented in Table 2-4, which also describes the sample containers and the field preservation / storage conditions. Post-survey, samples were transferred to cold boxes containing ice packs (with the exception of macrofaunal samples). All samples were then transferred under chain-of-custody procedures to the various analytical laboratories. The same laboratories that have previously been used for the analysis of sediment samples at the SW1 and SW3 locations were also used during this survey as they are familiar with the analytical requirements for the samples, and are thus able to analyse at the low levels of detection required.

Table 2-4: Sediment sample processing and analysis details

Parameter	No./Volume	Container	Preservation / storage	Receiving Lab
Benthic macro-invertebrates	3x1 complete (separate) grab replicate samples	Double-labelled plastic bucket / pot	4–10 % buffered formaldehyde solution	Hebog Environmental
Particle size analysis (PSA)	~1 kg	Labelled plastic pot/poly bag	Frozen	Environment Agency National Laboratory Service (Samples received 7/10/2014. Analysis completed and reported on by 18/11/2014)
Total organic carbon (TOC)				
Metals: Al, Ag, As, Ba, Cd, Cr, Cu, Fe, Hg, Li, Mn, Ni, Pb, Se, V, Zn by ICPOES and HF digest and ICPMS depending on parameter	~1 kg	Labelled plastic tub/poly bag	Frozen	

Parameter	No./Volume	Container	Preservation / storage	Receiving Lab
Organics: polycyclic aromatic hydrocarbons (2-6 ring EPA16 PAH and NPD (naphthalenes, phenanthrenes, dibenzothiophenes + alkylated homologues)	~300 ml	2x labelled glass jars	Frozen	Environment Agency National Laboratory Service For samples at SW1 and at M-Scan Laboratories for samples at SW3 (Analysis completed and reported on by 18/11/2014 for EA, and c.7/10/2014 – M-Scan)
Solvent extraction to produce a total organic extract (TOE), qualitative and quantitative analysis of the total hydrocarbon fraction by GC-FID	~300 ml	2x labelled aluminium tins	Frozen	M-Scan Laboratories for samples at SW3 only (Analysis undertaken c.7/10/2014)

Data from sediment samples analysed for particle size analysis were classified according to Folk (1954) (Figure 2.4) based on the relative contents of gravel (>2 mm), sand (>63 µm to 2 mm) and mud (<63 µm).

Figure 2.4: Folk scale of sediment classification

In addition samples were further classified using the Udden Wentworth Classification, which is calculated initially from the geometric median particle size from the 16^{th}, 50^{th} and 84^{th} percentiles.

To assess the accuracy of the analytical laboratory in determining levels of metals in marine sediment, a sample of Certified Reference Material (CRM) of marine sediment containing certified levels of metals, was provided to the Environment Agency (EA) laboratory. The CRM used was the MESS-3 specification (marine sediment), produced by the National Research Council of Canada (NRCC).

2.1.6.3 Sediment macrofaunal analysis

After sieving over a 0.5mm-mesh sieve, samples were sorted and any macrofaunal invertebrates separated out and identified and enumerated. Organisms were identified to species level according to the nomenclature of the World Register of Marine Species (WoRMS - www.marinespecies.org). Colonial and encrusting organisms were recorded by presence alone.

In some instances a combination of the coarse nature of the sediments, and the sheer volume of the samples collected resulted in the sample not reducing in volume significantly. In order to ensure that sufficient survey consumables were retained to be able to preserve and store samples from all stations the decision was taken to sub sample 50 % of certain samples by volume. This was done while the sample was retained in the grab, ensuring that the surface and underlying sediments were kept. Stations where grab replicates were sub sampled by 50 % (divided in half) were S2, S6, and S6R. The implications that this sub sampling had on the statistical analyses is discussed in Section 4.1.1.4.

These data were then used to collate a number of common ecological indices (calculated using PRIMER version 6) as follows:

- *Species richness (d)*: the number of species present, using Margalef's Index;
- *Abundance (N)*: the number of individuals present;
- *Diversity (Shannon-Wiener, H')*: an integrated index of species richness and relative abundance;
- *Evenness (Pielou's, J')*: evenness of the distribution of individuals amongst different species in each sample; and
- *Dominance (Simpsons, λ)*: dominance, essentially the reverse of evenness.

In addition, numerical data were then used in multivariate analyses to calculate a number of indices. These were:

- *Cluster analysis*: determination of inherent groupings within species and station data. In this study Bray-Curtis similarity was calculated using the PRIMER statistical package;
- *Multi-dimensional scaling (MDS)*: using similar data to cluster analysis, this presents groupings on a 2-D plot;
- *SIMPER*: this identifies those species most responsible for the defining similarities in each group; output is given as a percentage of

similarity/dissimilarity and ranks those species that contribute most to this value; and

- *BIOENV*: performed within PRIMER, this incorporates physical or chemical data from each station (e.g. water depth, sediment size fraction) to determine the degree of correlation between this and the communities present.

2.1.6.4 *Water quality processing and analysis*

Recovered water samples were sub-sampled into the appropriate containers for analysis. The parameters to be analysed are outlined in Table 2-5, which also describes the sample containers and the field preservation. Samples were immediately placed into cold storage boxes with frozen ice packs to maintain them in a chilled state prior to dispatch to the laboratory. Samples were analysed at the Environment Agency's UKAS accredited National Laboratory in Leeds, UK on the 23rd Oct 2014. The National Laboratory Service has previously undertaken the analysis for seawater samples collected at the Erris Head outfall (SW1) and at SW3 and are able to analyse at the low levels of detection (minimum reportable value (MRV)) that are required for seawater samples from these areas.

Table 2-5: Water quality sample processing and analysis details

Parameter	No./Volume	Container	Preservation / Storage	Receiving Lab	Analytical Test and Minimum Reportable Value (MRV)
Total suspended solids	1000 ml	PET	-	Environment Agency National Laboratory Service (Samples received 7/10/2014. Analysis completed and reported on 23/10/2014)	Double paper solids, suspended at 105 °C (3 mg/l)
Ammoniacal N	125 ml	Polypropylene	-		Nutrients Saline (0.01 mg/l)
Metals Cd Cu Pb Ni Zn Cr Ag	125 ml	Polypropylene			ICPMS Saline Total 0.03 µg/l 0.2 µg/l 0.04 µg/l 0.3 µg/l 0.4 µg/l 0.5 µg/l 1 µg/l
Arsenic	125 ml	Polypropylene			Total Arsenic (1 µg/l)

Mercury	125 ml	Glass	1ml of 2.5 % K-dichromate in 50 % HNO_3		Total Mercury (0.01 µg/l) Analysis of Aqueous Mercury by Cold Vapour Atomic Fluorescence Spectrometry (CVAF)
Phenols	250 ml	Glass	1 molar H_2SO_4		Phenols (0.02 µg/l)
PAHs	1000 ml	Glass	-		Phenols (0.02 µg/l)

A certified reference material (CRM) containing known levels of metals, was provided to the Environment Agency (EA) along with other samples in order to determine their analytical accuracy. The CRM used was SLEW-3 specification (estuarine waters), produced by the National Research Council of Canada (NRCC).

2.2 2016 Survey Campaign

2.2.1 Survey Vessel

The survey was carried out from the construction support vessel *Olympic Ares* operated by Bibby Offshore. The vessel was being used by Shell to undertake a wider programme of work, of which the water sampling formed a small part of the overall scope.

2.2.2 Personnel

Shell commissioned RSK to design the scope of the water quality monitoring survey in response to the additional sampling requirements outlined by the EPA. RSK provided the surveyor and managed the environmental aspects of the work. Support was provided by Bibby Offshore with regards to the actual sampling (since this was undertaken using the vessel's Remotely Operated Vehicle (ROV).

2.2.3 Survey Dates

Table 2-6 presents key dates of the survey.

Table 2-6: Dates of 2016 environmental survey

Date	Task	Location
16th May 2016	*Olympic Ares* mobilisation	Killybegs
20th May 2016	Water sampling and water column profiling	Corrib Field (SW3 vicinity)
21st May 2016	Water column profiling	Corrib Field (SW3 vicinity)

27th May 2016	Water sampling and water column profiling	Erris Head outfall (SW1 vicinity)
9th June 2016	*Olympic Ares* demobilisation	Peterhead

The vessel originally mobilised in Montrose, ahead of its remobilisation in Killybegs. The RSK appointed scientist did not however, join the vessel until the 16th May in Killybegs.

2.2.4 Sampling locations

Seawater quality sampling was undertaken at 3 positions in the vicinity of each of the SW3 (Central manifold at the Corrib Field) and SW1 (Erris Head outfall for treated surface water runoff from Bellanaboy Bridge Terminal) locations. As such a total of 6 stations were sampled.

At each station samples were taken close to the discharge location, and then two further stations positioned up and down current orientated along the direction of the prevailing currents. Where possible, stations that had previously been sampled for seawater quality were utilised, such that a degree of direct comparison with previous data could be made, allowing for the identification of any possible changes over time. The stations sampled as part of this 2016 campaign were all previously sampled in 2013, while some of the stations were also sampled for seawater quality in 2014 and 2015.

The following table shows the locations proposed for seawater sampling stations.

Table 2-7: Seawater quality sampling stations sampled during the 2016 survey campaign

Sampling Station	Easting (UTM 29N (WGS-84)	Northing (UTM 29N (WGS-84)	Longitude (WGS-84)	Latitude (WGS-84)
SW3				
Central Location (Station 1)	366057	6023160	-11.060290	54.338664
NE (Station 3)	366511	6023565	-11.053483	54.342421
SW (Station 5)	365804	6022855	-11.064034	54.335863
SW1				
W4	435090	6020123	-9.998042000	54.324834000
W7	436016	6020760	-9.983941000	54.330676000
W12	435561	6020617	-9.990907000	54.329328000

Figure 2.5 and Figure 2.6 show plans of the 2016 sampling locations at the Corrib Field and off Erris Head respectively.

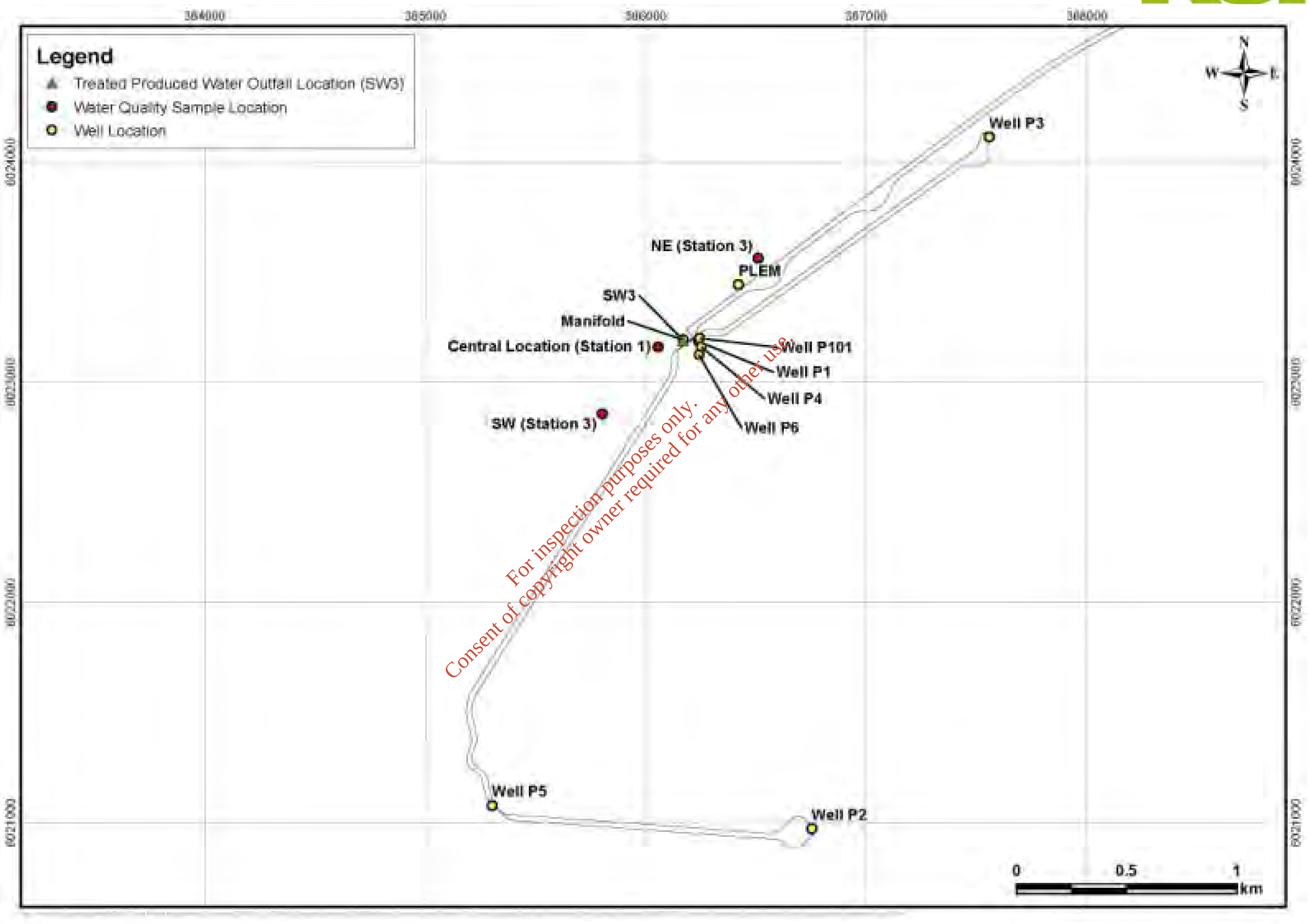

Figure 2.5: Plan of 2016 seawater sampling stations at SW3 within the Corrib Field

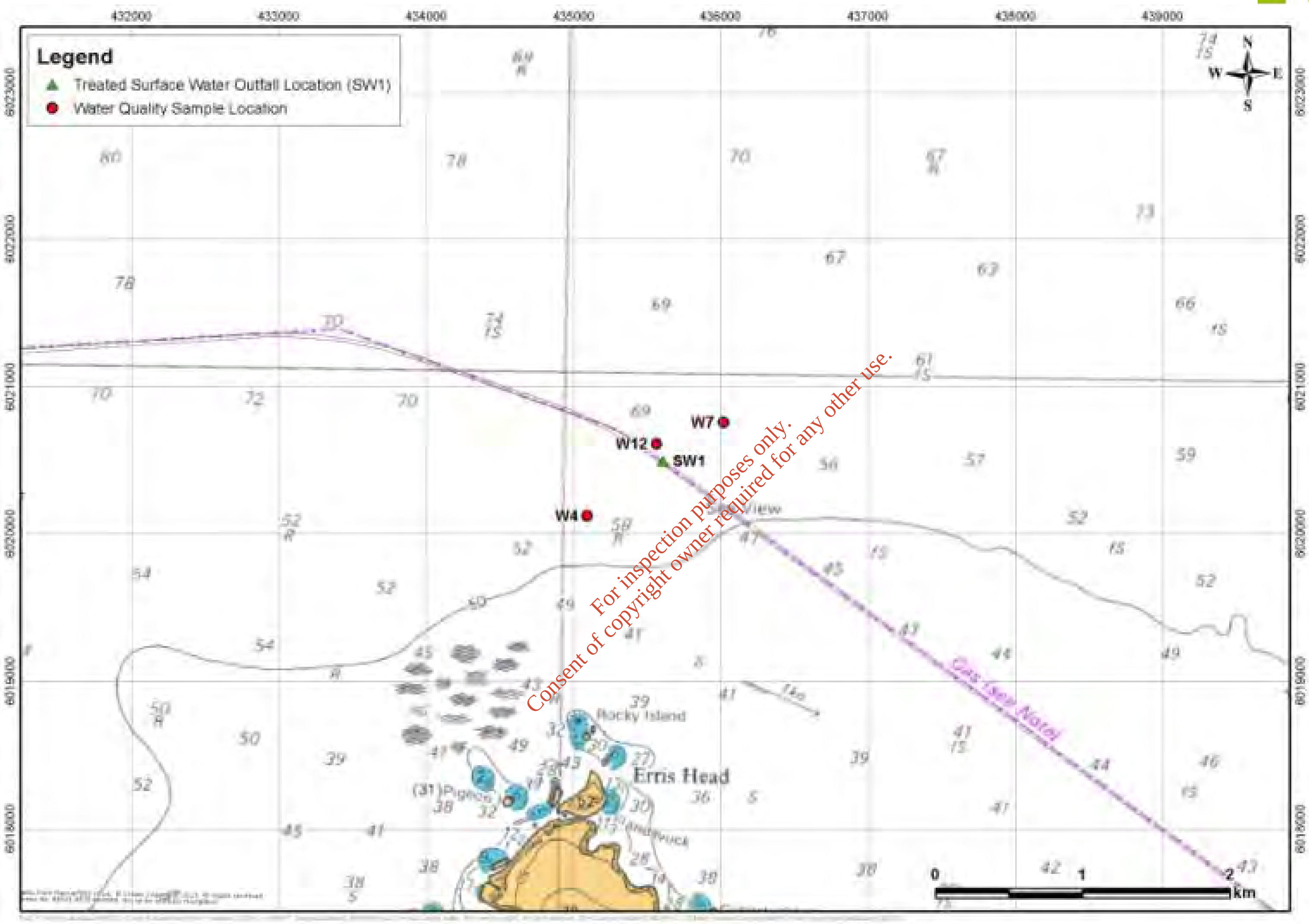

Figure 2.6: Plan of 2016 seawater sampling stations at the SW1 outfall location off Erris Head

2.2.5 Sampling Methods

Environmental survey operations at the SW1 and SW3 locations in 2016 comprised the collection of seawater quality samples for the analysis of nutrients as requested under the revised conditions to the IED licence (Condition 6.14). In particular these were nitrates, phosphates, and silicates. Samples were collected using similar methods as for the 2014 survey programme whereby a sample was taken at near seabed and near surface depths from each sampling station. In addition to the samples for phosphates, nitrates and silicates, there was a requirement for additional water column profiles of dissolved oxygen (which had not previously been recorded). A CTD – DO profiling instrument was deployed on the ROV along with the water sampler.

2.2.5.1 Near seabed samples

Water samples were collected at a depth of around 10m above the seabed using a 1.7 litre Niskin type water sampler. The water sampler was deployed from the vessel's work class ROV along with a CTD and DO profiler. The seawater profiler was a Valeport Midas CTD+ multiparameter instrument. This was set in continuous recording mode, recording temperature, salinity, dissolved oxygen, pH, and turbidity, against depth. The water sampler was triggered to close at the required depth using the ROVs manipulator arm. The CTD-DO profiler was allowed to equilibrate in the surface waters for 3 minutes prior to descending throughout the full depth of the water column.

2.2.5.2 Near surface samples

Subsurface seawater sampling was undertaken using a 1.5 litre NIO type water sampler deployed from the vessel's winch and triggered at a sample depth where it was deemed to be clear of the vessel hull. This sample was taken at a depth of approximately 2m below the surface however. The sampler was triggered by sending a messenger weight down the deployment wire.

During all surface water sampling, care was taken to avoid any contamination from the survey vessel itself. Therefore, all vessel outlets (deck scupper, bilge pump, water maker outlets etc.) were identified and avoided as far as possible during the water sampling operations. Due to the relatively light weight of the equipment it was possible to deploy the sampler by hand using light line for surface water samples, thus making it easier to avoid potential sources of contamination from the vessel discharges.

2.2.5.3 Seawater quality sample processing and analysis

Recovered water samples were sub-sampled into the appropriate containers for the analysis of nitrates, phosphates and silicates. All sub-samples were stored in polypropylene containers and were immediately frozen prior to dispatch to the laboratory when the vessel demobilised in Peterhead. Samples were received frozen on 9th June 2016 and analysed at the Environment Agency's UKAS accredited National Laboratory in Leeds, UK on 10th/11th June 2016. The National Laboratory Service has previously undertaken the analysis for seawater samples collected at the Erris Head outfall (SW1) and at SW3 and are able to analyse at the low levels of detection (minimum reportable value (MRV)) that are required for seawater samples from these areas.

3 RESULTS

3.1 2014 Survey Campaign

3.1.1 SW1 Treated Surface Water Outfall

3.1.1.1 Planned and actual sample collection

The respective positions of planned and actual sampling are presented in Table 3-1, which provides a summary of the survey navigation log. A total of 8 stations were surveyed using the drop-down camera system, 7 stations were sampled with the benthic grab sampler (station S1 was not sampled), and one station was sampled for seawater quality (Station W1 was not sampled). Table 3-1 summarises the planned and actual sampling undertaken in the vicinity of the SW1 Treated Surface Water Outfall location.

All stations were surveyed using the camera system without any problems. Grab sampling had minor problems at three locations. At station S2 and S17 the first and second grab deployment respectively only resulted in a sample in a single bucket of the Double Van-Veen grab and as a consequence a third deployment was required in order to obtain the necessary number of samples. At station S9 the grab was triggered in the water due to heavy seas soon after deployment and the grab was recovered immediately to the deck and redeployed.

Due to the increasing sea state and deteriorating weather forecast the decision was taken to not sample at Station S1 / W1.

The outfall stations were sampled first using the grab sampler as this equipment was ready to be deployed following completion of survey operations in the vicinity of the Corrib Field. All actual grab samples were taken within the range of 0.8–5.5 m (mean 2.8 m) of the target location for the respective sampling positions.

Seabed imagery transects were acquired successfully as close as possible to the target locations. Each transect was completed after an approximate distance of 50 m.

Water sampling at Station W12 was completed successfully, and the decision not to sample for seawater quality and seabed sediments at Station W1/S1 was taken for operational / safety reasons, not due to a failure to successfully obtain samples.

Considering the weather and sea conditions, the overall precision of the sampling was considered to be excellent and more than met the requirements of the survey.

Table 3-1: Planned and actual sediment and water samples taken

Station	Sediment				Water			Photography
	Macrofauna	PSA/TOC	Chem	Organics	Surface water	Near-seabed water	CTD profile	Seabed video/stills transect
S1 and W1	3	1+1	1	1+1	1	1	1	1
S2	3	1+1	1	1+1	-	-	-	1
S6	3	1+1	1	1+1	-	-	-	1
S6R	3	1+1	1	1+1	-	-	-	1

Station	Sediment				Water			Photography
	Macrofauna	PSA/TOC	Chem	Organics	Surface water	Near-seabed water	CTD profile	Seabed video/stills transect
S9	3	1+1	1	1+1	-	-	-	1
S10	3	1+1	1	1+1	-	-	-	1
S11	3	1+1	1	1+1	-	-	-	1
W12	-	-	-	-	1	1	1	-
S17	3	1+1	1	1+1	-	-	-	1
Planned	**24 (8x3)**	**8 + 8**	**8**	**8+8**	**2**	**2**	**2**	**8**
Actual	**21 (7x3)**	**7 + 7**	**7**	**7+7**	**1**	**1**	**1**	**8**
Not collected	**3**	**1+1**	**1**	**1+1**	**1**	**1**	**1**	**0**

3.1.1.2 Seabed Photography

Table 3-2 shows a summary of the observations made during the seabed photography at the eight sediment sampling stations in the vicinity of the SW1 Treated Surface Water Outfall. Additionally, the following descriptions and photographs describe qualitatively the observations made regarding sediments and obvious surface fauna in the vicinity of the SW1 Treated Surface Water Outfall.

Seabed Sediments

Generally the sediment type at the Erris Head outfall area conformed to rippled granular sand with varying quantities of shell fragments. Example images of this habitat type are given in Figure 3.1, which shows photos taken at Stations S2 and S10.

Figure 3.1: Seabed images at Stations S2 and S10, showing megarippled sand

Some evidence of bioturbation was observed at station S9, and the underwater photography at station S10 also indicated an elevated quantity of shell material, whilst exposures of bedrock were also present at stations S1 and S6R. Example images from the camera transect at station S6R are shown in Figure 3.2.

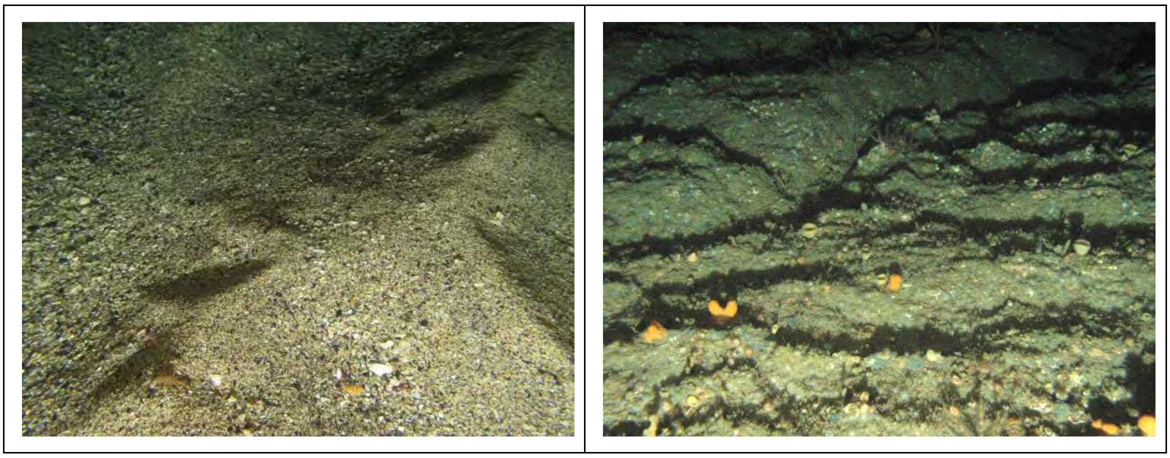

Figure 3.2: Seabed images at Station S6R, showing gravelly rippled sand and exposed bedrock

The camera transect over station S1 indicated numerous sediment types, consisting of: mega rippled gravel, which then merged into sandy gravel followed by gravelly sand and then a region of exposed bedrock. Examples of each of these sediment types are given in Figure 3.3.

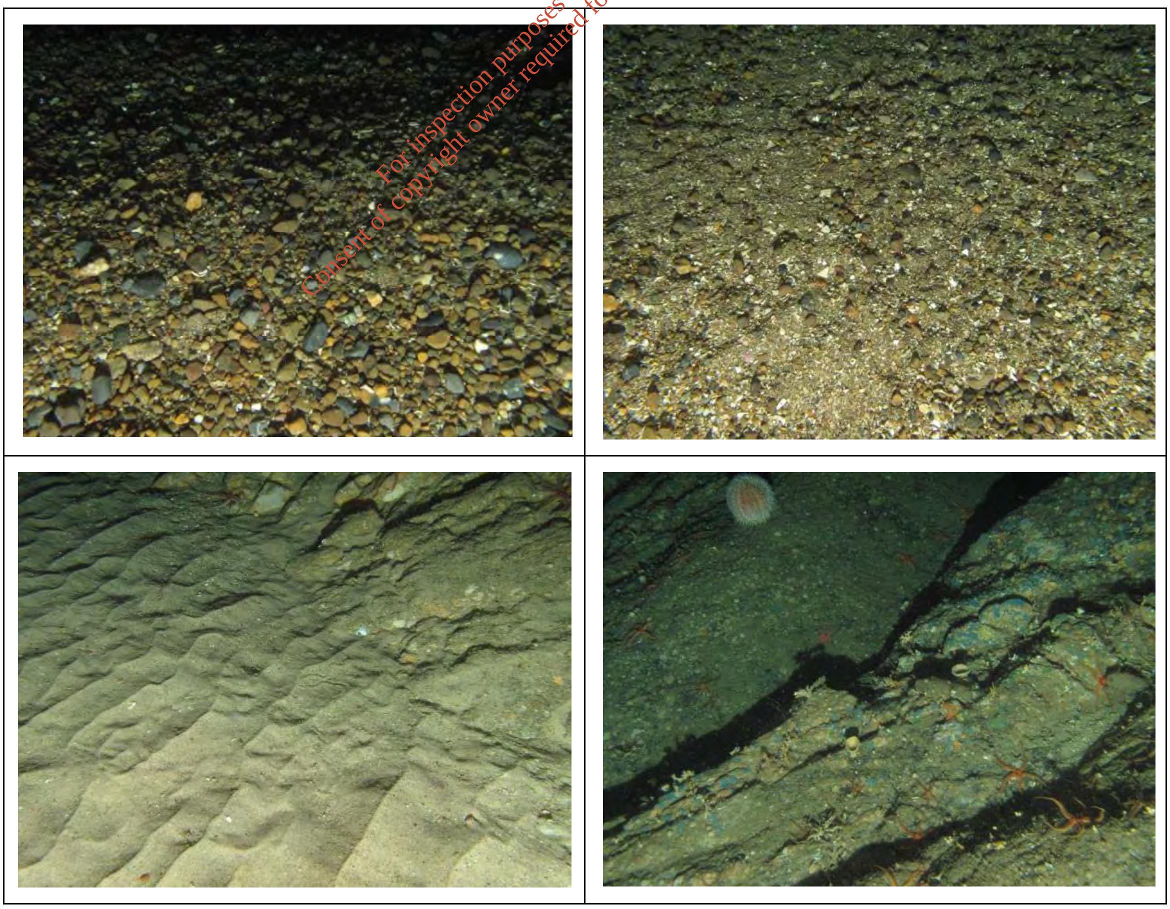

Figure 3.3: Seabed images at Station S1, showing the sediment changes encountered

Conspicuous Fauna

Conspicuous fauna in the area of the SW1 Treated Surface Water Outfall showed considerable variation, with the highest numbers of species observed in areas of bedrock exposure, with a number of species attached to the hard substrate. Comparatively fewer conspicuous fauna were present in the video footage and stills images where sediments reflected rippled granular sand with shell fragments, although polychaetes were noted in the sediment samples.

At stations S1 and S6R conspicuous fauna comprised ophiuroids (including possibly *Ophiothrix fragilis*), crinoids (possibly *Antedon* sp.), anemones (possibly *Parazoanthus* sp. and *Actinauge richardi*), gastropods (*Calliostoma zizyphinum)* and sea urchins (*Echinus esculentus)*. Other fauna included: Porifera sp. (including possibly *Axinella* sp. and *Polymastia* sp.), asteroids (starfish, possibly *Asterina gibbosa* and *Anseropoda placenta*), and various teleosts, including Gadiforme sp. In addition, a single sand-eel, likely *Hyperoplus immaculatus* (Corbin's sand-eel), was recorded in the sediment sample at S6R. A selection of example images of the fauna recorded are given in Figure 3.4.

Ophiuroidea: Possibly *Ophiothrix fragilis*

Crinoidea: Possibly *Antedon* sp.

Gastropoda: *Calliostoma zizyphinum*

Echinoidea: *Echinus esculentus*

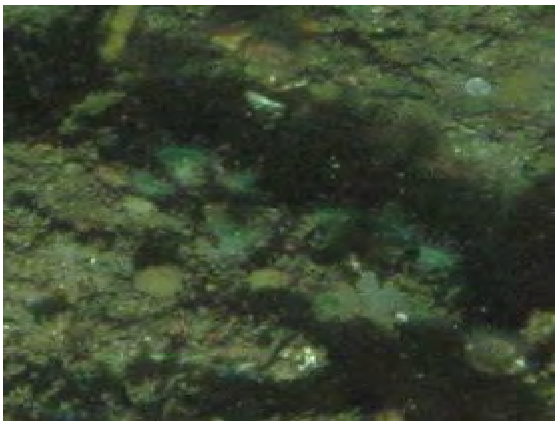 Anemone: Possibly *Parazoanthus* sp.	 Porifera: Possibly *Polymastia* sp.

Figure 3.4: Examples of conspicuous fauna at stations in the vicinity of the SW1 Treated Surface Water Outfall

The majority of the conspicuous fauna recorded reflects the presence of hard substrate in the form of bedrock exposure at stations S1 and S6R. The presence of sand-eels is in line with the coarse nature of the sediments encountered across the majority of the SW1 Treated Surface Water Outfall area, as *Ammodytidae* sp. favour substrates with high proportions of medium to coarse sand and minimal silt content (Holland *et al.* 2000).

Table 3-2: Summary of in-field observations during seabed photography at SW1

Station	Water Depth (m)	No. of Still Photos	Video Duration (mins)	Sediment Description	Conspicuous Fauna
S1 and W1	89	14	6	Gravelly. Megarippled, sandy gravel, gravelly sand and some exposed bedrock	Ophiuroids (possibly *Ophiothrix fragilis*), feather stars (possibly *Antedon* sp.), anemones (possibly *Parazoanthus* sp. and *Actinauge richardi*). Teleost sp., possibly *Reteporella grimaldii, Porifera* sp., possibly *Asterina gibbosa, Bryazoa* sp., possibly *Axinella* sp., *Asteroidea* sp. *Calliostoma zizyphinum*, possibly *Flustra foliacea, Echinus esculentus*, possibly *Anseropoda placenta*, and *Gadiforme* sp.
S2	54	10	5	Rippled granular sand with shell fragments	Polychaetes
S6	67	9	5	Rippled granular sand with shell fragments	Polychaetes
S6R	65	11	5	Rippled granular sand with shell fragments. Some exposed bedrock	*Hyperoplus immaculatus*, polychaeta sp., Gadiforme sp., anemones (possibly *Parazoanthus* sp.), ophiuroids, *Porifera* sp., *Asteroidea* sp., hydroids, possibly *Axinella* sp., *Callistioma zizyphinum*, possibly *Alycionium digitatum*, feather stars (possibly *Antedon* sp.), possibly *Flustra foliacea*, possibly *Asterina gibbosa, Polmastia* sp., possibly *Sagartia* sp., *Echinus esculentus*.
S9	57	11	6	Rippled granular sand with shell fragments and evidence of bioturbation	Polychaetes
S10	79	11	5	Rippled granular sand with shell fragments	Polychaetes, tubeworm casts also observed
S11	73	11	4	Rippled granular sand with shell fragments	Polychaetes
S17	45	11	5	Rippled granular sand with shell fragments	Teleost sp., polychaetes

3.1.1.3 Sediment Physico-chemistry

Particle Size Analysis (PSA) and Total Organic Carbon (TOC)

Summary results for particle size analysis (PSA) and total organic carbon (TOC) are presented in Table 3-3.

Table 3-3: Sediment Particle Size Analysis and Total Organic Carbon results for stations at the SW1 Treated Surface Water Outfall

Station	% Gravel (>2mm)	% Sand (63µm-2mm)	% Mud (<63µm)	Median particle size (mm)	Geometric Median particle size (µm)	Classification (Folk, 1954)	Classification Udden Wentworth	TOC %
S2	0.884	99.186	0	0.832	960.8	Sand	Coarse Sand	2.63
S6	0.90367	86.841	0	0.601	832.7	Sand	Coarse Sand	2.41
S6R	25.349	74.7015	0	1.12	2624.8	Gravelly sand	Gravel	1.78
S9	0.02598	100.0478	0	0.362	424.0	Sand	Medium Sand	1.49
S10	0.1771	98.2243	1.5548	0.194	233.8	Sand	Fine Sand	1.44
S11	0.7196	99.191	0	0.404	491.9	Sand	Medium Sand	1.46
S17	0.01488	100.0328	0	0.363	417.6	Sand	Medium Sand	5.6

The sediments at all stations (with the exception of Station S6R) are classified as sand according to the Folk Classification, as well as (with the exception of Station 6SR) being within the sand classification according to the Udden Wentworth Classification. Station S6R is classed as gravelly sand (Folk) and gravel (Udden Wentworth) and in terms of median particle size (1.12 mm) is notably higher than the other 7 stations sampled in the vicinity of the SW1 Treated Surface Water Outfall. Stations S2 and S6 are classed as coarse sand under the Udden Wentworth classification, while S9, S11, and S17 are all classed as medium sand. Station S10 is classed as fine sand according to the Udden Wentworth Classification.

With the exception of Stations S6R and S6 the sand fraction of the sediments was in excess of 98%. Station 6 and Station S6R having sand fractions of 86.8 and 74.7 % respectively.

In most samples, the gravel fraction was not important, although it comprised a significant component at station S6R (25.3 %), resulting in the sample being classified gravelly sand. Fine sediment fractions (<63 µm) were absent at all but one station, with a maximum of 1.6 % at S10.

TOC ranged from 1.44 – 5.6 %. There was no clear pattern in the distribution of TOC levels, with for example stations with relatively high levels (S17) adjacent to stations with lower levels (for example S9). There appeared to be no clear correlation between levels of TOC and grain size. The unclear pattern with regards TOC and grain size provides further confirmation of the heterogeneous nature of the seabed within a relatively small spatial extent that was observed in the underwater photography.

Together, the particle size and TOC data are consistent with a high-energy marine environment with no significant terrestrial (i.e. estuarine) inputs.

Metals

Results for concentrations of metals in the seabed sediments at the SW1 Treated Surface Water Outfall are presented in Table 3-4, which indicate that no single station completely dominated in terms of relatively high, or low, levels of metals. A degree of inter-station variability in levels of some metals was identified, however others varied within a relatively small range (e.g. mercury, lithium, and selenium).

Aluminium concentrations ranged from 7170 mg/kg to 18400 mg/kg, reflecting the similarity in sediment grain sizes across the survey sites. This is shown in the sediment granulometry in Table 3-3, though the underwater camera results did show a range in seabed physical conditions.

Aluminium is often used as a surrogate for grain size, with high concentrations indicating low grain sizes. Finer grained sediments have higher numbers of binding sites to which metal ions can attach; hence it is normal that finer grained sediments have higher concentrations of many metals than coarser sediments which have been exposed to the same metal inputs. Site S10, with an aluminium concentration of 15900 mg/kg (2nd highest recorded levels), also has highest concentrations of chromium, iron, lithium, and nickel, as well as the 2nd highest concentrations of mercury, lead, vanadium and zinc. S10 had the smallest mean particle size, and highest proportion of fines of all stations sampled, yet despite these factors conversely had the lowest levels of TOC of all stations sampled. This would normally be expected to indicate that the potential for binding sites for metals was lowest of the stations sampled (Table 3-3).

No highly elevated outliers, indicative of localised anthropogenic contamination, were recorded, and other than the trends discussed above no other obviously discernible patterns could be observed with regards metal concentrations across stations at the SW1 Treated Surface Water Outfall.

Comparison of the concentrations recorded against previous data from the SW1 Treated Surface Water Outfall area, and international standards can be found in section 4.1.1.3.

Table 3-4: Concentrations of metals in seabed sediments at sampling stations in the vicinity of the SW1 Treated Surface Water Outfall

Station	Al	Ag	As	Ba	Cd	Cr	Cu	Fe	Hg	Li	Mn	Ni	Pb	Se	V	Zn
	mg/kg															
S2	7170	<1	4.11	16.6	0.104	3.72	2.05	1840	0.00239	4.44	174	2.71	2.84	<0.1	6.36	6.28
S6	10700	<1	12.1	11.9	0.064	11.2	1.64	5200	0.00323	4.41	278	3.03	5.93	<0.1	17.8	7.64
S6R	10600	<1	5.49	12.7	0.076	13.7	14.2	3260	0.00294	5.05	103	2	9.63	<0.1	7.7	21.5
S9	14500	<1	4.2	9.15	0.055	8.84	1.92	3310	0.00259	4.43	95.7	1.89	7.06	<0.1	8.31	10.8
S10	15900	<1	4.07	5.23	0.062	38.7	2.22	6400	0.00368	5.1	117	4.75	7.53	<0.1	13.8	14.4
S11	12800	<1	5.39	9.46	0.063	19.8	5.98	3720	0.004	3.1	162	1.78	6.56	<0.1	11.1	11.3
S17	18400	<1	2.41	11.1	0.039	6.5	1.54	2650	0.00213	4.58	76.1	1.82	6.05	<0.1	6.49	8.65

Green: lowest result; Orange: highest result.

Metals in Sediment QA/QC

Table 3-5 presents the certified concentration data for the MESS-3 marine sediment CRM from the NRCC, together with the results of the analysis performed on the sample by the EA's National Laboratory Service.

Table 3-5: Concentrations of metals in the CRM sample

	Analysis of Marine Sediment CRM (MESS-3) (mg/kg)		
Determinand	**2014 EA NLS results**	**NRCC Reference value**	**Difference (%)**
Ag	<1	0.18	N/A
Al	74,440	85,900	-13.34
As	23.8	21.2	10.92
Cd	0.266	0.24	9.77
Cr	109	105	3.67
Cu	35.7	33.9	5.04
Fe	40,400	43,400	-6.91
Hg	0.0776	0.091	-14.73
Li	73.6	73.6	N/A
Mn	262	324	-19.14
Ni	37.7	46.9	-19.62

	Analysis of Marine Sediment CRM (MESS-3) (mg/kg)		
Determinand	**2014 EA NLS results**	**NRCC Reference value**	**Difference (%)**
Pb	23	21.1	8.26
Se	0.763	0.72	5.64
Vn	107	243	-55.97
Zn	171	159	7.02

The similarity between the certified and measured results shows overall confidence in the EA analysis of sediment samples in the vicinity of the SW1 Treated Surface Water Outfall. The single analysis that does stand out, however, is that for vanadium.

The degree of error observed in the results for vanadium are because the EA laboratory prepares its sediment samples for analysis using an aqua regia digestion, rather than a hydrofluoric acid digestion. Aqua regia is a significantly less vigorous digestion technique that achieves lower recoveries than hydrofluoric acid digestion, upon which the reference values for the CRM are based. The EA have stated that the reason they use aqua-regia is that it releases only the vanadium which is biologically available, rather than all of the metal in the sediment. Hence the results from the field samples reflect the biologically available vanadium.

Hydrocarbons

Table 3-6 presents the concentrations of hydrocarbons in sediments at the sampling stations in the vicinity of the SW1 Treated Surface Water Outfall. Total hydrocarbons range between 1.2 and 0.336 mg/kg. These are considered low. A comparison of the observed concentrations in the sediments in 2014 and the results from previous surveys at the SW1 Treated Surface Water Outfall, as well as international standards can be found in Section 4.1.1.3.

In almost all cases the PAHs were at concentrations below the levels of detection for their respective analyses. The only exception to this was for Naphthalene, which was recorded at a concentration above the limits of detection at Station S9. Naphthalene was recorded at a concentration of 15.1 µg/kg at S9.

Table 3-6: Concentrations of hydrocarbons in seabed sediments at sampling stations in the vicinity of the SW1 Treated Surface Water Outfall

Analyte	Unit	MRV	S2	S6	S6R	S9	S10	S11	S17
Hydrocarbons : Total : Dry Wt as Ekofisk	mg/kg	0.3	0.411	0.697	0.766	0.57	1.2	0.814	0.336
Acenaphthene : Dry Wt	µg/kg	1	<1	<1	<1	<1	<1	<1	<1
Acenaphthylene : Dry Wt		1	<1	<1	<1	<1	<1	<1	<1
Anthracene : Dry Wt		1	<1	<1	<1	<1	<1	<1	<1
Benzo(a)anthracene : Dry Wt		1	<1	<1	<1	<1	<1	<1	<1
Benzo(a)pyrene : Dry Wt		1	<1	<1	<1	<1	<1	<1	<1
Benzo(b)fluoranthene : Dry Wt		1	<1	<1	<1	<1	<1	<1	<1
Benzo(e) pyrene : Dry Wt		5	<5	<5	<5	<5	<5	<5	<5
Benzo(ghi)perylene : Dry Wt		1	<1	<1	<1	<1	<1	<1	<1
Benzo(j)fluoranthene : Dry Wt		10	<10	<10	<10	<10	<10	<10	<10
Benzo(k)fluoranthene : Dry Wt		1	<1	<1	<1	<1	<1	<1	<1
Chrysene + Triphenylene : Dry Wt		3	<3	<3	<3	<3	<3	<3	<3
Chrysene : Dry Wt		3	<3	<3	<3	<3	<3	<3	<3
Dibenzo(ah)anthracene : Dry Wt		1	<1	<1	<1	<1	<1	<1	<1
Dibenzothiophene : Dry Wt		5	<5	<5	<5	<5	<5	<5	<5
Fluoranthene : Dry Wt		1	<1	<1	<1	<1	<1	<1	<1
Fluorene : Dry Wt		5	<5	<5	<5	<5	<5	<5	<5
Indeno(1,2,3-c,d)pyrene : Dry Wt		1	<1	<1	<1	<1	<1	<1	<1
Naphthalene : Dry Wt		5	<5	<5	<5	15.1	<5	<5	<5
Perylene : Dry Wt		5	<5	<5	<5	<5	<5	<5	<5
Phenanthrene : Dry Wt		5	<5	<5	<5	<5	<5	<5	<5
Pyrene : Dry Wt		1	<1	<1	<1	<1	<1	<1	<1

Green: lowest result; Orange: highest result. CRM not included.

3.1.1.4 Sediment Macrofauna

This section of the report contains summary information for the various analyses of benthic macrofaunal samples. Full details (including raw data) are available in Appendix 1.

Taxonomic Composition

Species numbers and abundances for macrofauna are shown on a per site basis (Table 3-7). Percentage of each phylum that contributed to community composition at each site is also shown. Species that are encrusting and/or colonial are included in the number of species per site but were excluded from overall abundance counts.

Species numbers were moderate to high ranging from an average of 165 per site at site S2 to 297 at site S6R and abundances were moderate ranging from 663 individuals per site at S17 to 5013 per site at S6R. Both number of species and abundance showed relatively little variation throughout the study area and at no site was there an obvious paucity of fauna or a particularly enriched community.

Ranked taxa illustrating the 10 most abundant species at each site are shown in Appendix 2. No single phyla dominated throughout the study area but polychaetes were important in varying proportions and contributed to over 20 % of all animals recorded at each site. Crustaceans were the least common organism, not dominant at any site and made up a maximum of 12 % of the faunal community. Molluscs, Echinoderms and 'Other' phyla, particularly nematodes and nemerteans were represented at each site but their importance in community composition varied. Molluscs and echinoderms tended to be more common at sites S9, S10 and S17 whilst 'Other' phyla were most dominant at sites S2, S6 and S6R.

Nematodes numerically dominated the dataset and were found to be the most commonly recorded animal in the study area. At all but one site (S10) they were in the top 10 animals which contributed most to faunal assemblage and out of these they were the most abundant species at four of the sites- S2, S6, S6R and S9.

The study area can be broadly split into two contrasting community types. Assemblages at sites S2, S6, S6R were dominated by interstitial fauna such as nematodes, nemerteans and the polychaetes *Pisione remota, Hesionura elongata* and *Polygordius*, species of syllid polychaete, the polychaetes *Glycera lapidum* and *Protodorvillea kefersteini* and venerid and *Spisula* bivalves both of which were frequently recorded but not abundant. These species are typical of coarse sands and gravels. This was in contrast to communities identified at sites S9, S10 and S17 where species characteristic of finer sediments such as the pea urchin, *Echinocyamus pusillus*, sea potato, *Echinocardium flavescens*, the tellinid bivalve *Abra pristmatica*, the spionid polcyhaete *Spiophanes bombyx* and the sand- tube dwelling polychaete *Owenia borealis* were found to be important to community composition.

Site S11 mainly comprised of species common to those identified at site S2, S6 and S6R but also contained species such as *Echinocyamus pusillus* and *Abra prismatica* which are more typical of finer sediments.

Diversity Indices

Summary results for a range of univariate parameters, and percentage contribution of each phyla per station (replicates pooled), are presented in Table 3-7. Note that these data do not include encrusting species, with the exception of number of species per site (S).

Table 3-7: Summary per-station sediment macrofauna results: univariate indices and taxonomic composition by sampling station in the SW1 study area

Station	Number of species (including encrusting species)	Abundance	Species Richness (Margalef's)	Evenness (Pielou's)	Diversity (Shannon-Wiener)	Dominance (Simpson's)	% abundance				
	S (per site)	N (m^{-2})	d	J'	H'	λ	Poly.	Crust.	Molluscs	Echino.	Other
S2	165	4860	8.57	0.47	1.87	0.32	41.02	0.14	1.65	1.17	56.04
S6	174	2323.3	9.73	0.67	2.67	0.13	60.83	0.29	2.58	2.01	34.29
S6R	297	5013.3	13.51	0.60	2.64	0.17	52.53	1.66	1.86	4.85	39.1
S9	249	1606.7	13.98	0.77	3.30	0.06	22.2	11.62	22.82	24.48	18.88
S10	288	2813.3	16.31	0.82	3.70	0.04	37.91	4.15	30.69	13.86	13.39
S11	285	1666.7	17.79	0.83	3.74	0.03	53.8	9	13.6	12	11.6
S17	180	663.3	10.97	0.83	3.18	0.06	27.64	12.06	20.10	30.15	10.05

Green: lowest result; Orange: highest result. Poly = Polychaetes Crust=crustaceans; echino=echinoderms

S = Number of species (including encrusting species) (per site); N = Number of individuals (average per site); d = Species Richness (Margalef's); J' = Pielou's Evenness; H'= Shannon-Weiner Diversity ($\log_e$), λ'=Simpson Dominance

Overall the study area was one of moderate to high faunal diversity (H') and ranged from 1.87 at site S2 to 3.74 at site S11. Evenness (J') tended to be high throughout the study area with only site S2 recording an evenness of less than 0.5. Sites S2, S6 and S6R had lower diversity and evenness and high dominance (λ) of one or a few species than sites S9, S10, S11 and S17, potentially indicating a less mature community at sites S2, S6 and S6R.

Community Clustering

The results of per replicate group average clustering analysis using Bray Curtis similarity are shown per replicate (within site variability) (Appendix 3) and per site (Figure 3.5).

Firstly, the data underwent multivariate analysis (after square root transformation) on a per replicate basis. Within site variability was found to be relatively low. Replicates at each site had communities with a 50 % or higher similarity and only 2 of the sites had replicates that were significantly different to each other. However, even at these sites all replicates clustered together.

Community heterogeneity within the study area was evident, the main split between the sites with species associated with coarse sediment and those sites with assemblages characteristic of finer sediments occurred at a similarity level of approximately 20 %, as shown in Figure 3.5.

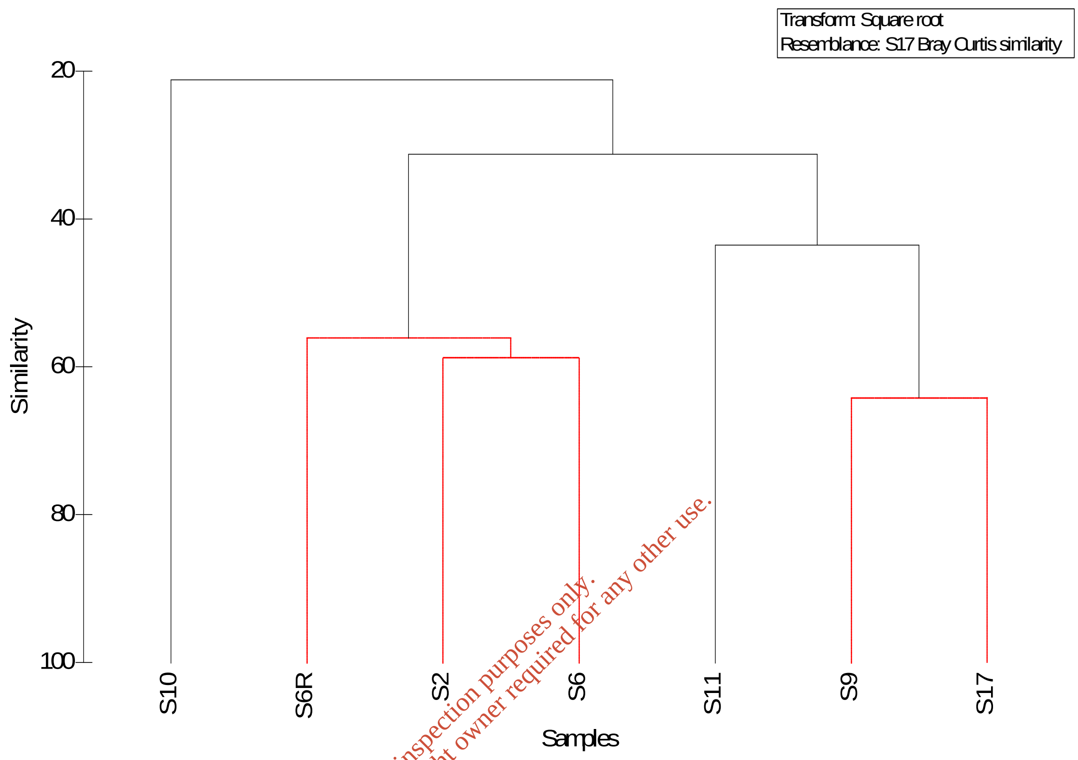

Figure 3.5: Dendrogram showing clustering of communities using average replicate (per site) data from the SW1 Treated Surface Water Outfall study area. Black lines indicate a significant difference between clusters (generated by a SIMPROF test).

Replicates were averaged to produce a per site dataset. The resulting dendrogram showed very similar patterns to that generated by the per replicate data. A SIMPROF test was performed to identify significant differences between clusters. Four significantly different clusters were found and are shown in Figure 3.5. Cluster 1 contained site S11; cluster 2 sites S2, S6 & S6R; cluster 3 site S10 and cluster 4 sites S9 & S17. This is further supported by the MDS plot (Figure 3.6).

The results of multi-dimensional scaling using the similarity matrices derived from cluster analysis are plotted two dimensionally for each site (averaged replicate) as shown in Figure 3.6.

Sites S2, S6 and S6R are positioned at the right hand side of the MDS plots whilst S9 and S17 are towards the upper left hand side of the plot. S11 lies in-between these two clusters and the community at site S10 appeared to be different from those at all other sites sampled and lay away in the bottom left corner of the MDS plots. This clustering can be clearly observed in both the dendrogram (Figure 3.5) and in the MDS plot (Figure 3.6).

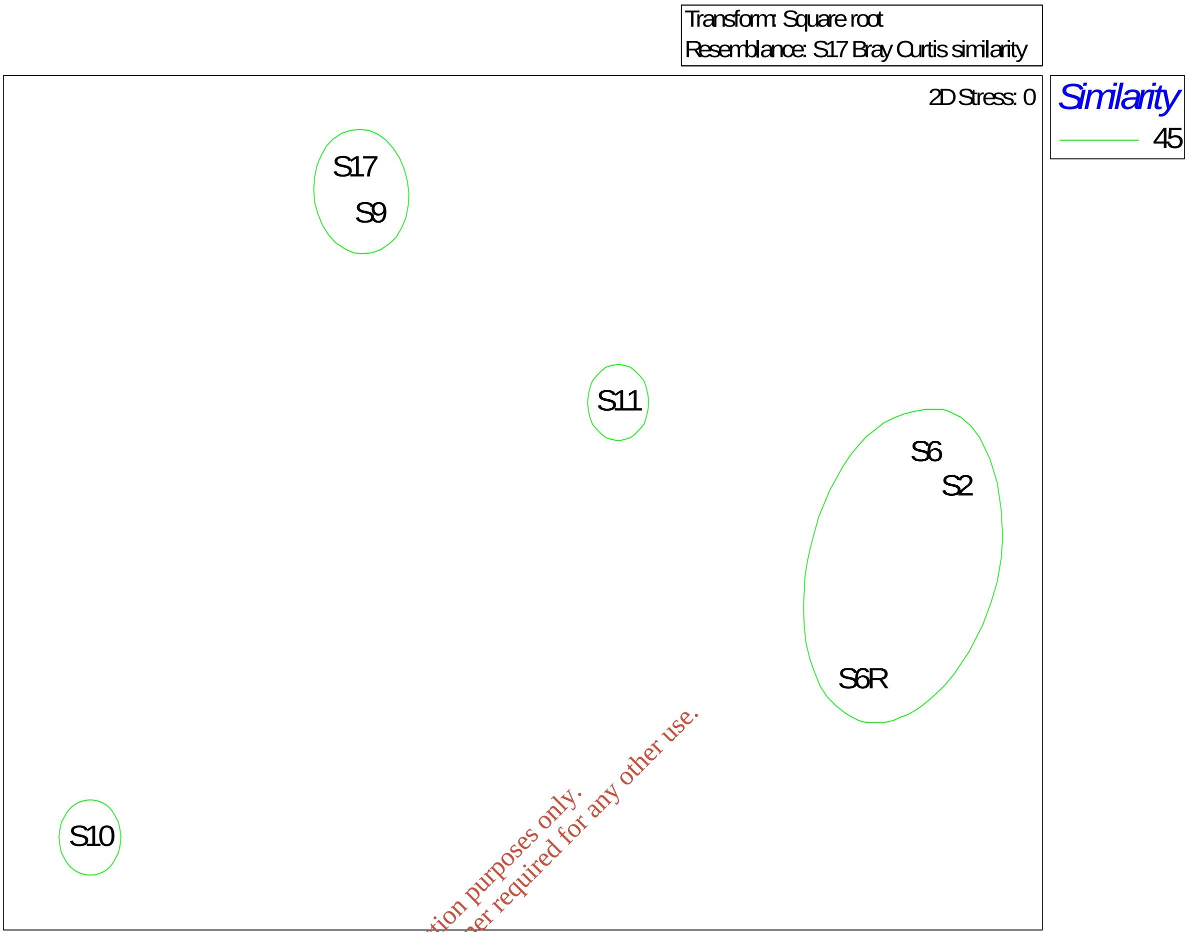

Figure 3.6: MDS plot of the SW1 Treated Surface Water Outfall sites (averaged replicate data / site) in 2014 with superimposed contours at a similarity level of 45 % to highlight defined clusters.

The stress value was very low (0), indicating that the two-dimensional MDS diagram was an extremely good representation of how sites are related to each other and that there are very few factors involved in explaining the variance observed between these samples.

A SIMPER was performed upon these clusters to determine which species are typical of the assemblages recorded there and which species contributed to the differences observed between the clusters. The results of this analysis are shown in Table 3-8.

Table 3-8: SIMPER output of those species that contribute to the similarity between clusters of Corrib Treated Surface Water Outfall sites using Bray-Curtis similarity on standardised square root transformed data. The columns shown give the average abundance, the average contribution to the similarity, the percentage contribution to overall similarity and the cumulative contribution to similarity.

Cluster 1 (site 11)	**Average similarity: 54.30**			
Species	**Av. Abund**	**Av. Sim**	**% Contrib**	**Cum %**
Glycera lapidum	3.46	4.08	7.51	7.51
Aonides pauchibrnahciata	3.73	3.89	7.15	14.67
Nematoda	3.39	2.84	5.22	19.89
Pisione remota	2.55	2.75	5.06	24.95
Abra prismatica	2.54	2.74	5.05	30.00
Enchytraeidae	2.35	2.54	4.67	34.67
Echinocardium flavescens	2.60	2.38	4.38	39.05
Echinocyamus pusillus	2.57	2.34	4.31	43.36
Cluster 2 (sites S2, S6 & S6R)	**Average similarity: 54.63**			
Species	**Av. Abund**	**Av. Sim**	**% Contrib**	**Cum %**
Nematoda	12.66	12.00	21.97	21.97
Polygordius sp.	5.82	5.85	10.70	32.67
Pisione remota	5.63	5.54	10.14	42.81
Cluster 3 (site 10)	**Average similarity: 66.35**			
Species	**Av. Abund**	**Av. Sim**	**% Contrib**	**Cum %**
Echinocyamus pusillus	4.47	3.83	5.78	5.78
Peresiella clymenoides	3.80	3.03	4.56	10.34
Abra prismatica	4.77	2.97	4.47	14.81
Spiophanes bombyx	4.06	2.96	4.46	19.28
Phoronis sp.	3.58	2.90	4.37	23.64
Chamelea striatula	3.40	2.80	4.22	27.87
Magelona filiformis	3.97	2.74	4.13	32.00
Edwardsiidae	3.71	2.56	3.86	35.86
Dosinia lupinus	3.30	2.45	3.70	39.55
Glycinde nordmanni	2.38	2.06	3.10	42.65
Cluster 4 (sites 9 & 17)	**Average similarity: 52.29**			
Species	**Av. Abund**	**Av. Sim**	**% Contrib**	**Cum %**
Echinocardium flavascens	3.39	4.62	8.84	8.84
Abra prismatica	3.13	4.26	8.14	16.98
Echinocyamus pusillus	2.88	3.91	7.47	24.45
Nemertea sp.	1.84	2.99	5.71	30.16
Enchytraeidae sp.	1.70	2.88	5.51	35.67
Owenia borealis	1.81	2.84	5.43	41.10

Av. = Average; Abund.= Abundance; Sim.= Similarity; Contrib = Contribution; Cum = Cumulative

Average similarities within each defined cluster were greater than 50 % which showed that there was little variance between the faunal assemblages within each of these clusters.

The assemblages that comprised Cluster 2 (sites S2, S6 and S6R) were indicative of sublittoral coarse sand and gravel environments. These communities had a lower diversity than other sites sampled due to the dominance of high numbers of nematodes which consequently decreased the evenness at these sites. The interstitial polychaetes *Polygordius* sp. and *Pisione remota* contributed highly to the similarities observed between communities and conversely their relative abundances explained their dissimilarity to all other clusters.

Molluscs and echinoderms were more important in the communities of Cluster 4 (sites S9 and S17). The sea potato *Echinocardium flavascens*, the pea urchin *Echinocyamus pusillus* and the tellind bivalve *Abra prismatica* were characteristic of the community composition here. Also important were nemerteans, the *Enchytraeid* oligochaetes and the sand-tube dwelling polychaete *Owenia borealis*. Again, the presence and relative abundance of these animals contributed to the differences between this and the other clusters.

Cluster 1, (site S11) contained elements of both these communities. Polychaetes typical of coarse sediment such as *Glycera lapidum, Pisione remota* and *Aonides pauchibranchiata* were present but more delicate fauna from finer, less mobile sediments like those at sites from Cluster 4 such as *Abra prismatica, Echinocyamus pusillus* and *Echinocardium flavascens* were also recorded here.

Cluster 3, site S10 also contained some species similar to those samples at site S9 and S17 but polychaetes, particularly the spionids *Spiophanes bombyx* and *Magelona filiformis* were more important contributors to community composition.

Environmental Factors

BIO-ENV analysis was performed for all sites. This looked at the best correlation between the biological and environmental data and endeavoured to show which set of physical and chemical variables best explained the variations observed in the biological communities. Various heavy metal and hydrocarbon concentrations, particle size and total organic carbon (TOC) were included in the analysis.

The BIO-ENV analysis showed that there was a very strong correlation between some of the variables and the observed variance between communities. The combination of variables which best explained this variance were sediment grain size fractions (within the general classification of sand), which have been broadly subdivided as follows: 177-250 µm (fine sand), 250-354 µm (medium sand), 500-707 µm (coarse sand); and concentration of aluminium. MDS overlays of these variables were plotted for the different grain size fractions and concentrations of aluminium and are presented in Appendix 4.

The figures illustrated that sites S2, S6 and S6R contained coarser sediment than at all other sites. They were characterised by low proportions of fine and medium sand grains and high amounts of coarse sand particles. Site S10 had the finest sediments, had the highest proportions of fine sand and contained very little coarse sand.

Aluminium showed little variation between sites but was found to be the lowest at sites S2, S6 and S6R.

Biotope Descriptions

Table 3-9 provides a summary of the biotopes encountered in the SW1 study area. Descriptions and biotope designations are type based on those in *The Marine Habitat Classification for Britain and Ireland* Version 04.05 (Connor *et al*., 2004).

Whilst sites may not absolutely conform to the designated biotopes, they agree with the majority of elements within each of them. This is a well-known problem with macrofaunal communities in Ireland (Scally *pers. comm*.). However, site S10 obviously had components of two biotopes which are known to be closely related and depends upon the amount of mud fraction to which the community inhabits.

Table 3-9: Biotope designation and description for each sampling station at the SW1 Treated Surface Water Outfall location

Site	Biotope Code	Code definition	Typical features
S2	**SS.SCS.CCS.Blan**	*Branchistoma lanceolatum* in circalittoral coarse sand with shell gravel	Relatively low number of species. *Glycera lapidum* and interstitial polychaetes *Pisione remota, Hesionura elongata, Polygordius.*
S6	**SS.SCS.CCS.Blan**	*Branchistoma lanceolatum* in circalittoral coarse sand with shell gravel	Relatively low number of species. *Glycera lapidum* and interstitial polychaetes *Pisione remota, Hesionura elongata, Polygordius.*
S6R	**SS.SMx.OMx.PoVen**	Polychaete-rich deep *Venus* community in offshore mixed sediments	Diverse biotope typified by importance of polychaetes *Aonides paucibranchiata* and *Mediomastus fragilis* and a significant venerid component (*Timoclea ovata*, *Clausinella fasciata*)
S9	**SS.SSa.CFiSa.EpusOborApri**	*Echinocyamus pusillus, Ophelia borealis* and *Abra prismatica* in circalittoral fine sand	Pea urchin *Echinocyamus pusillus*, tellind bivalve *Abra prismatica, Owenia* polychaetes.
S10	**SS.SSa.CFiSa.AprBatPo grading towards SS.SMu.CSaMu.AfilNten as mud fraction increases.**	*Abra prismatica, Bathyporeia elegans* and polychaetes in circalittoral fine sand and *Amphiura filiformis* and *Nuculoma tenuis* in circalittoral and offshore sandy mud	High abundance of *Abra prismatica* and spionid polychaetes (*Spiophanes bombyx, Magelona filiformis*) but without *Bathyporeia elegans* typical of the SS.SSa.CFiSa.AprBatPo biotope and contains large numbers of *Echinocardium flavescens* as found in the SS.SMu.CSaMu.AfilNten.
S11	**SS.SCS.ICS.MoeVen**	*Moerella spp* with venerid bivalves in infralittoral gravelly sand	Polychaetes *Pisione remota, Glycera lapidum* and *Aonides pauchibranchiata*. Robust bivalves- *Moerella pygmaea*
S17	**SS.SSa.CFiSa.EpusOborApri**	*Echinocyamus pusillus, Ophelia borealis* and *Abra prismatica* in circalittoral fine sand	Pea urchin *Echinocyamus pusillus*, tellind bivalve *Abra prismatica, Owenia* polychaetes.

Species of Particular Interest

No protected species were recorded in the study area.

The barnacle *Megatrema anglicum* was present at site S6R and its presence is associated with corals particularly the cup coral *Carophyllia smithii*. Although only one live specimen was found, empty shells were found in many of the coarser samples. This species is a warm water species and has only previously been record from the south west of Ireland and the British Isles so this record is of particular interest.

3.1.1.5 Seawater Quality

Temperature

A temperature-depth profile for station W12 is presented in Figure 3.7. This station is close to the outfall diffuser and water quality measurements and samples taken at this location are considered representative of the vicinity of the SW1 location.

Water temperature remained relatively consistent between the surface waters and throughout the majority of the water column. Temperature starts to decrease gradually beyond 50 m before decreasing more significantly at about 60 m. Lowest temperatures were observed close to the seabed at around 70 m, while highest temperatures were in surface waters. The overall range in temperatures observed was between 15.13 °C in surface waters and 14.85 °C at the seabed (a difference of 0.28 °C).

This would tend to indicate a gradually decreasing temperature with increased depth, although the water column is relatively homogenous and well mixed between the surface and around 50 m. It is at around this depth that a distinct stratification (thermocline) is observed. This trend is supported by the depth profiles obtained at the Corrib Field (SW3), which show a similar pattern.

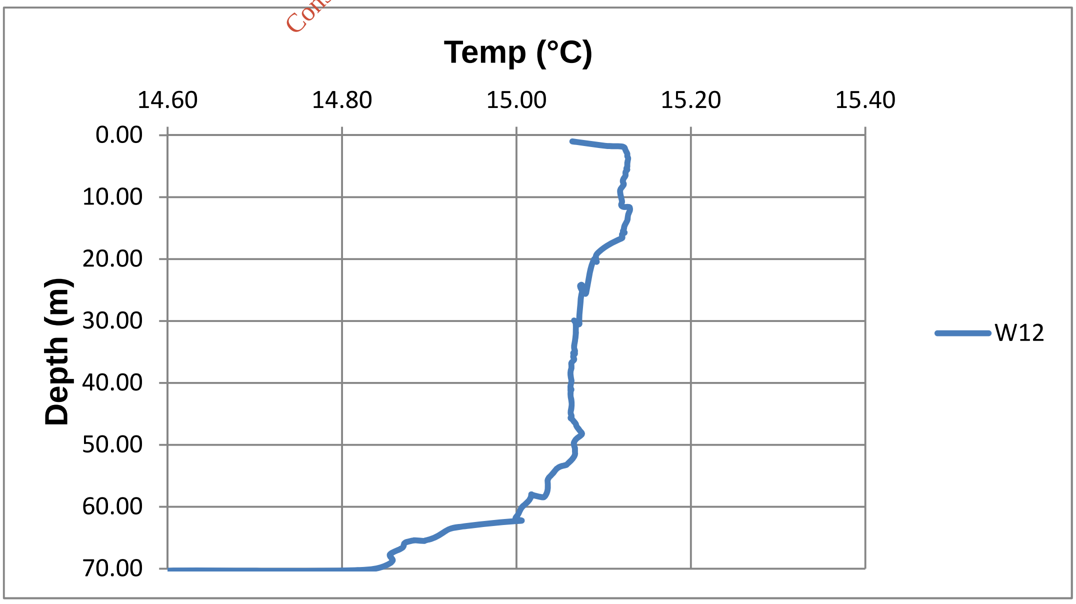

Figure 3.7: Temperature depth profiles for station W12 sampled in the vicinity of the SW1 Treated Surface Water Outfall.

Salinity

A salinity-depth profile for station W12 is presented in Figure 3.8.

The data shows a gradual increase in salinity with depth. It should be noted though that the total range in salinity is between 35.03 PSU in surface waters and 35.1 PSU close to the seabed (difference of 0.07 PSU). From the profile that was obtained it is difficult to determine any obvious stratification; however comparison with data obtained at the Corrib Field would tend to indicate that between water depths of around 50-70 m there is a noticeable fluctuation in salinity corresponding with the thermal stratification also observed.

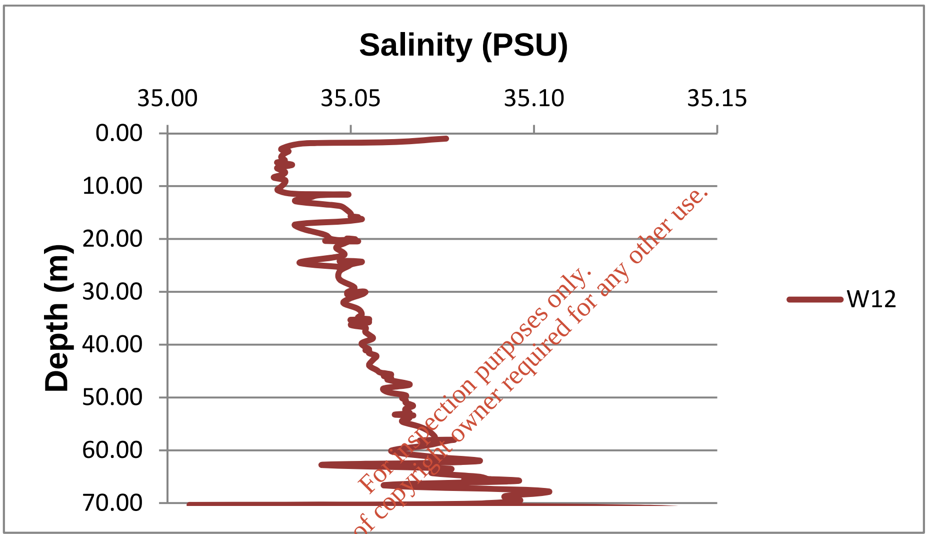

Figure 3.8: Salinity - depth profiles for station W12 sampled in the vicinity of the SW1 Treated Surface Water Outfall location.

Water Samples

Results for suspended particulate matter (SPM) and ammoniacal nitrogen are presented in Table 3-10.

Table 3-10: Suspended particulate matter (SPM) and ammoniacal nitrogen in seawater samples collected in the vicinity of the Corrib Treated Surface Water Outfall SW1 (Station W12)

Station	Depth	Suspended particulate matter (SPM)	Ammoniacal nitrogen as N
		mg/l	
Station W12	Surface	<3.0	<0.01
	Bottom	<3.0	<0.01

Suspended particulate matter (SPM)

As Table 3-10 shows SPM levels were below that of the MRV, i.e. <3.00 mg/l, both near the surface and near the seabed. Overall these levels are considered to be low.

Ammoniacal nitrogen

Levels of ammoniacal nitrogen had results below that of the detection limit (MRV), i.e. <0.01 mg/l in both the near surface and near seabed water depths. These results are all below the EU Water Framework Directive Environmental Quality Standard (EQS) for ammoniacal nitrogen of 0.021 mg/l, as shown in Table 3-10.

Metals

Results for metals in sampled seawater at the SW1 Treated Surface Water Outfall are presented in Table 3-11. Concentrations of cadmium, nickel, mercury, chromium, and silver were all below their respective MRV's in both near surface and near seabed samples.

Levels of arsenic were consistent between near surface and near seabed waters and were recorded in the range 1.10 – 1.04 µg/l.

Copper was recorded at levels above the MRV in both near surface and near seabed water samples (range 1.12 – 1.88 µg/l).

Lead concentrations ranged from 0.153 µg/l at the surface and 1.47 µg/l close to the seabed.

Zinc concentrations were recorded in the range of 7.91 µg/l at the surface to 18.4 µg/l close to the seabed.

Table 3-11: Metals in seawater sampled in the vicinity of the SW1 Treated Surface Water Outfall (Station W12)

Station		**As**	**Cd**	**Cu**	**Pb**	**Ni**	**Zn**	**Hg**	**Cr**	**Ag**
		µg/l								
Station W12	Surface	1.10	<0.03	1.12	0.153	<0.3	7.91	<0.01	<0.5	<1
	Bottom	1.04	<0.03	1.88	1.47	<0.3	18.4	<0.01	<0.5	<1

Metals in water QA/QC

Results from the EA - NLS analytical laboratory as compared to the pre-determined levels in the SLEW-3 CRM are presented in Table 3-12. All differences between certified and the laboratory results are small, with a maximum difference of 16.70 % (cadmium). The majority of analytes were recorded at levels below the limits of detection, which also corresponded to levels that would be in a similar range to the certified concentrations within the reference sample.

Table 3-12: Comparison of analytical results for metals in seawater from EA NLS laboratory against Certified Reference Material (CRM) values

Metal	**EA - NLS result** (µg/l)	**CRM value** (µg/l)	**% difference**
Ag	<1.00	0.003	N/A
As	No result	1.36	N/A

Cd	0.04	0.048	-16.70
Cr	<0.50	0.183	N/A
Cu	1.45	1.55	-6.45
Ni	1.20	1.23	-2.44
Pb	<0.04	0.009	N/A
Zn	<0.4	0.201	N/A

Organics

Of the 43 compounds analysed in the seawater samples at station W12, only one was recorded at levels above its respective MRV (see Table 3-13). Phenol was recorded at a low level of concentration above its MRV in both near surface and near seabed water samples.

For a number of compounds analysed in near seabed waters a higher than normal MRV was specified due to an unspecified issue during the laboratory analysis. All these analytes were still recorded at levels below the revised limits of detection and there is no reason to suggest that the higher MRV meant that the concentration in the sample is any higher than the surface waters sample with lower MRV.

Table 3-13: Organic compounds in seawater at the SW1 Treated Surface Water Outfall

Compound (µg/l)	**MRV (µg/l)**	**Station**	
		W12 - Surface	**W12 - Seabed**
Acenaphthene	0.01	<0.01	<0.01
Acenaphthylene	0.01	<0.01	<0.01
Anthracene	0.01	<0.01	<0.01
B(a)anthracene	0.01	<0.01	<0.01
B(a)pyrene	0.01	<0.01	<0.01
B(b)fluoranthene	0.01	<0.01	<0.01
Benzo(e)pyrene	0.01	<0.01	<0.01
B(ghi)perylene	0.01	<0.01	<0.01
B(k)fluoranthene	0.01	<0.01	<0.01
Chrysene	0.01	<0.01	<0.01
DiB(ah)anthracene	0.01	<0.01	<0.01
Fluoranthene	0.01	<0.01	<0.01
Fluorene	0.01	<0.01	<0.01
Indeno123cdPyrene	0.01	<0.01	<0.01
Naphthalene	0.01	<0.01	<0.01
Perylene	0.01	<0.01	<0.01
Phenanthrene	0.01	<0.01	<0.01
Pyrene	0.01	<0.01	<0.01
2,3,5,6-Tetrachlorophenol	0.02	<0.02	<0.2 (Elevated MRV – Possible matrix interference)
2,3-Dichlorophenol	0.02	<0.02	<0.2 (Elevated MRV – Possible matrix interference)
2,3-Dimethylphenol {2,3-Xylenol}	0.02	<0.02	<0.2 (Elevated MRV – Possible matrix interference)
2,4,5-Trichlorophenol	0.02	<0.02	<0.2 (Elevated MRV – Possible matrix interference)
2,4,6-Trichlorophenol	0.02	<0.02	<0.2 (Elevated MRV – Possible matrix interference)

Compound (µg/l)	MRV (µg/l)	Station	
		W12 - Surface	W12 - Seabed
2,4-Dichlorophenol	0.02	<0.02	<0.2 (Elevated MRV – Possible matrix interference)
2,4-Dimethylphenol {2,4-Xylenol}	0.02	<0.02	<0.2 (Elevated MRV – Possible matrix interference)
2,5-Dichlorophenol	0.02	<0.02	<0.2 (Elevated MRV – Possible matrix interference)
2,5-Dimethylphenol {2,5-Xylenol}	0.02	<0.02	<0.2 (Elevated MRV – Possible matrix interference)
2,6-Dichlorophenol	0.02	<0.02	<0.2 (Elevated MRV – Possible matrix interference)
2,6-Dimethylphenol {2,6-Xylenol}	0.02	<0.02	<0.2 (Elevated MRV – Possible matrix interference)
2-Chlorophenol	0.02	<0.02	<0.2 (Elevated MRV – Possible matrix interference)
2-Ethylphenol	0.02	<0.02	<0.2 (Elevated MRV – Possible matrix interference)
2-Methylphenol {o-Cresol}	0.02	<0.02	<0.2 (Elevated MRV – Possible matrix interference)
3,4-Dimethylphenol {3,4-Xylenol}	0.02	<0.02	<0.2 (Elevated MRV – Possible matrix interference)
3,5-Dimethylphenol {3,5-Xylenol}	0.02	<0.02	<0.2 (Elevated MRV – Possible matrix interference)
3-Chlorophenol	0.02	<0.02	<0.2 (Elevated MRV – Possible matrix interference)
3-Methylphenol {m-Cresol}	0.02	<0.02	<0.2 (Elevated MRV – Possible matrix interference)
4-Chloro-2-methylphenol {p-Chloro-o-cresol}	0.02	<0.02	<0.2 (Elevated MRV – Possible matrix interference)
4-Chloro-3, 5 –dimethylphenol {PCMX}	0.02	<0.02	<0.2 (Elevated MRV – Possible matrix interference)
4-Chloro-3-methylphenol {p-Chloro-m-cresol}	0.02	<0.02	<0.2 (Elevated MRV – Possible matrix interference)
4-Chlorophenol	0.02	<0.02	<0.2 (Elevated MRV – Possible matrix interference)
4-Methylphenol {p-cresol}	0.02	<0.02	<0.2 (Elevated MRV – Possible matrix interference)
Pentachlorophenol	0.02	<0.02	<0.2 (Elevated MRV – Possible matrix interference)
Phenol	0.05	0.112	1.30

3.1.2 SW3 Location at the Corrib Field

3.1.2.1 Planned and actual sample collection

The respective positions of planned sampling are presented in Figure 2.1 and Table 2-2 which provides a summary of the survey navigation log. A total of 16 stations were surveyed using the drop-down camera system, 14 of these stations were sampled with the benthic grab sampler (stations F4 and 5 were not sampled), and one station was sampled for seawater quality (the station directly above the central manifold was not sampled). Table 3-1 summarises the planned and actual sampling undertaken in the vicinity of the Corrib Field (SW3).

All stations were surveyed using the camera system without any problems. Grab sampling had minor problems at four locations. At stations Z5, 6, and 10 the initial grab deployments failed to sample as the grab did not trigger the closing mechanism at the seabed. Samples were obtained successfully in subsequent deployments. At station A4 the grab was triggered in the water due to heavy seas soon after deployment and the grab was recovered immediately to the deck and redeployed. Samples were subsequently obtained at station A4 successfully.

Due to a deteriorating weather forecast and a shortening of the window of weather available in which to undertake the survey works the decision was taken to not sample at Stations F4 and F5, and instead to transit to the area off Erris Head to undertake sampling operations in the vicinity of SW1.

The sampling stations were first surveyed using the camera system, prior to grab sampling. All actual grab samples were taken within 10 m (mean 6.1 m) of the target location for the respective sampling positions.

Seabed imagery transects were acquired successfully as close as possible to the target locations. Each transect was completed after an approximate distance of 50 m.

Water sampling at station Z11 was completed successfully, and the decision not to sample for seawater quality at the Corrib Central manifold location (Station SW3) was taken for operational / safety reasons, not due to a failure to successfully obtain samples.

Considering the weather and sea conditions, the overall precision of the sampling was considered to be excellent and more than met the requirements of the survey.

Table 3-14: Planned and actual sediment and water samples taken in the vicinity of SW3

Station	Sediment				Water			Photography
	Macrofauna	PSA/TOC	Chem	Organics	Surface water	Near-seabed water	CTD profile	Seabed video/stills transect
Z11	3	1+1	1	1+1	1	1	1	1
Z12	3	1+1	1	1+1	-	-	-	1
Z10	3	1+1	1	1+1	-	-	-	1
Z9	3	1+1	1	1+1	-	-	-	1
Z6	3	1+1	1	1+1	-	-	-	1
Z5	3	1+1	1	1+1	-	-	-	1
Z4	3	1+1	1	1+1	-	-	-	1

Station	Sediment				Water			Photography
	Macrofauna	PSA/TOC	Chem	Organics	Surface water	Near-seabed water	CTD profile	Seabed video/stills transect
Z3	3	1+1	1	1+1	-	-	-	1
F8	3	1+1	1	1+1	-	-	-	1
F6	3	1+1	1	1+1	-	-	-	1
F5	3	1+1	1	1+1	-	-	-	1
F4	3	1+1	1	1+1	-	-	-	1
F3	3	1+1	1	1+1	-	-	-	1
C4	3	1+1	1	1+1	-	-	-	1
SW3	-	-	-	-	1	1	1	-
C1	3	1+1	1	1+1	-	-	-	1
A4	3	1+1	1	1+1	-	-	-	1
Planned	**48 (16x3)**	**16 + 16**	**16**	**16+16**	**2**	**2**	**2**	**16**
Actual	**42 (14x3)**	**14 + 14**	**14**	**14+14**	**1**	**1**	**1**	**16**
Not collected	**6**	**2+2**	**2**	**2+2**	**1**	**1**	**1**	**0**

3.1.2.2 Seabed Photography

Table 3-2 summarises the observations made during the seabed photography at the 16 sediment sampling stations at the Corrib Field. Additionally, the following descriptions and photographs describe qualitatively the observations made regarding sediments and obvious surface fauna in the vicinity of Corrib Field. Examples of the seabed photography at each sampling station can be found in Appendix 6.

Seabed Sediments

Generally the sediment type at the Corrib Field was fine silty sand. The photographs show that the seabed is very homogenous in nature and comprised heavily bioturbated olive grey silty sands. Numerous faunal burrows were observed at all stations surveyed, with varying levels of conspicuous fauna. Example images of this habitat type are given in Figure 3.1, which shows photos taken at Stations Z6 and C1.

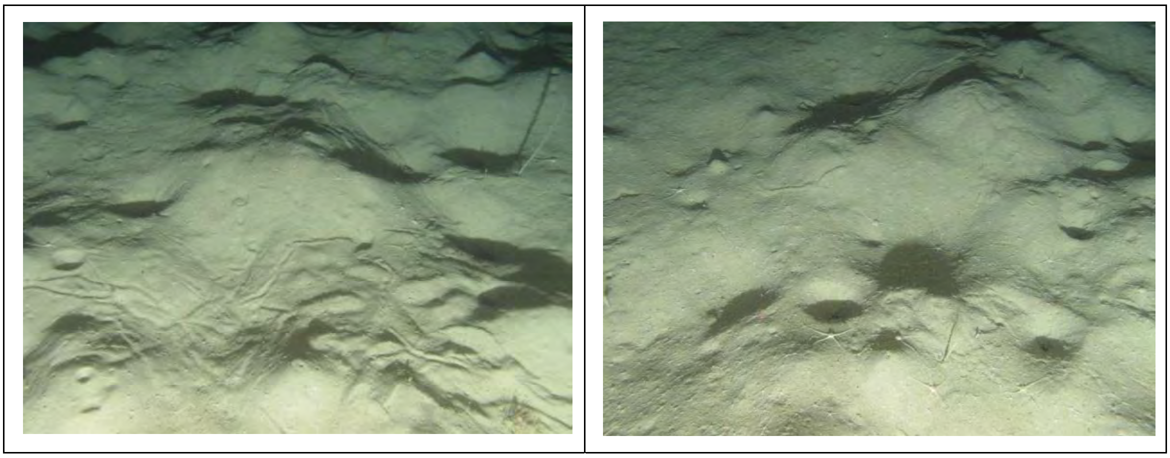

Figure 3.9: Seabed images at Stations Z6 (left) and C1 (right) at the Corrib Field (SW3), showing heavily bioturbated silty sand

Conspicuous Fauna

Conspicuous fauna in the area of the Corrib Field, as indicated by the still images and video footage, included ophiuroids, anemones (possibly *Actinauge richardi*), Pennatulids (possibly *Funiculina quadrangularis*), the sand mason worm (*Lanice conchilega)* and the Purple Heart urchin (*Spatangus purpureus)*. Other fauna included paguroids (hermit crabs), asteroid starfish, decapod shrimps, hagfish (Myxinidae sp.), Gadiforme sp., and the anglerfish *Lophius* sp. Examples of the conspicuous fauna observed during the seabed photography transects are shown in Figure 3.4.

 Paguroidea sp.	 Pennatulacea: Possibly *Funiculina quadrangularis*
 Ophiuroidea sp.	 Anemone: Possibly *Actinauge richardi*
 Terribellidae: *Lanice concheliga*	 Echinoidea: *Spatangus purpureus*

Figure 3.10: Examples of conspicuous fauna at stations in the vicinity of the Corrib Field (SW3)

3.1.2.3 Sediment Physico-chemistry

Particle Size Analysis (PSA) and Total Organic Carbon (TOC)

Summary results for particle size analysis (PSA) and total organic carbon (TOC) are presented in Table 3-16.

Table 3-15: Summary of in-field observations during seabed photography at the Corrib Field (SW3)

Station	Water Depth (m)	No. of Still Photos	Video Duration (mins)	Sediment Description	Conspicuous Fauna
A4	330	12	4	Silty sand with evidence of faunal burrows and bioturbation of sediments	Ophiuroids, anemones (including possibly *Actinauge richardi*), Pennatulids (possibly *Funiculina quadrangularis*), *Lanice conchilega*, *Spatangus purpureus*, decapod shrimp sp.
C1	351	12	7	Silty sand with evidence of faunal burrows and bioturbation of sediments	Ophiuroids, anemones (including possibly *Actinauge richardi*), Pennatulids (possibly *Funiculina quadrangularis*), *Lanice conchilega*, *Spatangus purpureus*, possibly Myxinidae sp.
C4	348	15	8	Silty sand with evidence of faunal burrows and bioturbation of sediments	Ophiuroids, anemones (including possibly *Actinauge richardi*), Pennatulids (possibly *Funiculina quadrangularis*), *Lanice conchilega*, decapod shrimp sp., *Spatangus purpureus*, Asteroidea sp.
F3	338	12	5	Silty sand with evidence of faunal burrows and bioturbation of sediments	Hermit crabs, anemones (including possibly *Actinauge richardi*), Pennatulids (possibly *Funiculina quadrangularis*), Gadidae sp., ophiuroids
F4	340	13	6	Silty sand with evidence of faunal burrows and bioturbation of sediments	Ophiuroids, anemones (including possibly *Actinauge richardi*), Pennatulids (possibly *Funiculina quadrangularis*), *Lanice conchilega*, *Spatangus purpureus*, Gadidae sp., decapod shrimp sp.
F5	332	12	7	Silty sand with evidence of faunal burrows and bioturbation of sediments	Ophiuroids, anemones (including possibly *Actinauge richardi*), Pennatulids (possibly *Funiculina quadrangularis*), squat lobster, decapod shrimp sp.
F6	343	12	5	Silty sand with evidence of faunal burrows and bioturbation of sediments	Anemones (including possibly *Actinauge richardi*), ophiuroids, *Spatangus purpureus*
F8	349	14	7	Silty sand with evidence of faunal burrows and bioturbation of sediments	Anemones (including possibly *Actinauge richardi*), ophiuroids, *Spatangus purpureus*, Pennatulids (possibly *Funiculina quadrangularis*), Pleuronectiforme sp. (possibly *Glyptocephalus cynoglossus*)
Z3	347	14	8	Silty sand with evidence of faunal burrows and bioturbation of sediments	Hermit crabs, anemones (including possibly *Actinauge richardi*), Pennatulids (possibly *Funiculina quadrangularis*), ophiuroids, *Lanice conchilega*, Asteroidea sp., Decapod shrimp sp., *Spatangus purpureus*

Z4	344	18	10	Silty sand with evidence of faunal burrows and bioturbation of sediments	Ophiuroids, anemones (including possibly *Actinauge richardi*), Pennatulids (possibly *Funiculina quadrangularis*), *Lanice conchilega*, polychaete tubes, Asteroidea sp.
Z5	341	18	9	Silty sand with evidence of faunal burrows and bioturbation of sediments	Ophiuroids, anemones (including possibly *Actinauge richardi*), Pennatulids (possibly *Funiculina quadrangularis*), *Lanice conchilega*
Z6	341	17	9	Silty sand with evidence of faunal burrows and bioturbation of sediments	Ophiuroids, anemones (including possibly *Actinauge richardi*), Pennatulids (possibly *Funiculina quadrangularis*), *Spatangus purpureus*, *Lanice conchilega*
Z9	340	16	7	Silty sand with evidence of faunal burrows and bioturbation of sediments	Anemones (including possibly *Actinauge richardi*), ophiuroids, *Spatangus purpureus*, Pennatulids (possibly *Funiculina quadrangularis*), *Lanice conchilega*, Teleost sp., Asteroidea sp., Crustacea sp., Porifera sp., Anglerfish (*Lophius* sp.)
Z10	341	11	6	Silty sand with evidence of faunal burrows and bioturbation of sediments	Ophiuroids, anemones (including possibly *Actinauge richardi*), Pennatulids (possibly *Funiculina quadrangularis*), Gastropod sp., *Lanice conchilega*
Z11	340	11	7	Silty sand with evidence of faunal burrows and bioturbation of sediments	Ophiuroids, anemones (including possibly *Actinauge richardi*), Pennatulids (possibly *Funiculina quadrangularis*), Crustacea sp
Z12	340	16	8	Silty sand with evidence of faunal burrows and bioturbation of sediments	Ophiuroids, anemones (including possibly *Actinauge richardi*), Pennatulids (possibly *Funiculina quadrangularis*), *Spatangus* purpureus, *Lanice conchilega*

Table 3-16: Sediment Particle Size Analysis and Total Organic Carbon results for stations at the Corrib Field (SW3)

Station	% Gravel (>2mm)	% Sand (63µm-2mm)	% Mud (<63µm)	Median particle size (mm)	Geometric Median particle size (µm)	Classification (Folk, 1954)	Classification Udden Wentworth	TOC %
C1	0	74.11	25.88	0.097	118	Muddy sand	Very Fine Sand	2.15
C4	0	74.83	25.18	0.105	128	Muddy sand	Fine Sand	2.12
F8	0	76.88	23.04	0.109	129	Muddy sand	Fine Sand	2.25
Z3	0	69.67	30.29	0.093	113	Muddy sand	Very Fine Sand	2.63
Z4	0	68.44	31.48	0.094	116	Muddy sand	Very Fine Sand	3.53
Z10	0.46	72.72	26.79	0.102	124	Muddy sand	Very Fine Sand	2.19
Z9	0	75.54	24.38	0.105	126	Muddy sand	Fine Sand	2.23
Z5	0	74.82	25.16	0.105	126	Muddy sand	Fine Sand	2.32
Z6	0	75.33	24.69	0.105	126	Muddy sand	Fine Sand	2.21
Z11	0	77.04	22.84	0.112	133	Muddy sand	Fine Sand	2.12
Z12	0	77.53	22.50	0.106	127	Muddy sand	Fine Sand	2.90
F6	0	75.24	24.82	0.102	123	Muddy sand	Very Fine Sand	2.07
F3	0	71.49	28.50	0.092	112	Muddy sand	Very Fine Sand	2.35
A4	0	73.51	26.54	0.103	122	Muddy sand	Very Fine Sand	2.09

Sediment types recorded are relatively consistent across the Corrib Field in that the largest proportion of the material is sand (more than two thirds in all cases), with the remaining third being mud.

The sediments at all stations in the vicinity of the Corrib Field are classified as muddy sand according to the Folk Classification and as either very fine sand or fine sand according to the Udden Wentworth Classification.

In all samples, the gravel fraction was not important, although it comprised a very minor component at station Z10 (0.46 %). The sand fraction ranged between c. 68 and 78 % with the mud fraction comprising between 22 and 31 % at all stations. This highlights the uniform and homogenous nature of the sediments in the vicinity of the field.

TOC ranged from 2.07 – 3.53 %. There was no clear pattern in the distribution of TOC levels compared with sediment grain size. The exception to this was at station Z4; this station had the highest levels of TOC and also the highest corresponding levels of mud present in the sample. TOC levels are consistent with the higher levels of fine sediments (mud fraction) present in the samples.

The distribution of the two described sediment types (fine sand and very fine sand) is difficult to attribute to the field development activities, and the sediments sampled throughout the Corrib Field are considered to be typical of those within the wider area and for similar water depths.

Metals

Results for concentrations of metals in the seabed sediments at the Corrib Field are presented in Table 3-17. The results indicate no particular patterns in terms of levels of metals in sediments, with the exception that Station Z3 dominated in terms of having the overall highest concentrations, with six metals represented at their highest concentrations here. Station F3 had lowest concentration of 7 of the metals. A degree of inter-station variability in levels of some metals was identified (e.g. barium), however others varied within a relatively small range (e.g. lead, silver, arsenic, cadmium, copper, nickel, lithium, and selenium).

Aluminium concentrations ranged from 24900 mg/kg to 47300 mg/kg, however this higher value was observed only at station F8, and if this station is not included then the range would be between 24900 and 31900 mg/kg. This range excluding station F8 reflects the quantity of fine sediments in samples and the similarity in sediment grain sizes across the survey sites. This is shown in the sediment granulometry results in Table 3-17, and further reflected in the underwater camera results.

Aluminium is often used as a surrogate for grain size, with high concentrations indicating low grain sizes. Finer grained sediments have higher numbers of binding sites to which metal ions can attach; hence it is normal that finer grained sediments have higher concentrations of many metals than coarser sediments which have been exposed to the same metal inputs. Site Z3, while not having the highest concentration of aluminium (26700 mg/kg) did have the highest recorded values for arsenic, iron, manganese, nickel, selenium and vanadium. This site also had the second highest proportion of the mud fraction (30.29 %) and second lowest median particle size.

Elevated concentrations of barium were found at several sites, which may be a consequence of local drilling activities. Barium is a constituent of water-based drilling muds and in 2014 the highest value for barium was recorded at station Z4, which is located adjacent to the manifold and production well P101, and relatively close to P1, P4 and P6. A clear pattern of elevated barium levels was observed in samples in close proximity to the Corrib Central Manifold and central wells cluster. This trend is discussed further in section 4.1.2.3.

With the exception of barium and the elevated level of aluminium at station F8 no further highly elevated outliers, indicative of localised anthropogenic contamination, were recorded. Other than the trends discussed above no other obviously discernible patterns could be observed with regards metal concentrations across stations at the Corrib Field.

Comparison of the concentrations recorded against previous data from the Corrib Field area, and international and regional standards can be found in section 4.1.2.3.

Table 3-17: Concentrations of metals in seabed sediments at sampling stations at the Corrib Field (SW3)

Station	Ag	Al	As	Ba	Cd	Cr	Cu	Fe	Hg	Li	Mn	Ni	Pb	Se	V	Zn
	mg/kg															
C1	<1	28000	3.98	336	0.091	59.9	5.98	10900	0.0096	17.1	270	9.29	8.14	0.117	17.8	26.7
C4	<1	25400	4.47	344	0.121	56.9	7.78	11400	0.0102	14.7	276	9.44	9.26	0.125	18.8	30
F8	<1	47300	3.55	257	0.089	46.1	6.55	10200	0.0099	16.2	247	9.14	8.07	0.115	17	23.7
Z3	<1	26700	4.67	1080	0.095	59.6	6.96	11800	0.0119	19	279	10	8.62	0.146	19.6	26.2
Z4	<1	29700	4.35	1820	0.106	57.8	7.65	10600	0.0138	19.1	248	9.22	9.44	0.118	18	28.9
Z10	<1	26900	4.14	1680	0.103	45.5	7.81	10800	0.0157	19.9	250	9.79	8.61	0.126	18.8	27.5
Z9	<1	31900	4.08	1680	0.096	54	6.95	10000	0.0113	17.8	247	9.2	8.11	0.118	17.6	24.5
Z5	<1	30000	4.29	1580	0.101	48.2	6.92	10400	0.0245	17.5	253	9.66	10.2	0.141	18.4	28.3
Z6	<1	29800	3.68	1680	0.106	56.1	7.74	10200	0.0152	18.2	250	9.5	9.24	0.139	18.3	27.5
Z11	<1	30500	4.01	339	0.106	62.7	6.32	10000	0.00997	17.6	251	8.93	8.32	0.107	18	24.1
Z12	<1	26400	3.94	124	0.093	45.6	6.31	9420	0.0095	18.6	231	8.65	8.2	0.104	16.6	22.8
F6	<1	29700	3.97	143	0.104	54.2	7.91	9920	0.00955	17.2	246	9.12	8.33	0.11	18.1	24
F3	<1	24900	3.94	82.3	0.098	49.5	5.81	9210	0.00898	17.8	233	8.72	8.01	0.105	17.3	22.5
A4	<1	26300	4.11	137	0.103	52.6	6.73	9570	0.0126	20.1	230	9.79	8.57	0.144	17.9	25.2

Green: lowest result; Orange: highest result.

Metals in Sediment QA/QC

Table 3-18 presents the certified concentration data for the MESS-3 marine sediment CRM from the NRCC, together with the results of the analysis performed on the sample by the EA's National Laboratory Service.

Table 3-18: Concentrations of metals in the CRM sample

	Analysis of Marine Sediment CRM (MESS-3) (mg/kg)		
Determinand	**2014 EA NLS results**	**NRCC Reference value**	**Difference (%)**
Ag	<1	0.18	N/A
Al	74,440	85,900	-13.34
As	23.8	21.2	10.92
Cd	0.266	0.24	9.77
Cr	109	105	3.67
Cu	35.7	33.9	5.04
Fe	40,400	43,400	-6.91
Hg	0.0776	0.091	-14.73
Li	73.6	73.6	N/A
Mn	262	324	-19.14
Ni	37.7	46.9	-19.62
Pb	23	21.1	8.26
Se	0.763	0.72	5.64
Vn	107	243	-55.97
Zn	171	159	7.02

The similarity between the certified and measured results shows overall confidence in the EA analysis of sediment samples in the vicinity of the Corrib Field. The single analysis that does stand out, however, is that for vanadium.

The degree of error observed in the results for vanadium are because the EA laboratory prepares its sediment samples for analysis using an aqua regia digestion, rather than a hydrofluoric acid digestion. Aqua regia is a significantly less vigorous digestion technique that achieves lower recoveries than hydrofluoric acid digestion, upon which the reference values for the CRM are based. The EA have stated that the reason they use aqua-regia is that it releases only the vanadium which is biologically available, rather than all of the metal in the sediment. Hence the results from the field samples reflect the biologically available vanadium.

Hydrocarbons

Saturates (Total Organic Extracts)

Table 3-19 presents a summary of total organic extractables (TOE) data for the Corrib Field stations. The sediment recovered was analysed for Ecomul, Ecosol and

Esterkleen, as these are all base oils present in oil-based (synthetic-based) drilling muds (OBMs) historically used in drilling activity in the Corrib Field.

All TOE listed in Table 3-19 commonly occur in OBMs, the discharge of which has effectively been banned since 16 January 2001 (when the OSPAR Decision 2000/3 entered into force). Since this date, only water-based drilling muds (WBMs) have been used in the Corrib Field.

In the 2014 Corrib Field survey, Ecomul was only detected at six of the sampled stations (C1, C4, Z5, Z6, Z9, and Z10). In all cases concentrations are considered to be low. Ecosol and Low-toxicity OBM were not detected at any sites. Similarly Esterkleen and Diesel range OBM were 'not detectable' at any of the sample stations in the Corrib Field, sampled in 2014. Aside from Ecosol, all other maximum values for the analysed saturates were recorded at station Z10.

When comparing recorded levels of saturates across the sampled stations, two sites have levels that are slightly elevated. Station Z10 and to a less extent Z9, both close to the east of the Corrib Manifold and central wells, show higher levels of TOE and Ecomul compared with the other stations sampled, the highest concentrations being recorded at Z10 (closest to the wells and Central Manifold). The average TOE and Ecomul recorded at the 12 other stations sampled at the Corrib Field was 8.9 and 0.028 µg/g respectively , compared with 11.9 and 0.28 µg/g for stations Z9 and Z10. All Corrib Field sites had TOE values in excess of 5µg/g (typically ca. 9µg/g.

A comparison of the observed concentrations in the sediments in 2014 and the results from previous surveys at the Corrib Field as well as international standards can be found in Section 4.1.2.3.

Table 3-19: Concentrations of Total Organic Extracts in seabed sediments at sampling stations in the vicinity of the Corrib Field (SW3)

	Sample	TOE	Ecomul	Ecosol	Esterkleen	Low Toxicity Base Oil	Diesel Range Base Oil
		(µg/g; ppm)					
Corrib Field Stations	C1	6.8	0.08	*nd*	*nd*	*nd*	*nd*
	C4	11/9.4*	0.10/0.06*	*nd/nd**	*nd/nd**	*nd/nd**	*nd/nd**
	F3	7.1	*nd*	*nd*	*nd*	*nd*	*nd*
	F6	9.4	*nd*	*nd*	*nd/nd**	*nd*	*nd/nd**
	F8	7.9	*nd*	*nd*	*nd*	*nd*	*nd*
	Z3	10	*nd*	*nd*	*nd*	*nd*	*nd*
	Z4	9.8/7.5*	*nd/nd**	*nd/nd**	*nd/nd**	*nd/nd**	*nd/nd**
	Z5	11	0.1	*nd*	*nd*	*nd*	*nd*
	Z6	8.7	0.08	*nd*	*nd*	*nd*	*nd*
	Z9	9.7	0.15	*nd*	*nd*	*nd*	*nd*
	Z10	14	0.41	*nd*	*nd*	*nd*	*nd*
	Z11	12	*nd*	*nd*	*nd*	*nd*	*nd*
	Z12	8.3	*nd*	*nd*	*nd*	*nd*	*nd*
	A4	6.8	*nd*	*nd*	*nd*	*nd*	*nd*

Key:
- (orange) *Shows maximum value recorded*
- (green) *Shows minimum value recorded (minimums have not been recorded where non detectable (nd) values exist)*
- * *Duplicate sample was analysed for quality assurance purposes. Both results are shown.*

Polycyclic Aromatic Hydrocarbons (PAHs)

Raw data for concentrations of polycyclic aromatic hydrocarbons (PAHs) in the seabed sediments at the Corrib Field are listed in Table 3-20 (a duplicate sample was analysed for quality assurance purposes at station Z4 and both results are shown). These include naphthalenes, phenanthrenes, dibenzothiophenes (NPD) and the 16 priority PAHs defined by the US EPA (Environment Protection Agency).

The concentrations of NPDs, which are generally thought to be of petrogenic origin, ranged from 0.02 µg/kg (ppb) at station Z4, to 3 µg/kg at station C1. The measured concentration of the NPD fraction in the duplicate sample from station Z4 was 1.1 µg/kg and it is considered likely that this difference may be due to minor heterogeneity of the sample. The concentration of NPD does not exceed 10 µg/kg at any of the 14 stations sampled, and concentrations of NPDs are generally considered consistent with 'background' levels seen previously in the vicinity of the Corrib Field (see section 4.1.2.3).

The concentrations of the EPA 16 PAHs ranged from 1.4 µg/kg at station F6 to 4.8 µg/kg at station C1. As with the NPD concentrations, the levels are generally similar to the background levels seen previously in the vicinity of the Corrib Field, and levels of up to around 10 µg/kg have previously been recorded locally. These results are also generally similar to the background levels observed in North Atlantic sediments as shown in Section 4.1.2.3.

Table 3-20. Concentrations of 2-6 Ring Polycyclic Aromatic Hydrocarbons in Samples from the Corrib Field (SW3) (µg/kg or ppb; dry weight basis)

Sample Reference	C1	F6	F3	Z3	Z11	Z10	Z4	F8	C4	A4	Z6	Z9	Z5	Z12
Naphthalene (N)	2.8	0.09	0.14	0.39	0.09	0.28	nd/0.111	0.06	0.2	0.06	0.1	0.1	0.1	0.03
C_1-Naphthalenes	0.11	nd	nd	nd	nd	0.1	nd/nd1	nd	0.06	nd	0.04	nd	nd	nd
C_2-Naphthalenes	nd	nd	nd	nd	nd	0.09	nd/nd1	nd	nd	nd	nd	nd	nd	nd
C_3-Naphthalenes	nd	nd	nd	nd	nd	nd	nd/nd1	nd	nd	nd	nd	nd	nd	nd
C_4-Naphthalenes	nd	nd	nd	nd	nd	nd	nd/nd1	nd	nd	nd	nd	nd	nd	nd
Total Naphthalenes (N)	**2.9**	0.09	0.14	0.39	0.09	0.46	nd/0.111	0.06	0.26	0.06	0.14	0.1	0.1	0.03
Phenanthrene	0.06	0.03	0.03	0.06	0.08	0.28	0.02/0.10	0.02	0.16	0.04	0.04	0.05	0.07	0.01
C_1-Phenanthrenes	nd	nd	nd	nd	nd	0.17	nd/nd1	nd	0.23	nd	nd	nd	nd	nd
C_2-Phenanthrenes	nd	nd	nd	nd	nd	0.12	nd/nd1	nd	0.19	nd	nd	nd	nd	nd
C_3-Phenanthrenes	nd	nd	nd	nd	nd	nd	nd/nd1	nd	nd	nd	nd	nd	nd	nd
Total Phenanthrenes (P)	**0.06**	0.03	0.03	0.06	0.08	0.57	0.02/0.101	0.02	0.59	0.04	0.04	0.05	0.07	0.01
Dibenzothiophene (D)	nd	nd	nd	nd	nd	nd	nd/0.011	nd	0.03	nd	nd	nd	nd	nd
C_1-Dibenzothiophenes	nd	nd	nd	nd	nd	nd	nd/0.171	nd	0.37	nd	nd	nd	nd	nd
C_2-Dibenzothiophenes	nd	nd	nd	nd	nd	nd	nd/0.421	nd	0.77	nd	nd	nd	nd	nd
C_3-Dibenzothiophenes	nd	nd	nd	nd	nd	nd	nd/0.261	nd	0.28	nd	nd	nd	nd	nd
Total Dibenzothiophenes (D)	**nd**	nd	nd	nd	nd	nd	nd/0.861	nd	1.45	nd	nd	nd	nd	nd
Sum of NPDs	**3**	0.12	0.17	0.45	0.17	1	0.02/1.11	0.08	2.3	0.1	0.17	0.15	0.17	0.04
Acenaphthylene	nd	nd	nd	nd	nd	nd	nd/nd1	nd	nd	nd	nd	nd	nd	nd
Acenaphthene	nd	nd	nd	nd	nd	nd	nd/nd1	nd	nd	nd	nd	nd	nd	nd
Fluorene	nd	nd	nd	nd	nd	nd	nd/nd1	nd	nd	nd	nd	nd	nd	nd
Anthracene	nd	nd	nd	nd	nd	nd	nd/nd1	nd	nd	nd	nd	nd	nd	nd
Fluoranthene	0.09	0.06	0.08	0.06	0.12	0.3	0.08/0.161	0.12	0.16	0.16	0.12	0.12	0.16	0.11
Pyrene	0.09	0.05	0.06	0.11	0.1	0.43	0.10/0.141	0.12	0.13	0.1	0.09	0.1	0.11	0.07
C_1-Fluoranthenes/Pyrenes	nd	nd	nd	nd	nd	0.13	nd/nd1	nd	nd	nd	nd	nd	nd	nd
C_2-Fluoranthenes/Pyrenes	nd	nd	nd	nd	nd	nd	nd/nd1	nd	nd	nd	nd	nd	nd	nd
C_3-Fluoranthenes/Pyrenes	nd	nd	nd	nd	nd	nd	nd/nd1	nd	nd	nd	nd	nd	nd	nd
Benzo(a)anthracene	nd	0.01	0.03	nd	nd	0.06	0.02/0.051	0.04	0.05	0.04	0.01	0.03	0.02	nd
Chrysene	0.06	0.04	0.05	nd	0.07	0.25	0.06/0.181	0.09	0.11	0.07	0.06	0.07	0.11	0.04
C_1-Benzanthracenes/Chrysenes	nd	nd	nd	nd	nd	0.13	nd/nd1	nd	nd	nd	nd	nd	nd	nd
C_2-Benzanthracenes/Chrysenes	nd	nd	nd	nd	nd	nd	nd/nd1	nd	nd	nd	nd	nd	nd	nd
Benzo(b)fluoranthene	0.63	0.43	0.48	0.58	0.58	0.91	0.66/0.751	0.81	0.73	0.72	0.6	0.53	0.78	0.55
Benzo(k)fluoranthene	0.07	0.04	0.04	0.04	0.08	0.12	0.06/0.061	0.1	0.11	0.12	0.07	0.06	0.09	0.06
Benzo(a)pyrene	0.04	0.03	nd	0.05	0.08	0.16	nd/0.241	0.07	0.07	0.06	0.05	0.07	0.09	0.03
C_1-BF/BP	nd	nd	nd	nd	nd	nd	nd/0.881	nd	nd	nd	nd	nd	nd	nd
C_2-BF/BP	nd	nd	nd	nd	nd	nd	nd/1.21	nd	nd	nd	nd	nd	nd	nd
Indeno(1,2,3-cd)pyrene	0.57	0.35	0.35	0.34	0.5	0.77	0.44/0.751	0.59	0.69	0.66	0.54	0.47	0.69	0.53
Dibenzo(a,h)anthracene	0.03	0.02	0.01	nd	0.02	0.02	nd/0.151	0.03	0.05	0.02	nd	0.04	0.03	0.02
Benzo(ghi)perylene	0.39	0.23	0.29	0.29	0.35	0.71	0.44/0.751	0.51	0.52	0.49	0.41	0.37	0.59	0.34
Sum of EPA 16	**4.8**	1.4	1.6	1.9	2.1	4.3	1.9/3.41	2.6	3	2.5	2.1	2	2.8	1.8

3.1.2.4 *Sediment Macrofauna*

This section of the report contains summary information for the various analyses of benthic macrofaunal samples. Full details (including raw data) are available in Appendix 7.

Taxonomic Composition

Species numbers and abundances for macrofauna are shown on a per site basis (Table 3-21). Percentage of each phylum that contributed to community composition at each site is also shown. Species that are encrusting and/or colonial are included in the number of species per site but were excluded from overall abundance counts.

Species numbers were moderate to high ranging from 180 per site at Z6 to 306 at site Z3 and abundances were moderate ranging from 880/m^2 at site Z12 to 2497/m^2 at F3. Both number of species and abundance showed relatively little variation throughout the study area and at no site was there paucity of fauna or a particularly enriched community.

Ranked taxa illustrating the 10 most abundant species at each site are shown in Appendix 8. Sites showed very little variation in community composition and the small tube-dwelling polychaete *Galathowenia oculata* was found to be by far the most dominant organism in the area. This species numerically dominated at 12 of the 14 sites and at the other two sites it was in the top 5 most numerically dominant taxa. These findings were also reflected in the overall importance of polychaetes in these communities, this phylum was found to be the most abundant at all sites sampled and contributed to over a third of all animals recorded at each site. Other polychaetes which were characteristic of the faunal assemblages at these sites included spionids such as *Prionopsio*, *Aricidea*, *Levinsenia gracilis*, *Spiophanes* and *Minuspio*. Whilst crustaceans on the whole were not as commonly recorded as other phyla, the amphipod *Urothoe elegans* was present at all sites and found to be relatively abundant at 12 of these sites. Molluscs and Echinoderms showed varying importance in community composition but contributed up to 30% of the animals found at some of the sites. 'Other' phyla tended to make up less than 10% of the fauna identified at each site.

The communities in the study area were characteristic of muddy fine sand environments in the deeper sea and seemed to conform to some aspects of the deep sea biotope 'Formaniferans and Thyasira sp in deep circalittoral fine mud' (**SS.SMu.OMu.ForThy**) which has been identified in waters deeper than 100m in the northern North Sea (Connor *et al.,* 2004). Typifying these communities were species of Thyasirid bivalves such as *Adontorhina similis, Axinulus crouliensis* and *Mendicula ferruginea*, the ampharetid polychaete *Pterolysippe vanelli*, the tube-dwelling polychaete *Galathowenia oculata* and spionid polychaetes as mentioned above, the brittle star *Ophiocten affinis* and the echiuran *Echiurus echiurus*.

Some species recorded were those only found in deeper or colder waters such as the mysids *Hypererythrops serriventer* and *Pseudomma affine* which are both reported in depths of more than 200 m off the west coast of Ireland (Tattersall and Tattersall, 1951), the deep sea amphipods *Nicippe tumida* and *Syrrhoe affinis* and the deep water anemone *Actinauge richardi*. This anemone was of particular interest as it usually attaches to a ball of mud which it uses as an anchor as opposed to attaching to hard substrata. It has been reported as a deep water species in the north-east Atlantic (Manuel, 1988).

Diversity Indices

Summary results for a range of univariate parameters, and percentage contribution of each phyla per station (replicates pooled), are presented in Table 3-21. Note that these data do not include encrusting species, with the exception of number of species per site (S).

Table 3-21: Summary per-station sediment macrofauna results: univariate indices and taxonomic composition at the Corrib Field (SW3)

Station	Number of species (including encrusting species) S (per site)	Abundance N (m^{-2})	Species Richness (Margalef's) d	Evenness (Pielou's) J'	Diversity (Shannon-Wiener) H'	Dominance (Simpson's) λ	% abundance Poly.	Crust.	Molluscs	Echino.	Other
A4	231	1786.7	13.50	0.66	2.82	0.13	43.10	4.10	12.87	27.99	11.94
C1	231	1173.3	15.74	0.83	3.58	0.04	40.63	11.08	20.74	15.63	11.93
C4	189	1260	12.61	0.75	3.08	0.09	50.00	7.67	18.52	11.90	11.90
F3	279	2496.7	16.49	0.73	3.32	0.10	60.61	4.01	14.02	14.15	7.21
F6	243	1163.3	16.40	0.79	3.46	0.06	54.15	11.75	12.03	14.04	8.02
F8	249	2003.3	15.09	0.65	2.86	0.19	65.89	7.32	14.81	8.99	3.00
Z3	306	1913.3	18.84	0.77	3.53	0.06	53.83	6.62	13.76	19.16	6.62
Z4	291	1666.7	18.37	0.80	3.65	0.05	55.40	8.00	14.60	15.20	6.80
Z5	228	1596.7	14.19	0.77	3.32	0.08	52.82	9.60	16.08	13.15	8.35
Z6	180	936.7	13.00	0.79	3.23	0.07	37.37	10.32	32.03	12.46	7.83
Z9	237	1240	15.56	0.79	3.41	0.06	39.25	10.22	28.49	12.63	9.4
Z10	267	1346.7	17.54	0.82	3.65	0.04	34.2	9.90	31.19	7.92	16.83
Z11	207	1453.3	13.46	0.64	2.71	0.18	54.82	7.80	13.99	19.04	4.36
Z12	213	880	15.19	0.80	3.40	0.07	48.1	11	16.7	22	2.3

Green: lowest result; Orange: highest result. Poly = Polychaetes Crust=crustaceans; echino=echinoderms

S = Number of species (including encrusting species) (per site); N = Number of individuals (average per site); d = Species Richness (Margalef's); J' = Pielou's Evenness; H'= Shannon-Weiner Diversity (log_e), λ'=Simpson Dominance

Overall, the study area was one of high faunal diversity (H') and ranged from 2.71 at site Z11 to 3.65 at sites Z4 and Z10. Evenness (J') was high throughout the study area with an evenness of more than 0.6 being calculated for all sites.

Community Clustering

The results of per replicate group average clustering analysis using Bray Curtis similarity are shown per replicate (within site variability) (Appendix 9) and per site (Figure 3.11).

Firstly, the data underwent multivariate analysis (after square root transformation) on a per replicate basis. Within site variability was found to be relatively low. Replicates at the majority of sites were statistically the same (no significant differences were identified). Of the five sites that contained significantly different replicates only site Z11 had a replicate that showed less than 40% similarity to the other replicates.

Community homogeneity within the study area was very evident, apart from a few replicates, there was no obvious split of communities using the per replicate data.

Replicates were therefore averaged to produce a per site dataset. The results of clustering analysis on the per site data (averaged replicate data) showed that communities split into two clusters which were significantly different from each other. This split occurred at an approximate similarity of 60% as shown in Figure 3.11. This is further supported by the MDS plot (Figure 3.12).

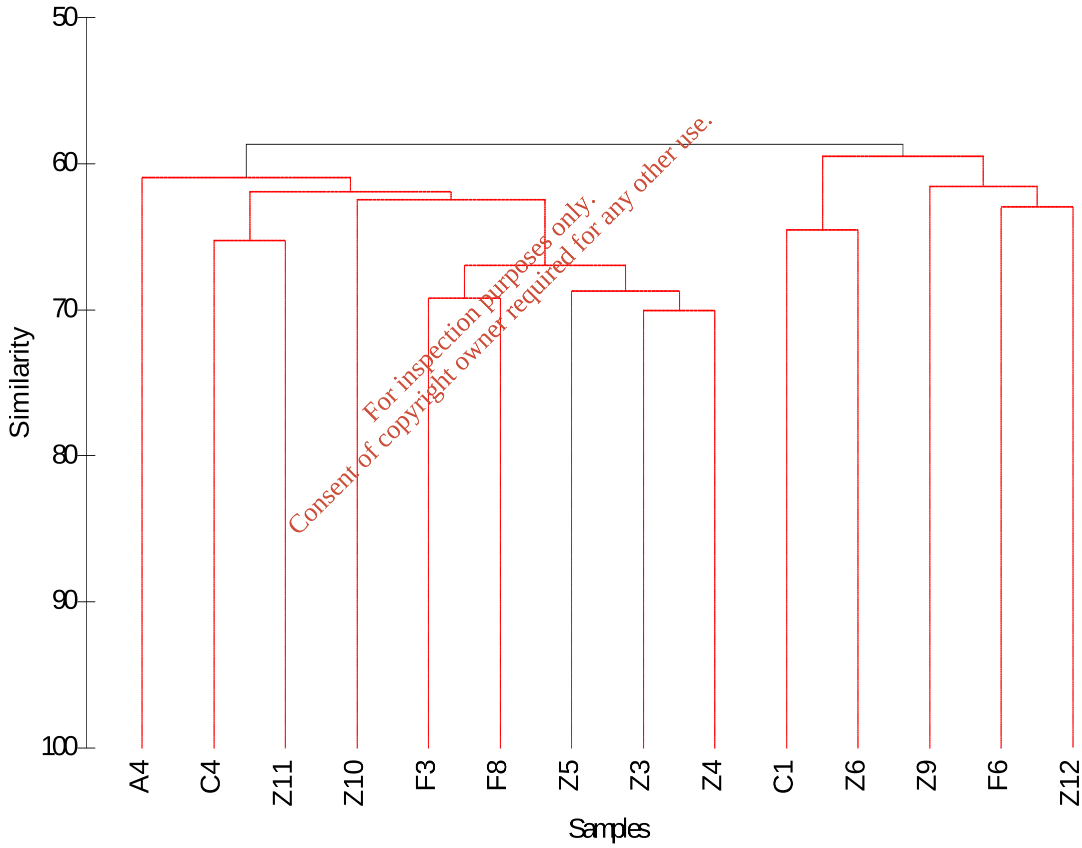

Figure 3.11: Dendrogram showing clustering of communities using averaged replicate (per site) data from the Corrib Field (SW3) study area. Black lines indicate a significant difference between clusters (generated by a SIMPROF test).

The results of multi-dimensional scaling using the similarity matrices derived from cluster analysis are plotted two dimensionally for each site (averaged replicate) as shown in Figure 3.12, which clearly shows the two clustered communities.

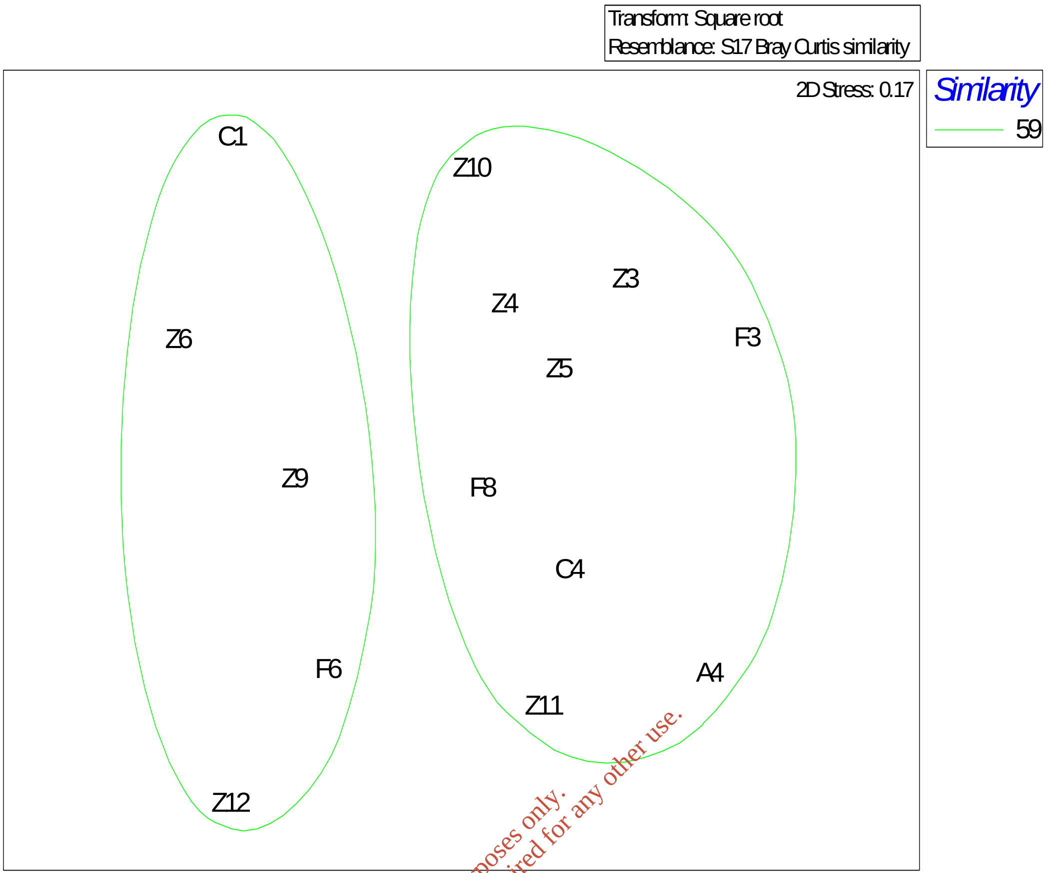

Figure 3.12: MDS plot of the Corrib Field (SW3) sites (averaged replicate data / site) in 2014 with superimposed contours at a similarity level of 59 % to highlight defined clusters.

The stress value was high (0.17) which indicated that there are many factors involved in determining the differences in community composition. This result may have occurred because the sites showed few major differences in their faunal assemblages and any small scale changes in fauna were possibly caused by numerous, small variations in the physical, chemical or biological characteristics of the sediment including food availability or larval transport.

It was apparent from the plot that the averaging of replicates to produce a per site community dataset reduced some of the anomalies in the dataset as a whole. However, even though a significant difference was identified as a result of this reduction it is unclear as to whether this difference actually existed in the study area as the clusters exhibited a 60% similarity to one another and this finding was contradictory to that calculated during the per replicate analysis.

Although this result was treated with caution a SIMPER analysis was performed to determine which species are typical of the assemblages recorded there and which species contributed to the differences observed between the two clusters. This helped in highlighting actual differences (and not small scale changes) in faunal assemblages. The results of this analysis are shown in Table 3-22.

Table 3-22: SIMPER output of those species that contribute to the similarity between clusters of sites in the vicinity of the SW3 location (Corrib Field) using Bray-Curtis similarity on standardised square root transformed data.

Cluster 1 (sites A4, C4, F3, F8, Z3, Z4, Z5, Z10, Z11)	Average similarity: 63.52			
Species	**Av. Abund**	**Av. Sim**	**% Contrib**	**Cum %**
Galathowenia oculata	6.51	6.13	9.65	9.65
Ophiocten affinis	4.02	3.52	5.55	15.20
Adontorhina similis	3.07	3.21	5.05	20.26
Axinulus crouliensis	2.61	2.54	3.99	24.25
Urothoe elegans	2.30	2.31	3.63	27.88
Eclsippe vanelli	2.18	1.90	2.98	30.86
Cluster 2 (sites C1, F6, Z6, Z9, Z12)	**Average similarity: 60.75**			
Species	**Av. Abund**	**Av. Sim**	**% Contrib**	**Cum %**
Galathowenia oculata	4.49	6.00	9.88	9.88
Urothoe elegans	2.46	3.19	5.26	15.14
Adontorhina similis	2.81	3.00	4.94	20.07
Axinulus crouliensis	2.39	2.82	4.64	24.72
Ophiocten affinis	2.41	2.77	4.56	29.28
Eclysippe vanelli	1.58	2.03	3.34	32.62

Av. = Average; Abund.= Abundance; Sim.= Similarity; Contrib = Contribution; Cum = Cumulative

The columns shown give the average abundance, the average contribution to the similarity, the percentage contribution to overall similarity and the cumulative contribution to similarity.

The taxa important in defining the two clusters were found to be very similar. Those that contributed to approximately 30% similarity in each cluster (a total of 5 species) were exactly the same. They were found to differ in the importance of the brittle star *Ophiocten affinis* the amphipod *Urothoe elegans.* Conversely, it was the proportion of these taxa which also contributed to the dissimilarity of these two clusters.

This analysis contributed to the evidence that no significant differences exist between these two clusters of sites and it is likely that the averaging of these sites produced the error that resulted in the apparent dissimilarity.

Further statistical analysis and correlation with environmental variables is unnecessary as no significant differences existed within the dataset. As such the community clustering shown in Appendix 9 (per replicate basis) is more likely to be representative of the community structure at the Corrib Field stations in 2014 than that shown in Figure 3.12.

Species of Particular Interest

A number of interesting species were identified which were particularly associated with inhabiting deeper waters. These species included the mysids *Hypererythrops serriventer* and *Pseudomma affine*, amphipods *Nicippe tumida* and *Syrrhoe affinis* and the anemone *Actinauge richardi*. These species were never abundant but were relatively frequently recorded throughout the dataset.

No protected species were recorded in the study area.

3.1.2.5 Seawater Quality

Temperature

A temperature-depth profile for station Z11 is presented in Figure 3.13. This station is close to the Corrib central manifold at the Corrib Field and water quality measurements and samples taken at this location are considered representative of the Corrib Field as a whole.

The recorded temperatures in the surface waters were around 15°C. Temperatures decreased slowly with depth to around 13-14°C at 40-50m depth, beyond which point the temperature fell more quickly with increasing depth. The surface water temperatures remained relatively homogenous (indicating that they were relatively well mixed). Between 40 and 70m temperatures markedly reduce indicating a thermocline is present. Temperatures then stabilised at around 75 m water depth at around 11°C and then remain relatively consistent, albeit reducing slightly with increased depth until seabed depths are reached at around 350 m. The temperature at the seabed is around 10°C.

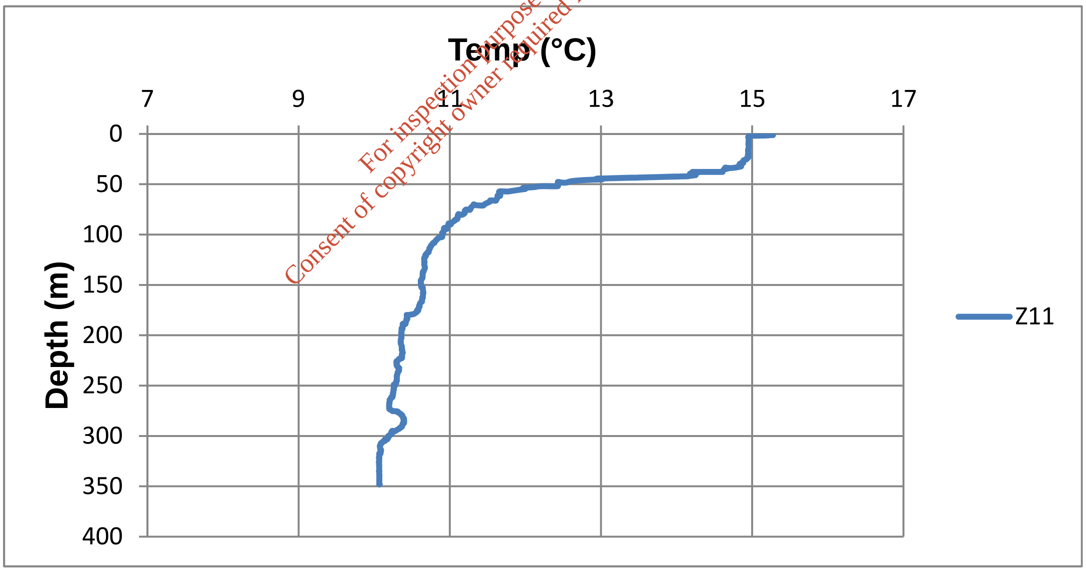

Figure 3.13: Temperature depth profile for station Z11 sampled in the vicinity of the Central Manifold (SW3) at the Corrib Field.

Salinity

A salinity-depth profile for station Z11 is presented in Figure 3.14.

The data would indicate that salinity remains relatively consistent at all depths. Some variation occurs close to the surface as the CTD acclimatised. Salinity is typically around 35.5 PSU in surface waters. This remains constant to a depth of around 30 m, at which point extensive variation occurs that corresponds with the thermocline at similar depths. Between around 30 and 70 m salinity varies between less than 35.2 PSU and 35.6 PSU. Below this depth salinity becomes more consistent at around 35.5 PSU to seabed depths at around 350 m. There are occasional minor variations, notably at around 175 m and 275 m. The total range in salinities recorded was between 35.6 and around 35.16 PSU. This increased range occurred at a depth of around 50 m where greatest variations were was observed and that corresponded approximately with the depth that thermal stratification also was noted.

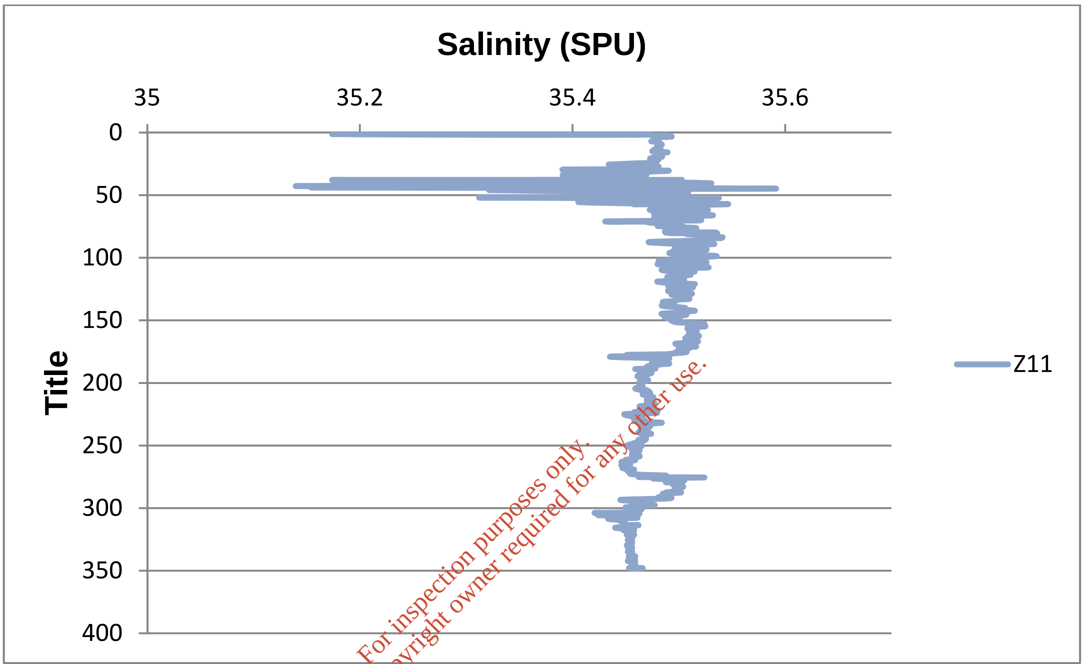

Figure 3.14: Salinity - depth profile for station Z11 sampled in the vicinity of the Central Manifold (SW3) at the Corrib Field.

Water Samples

Results for suspended particulate matter (SPM) and ammoniacal nitrogen are presented in Table 3-23.

Table 3-23: Suspended particulate matter (SPM) and ammoniacal nitrogen in seawater samples collected in the vicinity of the Central Manifold (SW3) at the Corrib Field (Station Z11)

Station	Depth	Suspended particulate matter (SPM)	Ammoniacal nitrogen as N
		mg/l	
Station Z11	Surface	<3.0	<0.01
	Bottom	<3.0	<0.01

Suspended particulate matter (SPM)

Table 3-23 shows SPM levels were below that of the MRV (<3.00 mg/l), both near the surface and near the seabed. Overall these levels are considered to be low.

Ammoniacal nitrogen

Levels of ammoniacal nitrogen were below that of the MRV, (<0.01 mg/l) in both the near surface and near seabed water depths. These results are all below the EU Water Framework Directive Environmental Quality Standard (EQS) for ammoniacal nitrogen of 0.021 mg/l, as shown in Table 3-23.

Metals

Results for metals in sampled seawater at station Z11 at the Corrib Field are presented in Table 3-24. Concentrations of cadmium, mercury, chromium, and silver were all below their respective MRVs in both near surface and near seabed samples and below the MRV for nickel in near seabed samples.

Levels of arsenic were consistent between near surface and near seabed waters and were recorded above the MRV in the range 1.29 – 1.47 µg/l.

Copper was recorded at levels above the MRV in both near surface and near seabed water samples (range 0.55 – 2.2 µg/l).

Lead concentrations ranged from 0.07 µg/l at the surface to 1.87 µg/l close to the seabed.

Zinc concentrations were recorded in the range of 5.93 µg/l at the surface to 29.9 µg/l close to the seabed.

Table 3-24: Metals in seawater sampled in the vicinity of the Central Manifold (SW3) (Station Z11) at the Corrib Field

Station		**As**	**Cd**	**Cu**	**Pb**	**Ni**	**Zn**	**Hg**	**Cr**	**Ag**
		µg/l								
Station Z11	Surface	1.29	<0.03	0.55	0.07	0.44	5.93	<0.01	<0.5	<1
	Bottom	1.47	<0.03	2.2	1.87	<0.3	29.9	<0.01	<0.5	<1

Metals in water QA/QC

Results from the EA - NLS analytical laboratory as compared to the pre-determined levels in the SLEW-3 CRM are presented in Table 3-25Table 3-12. All differences between certified and the laboratory results are small, with a maximum difference of 16.70 % (cadmium). The majority of analytes were recorded at levels below the limits of detection, which also corresponded to levels that would be in a similar range to the certified concentrations within the reference sample.

Table 3-25: Comparison of analytical results for metals in seawater from EA NLS laboratory against Certified Reference Material (CRM) values

Metal	**EA - NLS result (µg/l)**	**CRM value (µg/l)**	**% difference**
Ag	<1.00	0.003	N/A
As	No result	1.36	N/A

Metal	EA - NLS result (µg/l)	CRM value (µg/l)	% difference
Cd	0.04	0.048	-16.70
Cr	<0.50	0.183	N/A
Cu	1.45	1.55	-6.45
Ni	1.20	1.23	-2.44
Pb	<0.04	0.009	N/A
Zn	<0.4	0.201	N/A

Organics

Of the 43 organic compounds analysed in the seawater samples from station Z11, only phenol was recorded at a level above its respective MRV (see Table 3-26). The surface water sample from Z11 contained phenol at a concentration slightly above the MRV.

For a number of compounds analysed in near seabed waters a higher than normal MRV was specified due to an unspecified issue during the laboratory analysis. All these analytes were still recorded at levels below the revised limits of detection and there is no reason to suggest that the higher MRV meant that the concentration in the sample is any higher than the surface waters sample with lower MRV.

Table 3-26: Organic compounds in seawater in the vicinity of the Central Manifold (SW3) (Station Z11 at the Corrib Field)

Compound (µg/l)	MRV (µg/l)	Station	
		Z11 - Surface	Z11 - Seabed
Acenaphthene	0.01	<0.01	<0.01
Acenaphthylene	0.01	<0.01	<0.01
Anthracene	0.01	<0.01	<0.01
B(a)anthracene	0.01	<0.01	<0.01
B(a)pyrene	0.01	<0.01	<0.01
B(b)fluoranthene	0.01	<0.01	<0.01
Benzo(e)pyrene	0.01	<0.01	<0.01
B(ghi)perylene	0.01	<0.01	<0.01
B(k)fluoranthene	0.01	<0.01	<0.01
Chrysene	0.01	<0.01	<0.01
DiB(ah)anthracene	0.01	<0.01	<0.01
Fluoranthene	0.01	<0.01	<0.01
Fluorene	0.01	<0.01	<0.01
Indeno123cdPyrene	0.01	<0.01	<0.01
Naphthalene	0.01	<0.01	<0.01
Perylene	0.01	<0.01	<0.01
Phenanthrene	0.01	<0.01	<0.01
Pyrene	0.01	<0.01	<0.01
2,3,5,6-Tetrachlorophenol	0.02	<0.02	<0.02
2,3-Dichlorophenol	0.02	<0.02	<0.02
2,3-Dimethylphenol {2,3-Xylenol}	0.02	<0.02	<0.02
2,4,5-Trichlorophenol	0.02	<0.02	<0.02

Compound (µg/l)	MRV (µg/l)	Station	
		Z11 - Surface	Z11 - Seabed
2,4,6-Trichlorophenol	0.02	<0.02	<0.02
2,4-Dichlorophenol	0.02	<0.02	<0.02
2,4-Dimethylphenol {2,4-Xylenol}	0.02	<0.02	<0.02
2,5-Dichlorophenol	0.02	<0.02	<0.02
2,5-Dimethylphenol {2,5-Xylenol}	0.02	<0.02	<0.02
2,6-Dichlorophenol	0.02	<0.02	<0.02
2,6-Dimethylphenol {2,6-Xylenol}	0.02	<0.02	<0.02
2-Chlorophenol	0.02	<0.02	<0.02
2-Ethylphenol	0.02	<0.02	<0.02
2-Methylphenol {o-Cresol}	0.02	<0.02	<0.02
3,4-Dimethylphenol {3,4-Xylenol}	0.02	<0.02	<0.02
3,5-Dimethylphenol {3,5-Xylenol}	0.02	<0.02	<0.02
3-Chlorophenol	0.02	<0.02	<0.02
3-Methylphenol {m-Cresol}	0.02	<0.02	<0.02
4-Chloro-2-methylphenol {p-Chloro-o-cresol}	0.02	<0.02	<0.02
4-Chloro-3, 5 –dimethylphenol {PCMX}	0.02	<0.02	<0.02
4-Chloro-3-methylphenol {p-Chloro-m-cresol}	0.02	<0.02	<0.02
4-Chlorophenol	0.02	<0.02	<0.02
4-Methylphenol {p-cresol}	0.02	<0.02	<0.02
Pentachlorophenol	0.02	<0.02	<0.02
Phenol	0.05	0.102	<0.05

3.2 2016 Survey Campaign

3.2.1 SW1 Treated Surface Water Outfall

3.2.1.1 Planned and actual sample collection

The respective positions of planned sampling at SW1 are presented in Table 2-7 and Figure 2.6. Near seabed and near surface samples were collected successfully at the 3 proposed stations, within a few metres of the target positions. Water column profiles were also successfully obtained at the same time as the collection of near seabed samples.

3.2.1.2 Temperature

Temperature-depth profiles for stations W4, 7 and 12 are presented in Figure 3.15. These stations are close to the outfall diffuser (aligned with the prevailing currents) and water quality measurements and samples taken at this location are considered representative of the vicinity of the SW1 location.

While water temperature remained relatively consistent between the 3 stations as would be expected, some fluctuations were observed in the surface waters, as the equipment equilibrates and also as temperature decreases as the equipment goes from recording air to seawater temperature. Temperature decreases fairly rapidly in the surface waters becoming more consistent at a depths greater than 10m. Station W4 shows a slightly differing profile to that of W7 and W12, with an elevated temperature gradient in the surface waters. From a depth of approximately 20 m all three stations show similar profiles down to near seabed depths. At a depth of approximately 30 m temperature decreases from approximately 10.9°C to around 10.7°C at near seabed depths at around 65 m. Highest temperatures are observed in surface waters at around 11 – 11.4°C, decreasing to 10.7 °C at the seabed (a range 0.7 °C). Temperatures in surface waters differ between sampling stations, and a consistency in temperatures does not occur until depths of around 10m are reached.

The fluctuating temperatures in the surface water make it difficult to ascertain if a thermocline exists at around 10 m, however it is clear that at a depth of around 30 m that distinct stratification (thermocline) is observed. This trend is supported by the depth profiles obtained at the Corrib Field (SW3), which show a similar pattern.

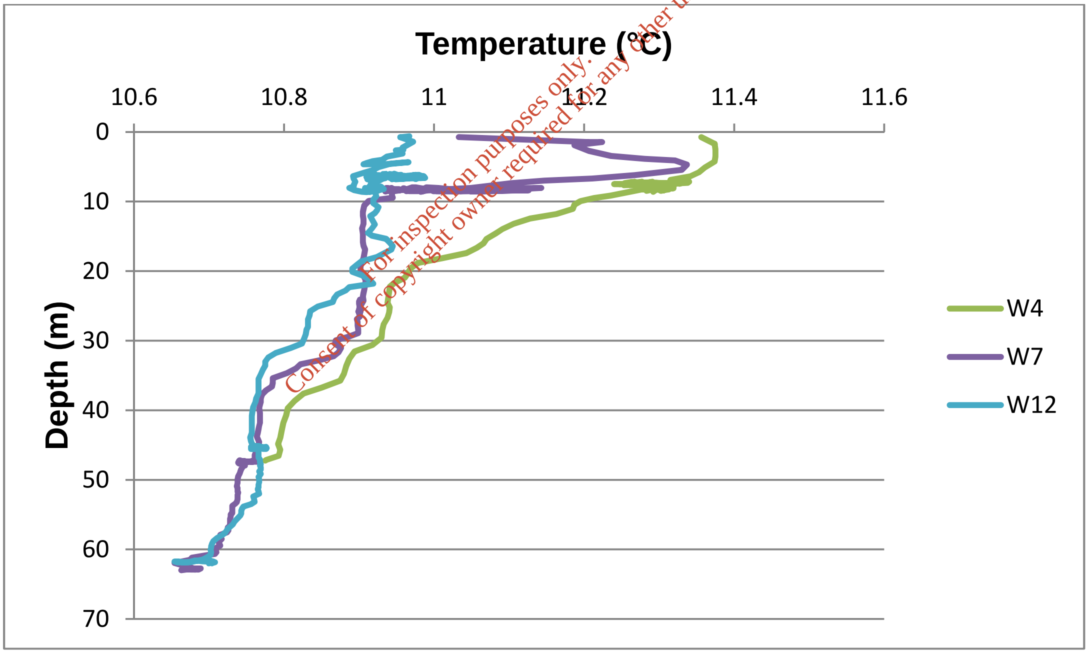

Figure 3.15: Temperature depth profiles for stations sampled in the vicinity of the treated surface water runoff outfall (SW1) off Erris Head in 2016.

3.2.1.3 Salinity

Figure 3.16 shows the salinity – depth profiles for all stations sampled in the vicinity of the SW1 outfall off Erris Head.

Salinity recorded at stations off Erris Head varied little between stations and depths. Salinity was recorded within the range 34.7 – 34.9 PSU as shown in Figure 3.16. This range of around 0.2 PSU was present in the surface waters above 10 m depth. Salinity varied little and remained around 34.8 PSU at all stations between a depth of 10 m and near seabed water depths. The recorded range in salinity in the surface waters (in particular at station W7) is likely to be due to initial acclimatisation of the CTD-DO meter as it was deployed, and is unlikely to be a true reflection of the salinities of the immediate surface waters. The slight fluctuations in salinities observed at a depth of around 10 m (observed at all stations) correspond to similar trends observed in temperature.

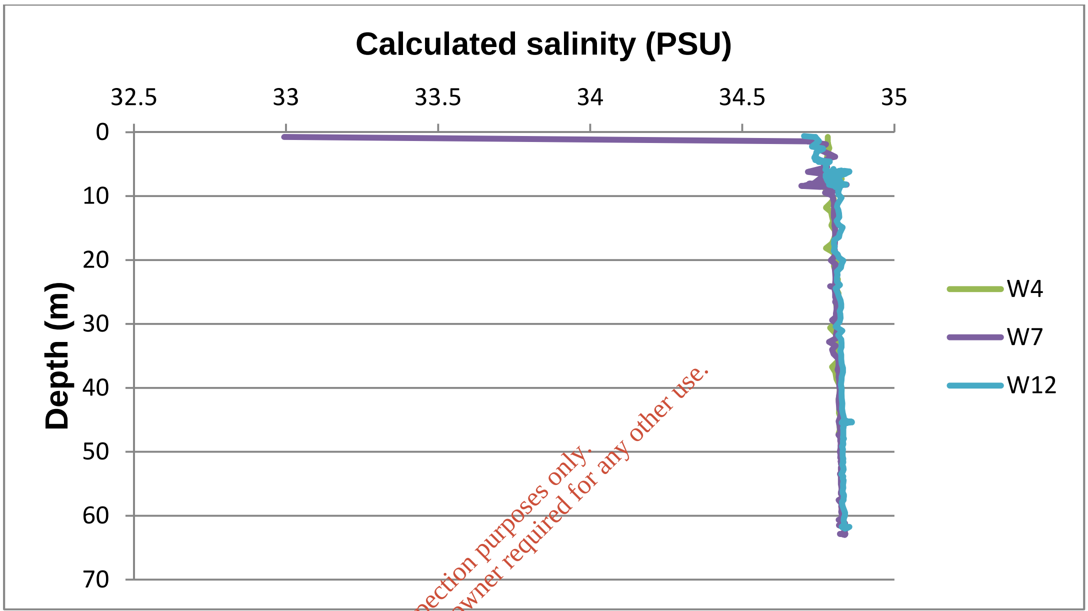

Figure 3.16: Salinity depth profiles for stations sampled in the vicinity of the treated surface water runoff outfall (SW1) off Erris Head in 2016.

3.2.1.4 Dissolved Oxygen

Figure 3.17 shows profiles of dissolved oxygen saturation in the water column for stations in the vicinity of the SW1 outfall off Erris Head.

Profiles of dissolved oxygen saturation are consistent between stations in the vicinity of SW1. In all cases dissolved oxygen saturation increases with depth until a depth of around 45 m, at which point it noticeably decreases, before remaining constant for approximately 10 -12 m depth, before showing a noticeable decrease again at near seabed depths.

The overall range in dissolved oxygen saturation varies between 77% at station W7 in surface waters and 93% at station W4 at a depth of around 48 m. The overall range is therefore 16%.

Observed at all 3 stations, and similar to the observations made for both temperature and salinity, a noticeable fluctuation in dissolved oxygen saturation is observed in the surface waters at around 7-10 m water depth. In the case of all 3 stations dissolved oxygen decreases markedly, before continuing on an increasing trend as depth increases beyond 10 m.

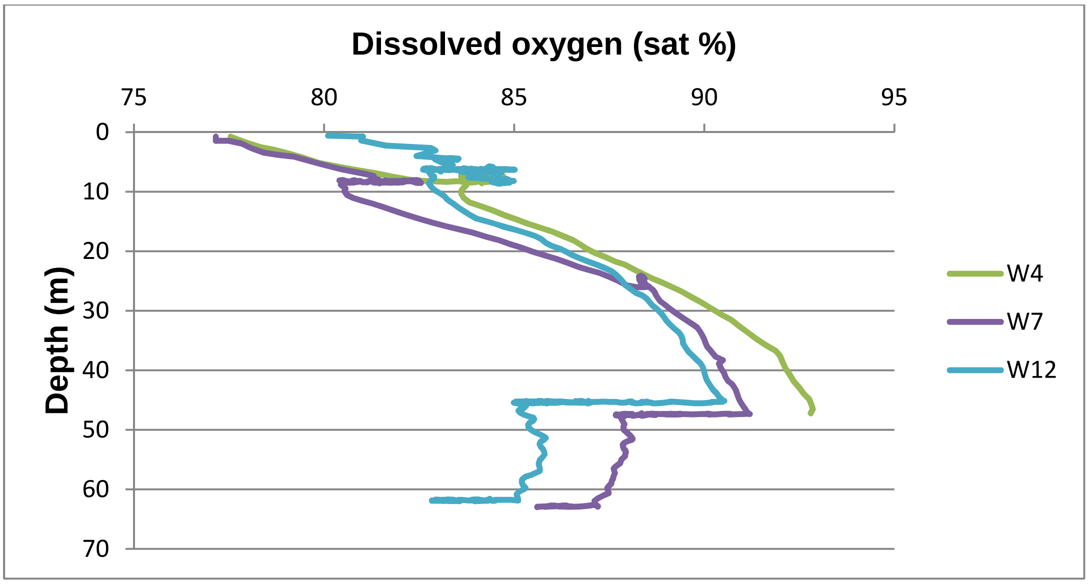

Figure 3.17: Dissolved oxygen - depth profiles for stations sampled in the vicinity of the treated surface water runoff outfall (SW1) off Erris Head in 2016.

3.2.1.5 Turbidity

Figure 3.18 shows profiles of turbidity against depth in the water column for stations in the vicinity of the SW1 outfall off Erris Head. There are some fluctuations in the readings from the equipment, but the general trend shows that turbidity is uniform at around 1 FTU. This trend is observed at all 3 stations recorded. Variation is observed at Station W7 in the surface waters, and it is considered likely that this is due to the equipment becoming acclimated as it is first put into the water.

Seawater turbidity is low, as is to be expected in an open ocean environment, with little input from rivers and coastal waters that can be a source of elevated levels of suspended sediments that increase turbidity.

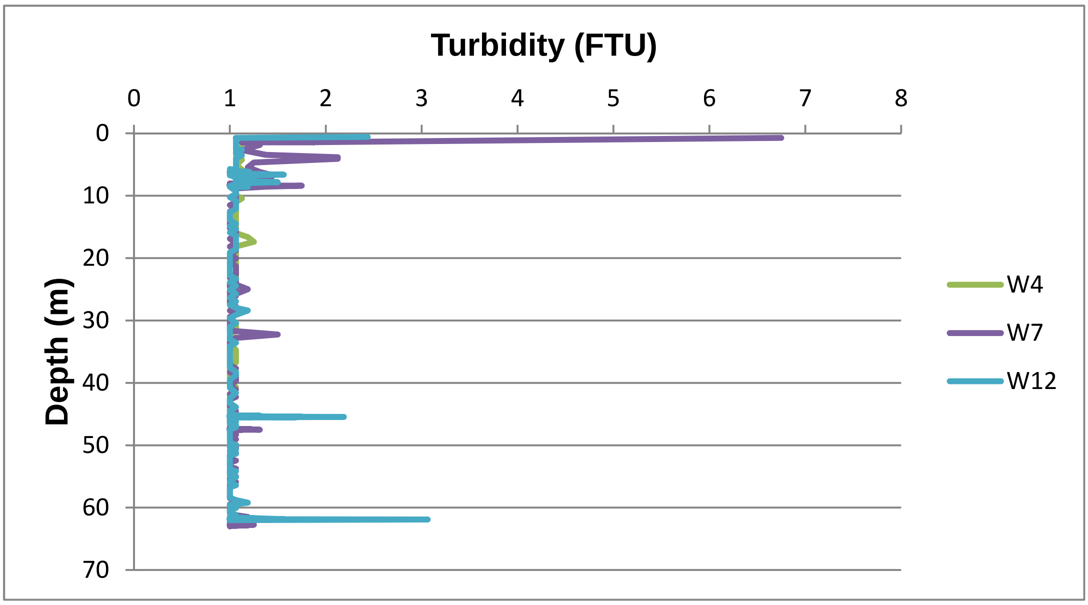

Figure 3.18: Turbidity - depth profiles for stations sampled in the vicinity of the treated surface water runoff outfall (SW1) off Erris Head in 2016.

3.2.1.6 pH

Figure 3.19 shows pH - depth profiles for stations sampled in the vicinity of the SW1 outfall off Erris Head.

The data shows variation in the surface waters, before following a more stable profile that shows little variation in pH with increased depth below around 10 m.

pH at stations W4 and W7 show similar profiles with depth at around 5.7-6.2, while Station W12 shows much more variability in the surface waters (likely to be the result of the equipment acclimating) before following a more stable reading at around 6.3.

Both Station W7 and W12 show a fluctuation in pH at around 45-48 m water depth.

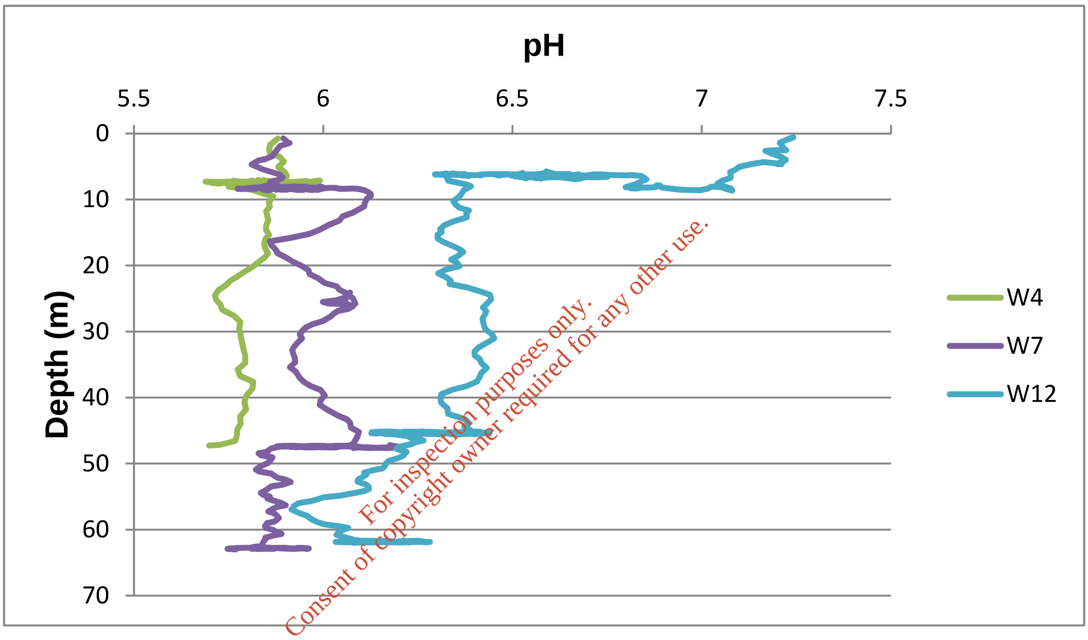

Figure 3.19: pH - depth profiles for stations sampled in the vicinity of the treated surface water runoff outfall (SW1) off Erris Head in 2016.

3.2.1.7 Water Samples

The results for the analysis of nitrates, phosphates and silicates in both near surface and near seabed seawater samples from stations in the vicinity of the SW1 outfall are presented in Table 3-27.

All nutrient concentrations were below their respective limits of detection at all near surface and near seabed samples with the exception of total phosphorous in the near surface water sample at Station W4. The recorded value in this sample was 0.493 mg / l.

The very low levels of nutrients recorded in the vicinity of the Erris Head SW1 outfall are reflective of the pristine nature of this fully marine environment.

Table 3-27: Nutrients in seawater samples from stations in the vicinity of the SW1 outfall.

Station	Analyte (mg/l)		
	Nitrogen (Total Oxidised Nitrogen)	Silicate (reactive as SiO2)	Phosphorous (Total)
Minimum Reportable Value (MRV) (mg/l)	*0.2*	*0.2*	*0.02*
Station W4 - Surface	<0.2	<0.2	0.0493
Station W4 – Seabed	<0.2	<0.2	<0.02
Station W7 - Surface	<0.2	<0.2	<0.02
Station W7 - Seabed	<0.2	<0.2	<0.02
Station W12 - Surface	<0.2	<0.2	<0.02
Station W12 - Seabed	<0.2	<0.2	<0.02

3.2.2 SW3 Corrib Field

3.2.2.1 Planned and actual sample collection

Threspective positions of planned sampling at SW3 are presented in Table 2-7 and

Figure 2.5. Near seabed and near surface samples were collected successfully at the 3 proposed stations, within a few metres of the target positions. Water column profiles were also successfully obtained at the same time as the collection of near seabed samples.

3.2.2.2 Temperature

Temperature-depth profiles for stations in the vicinity of the SW3 Corrib Field central manifold are presented in Figure 3.20.

All stations sampled at the Corrib Field in 2016 exhibit temperature depth profiles that are consistent with each other. Temperature varies between 11.4 °C in surface waters and 9.8 °C at approximately 300 m water depth. Greatest variation in temperatures is observed in surface waters at all stations, and temperature reduces to around 10 °C at a depth of around 40 m and then is relatively consistent at around this temperature, showing a very gradual reduction toward seabed depths.

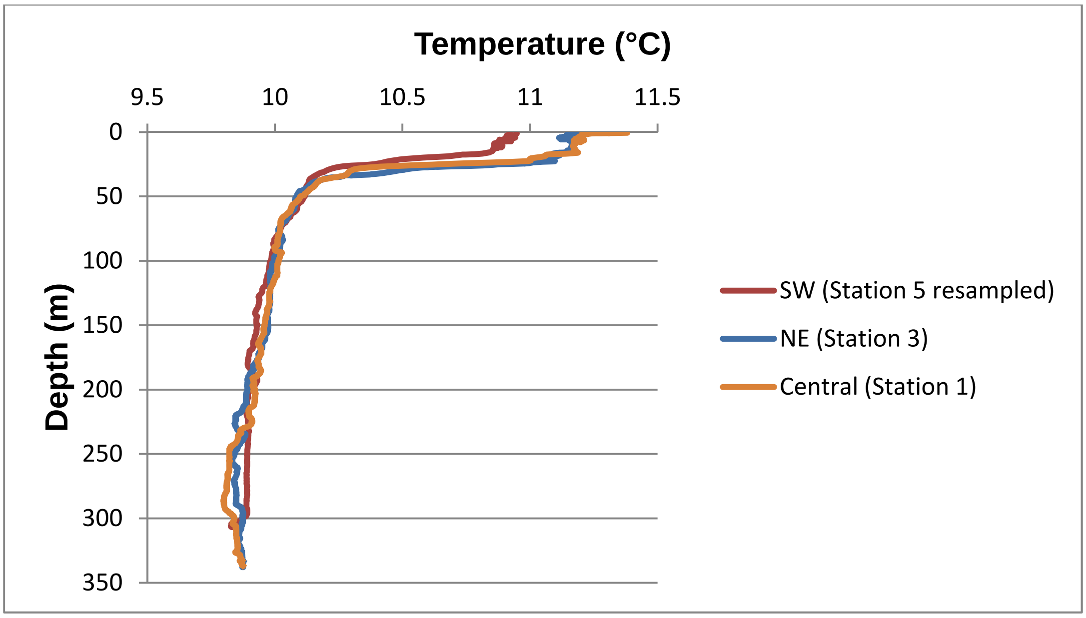

Figure 3.20: Temperature- depth profiles for stations sampled in 2016 in the vicinity of the SW3 outfall at the Corrib Field.

3.2.2.3 Salinity

Salinity-depth profiles for stations in the vicinity of the SW3 Corrib Field central manifold are presented in Figure 3.21.

As with the majority of profiles, a degree of fluctuation is observed in the immediate surface waters as the equipment acclimates to the ambient conditions. The general trend in the salinity profiles is relatively uniform with increasing depth. Salinity does gradually increase, and highest salinities are observed at all 3 stations at near seabed depths. The overall range in observed salinities (when obvious equipment acclimatisation readings are discounted) is between 35.1 PSU and 35.35 PSU.

Lowest salinities are observed in surface waters, while highest salinities are observed in near seabed water depths.

A degree of fluctuation in salinities are observed for all stations in shallower waters. Fluctuations are greatest at a water depth of around 20-30m. Below this depth the salinity profiles take on a more uniform shape, showing only a very gradual increase with depth.

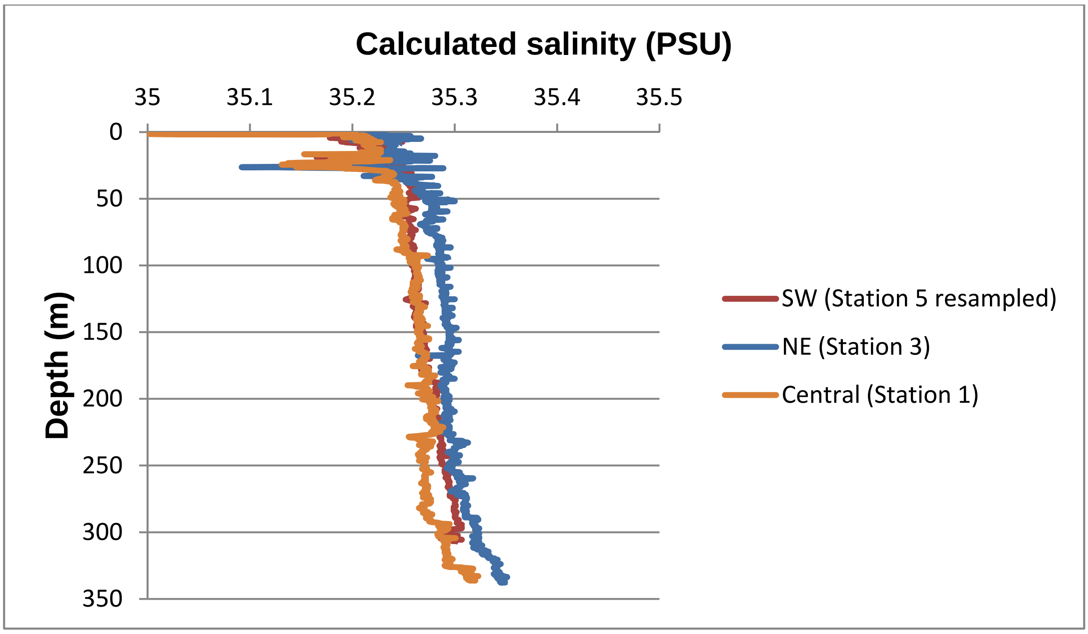

Figure 3.21: Salinity depth profiles for stations sampled in 2016 in the vicinity of the SW3 outfall at the Corrib Field.

3.2.2.4 Dissolved Oxygen

Figure 3.22 shows profiles of dissolved oxygen saturation in the water column for stations in the vicinity of the SW3 outfall at the Corrib Field.

The dissolved oxygen saturations for the 3 stations sampled at the Corrib Field differ, however they do all show similar profiles. Station 3 shows a markedly higher degree of oxygen saturation throughout the water column than either station 1 or 5, while station 5 is lower than would be expected. The profile at Station 5 is considered to be anomalous, as it is so much lower than any of the other profiles recorded at all other stations. The possible reasons for the disparity between the profiles at the 3 stations will be explained in the Discussion sections of this report.

Fluctuating readings are observed in the surface waters at all 3 stations as the equipment acclimates during initial deployment. In the case of all 3 stations oxygen saturation initially increases before decreasing to its lowest levels at a water depth of around 50 m. Oxygen levels then increase gradually with increasing depth, with maximum saturation levels observed at all stations at an approximate water depth of 200 m. Between 200m and near seabed depths the trend shows a gradual decrease in oxygen levels.

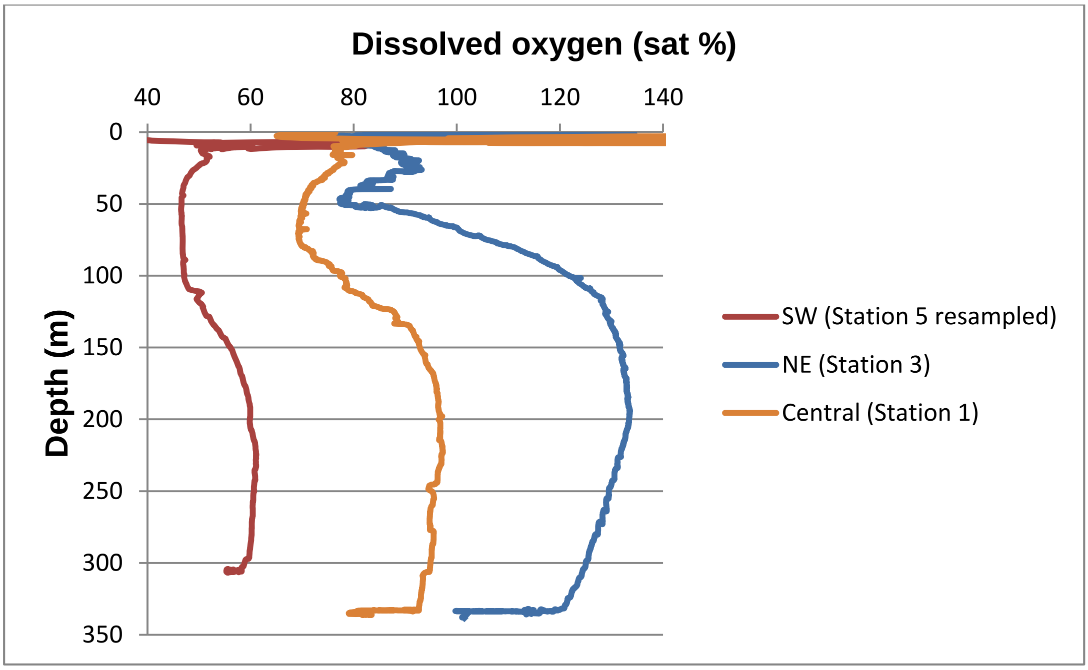

Figure 3.22: Dissolved oxygen saturation depth profiles for stations sampled in 2016 in the vicinity of the SW3 outfall at the Corrib Field.

3.2.2.5 Turbidity

Figure 3.23 shows profiles of seawater turbidity against depth in the water column for stations in the vicinity of the SW3 outfall at the Corrib Field.

Based on the profiles obtained for the 3 sampling stations at the Corrib Field it can be determined that turbidity levels are uniform with depth throughout the water column. A degree of variation is observed in surface waters, and all stations show an initial decrease in the upper 30-40 m. Below 50 m the profile is relatively uniform for all stations at approximately 1 FTU throughout the rest of the water column.

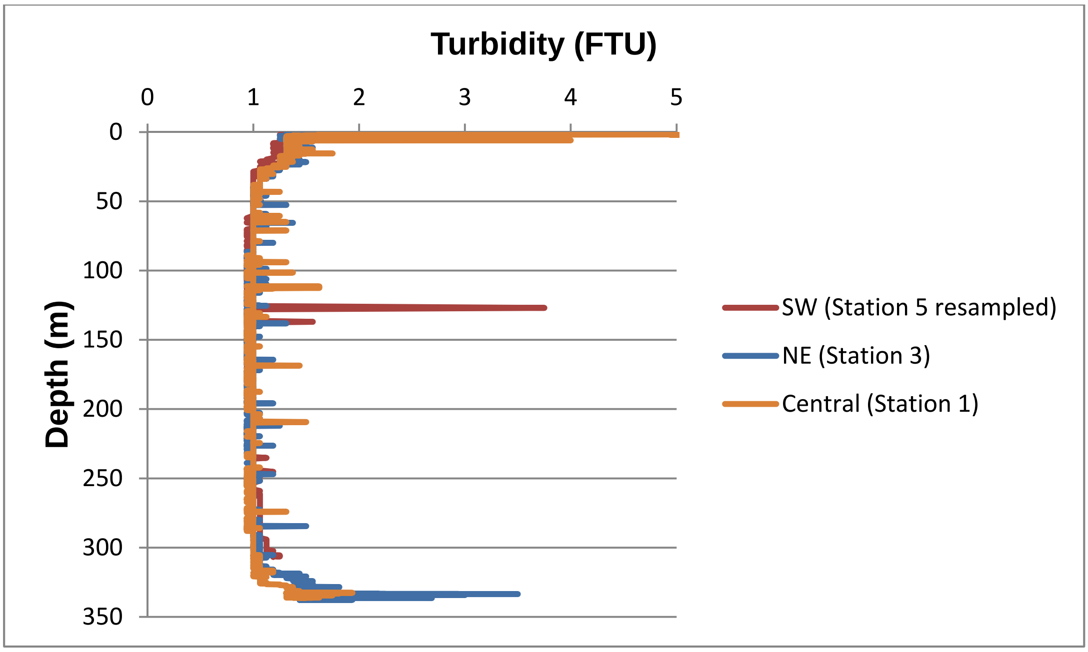

Figure 3.23: Turbidity - depth profiles for stations sampled in 2016 in the vicinity of the SW3 outfall at the Corrib Field.

3.2.2.6 pH

Figure 3.24 shows profiles of pH against depth in the water column for stations in the vicinity of the SW3 outfall at the Corrib Field.

The pH profiles at the Corrib Field show profiles that are relatively consistent between sampling stations.

A degree of variation in surface waters is observed as the equipment acclimates during deployment. pH is shown to be in the range of 5.8 – 6.5 (once errors for equipment acclimatisation are removed).

The general trends show a gradual decrease in pH with increased depth to approximately 100 m). Between 100 m and 150 m (200 m for station 5) the trend shows an increase in pH. pH then decreases to lowest levels at between 200 m and 230 m water depth, and is then fairly uniform with increasing depth to near seabed depths.

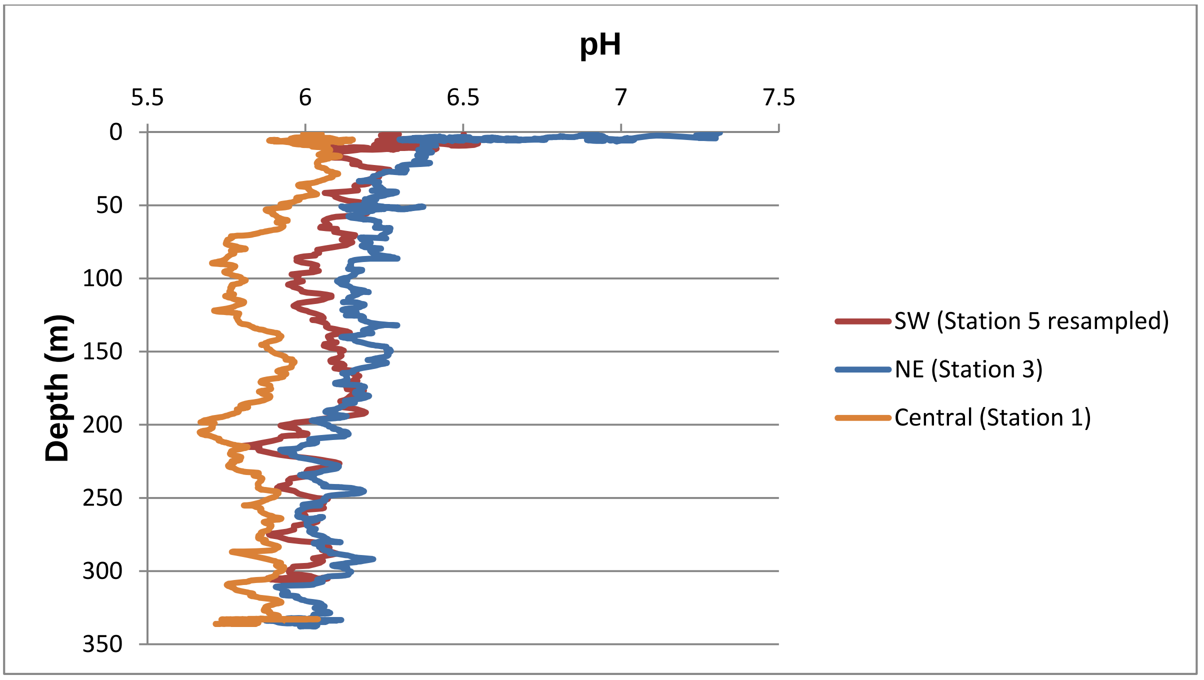

Figure 3.24: pH - depth profiles for stations sampled in 2016 in the vicinity of the SW3 outfall at the Corrib Field.

3.2.2.7 Water Samples

The results for the analysis of nitrates, phosphates and silicates in both near surface and near seabed seawater samples from stations in the vicinity of the SW3 outfall at the Corrib Field are presented in Table 3-28.

All nutrients concentrations were below their respective limits of detection at all near surface and near seabed samples with the exception of silicates in near seabed water samples at all 3 stations sampled. The recorded values for silicates in these near seabed samples were slightly above the MRV of 0.2 mg / l. In the near seabed samples at Stations 1 and 5 silicate concentrations of 0.23 mg/l were recorded, while in the near seabed sample at Station 3 the silicate concentration was 0.21 mg/l.

Silicates in near seabed samples were considered very low..

Overall the very low levels of sampled nutrients recorded in the vicinity of the SW3 outfall at the Corrib Field are considered to be reflective of the pristine nature of this fully marine environment.

Table 3-28: Nutrients in seawater samples from stations in the vicinity of the SW3 outfall at the Corrib Field.

Station	Analyte (mg/l)		
	Nitrogen (Total Oxidised Nitrogen)	Silicate (reactive as SiO_2)	Phosphorous (Total)
Minimum Reportable Value (MRV) (mg/l)	*0.2*	*0.2*	*0.02*
Station 1 (Central) - Surface	<0.2	<0.2	<0.02
Station 1 (Central) – Seabed	<0.2	0.230	<0.02
Station 3 (NE) - Surface	<0.2	<0.2	<0.02
Station 3 (NE) - Seabed	<0.2	0.210	<0.02
Station 5 (SW) - Surface	<0.2	<0.2	<0.02
Station 5 (SW) - Seabed	<0.2	0.230	<0.02

4 DISCUSSION

4.1 2014 Survey Campaign

4.1.1 SW-1 Treated Surface Water Outfall

4.1.1.1 Seabed Photography

The 2014 survey was the first to use seabed photography techniques to provide a more detailed picture of the seabed conditions in the vicinity of the SW1 Treated Surface Water Outfall. The results obtained provided a useful additional reference to compliment the results of sampling for sediment physico chemistry and infauna.

The seabed photographs concur with the sampling results, however they are also able to provide a wider picture of conditions that cannot be obtained solely from sampling, which provides information (albeit very detailed) for only a very small area. The imagery shows the degree of sand rippling on the seabed, highlighting the relatively high degree of hydrodynamic energy in the vicinity of the SW1 Treated Surface Water Outfall. It also shows the mosaiced distribution of the seabed sediments and how they range between fine sand – coarse sand – exposed bedrock within a very limited spatial extent.

The seabed images provided further evidence of the variation in surface biota at/and between the sites in the vicinity of the SW1 Treated Surface Water Outfall. The surface biota observed reflected the seabed substrates in a given area. As expected the highest numbers and greatest diversity of species of conspicuous fauna observed were in areas of hard rock substrate. Typical seabed sampling techniques (grab sampling) would not provide data from these sites. In these areas the seabed faunal community differed significantly from any data that was obtained through grab sampling. Accordingly, due to the patchy seabed habitat distribution observed, biotope descriptions at all sites would be expected to differ within a relatively short spatial extent from those provided in Section 3.1.1.4, which is based on the sediment infaunal results obtained from the grab sampling.

4.1.1.2 Sediment Physico-Chemistry

The physical characteristics of the sediment sampled in the vicinity of the SW1 Treated Surface Water Outfall were relatively consistent between the 2014 survey and previous surveys. Median grain sizes for samples taken in 2014 were in a similar range to those observed in previous surveys and all stations are still characterised by the presence of very little fine material. Both Folk and Udden Wentworth classifications are similar between the 2014 survey and previous ones. The notable exception is S6R which is described as gravel in 2014, but previously was recorded as very coarse sand according to the Udden Wentworth classification.

TOC is low, but also in a similar range to that observed in previous surveys.

4.1.1.3 *Sediment Chemistry*

Metals

Metal concentrations in sediment results for 2014 were very similar to those from previous surveys at the SW1 Treated Surface Water Outfall in 2007 and 2008. Metal concentrations in sediments were overall considered to be low, as would be expected in an area with minimal anthropogenic activity.

To determine the degree of any anthropogenic contamination in marine sediments, it is useful to compare observed metal concentrations in sediment with the following values:

- OSPAR (Northeast Atlantic)
  - Background Reference (**BC**)
  - Ecotoxicological Assessment Criteria (**EAC**), with lower and upper limits.
- Environment Canada
  - Threshold effects level (**TEL**): the concentration above which metals may start to be harmful to organisms; and
  - Predicted effects level (**PEL**): the concentration above which metals are likely to become harmful to organisms.

Metal concentrations from the 2014 survey in comparison to the results of the 2008 survey and the international reference values described above are presented in Table 4-1.

Table 4-1: Comparison of observed sediment metals data at SW1 to international standards

Metal	2014 SW1 Treated Surface Water Outfall station range	2008 SW1 Treated Surface Water Outfall station range	OSPAR			Upper limit exceeded?	Environment Canada		PEL exceeded?
			BC	EAC limits Lower	EAC limits Upper		TEL	PEL	
	mg/kg dry weight								
As	2.41 – 12.1	0.43–17.1	15	1	10	Yes	7.24	41.6	No
Cd	0.039 – 0.104	0.031–0.128	0.2	0.1	1	No	0.676	4.21	No
Cr	3.72 – 38.7	3.84–31.7	60	5	50	No	52.3	160	No
Cu	1.54 – 14.2	1.52–4.36	20	5	50	No	18.7	108	No
Hg	0.00213 – 0.004	<0.001–0.0034	0.05	0.05	0.5	No	0.13	0.7	No
Ni	1.78 – 4.75	0.78–6.96	30	5	50	No	15.9	42.8	No
Pb	2.84 – 9.63	3.47–19.5	25	5	50	No	30.3	112	No
Zn	6.28 – 21.5	8.9–19	90	10	100	No	124	271	No

It is also informative to compare observed values with reference data available from the UK. These data are presented in Table 4-2.

Table 4-2 Comparison of observed sediment metals data at SW1 to UK data

Metal	2014 SW1 Treated Surface Water Outfall station range	Liverpool Bay[1]	Cumbrian coast[2]	Scottish Minches[3]	North Sea[4]
	mg/kg dry weight				
As	2.41 – 12.1	No data	No data	4.3	1.2–33 (mean 11)
Cd	0.039 – 0.104	0.3–2.1	0.007–0.46	0.018	0.01–0.38– (mean 0.05)
Cr	3.72 – 38.7	0.5–35.9	10.7–85.8	57	No data
Cu	1.54 – 14.2	1.8–33.7	1.8–49.4	7.3	0.1–87 (mean 14)
Hg	0.00213 – 0.004	0.01–1.44	0.005–0.17	0.05	75% <0.025
Ni	1.78 – 4.75	1.2–16.5	No data	6.4	1.5–113 (mean 23)
Pb	2.84 – 9.63	6.9–101	10.3–69.7	24	1.7–288 (mean 21)
Zn	6.28 – 21.5	9.4–327	22.4–129.4	45	3–510 (mean 39)

Sources: 1 Taylor, 1986; 2 Nixon, 1985; 3 FRS/SEPA, 1998; 4 NSTF, 1993

Sediment metal results from the 2014 survey can be summarised as follows:

- Results from 2014 are in a similar range to those recorded during the 2008 survey and are as expected for an area with both little or no anthropogenic impact and low levels of fine material (with which many metals are generally associated).

- Results are generally well below concentrations that could potentially give rise to any biological effects, and hence give no cause for concern. No parameters recorded exceed the Environment Canada Predicted Effects Level (the concentration above which metals are likely to become harmful to organisms). And with the exception of arsenic do not exceed the upper limit of the OSPAR Ecotoxicological Assessment Criteria. This trend is similar to the results from 2008.

- Arsenic levels at a single station (S6) exceeded the OSPAR EAC upper limit (in 2008 a similar exceedence was observed at Station S2), although this does not exceed the PEL. This result is not unexpected and reflects the naturally high levels of this element present in Donegal Bay. Higher levels of arsenic have also been found in intertidal sediment in Sruwaddacon Bay, as well as the aforementioned elevated level from the 2008 survey at the SW1 Treated Surface Water Outfall. As such, these data are not a cause for concern.

- In general, metal concentrations were either at the lower end of, or similar to, the ranges encountered around the UK coast.
- The results reflect a pristine environment with little evidence for departures from typical background levels, and do not show any notable differences from the results at the same locations sampled in 2008.

Hydrocarbons

Total hydrocarbons recorded in the sediments at stations in the vicinity of the SW1 Treated Surface Water Outfall were considered low, reflecting the lack of anthropogenic influences.

Results from the present study are compared against reference criteria in Table 4-3. In all cases with the exception of naphthalene at Station S9, recorded PAH concentrations were below the detection levels for the analyses. The positive recorded level for naphthalene is likely to be an anomalous reading considering the results at other stations, and the levels of other compounds recorded at this station. This is further supported by the results from the 2008 survey. With the exception of the result for naphthalene at station S9, results for PAH's are similar or less than those recorded during the 2008 survey. Notably, the recorded concentration of naphthalene (15.1 µg/kg) at station S9 was well below the Environment Canada TEL and PEL and not at a concentration of potential concern.

The hydrocarbons in sediments results indicate a pristine environment with little or no anthropogenic influence.

Table 4-3: Comparison of observed sediment PAH data at SW1 to international standards. 2014 analysis MRV shown in brackets

PAH	Environment Canada		OSPAR*		2014 SW1 Treated Surface Water Outfall station max. (MRV µg/kg)
	TEL	PEL	*BC*	*BAC*	
	µg/kg				
Acenaphthene	6.7	88.9	-	-	*nd* (1)
Acenaphthylene	5.9	128	-	-	*nd* (1)
Anthracene	46.9	245	3	5	*nd* (1)
Benz(a)anthracene	74.8	693	9	16	*nd* (1)
Benzo(a)pyrene	88.8	763	15	30	*nd* (1)
Benzo(b)fluoranthene	No data	No data	-	-	*nd* (1)
Benzo(g,h,i)perylene	No data	No data	45	80	*nd* (1)
Benzo(k)fluoranthene	No data	No data	-	-	*nd* (1)
Chrysene	108	846	11	20	*nd* (3)
Dibenz(a,h)anthracene	6.2	135	-	-	*nd* (1)
Fluoranthene	113	1,494	20	39	*nd* (1)
Fluorene	21.2	144	-	-	*nd* (5)

Indeno(1,2,3,cd)pyrene	No data	No data	50	103	*nd* (1)
Naphthalene	34.6	391	5	8	15.1 (5)
Phenanthrene	86.7	544	17	32	*nd* (5)
Pyrene	153	1,398	13	24	*nd* (1)

*Note the BC and BAC sediment figures are listed as a dry weight normalised to 2.5% organic carbon, whereas the Corrib SW1 Treated Surface Water Outfall samples were not normalised, however the majority of the data have organic carbons of <1%

(TEL = threshold effects level, PEL = probable effects level, BC = background concentration, BAC = background assessment concentration)

4.1.1.4 Sediment Macrofauna

The data generated from this study were compared with that produced in the 2007 and 2008 survey of the same area (RSK, 2008, 2009). To ensure consistency in data and to avoid identifying changes solely due to disagreement in species identification some results were reported at the genus level. Per site (average replicate) data was used during this analysis to reduce noise in the dataset.

Samples from site S2, S6 and S6R were sub sampled as described in Section 2.1.6.3 and therefore only 50 % of the samples from these sites were analysed. This was not a consistent practice throughout the 3 baseline surveys that have been undertaken here. This reduction in sample size may have lead to fewer species being recorded and a reduction in the estimated total abundance.

To lessen the effect of inconsistent sample sizes, species which contributed less than 3 % to the total abundance for that sample were removed as recommended and described by Clarke and Warwick (2001). Resulting values were squared root transformed prior to multivariate analysis.

It is also noteworthy that many of the sites sampled in 2007 were re-located in 2008 due to difficulties in being able to obtain samples at these sites (the mosaic type seabed substrate distribution can be observed clearly in Figure 3.3). The 2014 survey replicated the 2008 locations as closely as possible.

Core communities, those which contributed to more than 3 % of total abundance at each site, changed little throughout the study area, both in terms of community composition and how they were related to each other during the 3 survey periods (2014, 2008, and 2007).

An analysis of similarity ANOSIM performed upon the reduced dataset found that even though there were significant differences between sites, no significant differences lay between year groups. This test was repeated to include the whole dataset (previously those stations that were sub sampled were excluded) and significant differences were found between years. It is difficult to ascertain as to whether this is due to the inconsistencies with sampling protocol (sub sampling at S2, 6, and 6R) or an actual change in the whole communities, albeit the rarer species, had occurred. However, the species which are typical to these assemblages remained consistent.

In summary, the sites in the study area supported communities of moderate to high diversity which could be separated into two general biotope types- sublittoral coarse sand communities and sublittoral sand communities. Sites S2, S6 and S6R consisted of species typical of coarser sediment such as nematodes, nemerteans and the polychaetes *Pisione remota, Hesionura elongata* and *Polygordius*, species of syllid polychaete, the polychaetes *Glycera lapidum* and *Protodorvillea kefersteini* and robust molluscs such as venerid and *Spisula* bivalves whereas communities at site S9, S10 and S17 were characteristic of finer sediments and included species such as the pea urchin, *Echinocyamus pusillus*, sea potato, *Echinocardium flavescens*, the tellind bivalve *Abra pristmatica*, the spionid polcyhaete *Spiophanes bombyx* and the sand-tube dwelling polychaete *Owenia borealis*.

Site 11 contained species common to those identified at site S2, S6 and S6R but also had species such as *Echinocyamus pusillus* and *Abra prismatica* which are more typical of finer sediments.

Grain size proved to be an important factor in determining community composition within the study area. There were very strong correlations between assemblage type and the grain sizes 177-250 µm, 250-354 µm, 500-707 µm which broadly represented fine sand, medium sand and coarse sand respectively. In addition, concentration of aluminium was found to be an important factor in explaining the observed variance between communities (higher aluminium levels are typically associated with higher levels of fine sediment particle sizes). However, these concentrations showed only slight variations between sites S2, S6 and S6R and all other sites.

Sediments were found to be coarser at sites S2, S6 and S6R than other sites. This finding was analogous to those detected in the biological analysis which identified species typical of coarse sediments at sites S2, S6 and S6R and species characteristic of finer sediments at other sites.

Temporal analysis showed that the communities had changed little over the 3 survey periods of 2007, 2008 and 2014 and that no significant differences were identified between the 'core' communities, those which made up more than 3 % of the abundance, at each site in 2007, 2008 and 2014. Any observed differences, particularly at site S11, could be explained by the re-positioning of sites in 2008 due to sampling difficulties encountered at that time.

4.1.1.5 Seawater Quality

Temperature

The temperature profile indicated that the surface water in the vicinity of the SW1 Treated Surface Water Outfall (recorded in 2014) was relatively well mixed to a depth of between 50-70 m, below which the temperature began to reduce. This trend was observed during the survey at the SW1 Treated Surface Water Outfall in 2013.

Temperatures were noticeably cooler off Erris Head during the surveys undertaken in the vicinity of the SW1 Treated Surface Water Outfall in 2013 compared to during this survey, however these results are broadly in line with those recorded during the surveys in 2007 and 2008. Highest surface temperatures during these earlier surveys were 15.82 °C and 14.23 °C in 2007 and 2008 respectively, compared with 12.3 °C in 2013. Highest surface temperature recorded during this survey was 15.13 °C. Differences between the 2013 temperatures and the surface temperatures recorded during this survey and 2007 and 2008 are to be expected, given the differing times of the year at which the surveys took place. The 2007 and 2008 surveys were conducted during the summer months; the 2014 survey was conducted during late September / early October, while the 2013 survey was conducted in November. Other variations are also to be expected as a result of diurnal temperature fluctuations (i.e. time of day of sampling) and the effect of other factors such as wind, tidal state and rainfall. The 2013 survey was conducted at night, while the water sampling during the 2014 survey was undertaken in daylight.

Data for both 2007 and 2008 show obvious thermal stratification at around 40-50m water depth off Erris Head, which was considered to be typical for summer months in temperate waters. This stratification was observed to a lesser degree during the 2014 survey, but at a slightly deeper depth, but no stratification was observed during the 2013 survey. It is likely that the seasonal thermocline observed during the 2007 and 2008 (summer) surveys had broken down, or was in the process of breaking down during the autumn months when sampling was carried out in 2013, and was either in the process of breaking down or had moved deeper at the time of the 2014 survey. This would result in the well mixed surface water column and less pronounced deeper thermocline that was observed during the 2014 survey.

Salinity

The salinity profile for the SW1 water column recorded in 2014 mirrors the temperature profile. Salinity is relatively stable (albeit marginally increasing) from the surface waters to around 60 m at which point fluctuations occur and salinity begins to increase. At SW1 this water depth roughly coincides with the seabed.

Salinities recorded during the surveys of 2007 and 2008 were marginally lower than recorded in 2013 and during the 2014 survey. Salinities recorded in 2013 and 2014 are similar (being slightly in excess of 35 PSU throughout much of the water column), with the salinities recorded in 2014, being very slightly lower than 2013. These minor variations may well be the result of slightly different equipment being used as well as slight seasonal variations with regards to the amount of freshwater input.

The salinity profile recorded in 2014 was considered consistent with a fully marine environment, with little or no freshwater influence.

Water Samples

Suspended Particulate Matter (SPM)

The non-detectable levels of SPM off Erris Head are considered indicative of the high clarity Atlantic waters sampled, with little local freshwater (and/or fine sediment) input. These results compare similarly with the surveys in 2007 and 2008, where all water samples were below the levels of detection. In 2013 water samples recorded levels of SPM in the range <0.3 – 4.7 mg/l.

Ammoniacal Nitrogen

This was non-detectable (i.e. <0.01mg/l) at the sampled station (W12) in the vicinity of the SW1 Treated Surface Water Outfall. These results are consistent with levels recorded during 2013, and would tend to indicate an unsurprising lack of anthropogenic influence (e.g. from fertiliser run-off).

Ammoniacal nitrogen levels can show a degree of seasonal variation; however the 2014 and 2013 results (both sampled in autumn) were comparable with those of the 2008 survey, and to a lesser extent with results from 2007 collected in the vicinity of the SW1 Treated Surface Water Outfall location despite these surveys taking place during summer months. A good comparison can be made with the EQS for un-ionised ammonia as nitrogen as stated in the Water Framework Directive (WFD) list of priority substances (WFD, 2015). The EQS for a good standard for transitional and coastal waters for ammoniacal nitrogen is 0.021 mg/l, which is considerably higher than the levels recorded at SW1 in 2014.

Metals

Table 4-4 shows the ranges in concentrations of metals in seawater samples collected at station W12 (near surface and near seabed samples) during the 2014 survey in the vicinity of the SW1 Erris Head outfall. The results are compared with other published sources of background data for oceanic seawater in the same general region, and previous surveys from 2007, 2008, and 2013.

The range of metal concentrations in the samples from 2014 compare very similarly with the results from the previous surveys as well as regional published data sources for oceanic seawater.

The results also correspond very well with the results of coastal water quality monitoring undertaken by the Marine Institute in 2004, 2005 and 2012, as well as the EQS levels for a number of priority substances under the Water Framework Directive.

The results continue to show that the waters off Erris Head have low concentrations of metals, well below the respective EQSs shown in Table 4-5, which is to be anticipated given the open nature of the outfall location, and low levels of anthropogenic input in the area.

Table 4-4: Measured metal concentrations at SW1 (Erris Head) compared with other published sources of regional data. NB. The data range from the 2014 survey has been converted to mg/l to aid comparison

Metal	2007	2008	2013	2014	Oceanic concentrations*	Marine Institute#	Marine Institute 2012^	Water Framework Directive Good Standard EQS Priority Substances 2015 for transitional and coastal waters
	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Arsenic	0.00109–0.00156	<0.001 – 0.00145	0.00112 – 0.0014	0.00104 - 0.0011		0.00115	0.001176 – 0.001443	0.025
Barium	<0.1	<0.1						-
Cadmium	<0.00004	<0.00004	<0.00003	<0.00003	0.00005	0.000055	<0.00005	0.00045
Chromium	<0.0005	<0.0005	<0.0005	<0.0005		0.000168	0.000109 – 0.000511	0.0006 (Chromium VI)
Copper	<0.0002–0.00245	<0.0002 – 0.00121	<0.0002 – 0.000643	0.00112 – 0.00188	0.0005	0.000659	0.0001 – 0.000386	-
Lead	<0.00004–0.000545	0.000056 – 0.0408	0.000047 – 0.000323	0.000153 – 0.00147	0.00003	0.00084	<0.0001	0.014
Mercury	<0.00001–0.00001	<0.00001-0.000019	<0.00001 – 0.0000245	<0.00001	0.0001–0.0004	<0.000008	<0.00001 – 0.000078	0.00007
Nickel	<0.00025–0.0011	<0.0003–0.00035	<0.0003 – 0.000305	<0.0003		0.0012	0.000084 - 0.000309	0.034
Silver	<0.001	<0.001	<0.001	<0.001		<0.001	<0.00005	-
Zinc	0.00097–0.00842	0.00139 – 0.0295	0.000455 – 0.00207	0.00791 – 0.0184	0.005	0.011	<0.001 – 0.00732	0.0068 plus ambient background concentration of c.0.0004

* - concentrations taken from OSPAR Region III QSR, 2000

- lowest concentrations measured for each metal during Marine Institute surveys of Shellfish waters around Ireland between winter 2004 and winter 2005

^ - 2012 data collected by the Marine Institute from 7 coastal locations around the coasts of the north west coast of Ireland under the Water Framework Directive (WFD) and Shellfish Waters Directive (SWD). Locations are: Blacksod Bay, Westport Bay, Achill Sound South, Achill Sound North, Broadhaven Bay, Donegal Bay, and Killala Bay.

Table 4-5: Ranges of metal concentrations in seawater samples from the 2014 survey at SW1 compared to international published reference sources and EQS's

Metal	2014 Erris Head (SW1) outfall range	EQS	BRC	EAC	WFD EQS (2015)
	µg/l				
As	1.04 -1.10	25	No data	1–10	25
Cd	<0.03	2.5	0.004–0.025	0.01–0.10	0.45
Cr	<0.5	15	0.09–0.12	1.0–10	0.6 (Chromium VI)
Cu	1.12 – 1.88	5	0.05–0.36	0.005–0.05	-
Hg	<0.01	0.3	0.0001–0.0005	0.005–0.05	0.07
Ni	<0.3	30	0.16–0.26	0.1–1.0	34
Pb	0.153 – 1.47	25	0.005–0.02	0.5–5.0	14
Zn	7.91 – 18.4	40	0.03–0.45	0.5–5.0	6.8 plus ambient background concentration of c.0.4

(EQS: EU Environmental Quality Standard for Dangerous Substances; BRC: OSPAR Background Reference Concentrations; EAC: OSPAR Ecotoxicological Assessment Criteria; WFD EQS 2015: Water Framework Directive Environmental Quality Standard for Priority Substances (2015) for transitional and coastal waters (This updates the earlier EU EQS))

Organics

The levels of organic compounds present in samples from the Erris Head (SW1) outfall were in similar ranges to those in samples collected in 2013, 2008, and 2007. The majority of the compounds analyzed were below their respective MRVs, with the exception of Phenols, which were recorded at levels slightly above the MRV.

In a very few cases the recovered seabed samples were in volumes slightly less than specified for the organics analysis, and in these instances a higher MRV applied. At these stations those compounds affected were still recorded at less than the revised MRV and there is no reason to suggest that the higher MRV meant that the concentration in the sample was any higher than at other stations with lower MRVs.

All organics analysed for were at extremely low concentrations and gave no cause for concern.

A comparison of concentrations of certain organic compound levels in the seawater samples at the Erris Head (SW1) outfall can be made against WFD EQS levels, as shown in Table 4-6.

The recorded concentrations are below the latest (2015) coastal and transitional waters EQS's for all compounds, highlighting the pristine nature of the water quality in the vicinity of the Erris Head (SW1) outfall location.

Table 4-6: Ranges of selected organics concentrations in seawater samples from the 2014 survey at SW1 compared to Water Framework Directive 2015 Priority Substance EQS's for coastal and transitional waters

Determinand	2014 Erris Head (SW1) outfall range	Water Framework Directive Good Standard EQS Priority Substances 2015 for transitional and coastal waters (Maximum Allowable Concentrations)
µg/l		
Anthracene	<0.01	0.1
B(a)pyrene	<0.01	0.027
B(b)fluoranthene	<0.01	0.017
B(k)fluoranthene	<0.01	0.017
Fluoranthene	<0.01	0.12
Naphthalene	<0.01	130
2,4-Dichlorophenol	<0.02	0.42
Phenol	0.112 – 1.30	7.7

4.1.2 Corrib Field (SW3)

4.1.2.1 Seabed Photography

The 2014 survey seabed photography provided a further overview of seabed conditions in the central areas of the Corrib Field. Previous surveys at the Corrib Field undertook a combination of surface facing and sediment profile imaging photographs, while this survey provided higher resolution surface images that combined a wider field of view with a good level of detail. The results obtained provided a useful additional reference to compliment the results of sampling for sediment physico chemistry and infauna.

The seabed photographs concur with the sampling results, however they are also able to provide a wider picture of conditions that cannot be obtained solely from sampling, which provides information (albeit very detailed) for only a very small area. The imagery highlights the homogenous nature of the seabed, with sediment types characterised by olive coloured muds and fine sands. These conditions were evidenced at all stations surveyed with the camera system. A selection of some of the still images obtained at each station are provided in Appendix 6.

The seabed images show some of the surface biota present at the Corrib Field and also the degree of bioturbation of the sediments. The surface biota observed and the observations of the seabed sediments characteristics support the sampling results which indicate a high degree of similarity in the biological community between stations. Furthermore the photography supports the overall biotope description for the seabed at the Corrib Field (obtained from the sediment sample macrofaunal analysis) of Formaniferans and Thyasira sp. in deep circalittoral fine mud' (**SS.SMu.OMu.ForThy**) (Connor *et al.,* 2004).

4.1.2.2 Sediment Physico-Chemistry

The physical characteristics of the sediment sampled at the Corrib Field were relatively consistent between the 2014 survey and the previous survey (carried out in 2008). Median grain sizes for samples taken in 2014 were in a similar range to those observed in previous surveys and all stations are still characterised by similar fractions of mud and sand with coarser sediments (>2mm) being almost completely absent across all stations at the Corrib Field. Both Folk and Udden Wentworth classifications are similar between 2014 and previous surveys with stations at the Corrib Field being either classified as Fine or Very Fine Sand.

TOC is in a range that is to be expected considering the degree of fine grained material in the sediment samples, and is typically slightly higher than results from the 2008 survey with less variability observed.

4.1.2.3 Sediment Chemistry

Metals

Metal concentrations in sediment results for 2014 were very similar to those from previous surveys at the Corrib Field in 2008 and from sampling undertaken as part of the offshore EIS studies undertaken in 2000. Metal concentrations in sediments were overall considered to be low, as would be expected in an area with minimal anthropogenic activity.

To determine the degree of any anthropogenic contamination in marine sediments, it is useful to compare observed metal concentrations in sediment with the following values:

- OSPAR (Northeast Atlantic)
    - Background Reference (**BC**)
    - Ecotoxicological Assessment Criteria (**EAC**), with lower and upper limits.

- Environment Canada
    - Threshold effects level (**TEL**): the concentration above which metals may start to be harmful to organisms; and
    - Predicted effects level (**PEL**): the concentration above which metals are likely to become harmful to organisms.

Selected metal concentrations from the 2014 survey in comparison to the results of the 2008 and 2000 surveys and the international reference values described above are presented in Table 4-7. It should be noted that these do not represent the full suite of metals sampled, only those against which a comparison against previously recorded data at the Corrib Field and other published international and regional standards have been made. The full suite of metals results from 2014 sampling is shown in Table 3-4.

Table 4-7: Comparison of observed sediment metals data at the Corrib Field (SW3) to international standards

Metal	2014 Corrib Field station range	2008 Corrib Field station range	2000 Corrib Field station range	OSPAR			Upper limit exceeded?	Environment Canada		PEL exceeded?
				BC	EAC limits Lower	EAC limits Upper		TEL	PEL	
	mg/kg dry weight									
As	3.55 – 4.67	1.94–4.13	1.7–4.7	15	1	10	No	7.24	41.6	No
Cd	0.089 – 0.121	0.073–0.131	<0.01–0.2	0.2	0.1	1	No	0.676	4.21	No
Cr	45.5 – 62.7	19.3–49.1	7.7–17	60	5	50	Yes	52.3	160	No
Cu	5.81 – 7.91	4.49–16.5	2.6–12	20	5	50	No	18.7	108	No
Hg	0.009 – 0.025	<0.004–0.033	No data	0.05	0.05	0.5	No	0.13	0.7	No
Ni	8.65 - 10	5.95–21.9	6.1–16	30	5	50	No	15.9	42.8	No
Pb	8.01 – 10.2	7.28–32.4	3.4–23	25	5	50	No	30.3	112	No
Zn	22.5 - 30	20.9–66.1	10–78	90	10	100	No	124	271	No

It is also informative to compare observed values from the 2014 survey with reference data available from the UK. These data are presented in Table 4-2.

Table 4-8 Comparison of observed sediment metals data at the Corrib Field (SW3) to UK data

Metal	2014 Corrib Field station range	Liverpool Bay[1]	Cumbrian coast[2]	Scottish Minches[3]	North Sea[4]
	mg/kg dry weight				
As	3.55 – 4.67	No data	No data	4.3	1.2–33 (mean 11)
Cd	0.089 – 0.121	0.3–2.1	0.007–0.46	0.018	0.01–0.38– (mean 0.05)
Cr	45.5 – 62.7	0.5–35.9	10.7–85.8	57	No data
Cu	5.81 – 7.91	1.8–33.7	1.8–49.4	7.3	0.1–87 (mean 14)
Hg	0.009 – 0.025	0.01–1.44	0.005–0.17	0.05	75% <0.025
Ni	8.65 - 10	1.2–16.5	No data	6.4	1.5–113 (mean 23)
Pb	8.01 – 10.2	6.9–101	10.3–69.7	24	1.7–288 (mean 21)
Zn	22.5 - 30	9.4–327	22.4–129.4	45	3–510 (mean 39)

Sources: 1 Taylor, 1986; 2 Nixon, 1995; 3 FRS/SEPA, 1998; 4 NSTF, 1993

Arsenic

Concentrations from 2014 were in a similar range to those recorded during the 2008 and 2000 surveys, with all sites being <5mg/kg, reflecting a situation similar to, but less than in the Scottish Minches (FRS/SEPA, 1998). Concentrations at all stations were below the Environment Canada TEL and OSPAR BC. The upper value recorded in 2014 is slightly higher than in 2008 and 2000, while the lower value has increased more significantly indicating a narrowing of the range in concentrations.

Cadmium

While the Corrib Field cadmium concentrations do not appear to be anthropogenically influenced (relatively low values recorded), the range recorded (0.089 – 0.121 mg/kg) is somewhat higher than for sediments from the central North Sea (where values as low as 0.01 mg/kg and a mean of 0.050 mg/kg have been reported – OSPAR, 2003). The observed range is below the OSPAR BC of 0.2 mg/kg and well below Environment Canada PEL shown in Table 4-7. Cadmium concentrations are in a similar range to those observed in previous surveys, although peak cadmium concentration recorded in 2014 was lower than in 2008 and 2000. (0.121 mg/kg compared with 0.131 and 0.2 mg/kg respectively).

Chromium

The results for chromium in the 2014 survey are higher for 2008 and 2000. The upper limit of the range exceeds the OSPAR background concentrations and the OSPAR Upper EAC limit. In addition the upper limit of the range is higher than the Environment Canada TEL, but is below the PEL.

The results (45.5 – 62.7 mg/kg) are consistent with those reported by Nixon (1985) and (FRS/SEPA, 1998) for the Cumbrian coast and the Scottish Minches.

Comparison of the 2014 chromium levels with those recorded in the 2008 and 2000 surveys shows that the results have elevated consistently, firstly between 2000 and 2008, and then between 2008 and 2014. The concentrations in 2014 are 3-4 times higher than those recorded in 2000.

Copper

Survey results recorded for 2014 were in the range 5.81 – 7.91 mg/kg, and as such are in a similar range to the findings from the survey conducted in 2008 (albeit with much lower upper range). The values are in accordance with the lower values reported from similar marine surveys around the UK (Table 4-8) and below the OSPAR BC (20 mg/kg) and Environment Canada TEL (18.7 mg/kg).

Copper levels had an elevated lower range in the sediment samples collected during the 2014 survey, when compared with those recorded in 2008 and 2000 however the upper limits of the range was much less than in these earlier surveys resulting in a much narrower overall range in values. The 2014 range of concentrations of copper was within that of the 2008 and 2000 ranges.

Mercury

The range of mercury levels in sediments sampled in the 2014 survey were very similar to those recorded during the 2008 survey. (0.009 – 0.025 and <0.004 – 0.033 mg/kg respectively). The 2000 survey scope did not include sampling for mercury. Compared with background levels, the highest recorded figure for 2014 was well below the OSPAR BC, as well as being below the majority of recorded concentrations from the UK waters used for comparison (Table 4-8).

Nickel

The results for nickel (8.65 -10 mg/kg) are consistent with the results from the previous surveys. In 2014 the lower limit of the range was slightly higher than in 2008 and 2000, however the upper value of the range was lower (10 mg/kg, compared with 21.9 and 16 mg/kg in 2008 and 2000 respectively). The range of values therefore was much narrower in 2014 than in earlier surveys and within these earlier ranges. All results from 2014 were significantly below the OSPAR BC and below the Environment Canada TEL. Results were slightly higher than the values obtained in the Scottish Minches (FRS/SEPA, 1998), but were on a par or below those recorded for other regional UK waters (Table 4-8).

Lead

Lead was recorded at concentrations of less than 10 mg/kg at all but one station. The range of concentrations was between 8.01 and 10.2 mg/kg. This further highlights the increasingly narrow range in concentrations for a number of metals in 2014 compared with earlier surveys at the Corrib Field. The upper limit of the concentration range was significantly lower in 2014 compared to 2008 (32.4 mg/kg) and 2000 (23 mg/kg).

The upper value recorded in 2014 was significantly below the OSPAR background concentration and Environment Canada TEL, as well as the other regional UK waters values used for comparison in Table 4-8.

Zinc

Zinc concentrations recorded at all stations were at levels equal to or below 30 mg/kg, similar to the lowest reported findings for Liverpool Bay (which receives contaminated run-off from the Mersey and was formerly a site for sea disposal of sewage sludge and dredging spoil) and the North Sea. The 2014 results are significantly below the accepted OSPAR BC (90mg/kg) and Environment Canada TEL and PEL.

The upper level recorded in 2014 was significantly lower than that sampled in the 2008 and 2000 surveys (66.1 and 78 mg/kg respectively), however the lower values are similar or higher (as shown in Table 4-7), indicating a similar trend to a number of the other metals recorded in 2014, of a narrowing of the range in concentrations.

Summary

Sediment metal results from the 2014 survey can be summarised as follows:

- Results from 2014 are broadly in a similar range, or lower than those recorded during the 2008 and 2000 surveys and are as expected for an area with little or no anthropogenic impact.
- Results are generally well below concentrations that could potentially give rise to any biological effects, and hence give no cause for concern. No parameters recorded exceed the Environment Canada Predicted Effects Level (the concentration above which metals are likely to become harmful to organisms). With the exception of chromium, the results do not exceed the upper limit of the OSPAR Ecotoxicological Assessment Criteria.
- In general, metal concentrations were either at the lower end of, or similar to, the ranges encountered around the UK coast.
- The results reflect a pristine environment with little evidence for departures from typical background levels. In a number of cases the lower limits in the range of certain metals have increased, while the upper limits remain on a par or are reduced compared with the upper limits from previous surveys. This has resulted in a narrowing in the range of values recorded. The most likely explanation for this is the reduced scope of the survey, which sampled at fewer stations, and concentrated on those in closer proximity to the wells and central manifold at the Corrib Field. The 2014 survey did not sample at the 4 reference stations that were sampled during the 2008 surveys. These reference stations

were characterised by some of the lowest values for a number of metals in 2008, and as such the fact that they were not sampled during 2014 could explain the increase in the lower values and narrowing in the range of recorded values.

Barium

Barium concentrations were high at a number of stations (Table 3-4), this may be a consequence of local drilling activities. This is a trend that was observed during previous surveys. Barium is a constituent of water-based drilling muds and in 2014 the highest value for barium was recorded at station Z4, which is located adjacent to the manifold and production well P101, and relatively close to P1, P4 and P6. Station Z4 had highest recorded levels of barium during the 2008 survey as well, although the maximum from the 2014 survey was slightly reduced from 2008.

By far the most abundant metal in the majority of drilling muds is barium, in the form of barite ($BaSO_4$). Owing to its low solubility and the fact that it is not as toxic as the sulphate, elevated barium concentrations are rarely of toxicological concern. However, sediment concentrations of barite/barium can provide valuable information concerning the extent to which drill cuttings have been transported from well locations.

To a degree there is a correlation between the levels of barium recorded at sampling stations and the proximity of these stations to areas at which there has been drilling activities. The scope of the 2014 survey was more limited, and as such did not sample the furthest outlying reference stations, where barium has previously been recorded in lowest concentrations, compared to those stations closest to drilling activities. Despite this, similar trends in the levels of barium concentrations could be observed between the 2014 survey and 2008. In a number of cases the levels had reduced in the period between 2008 and 2014, while at other stations they had increased. It is possible that these increases could be the result of further well intervention works that have taken place between 2008 and 2014 (such as the recent well intervention works that have been carried out at well P6).

Overall however, when comparing barium concentrations between 2000, 2008 and the present survey of 2014 at the Corrib Field, it is evident that there had been a decrease in the peak values recorded. The highest value recorded in 2000 was 4550 mg/kg, in 2008 this had reduced to 1880 mg/kg, while in 2014 this had reduced slightly to 1820 mg/kg.

Data for other sea areas are sparse, making comparisons difficult. There are no guideline concentrations for barium in sediments. The component chemicals of the WBM system are generally considered to pose little or no risk to organisms in the receiving water (both barite and bentonite are currently listed by OSPAR as posing little or no risk to the environment). They are typically of low toxicity with low bioaccumulation potential and are not persistent. The most common effect of WBM discharge is an elevation of barium concentrations in the sediments, which may extend up to 1,000m from the drilling location along the predominant tidal axis. The main effects of WBM use on the benthic communities are considered to be related to smothering, which is more closely associated with cuttings than with the discharge of drilling mud. It is unlikely that discharged WBM will cause a noticeable change to the marine ecosystem. This is discussed in Section 4.1.1.4.

Hydrocarbons

Saturates (Total Organic Extracts)

Total Organic Extracts (TOE) concentrations, as shown in Table 3-6, ranged from 6.8 µg/g (ppm) at stations C1 and A4 to 14.0 µg/g, at station Z10. Concentrations of TOE at all 14 stations are considered consistent with typical 'background' levels seen previously in the vicinity of the Corrib Field.

TOE concentrations previously recorded at the Corrib Field in 2008 ranged from 4.9-69 µg/g, with stations Z9 and Z10 having considerably the highest concentrations at 45 and 69 µg/g respectively. Overall there has been a substantial reduction in the TOE levels at the Corrib Field in surface sediments at stations in close proximity to the wells and central manifold. This trend was also observed between 2000 and 2008.

As the discharge of OBM on cuttings was effectively banned, concentrations of tracers of OBM in marine sediments would be expected to decrease with time and biota will recover. This has been borne out at the majority of stations sampled initially in 2000 and again in 2008, with the trend continuing through to the present 2014 study. However, the time scales vary depending upon:

- The type of mud;
- Depth of the cuttings pile; and
- Characteristics of the receiving environment, e.g. water depth, temperature, waves and currents.

The recovery for deeper accumulations of cuttings and mud is thought to be much slower than for thin accumulations. Initial cuttings pile depth will depend on the current profile and water depth. Stronger currents lead to wider dispersion before deposition, and greater water depth will generally lead to thinner initial deposits. The duration of impact upon the benthic community is related to the persistence of OBM cuttings accumulations and associated hydrocarbons in the sediment (International Association of Oil & Gas Producers, May 2003).

Comparison with previous data from surveys around North Sea fields (including both baseline studies and reference background stations from fields where drilling operations have taken place) suggests that the background concentration of total hydrocarbons typically ranges between 1-10 µg/g. This agrees with data from the North Sea Task Force (NSTF, 1993), and Law (Law *et al.*, 1982), although other studies have shown higher concentrations (e.g. McIntosh *et al.,* 1983; 10-60 µg/g in sediments between the Firth of Forth and the Forties field).

The only base oil detected in any of the samples was "Ecomul". "Ecomul" was detected in six of the 14 samples, where the concentrations ranged from 0.06µg/g to 0.41µg/g, with the highest concentration recorded in the sample from station Z10.

The levels of Ecomul have shown a marked reduction overall between 2008 and 2014, in particular at Station Z10, which showed a reduction from 3.41 to 0.41 µg/g. The majority of stations exhibited very low levels of Ecomul or results were below the levels of detection. Levels of Esterkeen, Low Tox Base Oils, and diesel Range Base Oils were all below the levels of detection at all stations sampled, which showed an overall reduction in concentrations at certain stations from 2008.

Overall the 2014 data showed no clear evidence of low-level UCMs (unresolved complex mixtures), normally associated with either a kerosene-range low-tox drilling mud or a diesel-range oil-based drilling mud at any of the stations at which sampling took place.

Polycyclic Aromatic Hydrocarbons (PAH's)

Concentrations of PAHs in the sediments at the Corrib Field in 2014 are given in Table 3-20 and include naphthalenes, phenanthrenes and dibenzothiophenes (NPD) and the 16 PAHs defined by the United States EPA.

The concentration of NPD does not exceed 10 µg/kg at any of the 14 stations, and these results are generally consistent with levels seen previously around the Corrib Field. The results do however show an overall reduction in concentration for the majority of compounds at Corrib Field stations between 2008 and 2014, as can be seen in Table 4-9. In all cases with the exception of Dibenz(a,h)anthracene and Naphthalene the maximum recorded concentrations in 2014 are below the maximum recorded concentrations for 2008.

Results from the present study are compared against reference criteria in Table 4-9. In all cases the levels of PAHs are well below the Environment Canada TELs and PELs and OSPAR standards for the respective compounds and no compounds recorded during 2014 are at levels that give cause for concern.

Table 4-9: OSPAR BCs and provisional BACs for PAHs in sediments (OSPAR 2005–6) and Environment Canada standards for polycyclic aromatic hydrocarbons (PAHs) in sediments as µg/kg (ppb) compared with data for the Corrib Field (SW3)

PAH	Environment Canada TEL (µg/kg, ppb)	Environment Canada PEL (µg/kg, ppb)	Sediment (µg/kg, ppb)*		Corrib Field Maximum, 2008 (µg/kg, ppb)	Corrib Field Range, 2014 (µg/kg, ppb)
			BC	***BAC***		
Acenaphthene	6.7	88.9	-	-	0.11	*nd*
Acenaphthylene	5.9	128	-	-	0.06	*nd*
Anthracene	46.9	245	3	5	0.18	*nd*
Benz(a)anthracene	74.8	693	9	16	0.53	0.01 - 0.06
Benzo(a)pyrene	88.8	763	15	30	0.88	0.03 - 0.24
Benzo(b)fluoranthene	No data	No data	-	-	1.8	0.43 - 0.91
Benzo(g,h,i)perylene	No data	No data	45	80	0.84	0.23 - 0.75[1]
Benzo(k)fluoranthene	No data	No data	-	-	0.52	0.04 - 0.12
Chrysene	108	846	11	20	1.1	0.04 - 0.25
Dibenz(a,h)anthracene	6.2	135	-	-	0.08	0.01 - 0.15[1]
Fluoranthene	113	1,494	20	39	1.9	0.06 - 0.3
Fluorene	21.2	144	-	-	0.10	*nd*
Indeno(1,2,3,cd)pyrene	No data	No data	50	103	1	0.34 - 0.77
Naphthalene	34.6	391	5	8	1.2	0.03 - 2.9
Phenanthrene	86.7	544	17	32	0.99	0.01 - 0.59
Pyrene	153	1,398	13	24	1.4	0.05 - 0.43

*Note, the BC and BAC sediment figures are listed as a dry weight normalised to 2.5% organic carbon, whereas the Corrib Field samples were not normalised. However, the majority of the 2014 data have organic carbon levels in a similar range.

(TEL = threshold effects level, PEL = probable effects level, BC = background concentration, BAC = background assessment concentration)

4.1.2.4 Sediment Macrofauna

Comparison against previous surveys at the Corrib Field

The data generated from this study were compared with those produced in the 2008 survey of the same area (RSK, 2009). To ensure consistency in data and to avoid identifying changes solely due to disagreement in species identification the dataset was examined thoroughly for inconsistencies in naming, some species were reduced to genus level and all taxonomic names were updated in the 2008 dataset. Replicate data was used during this analysis due to the anomalies encountered during the per site analysis.

The lists of key species that were encountered in both 2008 and 2014 were very similar; the tube-dwelling polychaete *Galathowenia oculata* proved a numerically important component of the community throughout the study area in 2008 and 2014 and species identified were typical of muddy fine sand and some were very characteristic of deeper waters.

However, changes in univariate measures throughout the years were observed by comparing the data from the 2014 and 2008 surveys at the Corrib Field. Figure 4.1 shows the number of species at each site in 2008 and 2014, Figure 4.2 shows the abundance and Figure 4.3 compares the Shannon-Weiner species diversity.

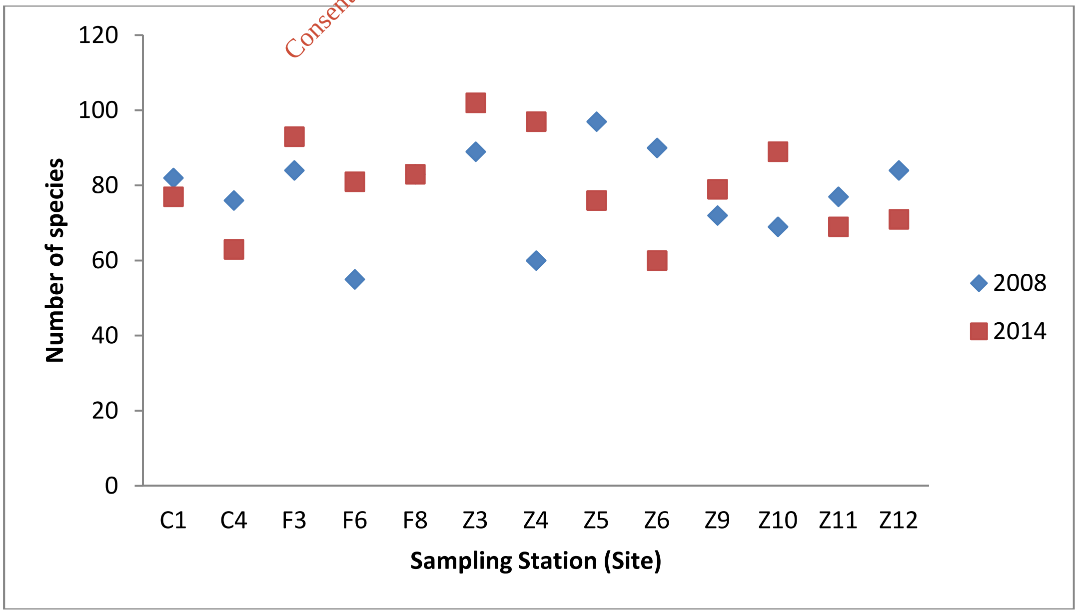

Figure 4.1: Comparison of the number of species at each sampling station (site) in the 2008 & 2014 surveys at the Corrib Field (SW3).

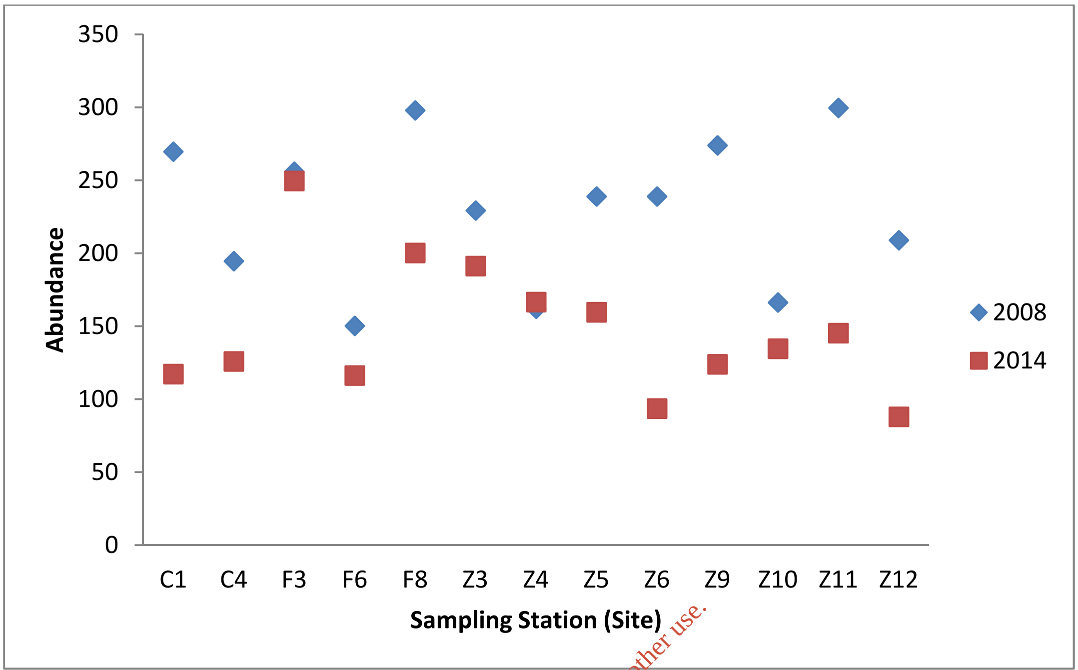

Figure 4.2: Comparison of Infaunal abundance (no. of individuals per 0.1m^2 (per grab)) at each sampling station (site) in 2008 & 2014 surveys at the Corrib Field (SW3)

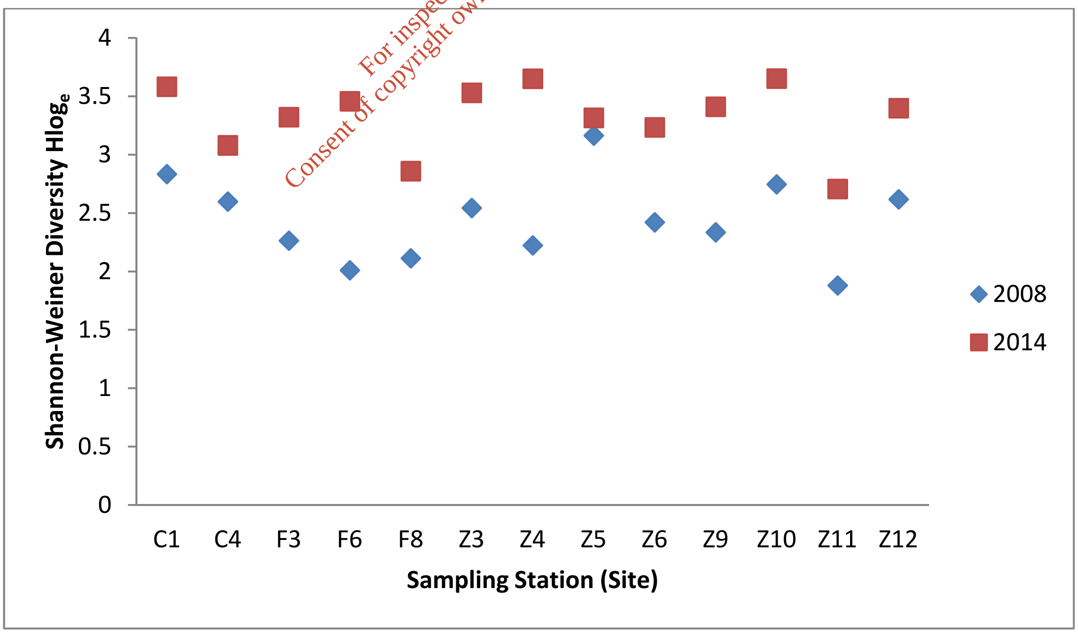

Figure 4.3: Comparison of Shannon-Weiner species diversity at each sampling station (site) in the 2008 and 2014 surveys at the Corrib Field (SW3)

The number of species recorded at each site in 2008 and 2014 varied slightly but showed no definite pattern, whilst abundance was consistently found to be the same or lower at each site in 2014. This fall in abundance corresponded to an increase in

Shannon-Weiner diversity which indicated that the numerical dominance of a few species had declined. In examination of the data matrices, it can be seen that *Galathowenia oculata*, although present in high numbers at sites in 2008 and 2014, does not show such a pronounced drop in dominance in 2014.

A cluster analysis of the data was performed using Bray Curtis similarity and the resulting MDS plot is shown in Figure 4.4.

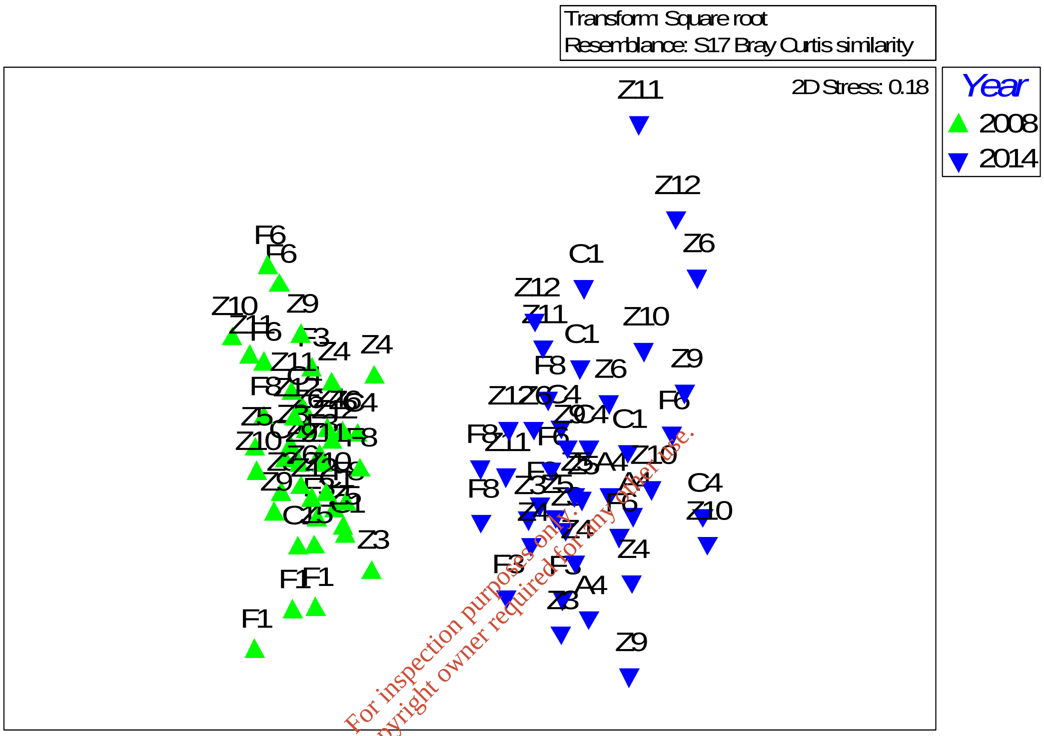

Figure 4.4: MDS plot of sampling locations (sites) (based on replicate data) in the Corrib Field (SW3) study area comparing data from 2008 and 2014.

The cluster analysis using Bray Curtis similarity showed that the communities showed quite a high degree of similarity over the two survey years. Apart from one replicate from site Z11 in 2014, all sites showed a similarity of 40% or more with each other. However, a SIMPROF analysis found that all communities sampled in 2008 were significantly different from all communities sampled in 2014. This was particularly apparent when examining the MDS plot (Figure 4.4) as communities form two obvious clusters: those sampled in 2008 and those sampled in 2014.

An Analysis of Similarity test was performed upon the dataset and confirmed that there were significant differences between sites. The dataset was analysed using the SIMPER test to identify which taxa contributed most to the observed changes, the results of this are shown in Appendix 10.

Galathowenia oculata and the Thyasirid bivalve molluscs *Adontorhina similis* and *Axinulus crouliensis* were important in defining the communities in 2008 and 2014. However, it can be seen in 2014 that the brittle star *Ophiocten affinis* and the amphipod *Urothoe elegans* were typical of communities in 2014 whilst in 2008 the spionid polychaete *Prionspio fallax* was common. The dissimilarities which occurred between the 2008 and 2014 survey were not due to a complete absence or addition of species but were a result of changing importance (relative abundance) of a few key species as shown in Appendix 10.

Even though significant differences were identified, inspection of the dataset revealed that very little had changed during the 2008 - 2014 period between sampling, both in terms of the biology and the physical and chemical parameters measured. The communities were typical of muddy fine sand of deeper waters and the changes in abundance of key species may be due to recruitment success or food availability both of which are of particular importance in deeper habitats.

Summary

The sites sampled in the survey area contained communities of high faunal diversity which comprised species characteristic of muddy fine sands and deeper, cooler waters. Typifying these communities were the tube-dwelling polychaete *Galathowenia oculata,* spionid polychaetes such as *Prionopsio*, *Aricidea*, *Levinsenia gracilis*, *Spiophanes* and *Minuspio*, the ampharetid polychaete *Pterolysippe vanelli,* species of Thyasirid bivalves such as *Adonotrhina simils*, *Axinulus crouliensis* and *Mendicula ferruginea*, the brittle star *Ophiocten affinis* and the echiuran *Echiurus echiurus*.

In addition, a number of interesting species were identified which were particularly associated with inhabiting deeper waters, these included the mysids *Hypererythrops serriventer* and *Pseudomma affine*, amphipods *Nicippe tumida* and *Syrrhoe affinis* and the anemone *Actinauge richardi*. These species were never abundant but were relatively frequently recorded throughout the dataset.

The communities in 2014 were extremely homogeneous and apart from a few replicates no significant differences were identified between them. A major significant difference existed between the communities surveyed in 2008 and 2014. However, once further tests had been conducted and the datasets were inspected it was revealed that the actual species recorded changed little but the relative proportions in which they were recorded at each site noticeably changed. In 2008, there was a great numerical dominance of the small tube-dwelling polychaete *Galathowenia oculata*, whereas in 2014 this dominance had diminished. The physical and chemical parameters measured showed only minor changes between these years so it may be that factors such as food availability and recruitment success determined these differences.

4.1.2.5 Seawater Quality

Temperature

The temperature profile indicated that the surface water in the vicinity of the Corrib Field (recorded in autumn 2014) was relatively well mixed to a depth of between 40-50 m, below which the temperature began to reduce, and an obvious thermocline is observed. Temperatures are then relatively consistent from around 75 m down to seabed depths, albeit with a slight reduction in temperature with increased depth. This trend was observed during the survey at the Corrib Field outfall in 2013.

Temperatures were noticeably cooler at the Corrib Field during the surveys undertaken in 2013 compared to during this survey. In addition the depth of the thermocline was observed to be noticeably deeper in 2013 (being at about 80-100 m).

Differences between the overall 2013 temperatures and those recorded during this 2014 survey are to be expected, given the differing times of the year at which the surveys took place. The 2014 survey was conducted during late September / early October, while the 2013 survey was conducted in November. Other variations are also to be expected as a result of diurnal temperature fluctuations (i.e. time of day of sampling) and the effect of other factors such as wind, tidal state and rainfall. The 2013 survey was conducted at night, while the water sampling during the 2014 survey was undertaken in daylight (this would help to account for the differences in water temperature in the immediate surface waters).

Salinity

The salinity profile at station Z11 at the Corrib Field recorded in 2014 corresponds with the temperature profile in so much that there is variation observed in the salinity at a similar depth to the thermocline. Salinity, otherwise is relatively stable in the surface waters above 40-50 m and then below 75 m as far as the seabed.

As with temperature the variation (occurring at a similar depth to the thermocline) is in shallower water depths than observed in 2013. However salinities recorded during both 2013 and during the 2014 survey are relatively similar (being slightly in excess of 35 PSU throughout much of the water column), although the 2014 data does not show the same slight increase in salinity with increased depth as in 2013.

Any minor variations between the 2013 and 2014 data may well be the result of slightly different equipment being used as well as slight seasonal variations with regards to the amount of freshwater input.

The salinity profile recorded in 2014 was considered consistent with a fully marine environment, with little or no freshwater influence.

Water Samples

Suspended Particulate Matter (SPM)

The non-detectable levels of SPM at the Corrib Field are considered indicative of the high clarity Atlantic waters sampled, with little local freshwater (and/or fine sediment) input. The results compare similarly with the survey in 2013, where the majority of water samples recorded levels of SPM below the levels of detection, or where detectable levels were recorded, at levels that were close to the Minimum Reportable Value.

Ammoniacal Nitrogen

This was non-detectable (i.e. <0.01mg/l) at the sampled station (Z11) in 2014, this is consistent with levels recorded during 2013, and would tend to indicate an unsurprising lack of anthropogenic influence (e.g. from fertiliser run-off).

A good comparison can be made with the EQS for un-ionised ammonia as nitrogen as stated in the Water Framework Directive (WFD) list of priority substances (WFD, 2015) (taken from EU Directive 2013/39). The EQS for a good standard for transitional and coastal waters for ammoniacal nitrogen is 0.021 mg/l, which is considerably higher than the levels recorded at SW3 in 2014.

SW1 and SW3 show consistent results, as was expected.

Metals

Table 4-4 shows the ranges in concentrations of metals in seawater samples collected at station Z11 (near surface and near seabed samples) during the 2014 survey in the vicinity of the Corrib Field. The results are compared with other published sources of background data for oceanic seawater in the same general region, and the previous survey at the Corrib Field undertaken in 2013.

The range of metal concentrations in the samples from 2014 compare very similarly with the results from the previous survey as well as regional published data sources for oceanic seawater.

The results also correspond very well with the results of coastal water quality monitoring undertaken by the Marine Institute in 2004, 2005 and 2012 and are within the EQS levels for metals as priority substances under the Water Framework Directive as a good standard for transitional and coastal waters.

Although in some instances the reported values are above the very low levels reported for oceanic waters in the published regional background sources, in no instance were any concentrations observed that would give rise to concern.

The results continue to show that the waters at the Corrib Field have low concentrations of metals, well below the respective EQSs shown in Table 4-10, which is to be anticipated given the distance offshore and open aspect to the North Atlantic, and low levels of anthropogenic input in the area.

Table 4-10: Measured metal concentrations at the Corrib Field (SW3) compared with other published sources of regional data.

Metal	2013	2014	Oceanic concentrations*	Marine Institute#	Marine Institute 2012^	Water Framework Directive Good Standard EQS Priority Substances 2015 for transitional and coastal waters
	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Arsenic	0.00127 – 0.00162	0.00129 – 0.00147		0.00115	0.001176 – 0.001443	0.025

Metal	2013	2014	Oceanic concentrations*	Marine Institute#	Marine Institute 2012^	Water Framework Directive Good Standard EQS Priority Substances 2015 for transitional and coastal waters
	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Cadmium	<0.00003 – 0.000039	<0.00003	0.00005	0.000055	<0.00005	0.00045
Chromium	<0.0005	<0.0005		0.000168	0.000109 – 0.000511	0.0006 (Chromium VI)
Copper	<0.0002 – 0.00039 (0.00315)	0.000511 – 0.0022	0.0005	0.000659	0.0001 – 0.000386	-
Lead	0.000118 – 0.000794 (0.00689)	<0.000066 – 0.00187	0.00003	0.00084	<0.0001	0.014
Mercury	<0.00001	<0.00001	0.0001–0.0004	<0.000008	<0.00001 – 0.000078	0.00007
Nickel	<0.0003 – 0.000336 (0.000585)	<0.0003 – 0.000443		0.0012	0.000084 – 0.000309	0.034
Silver		<0.001		<0.001	<0.00005	-
Zinc	0.000624 – 0.00334 (0.0151)	<0.00593 – 0.0299	0.005	0.011	<0.001 – 0.00732	0.0068 plus ambient background concentration of c.0.0004

NB. The data range from the 2014 survey has been converted to mg/l to aid comparison

* - concentrations taken from OSPAR Region III QSR, 2000

- lowest concentrations measured for each metal during Marine Institute surveys of Shellfish waters around Ireland between winter 2004 and winter 2005

^ - 2012 data collected by the Marine Institute from 7 coastal locations around the coasts of the north west coast of Ireland under the Water Framework Directive (WFD) and Shellfish Waters Directive (SWD). Locations are: Blacksod Bay, Westport Bay, Achill Sound South, Achill Sound North, Broadhaven Bay, Donegal Bay, and Killala Bay.

Table 4-11: Ranges of metal concentrations in seawater samples from the 2014 survey at the Corrib Field (SW3) compared to international published reference sources and EQSs

Metal	2014 Corrib Field range	EQS	BRC	EAC	WFD EQS 2015
	µg/l				
As	1.29 – 1.47	25	No data	1–10	25
Cd	<0.03	2.5	0.004–0.025	0.01–0.10	0.45
Cr	<0.5	15	0.09–0.12	1.0–10	0.6 (Chromium VI)
Cu	0.51 – 2.2	5	0.05–0.36	0.005–0.05	-
Hg	<0.01	0.3	0.0001–0.0005	0.005–0.05	0.07
Ni	<0.3 – 0.44	30	0.16–0.26	0.1–1.0	34
Pb	0.07 – 1.87	25	0.005–0.02	0.5–5.0	14
Zn	5.93 – 29.9	40	0.03–0.45	0.5–5.0	6.8 plus ambient background concentration of c.0.4

(EQS: EU Environmental Quality Standard for Dangerous Substances; BRC: OSPAR Background Reference Concentrations; EAC: OSPAR Ecotoxicological Assessment Criteria; WFD EQS 2015: Water Framework Directive Environmental Quality Standard for Priority Substances (2015) for transitional and coastal waters (This updates the earlier EU EQS))

Organics

The levels of organic compounds present in samples collected at Station Z11 at the Corrib Field were also in a similar range to those in samples collected in 2013. The majority of the compounds analyzed were below their respective MRVs, with the one exception of Phenol, which were recorded at levels slightly above the MRV in the sample taken close to the sea surface.

All organics analysed were at extremely low concentrations (in almost all cases below the low level of detection possible for the analytical techniques used) and gave no cause for concern, further reflecting the pristine nature of the water quality in the vicinity of the Corrib Field. The recorded levels of selected organic compounds were below the WFD EQSs considered for good standards of water quality in transitional and coastal waters, as shown in Table 4-12.

Table 4-12: Ranges of organic compound concentrations in seawater samples from the 2014 survey at the Corrib Field (SW3) compared to the 2015 WFD EQSs of priority substances for good quality transitional and coastal waters

Determinand	2014 Corrib Field (SW3) outfall range	Water Framework Directive Good Standard EQS Priority Substances 2015 for transitional and coastal waters (Maximum Allowable Concentrations)
µg/l		
Anthracene	<0.01	0.1
B(a)pyrene	<0.01	0.027
B(b)fluoranthene	<0.01	0.017
B(k)fluoranthene	<0.01	0.017
Fluoranthene	<0.01	0.12
Naphthalene	<0.01	130
2,4-Dichlorophenol	<0.02	0.42
Phenol	0.05-0.102	7.7

4.1.2.6 Summary conclusions for 2014

This survey report provides an appraisal of the overall environmental conditions that persist in the vicinity of the central Corrib Field as a whole. Sampling stations are deliberately set slightly away from the central manifold and any wellhead or flowline structures in order to reduce the potential for interaction. As such the minor impacts on the seabed from some of the more recent activities at the various well heads where the spatial extent of any impacts would only extend a very short distance from the point source, and for only a very short duration, would be unlikely to determined from this survey. This has proven to be the case.

The survey does however provide an updated baseline for the central Corrib Field area that continues to show that contaminant levels in sediments and the water column are below or close to background levels, reflecting the pristine nature of the environment.

In order to be able to monitor these expected low levels of contaminants in sediments and water quality, particularly low detection limits were specified for the laboratory analyses. In certain instances (for example barium in sediments at certain sampling stations and TOE (tracers of low toxicity water-based and oil-based drilling muds respectively)) levels are slightly higher at sampling stations close to areas where previous well drilling activities were known to have taken place. These elevated concentrations are believed to result from when the original wells at the Corrib Field were drilled, and the levels of these have shown a gradual reduction over the entire period that monitoring has taken place at the Corrib Field.

The survey indicates that the seabed environment including the biological community, and water quality at the Corrib Field is relatively pristine in nature and that its overall status is consistent with the findings of previous surveys (seabed environmental survey 2008, and seawater quality in 2013). It would also indicate that there have been no discernible changes at the stations sampled as a consequence of the more recent works at the Corrib Field.

4.2 2016 Survey Campaign

As described in Section 1 the focus of the 2016 survey campaign was on particular seawater quality aspects that had not been studied in previous survey campaigns. Seawater quality samples were analysed in particular only for Total Oxidised Nitrogen, Silicates and Total Phosphorus as per the request of the EPA. Water column profiles for a range of parameters were also measured, and included dissolved oxygen as an additional parameter required by the EPA that had not previously been measured. Where possible, all other data obtained from the water column profiles has been compared with similar data that has been previously collected at the SW1 and SW3 outfall locations.

4.2.1 Seawater Quality Profiles

4.2.1.1 Temperature

The seawater temperature data collected during the 2016 survey campaign show consistency between the stations sampled at each location. This is to be expected given that measurements were taken on the same day, and that sampling locations are in close proximity to one another.

The comparison of the SW1 and SW3 locations shows very similar results, which is again to be expected given that the locations were surveyed during the same survey period, during daylight hours, and within 50km of each other, and using the same equipment. The upper 70 m water depth in the profiles at the Corrib Field show a similar trend to the profiles measured at the SW1 location, and cover a similar range of temperatures.

At both locations (and as also shown in profiles for most parameters) a degree of variation exists in the surface waters as the equipment is initially deployed and is acclimated.

Temperatures recorded during the 2014 survey campaign are noticeably cooler than during 2016, which is to be expected given the differing times of the year at which the respective campaigns took place, while temperatures compare well with those during the 2013 survey (the 2013 survey was undertaken in November, and as such similar temperatures are to be expected between then and May / June, compared to the warmer temperatures observed in September 2014. One particularly noticeable feature that was observed was the depth of the thermocline. In 2013 this was observed at around 80-100 m, in 2014 at around 40-50 m, while in 2016 was at around 30-40 m water depth (although not observed as clearly at the SW1 location). These differing depths of the slight thermoclines that have developed are as to be expected due to the seasonal differences in thermal stratification. Below the thermocline in all cases seawater temperature gradually decreases, although despite this gradual decrease the water column is seen to be relatively homogenous in terms of temperature.

In addition to seasonal variation between surveys the variation observed between the Corrib Manifold area (SW3) and coastal waters off Erris Head is evident and this is probably due to differing water masses, movement of water masses and/or tidal streams at varying water depths.

4.2.1.2 *Salinity*

Salinity profiles at both the SW1 and SW3 locations both show a profile that is indicative of a fairly homogenous water column. In both cases a degree of variation is observed in the surface waters. At the SW1 location off Erris Head no discernible increase in salinity is observed with increased depth, however at SW3 the increase in salinity is only observable over the full depth of the water column to a depth in excess of 300 m, with the increase being most marked at deeper depths.

Overall salinity is marginally higher at the Corrib Manifold than off Erris Head as observed in 2016 data. This is a trend observed in 2013 data also, but not in the surveys conducted at single stations at both locations in 2014. It is unclear why there is a slight difference in salinity between the Corrib Field and the area off Erris Head, it is potentially due to differing water masses, movement of water masses and/or tidal streams at varying water depths, as with temperature. It is also likely that the small effects of coastal inputs into the Erris Head area could also result in a slight reduction.

Overall however, the salinity profiles at both locations in 2014 and 2016 are consistent with a fully marine environment, with little or no freshwater influences.

4.2.1.3 *Dissolved oxygen*

Dissolved oxygen profiles of the seawater columns were measured for the first time in 2016, and as such there is no previous data for the SW1 or SW3 locations to compare against. Both the SW1 and SW3 locations show profiles that are broadly in agreement with each other, showing a general trend of increasing saturation with depth, up to a certain point. Both SW1 and SW3 show an initial increase in oxygen saturation, which decreases suddenly at a depth of around 40-50 m. At SW3 maximum oxygen saturation is observed at a depth of around 150 m, after which it starts to slowly decrease with increased depth.

As with the majority of water column profiles, a degree of variation is observed in the surface waters as the equipment acclimates.

The profile at Station 5 at the Corrib Field (SW3 area) is considered to be anomalous, as it is so much lower than any of the other profiles recorded at all other stations. The calibration of the dissolved oxygen probe on the multi parameter instrument may have faltered towards the end of the survey campaign, could this could possible explain why the readings are lower than all other stations, which show a similar trend.

If this station is discounted, then the water column at both SW1 and SW3 shows oxygen saturation in excess of 75% at all depths.

Oxygen saturation in seawater is governed by a combination of pressure, salinity and temperature, as well as biological activity. Seasonality therefore also has a big role in determining the degree of oxygen saturation. This degree of oxygen saturation is considered typical for an open ocean environment in the NE Atlantic Ocean and for the time of year that the measurements were taken. It was noted that at the Corrib Field dissolved oxygen saturation in excess of 100% was recorded. This is due to the production of pure oxygen by photosynthetically active organisms in the water column. The time of the survey likely coincided with a period of phytoplankton blooming, and it is a common occurrence for saturation over 100% in environmental sampling of seawater.

4.2.1.4 *Turbidity*

Turbidity profiles of the seawater columns were measured for the first time in 2016, and as such there is no previous data for the SW1 or SW3 locations to compare against. Both the SW1 and SW3 locations show profiles that are broadly in agreement with each other however.

Turbidity is low, and uniform throughout the water column at both SW1 and SW3 vicinities, with the exception of some minor variation (close to the surface, probably due to equipment acclimation and close to the seabed) turbidity remains relatively constant through the water column at approximately 1 FTU.

The recorded turbidity levels are considered to be reflective of open ocean conditions off the west coast of Ireland, and for the time of year. Furthermore the turbidity levels reflect the pristine nature of the area, with little in the way of significant fluvial inputs with the potential to bring elevated levels of suspended sediments.

4.2.1.5 *pH*

Turbidity profiles of the seawater columns were measured for the first time in 2016, and as such there is no previous data for the SW1 or SW3 locations to compare against.

pH at stations sampled in the vicinity of both SW1 and SW3 are in a similar range between 5.7 and 6.5. This range does not include variation in surface waters which is likely the result of the equipment being slow to acclimatise. The recorded levels of pH are considered to be slightly lower than the range that is to be expected for open seawater, although considered within an acceptable range. The reasons for the lower readings at all stations is likely to be an equipment error, as it was consistent across all stations, and also samples were within the normal range for all other recorded parameters.

4.2.1.6 Water Samples

The samples collected for Total Oxidised Nitrogen (nitrate and nitrite), Silicates and Total Phosphorous at near seabed and near surface depths were very low. With the exception of Total Phosphorous at station W4 (surface) (SW1) and Silicates in near seabed samples at all stations around SW3, all concentrations were recorded at levels below the limits of detection (MRV –Minimum Reportable Value) for the sensitive analytical methods selected. The positive concentrations which were recorded above the MRV were considered to be extremely low.

Overall levels of nutrients vary with season, and in spring major changes in nutrient concentrations occur in all shelf waters as primary production resumes. This results in a depletion of these nutrients, until production slows during winter.

The OSPAR Quality Status Report for Region III (Celtic Seas) (OSPAR, 2000) which shows averaged nutrient concentrations for the period 1960-1990 (summer and winter) for the Outer Malin Shelf can be used to make following comparisons with the data collected at SW1 and SW3 (Figure 4.5):

Nitrates

Summer – 0.031 mg/l

Winter – 0.533 mg/l

Phosphates

Summer – 0.019 mg/l

Winter – 0.057 mg/l

Silicates

Summer – 0.05 mg/l

Winter – 0.327mg/l

Figure 4.5: Mean nutrient concentrations in seawater for the period 1960-1990 for the Outer Malin Shelf sea area (OSPAR, 2000).

The Outer Malin Shelf covers much of the area in the vicinity of the Corrib Project, as well as the waters to the north. This data shows background concentration levels of these nutrients in a similarly pristine open ocean area off the north and west coast of Ireland. As shown, the data collected at SW1 and SW3 is in a similar range or below the averaged background levels for the Outer Malin Shelf. It is difficult to make direct comparisons, however due to the range of concentrations observed throughout the seasons, as natural nutrient depletions and increases occur. The 2016 data may not be directly reflective of either summer or winter. It would be expected therefore that samples taken in late spring / early summer (as in this case) to fall within the published summer and winter background concentrations – this is shown to broadly be the case for the 2016 data at SW1 and SW3. Data collected during 2016 can therefore be considered within the range that is typical for the offshore area, with little or no riverine inputs of nutrients even to coastal waters.

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Appendix 1: Raw Infaunal Data for Sampling Stations at SW-1

		S2-a	S2-b	S2-c	S6-a	S6-b	S6-c	S6R-a	S6R-b
Cnidaria									
Anthoathecatae									
Pandeiidae									
Lovenella clausa									
Cerianthus lloydii									
Edwardsiidae									
Platyhelminthes									
Platyhelminthes									
Nemertea									
Nemertea		8	4	13	7	4	9	3	2
Tubulanus polymorphus					1		3	2	2
Cerebratulus									
Nematoda									
Nematoda		219	360	210	40	79	94	211	273
Sipuncula									
Phascolion strombus			1				1		
Aspidosiphon muelleri						1			
Annelida									
Pisione remota		80	50	19	16	50	31	22	29
Polynoidae			4		4		3	11	8
Eunoe nodosa									
Malmgrenia arenicolae				1					
Pholoe baltica (sensu petersen)								1	
Pholoe inornata (sensu petersen)									
Sthenelais									
Sthenelais limicola									
Eteone longa	Aggregate							2	
Hesionura elongata		15	13	2	11	8	9	8	21
Mystides caeca		1	4						
Pseudomystides limbata		1					1		
Anaitides lineata									
Anaitides longipes								2	
Anaitides rosea			1						
Eulalia mustela			1		1	2	3	2	3
Eumida		6	3					27	9
Lacydonia miranda				1				2	1
Glycera	Juveniles		2						
Glycera alba									
Glycera capitata									
Glycera lapidum		6	4	4	5	10	6	32	31
Glycera oxycephala		2	2	3		1	3	3	
Glycera tridactyla									
Goniadidae	Juveniles			1					
Glycinde nordmanni			1	1					1
Goniada maculata									
Goniadella bobretzkii		1			1	3	3	3	6
Sphaerodoropsis minuta			1						2
Nereimyra woodsholea								1	1
Psamathe fusca		1				1		6	
Podarkeopsis capensis									
Syllidia armata									
Syllis garciai		3			1			1	2
Syllis pontxioi		6	11	2	1	3	3	4	10
Syllis								1	
Trypanosyllis coeliaca		7						1	
Dioplosyllis cirrosa		1						1	
Odontosyllis fulgurans									
Opisthodonta pterochaeta		1	3	1	3	5	13		
Palposyllis prosostoma		1							
Streptosyllis bidentata					6	5	12		2
Streptosyllis websteri			1						
Syllides benedicti									
Brania							1		
Exogone hebes									
Sphaerosyllis bulbosa		3	3	1		1		16	6

		S2-a	S2-b	S2-c	S6-a	S6-b	S6-c	S6R-a	S6R-b
Syllides benedicti									
Brania							1		
Exogone hebes									
Sphaerosyllis bulbosa		3	3	1		1		16	6
Sphaerosyllis taylori					1		1	3	
Nephtys	Juveniles								
Nephtys assimilis								1	
Nephtys cirrosa					1				
Nephtys hombergii									
Aponuphis bilineata		1							
Hyalinoecia tubicola							1		
Lumbrineris gracilis									
Lumbrineris futilis									
Scoletoma magnidentata		1						1	
Ophryotrocha			1						
Protodorvillea kefersteini		18	8	9	2	27	15	9	14
Orbinia	Juveniles								
Orbinia sertulata									
Scoloplos armiger									
Aricidea w assi									
Aricidea cerrutii						2	4		
Aricidea simonae									
Poecilochaetus serpens									
Aonides paucibranchiata		7	3		2	4		50	17
Laonice bahusiensis					1			2	1
Minuspio cirrifera							2		
Prionospio	Juveniles				1	1		14	10
Prionospio fallax									
Scolelepis									
Scolelepis bonnieri									
Scolelepis gilchristi		1							
Spio	Damaged								
Spio decorata									
Spio filicornis		57	11	3		4	3	3	2
Spiophanes bombyx									1
Spiophanes kroyeri									
Magelona alleni									
Magelona filiformis									
Magelona johnstoni									
Magelona mirabilis									
Chaetopteridae									
Aphelochaeta "species A"									
Caulleriella alata									1
Caulleriella "species B"									
Chaetozone christiei									
Chaetozone zetlandica							1	1	
Dodecaceria									
Ctenodrilidae									
Macrochaeta clavicornis					1				
Mediomastus fragilis						1		71	66
Notomastus		6	1		1	2	3	3	4
Peresiella clymenoides									
Clymenella cincta									
Euzonus flabelligerus									
Ophelia celtica									
Ophelina acuminata									
Scalibregma inflatum									
Polygordius		59	76	49	21	18	26	34	12
Galathow enia oculata						1			
Myriochele danielsseni									
Ow enia borealis									2
Amphictene auricoma									
Lagis koreni									
Ampharetidae									
Ampharete lindstroemi									

		S2-a	S2-b	S2-c	S6-a	S6-b	S6-c	S6R-a	S6R-b
Amphictene auricoma									
Lagis koreni									
Ampharetidae									
Ampharete lindstroemi									
Sabellides octocirrata									
Lanice conchilega									
Phisidia aurea									
Polycirrus		3							7
Polycirrus medusa		6	1				1	5	
Polycirrus norvegicus				1					
Chone filicaudata								2	1
Tubificidae					1	7	2		
Enchytraeidae			1		5	12	23	6	10
Pycnogonida									
Anoplodactylus petiolatus									
Crustacea									
Verruca stroemia								P	
Megatrema anglicum									P
Ostracoda								1	
Oedicerotidae									
Monoculodes carinatus									
Perioculodes longimanus									
Pontocrates arenarius									
Synchelidium maculatum									1
Gitana sarsi								2	
Urothoe elegans									
Harpinia	Damaged								
Harpinia antennaria									
Acidostoma obesum									
Hippomedon denticulatus									
Lepidepecreum longicorne									
Tmetonyx similis									
Argissa hamatipes									
Atylus falcatus				1			1		1
Atylus vedlomensis								1	
Guernea coalita								2	1
Ampelisca brevicornis									
Ampelisca spinipes								1	
Ampelisca spooneri									1
Ampelisca typica									
Bathyporeia	Juveniles								
Megaluropus agilis									
Maera othonis									1
Maerella tenuimana					1				
Gammaropsis cornuta								3	
Siphonoecetes kroyeranus									
Siphonoecetes striatus									
Pariambus typicus									
Eurydice inermis								1	
Eurydice truncata									
Tanaidacea									
Bodotria arenosa									
Bodotria pulchella									
Iphinoe trispinosa									
Cumella pygmaea								1	
Pseudocuma similis									
Diastylis	Damaged								
Diastylis rugosa								1	
Crangonidae									
Philocheras bispinosus									
Paguridae	Juveniles	1							
Anapagurus laevis									
Liocarcinus marmoreus									
Liocarcinus pusillus								1	

		S2-a	S2-b	S2-c	S6-a	S6-b	S6-c	S6R-a	S6R-b
Scrupocellaria scruposa							P	P	
Cellaria fistulosa									
Celleporella hyalina									
Porella	Indet								
Palmiskenea skenei								P	
Pentapora fascialis		P							
Schizoporella									
Cellepora pumicosa								P	
Phoronis									
Phoronis									
Echinodermata									
Asteroidea	Juveniles								
Astropecten irregularis									
Ophiuroidea	Juveniles							46	7
Amphiura filiformis									
Ophiura	Juveniles								
Ophiocten affinis									1
Ophiura albida									
Echinoidea	Juveniles								
Echinocyamus pusillus		5	10	2	7	3	2	6	7
Echinocyamus pusillus									1
Echinocardium flavescens						1	1		
Labidoplax buskii									
Hemichordata									
Hemichordata									
Tunicata									
Tunicata				1					
Cnemidocarpa mollis		1							
Cephalochordata									
Branchiostoma lanceolatum									
Subsampled		50%	50%	50%	50%	50%	50%	50%	50%

Counts are individuals per $0.1m^2$ or part thereof
P = Present (colonial/encrusting species)

Cnidaria										
Anthoathecatae										
Pandeiidae					P	P	P		P	P
Lovenella clausa							P			
Cerianthus lloydii		1			3	5	2		1	
Edwardsiidae		1	1		8	9	28			
Platyhelminthes										
Platyhelminthes		1							2	
Nemertea										
Nemertea		5	3	5	1	4			3	3
Tubulanus polymorphus				2	4	2	1		5	
Cerebratulus					1	3		1	2	1
Nematoda										
Nematoda	94	8	25	37		1	1	3	22	14
Sipuncula										
Phascolion strombus										
Aspidosiphon muelleri										
Annelida										
Pisione remota	13							4	8	8
Polynoidae	4							2	3	2
Eunoe nodosa	1									
Malmgrenia arenicolae										
Pholoe baltica (sensu petersen)										
Pholoe inornata (sensu petersen)	1									
Sthenelais					1	1	1			
Sthenelais limicola		2	1	1		1				
Eteone longa										
Hesionura elongata	1		1						1	1
Mystides caeca										
Pseudomystides limbata								1		
Anaitides lineata			1	1	2				1	
Anaitides longipes						1				1
Anaitides rosea					3	2				
Eulalia mustela	2									
Eumida	1				1	1				
Lacydonia miranda										
Glycera										
Glycera alba					2		1			
Glycera capitata						1				
Glycera lapidum	6	2	1		1	1	1	13	10	13
Glycera oxycephala	3	1	1	1				4	2	6
Glycera tridactyla					1	1				
Goniadidae										
Glycinde nordmanni			1		6	5	6		1	
Goniada maculata						2	1			
Goniadella bobretzkii				1						1
Sphaerodoropsis minuta										
Nereimyra woodsholea										
Psamathe fusca										
Podarkeopsis capensis					1		1			
Syllidia armata									1	
Syllis garciai										
Syllis pontxioi	5							1	8	
Syllis										
Trypanosyllis coeliaca										
Dioplosyllis cirrosa										
Odontosyllis fulgurans						1				
Opisthodonta pterochaeta									1	1
Palposyllis prosostoma										
Streptosyllis bidentata								1	3	
Streptosyllis websteri										

	S6R-c	S9-a	S9-b	S9-c	S10-a	S10-b	S10-c	S11-a	S11-b	S11-c
Syllides benedicti	1									
Brania										
Exogone hebes				2					1	
Sphaerosyllis bulbosa	7			1						
Sphaerosyllis taylori									1	1
Nephtys		1	1	1	2			2		1
Nephtys assimilis							1			
Nephtys cirrosa		5	3	3						1
Nephtys hombergii					1	2	1			
Aponuphis bilineata										1
Hyalinoecia tubicola									2	
Lumbrineris gracilis					2	3	3			
Lumbrineris futilis			1							
Scoletoma magnidentata	1								1	
Ophryotrocha										
Protodorvillea kefersteini	20									
Orbinia			7	3						
Orbinia sertulata		4								
Scoloplos armiger										1
Aricidea wassi					2					
Aricidea cerrutii		1						1	3	5
Aricidea simonae						1				
Poecilochaetus serpens									1	
Aonides paucibranchiata	11	11	8	3	3	4	2	8	19	16
Laonice bahusiensis	1								2	1
Minuspio cirrifera					2		3			
Prionospio						1		1	17	5
Prionospio fallax					4	2				
Scolelepis									1	
Scolelepis bonnieri			1		1	2	1			
Scolelepis gilchristi										
Spio										
Spio decorata					2					1
Spio filicornis	2					1	1	1		
Spiophanes bombyx			2	2	25	19	8		1	
Spiophanes kroyeri					1	2	2			
Magelona alleni							2			
Magelona filiformis					13	30	8			
Magelona johnstoni							2			
Magelona mirabilis										
Chaetopteridae			2	1						
Aphelochaeta "species A"	1					2				
Caulleriella alata										
Caulleriella "species B"										1
Chaetozone christiei					5		4			
Chaetozone zetlandica								1	1	1
Dodecaceria					4	4	3			
Ctenodrilidae									10	1
Macrochaeta clavicornis										
Mediomastus fragilis	31							1	4	2
Notomastus	2		1					1		3
Peresiella clymenoides					11	20	13			
Clymenella cincta							1			
Euzonus flabelligerus										
Ophelia celtica								1		
Ophelina acuminata								1		
Scalibregma inflatum					1		1			
Polygordius	33	1	5					3	9	5
Galathowenia oculata							1		3	1
Myriochele danielsseni		1			13	8	3			
Owenia borealis		6	6	2	5	4	3			

	S6R-c	S9-a	S9-b	S9-c	S10-a	S10-b	S10-c	S11-a	S11-b	S11-c
Amphictene auricoma					1	1	1			
Lagis koreni						1				
Ampharetidae						1				
Ampharete lindstroemi										1
Sabellides octocirrata									1	
Lanice conchilega						2				
Phisidia aurea										1
Polycirrus	2				1		1	1		
Polycirrus medusa	1			1					4	
Polycirrus norvegicus									1	1
Chone filicaudata										
Tubificidae										
Enchytraeidae	9	2	2	2				4	5	8
Pycnogonida										
Anoplodactylus petiolatus		1								
Crustacea										
Verruca stroemia										
Megatrema anglicum										
Ostracoda	1									
Oedicerotidae				1						
Monoculodes carinatus									1	
Perioculodes longimanus		1	1	1		2	7			
Pontocrates arenarius	2									
Synchelidium maculatum			1							1
Gitana sarsi										
Urothoe elegans										1
Harpinia							2			
Harpinia antennaria						2	1			
Acidostoma obesum					2					
Hippomedon denticulatus			1					2	1	
Lepidepecreum longicorne				1				1	1	1
Tmetonyx similis										1
Argissa hamatipes				3						
Atylus falcatus			1							
Atylus vedlomensis										
Guernea coalita	1									
Ampelisca brevicornis		1			1	1	2			
Ampelisca spinipes	1									
Ampelisca spooneri								1	4	5
Ampelisca typica								1		
Bathyporeia					1	1				
Megaluropus agilis		2	7	3			2	3		
Maera othonis										
Maerella tenuimana										
Gammaropsis cornuta	1					1				
Siphonoecetes kroyeranus		1	5	1						
Siphonoecetes striatus						1	2			
Pariambus typicus							1			
Eurydice inermis										
Eurydice truncata									1	
Tanaidacea			1	1	2	1	1			1
Bodotria arenosa										1
Bodotria pulchella										
Iphinoe trispinosa				1						
Cumella pygmaea										
Pseudocuma similis		14	6	1				9		
Diastylis								1		
Diastylis rugosa								1		2
Crangonidae										1
Philocheras bispinosus						1			1	1
Paguridae			1							1

	S6R-c	S9-a	S9-b	S9-c	S10-a	S10-b	S10-c	S11-a	S11-b	S11-c
Anapagurus laevis										1
Liocarcinus marmoreus						1				
Liocarcinus pusillus										
Mollusca										
Gibbula										
Obtusella intersecta										
Caecum glabrum										
Naticidae							1			
Euspira pulchella		1								
Acteon tornatilis					1		3			
Cylichna cylindracea						1				
Philine										
Philine scabra			2	1	2	12	8		1	1
Retusa										1
Retusa obtusa									1	
Retusa umbilicata						1				
Modiolus						1				
Lucinoma borealis						1	1			
Thyasira flexuosa					4	7	4			
Montacuta substriata					1		2			
Tellimya ferruginosa		1		1	1	2	1		3	2
Kurtiella bidentata						3	3			
Epilepton clarkiae										
Goodallia triangularis		3		2						
Laevicardium crassum									1	
Mactridae		2	1						2	
Mactra stultorum				1						
Spisula elliptica	2	1	1					3		3
Pharidae		1				5	1			
Tellinidae	1					2				
Arcopagia crassa	1									
Fabulina fabula					4	9	10			
Moerella pygmaea		4	1	5				3	5	13
Gari						1				
Gari tellinella	1									
Abra prismatica		16	17	22	5	39	34	5	5	10
Veneridae	1			6					1	
Gouldia minima										1
Chamelea striatula		3	2		14	12	9			
Clausinella fasciata										
Timoclea ovata		1						1		
Dosinia				2					2	1
Dosinia lupinus		3			6	12	16			
Mysia undata				1	1					
Thraciidae		1		4						
Thracia villosiuscula								1	1	1
Cochlodesma praetenue		2	1	1	1	8	10			
Bryozoa										
Crisidia cornuta		P		P						
Crisia				P					P	
Crisia denticulata										
Crisia eburnea	P									
Crisia ramosa										
Plagioecia patina				P						
Aetea anguina				P						
Scruparia chelata	P	P								
Electra pilosa										
Carbasea carbasea			P							
Beania mirabilis										
Scrupocellaria										
Scrupocellaria scabra										

	S6R-c	S9-a	S9-b	S9-c	S10-a	S10-b	S10-c	S11-a	S11-b	S11-c
Scrupocellaria scruposa	P		P	P						
Cellaria fistulosa				P						
Celleporella hyalina				P						
Porella										
Palmiskenea skenei										
Pentapora fascialis										
Schizoporella										
Cellepora pumicosa			P							
Phoronis										
Phoronis		1			12	17	10			1
Echinodermata										
Asteroidea						1				
Astropecten irregularis		1								
Ophiuroidea	4	4		2		10	4	2	1	2
Amphiura filiformis					3	4	5			
Ophiura			6							
Ophiocten affinis		1						1		1
Ophiura albida								1		
Echinoidea						2				
Echinocyamus pusillus		12	12		1	6	1	5	14	3
Echinocyamus pusillus	1	12	2	1	3	7	10	1	4	3
Echinocardium flavescens		28	24	12	18	20	22	3	13	6
Labidoplax buskii			1							
Hemichordata										
Hemichordata							1			
Tunicata										
Tunicata										
Cnemidocarpa mollis										
Cephalochordata										
Branchiostoma lanceolatum	1									
Subsampled	50%									

Counts are individuals per 0.1m^2 or part thereof
P = Present (colonial/encrusting species)

	S17-a	S17-b	S17-c
Cnidaria			
Anthoathecatae	P		
Pandeiidae			P
Lovenella clausa			
Cerianthus lloydii			1
Edwardsiidae		1	
Platyhelminthes			
Platyhelminthes			
Nemertea			
Nemertea	4	2	2
Tubulanus polymorphus			2
Cerebratulus			
Nematoda			
Nematoda	4		4
Sipuncula			
Phascolion strombus			
Aspidosiphon muelleri			
Annelida			
Pisione remota			
Polynoidae			
Eunoe nodosa			
Malmgrenia arenicolae			
Pholoe baltica (sensu petersen)			
Pholoe inornata (sensu petersen)			
Sthenelais			
Sthenelais limicola			
Eteone longa			
Hesionura elongata			1
Mystides caeca			
Pseudomystides limbata			
Anaitides lineata		1	
Anaitides longipes			
Anaitides rosea			
Eulalia mustela			
Eumida			
Lacydonia miranda			
Glycera			
Glycera alba			
Glycera capitata			
Glycera lapidum			
Glycera oxycephala	3	1	
Glycera tridactyla			
Goniadidae			
Glycinde nordmanni			
Goniada maculata			
Goniadella bobretzkii			
Sphaerodoropsis minuta			
Nereimyra woodsholea			
Psamathe fusca			
Podarkeopsis capensis			
Syllidia armata			
Syllis garciai			
Syllis pontxioi			
Syllis			
Trypanosyllis coeliaca			
Dioplosyllis cirrosa			
Odontosyllis fulgurans			
Opisthodonta pterochaeta			
Palposyllis prosostoma			
Streptosyllis bidentata			
Streptosyllis websteri			

	S17-a	S17-b	S17-c
Syllides benedicti			
Brania			
Exogone hebes			
Sphaerosyllis bulbosa			
Sphaerosyllis taylori			
Nephtys		2	1
Nephtys assimilis			
Nephtys cirrosa	2		7
Nephtys hombergii			
Aponuphis bilineata			
Hyalinoecia tubicola			
Lumbrineris gracilis			
Lumbrineris futilis			
Scoletoma magnidentata			
Ophryotrocha			
Protodorvillea kefersteini			
Orbinia	1		
Orbinia sertulata			
Scoloplos armiger			
Aricidea wassi			
Aricidea cerrutii			
Aricidea simonae			
Poecilochaetus serpens			
Aonides paucibranchiata	3	1	2
Laonice bahusiensis			
Minuspio cirrifera			
Prionospio			
Prionospio fallax			
Scolelepis			
Scolelepis bonnieri			
Scolelepis gilchristi			
Spio			
Spio decorata			
Spio filicornis			
Spiophanes bombyx	1	4	2
Spiophanes kroyeri			
Magelona alleni			
Magelona filiformis			
Magelona johnstoni			
Magelona mirabilis	1		
Chaetopteridae		1	
Aphelochaeta "species A"			
Caulleriella alata			
Caulleriella "species B"			
Chaetozone christiei			
Chaetozone zetlandica			
Dodecaceria			
Ctenodrilidae			
Macrochaeta clavicornis			
Mediomastus fragilis			
Notomastus			
Peresiella clymenoides			
Clymenella cincta			
Euzonus flabelligerus		1	
Ophelia celtica			
Ophelina acuminata			
Scalibregma inflatum			
Polygordius			
Galathowenia oculata			
Myriochele danielsseni			
Owenia borealis	3	2	2

	S17-a	S17-b	S17-c
Amphictene auricoma			
Lagis koreni			
Ampharetidae			
Ampharete lindstroemi			
Sabellides octocirrata			
Lanice conchilega			
Phisidia aurea			
Polycirrus			
Polycirrus medusa		1	
Polycirrus norvegicus			
Chone filicaudata			
Tubificidae			
Enchytraeidae	4	5	3
Pycnogonida			
Anoplodactylus petiolatus			
Crustacea			
Verruca stroemia			
Megatrema anglicum			
Ostracoda			
Oedicerotidae			
Monoculodes carinatus			
Perioculodes longimanus	1		
Pontocrates arenarius			
Synchelidium maculatum			
Gitana sarsi			
Urothoe elegans			
Harpinia			
Harpinia antennaria			
Acidostoma obesum			
Hippomedon denticulatus	1		
Lepidepecreum longicorne	1		
Tmetonyx similis			
Argissa hamatipes	1		
Atylus falcatus			
Atylus vedlomensis			
Guernea coalita			
Ampelisca brevicornis			3
Ampelisca spinipes			
Ampelisca spooneri			
Ampelisca typica			
Bathyporeia			1
Megaluropus agilis	1		
Maera othonis			
Maerella tenuimana			
Gammaropsis cornuta			
Siphonoecetes kroyeranus	5	2	3
Siphonoecetes striatus			
Pariambus typicus			
Eurydice inermis			
Eurydice truncata			
Tanaidacea		1	
Bodotria arenosa			
Bodotria pulchella	2		
Iphinoe trispinosa			1
Cumella pygmaea			
Pseudocuma similis			1
Diastylis			
Diastylis rugosa			
Crangonidae			
Philocheras bispinosus			
Paguridae			

	S17-a	S17-b	S17-c
Anapagurus laevis			
Liocarcinus marmoreus			
Liocarcinus pusillus			
Mollusca			
Gibbula			
Obtusella intersecta			
Caecum glabrum			
Naticidae			
Euspira pulchella			1
Acteon tornatilis			
Cylichna cylindracea			
Philine			
Philine scabra			
Retusa			
Retusa obtusa			
Retusa umbilicata			
Modiolus			
Lucinoma borealis			
Thyasira flexuosa			
Montacuta substriata			
Tellimya ferruginosa		1	1
Kurtiella bidentata			
Epilepton clarkiae			
Goodallia triangularis		1	
Laevicardium crassum			
Mactridae		1	1
Mactra stultorum			1
Spisula elliptica	2	3	1
Pharidae			
Tellinidae			
Arcopagia crassa			
Fabulina fabula			
Moerella pygmaea	2		1
Gari			
Gari tellinella			
Abra prismatica	4	5	3
Veneridae			
Gouldia minima			
Chamelea striatula		2	
Clausinella fasciata			
Timoclea ovata			
Dosinia			1
Dosinia lupinus	3		
Mysia undata			
Thraciidae		2	
Thracia villosiuscula			
Cochlodesma praetenue	2		2
Bryozoa			
Crisidia cornuta	P	P	
Crisia			
Crisia denticulata	P	P	
Crisia eburnea		P	
Crisia ramosa			
Plagioecia patina			
Aetea anguina	P		
Scruparia chelata		P	P
Electra pilosa			
Carbasea carbasea			
Beania mirabilis			
Scrupocellaria			
Scrupocellaria scabra			

	S17-a	S17-b	S17-c
Scrupocellaria scruposa	P		
Cellaria fistulosa	P		
Celleporella hyalina	P	P	
Porella	P		
Palmiskenea skenei			
Pentapora fascialis			
Schizoporella	P		
Cellepora pumicosa			
Phoronis			
Phoronis			
Echinodermata			
Asteroidea			
Astropecten irregularis			
Ophiuroidea	1	1	
Amphiura filiformis			
Ophiura			
Ophiocten affinis			
Ophiura albida			
Echinoidea			
Echinocyamus pusillus	18	15	5
Echinocyamus pusillus	2	2	1
Echinocardium flavescens	4	6	5
Labidoplax buskii			
Hemichordata			
Hemichordata			
Tunicata			
Tunicata			
Cnemidocarpa mollis			
Cephalochordata			
Branchiostoma lanceolatum			
Subsampled			

Counts are individuals per $0.1m^2$ or part thereof
P = Present (colonial/encrusting species)

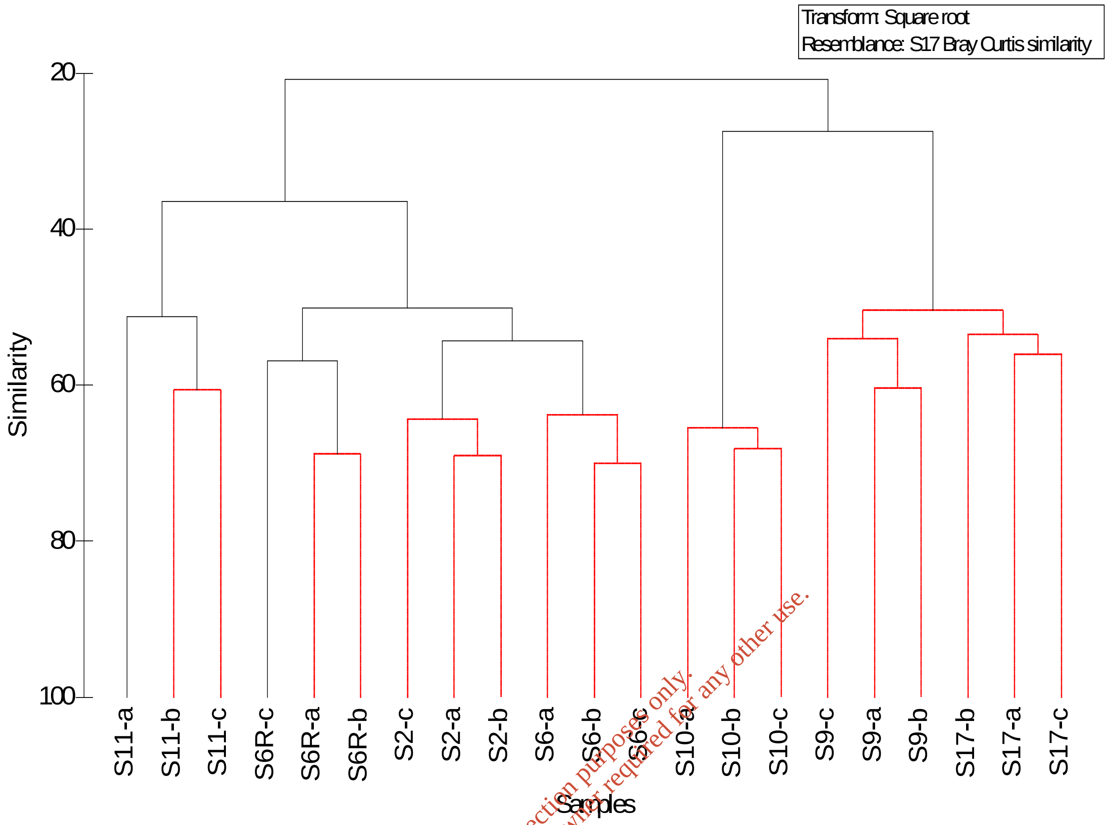
Appendix 2: Ranked Taxa Tables for Stations at SW-1

S2		S6		S6R		S9	
Nematoda	**263**	**Nematoda**	**71**	**Nematoda**	**193**	**Nematoda**	**23**
Polygordius	**61**	**Pisione remota**	**32**	**Mediomastus fragilis**	**56**	**Echinocardium flavescens**	**21**
Pisione remota	**50**	**Polygordius**	**22**	**Polygordius**	**26**	**Abra prismatica**	**18**
Spio filicornis	**24**	**Protodorvillea kefersteini**	**15**	**Aonides paucibranchiata**	**26**	**Echinocyamus pusillus juvs**	**8**
		Enchytraeidae	**13**	**Glycera lapidum**	**23**	**Aonides paucibranchiata**	**7**
Protodorvillea kefersteini	12	**Hesionura elongata**	**9**			**Pseudocuma similis**	**7**
Hesionura elongata	10			Pisione remota	21	**Echinocyamus pusillus**	**5**
Nemertea	8	Streptosyllis bidentata	8	Ophiuroidea	19	**Owenia**	**5**
Syllis pontxioi	6	Glycera lapidum	7	Protodorvillea kefersteini	14	**Nemertea**	**4**
Echinocyamus pusillus juvs	6	Opisthodonta pterochaeta	7	Eumida	12	**Megaluropus agilis**	**4**
Glycera lapidum	5	Nemertea	7	Hesionura elongata	10		
No. of individuals	486	No. of individuals	234	No. of individuals	507	No. of individuals	165
50% of individuals	243	50% of individuals	117	50% of individuals	254	50% of individuals	82

S10		S11		S17	
Abra prismatica	**26**	**Aonides paucibranchiata**	**14**	**Echinocyamus pusillus juvs**	**13**
Echinocardium flavescens	**20**	**Nematoda**	**13**	**Echinocardium flavescens**	**5**
Spiophanes bombyx	**17**	**Glycera lapidum**	**12**	**Enchytraeidae**	**4**
Magelona filiformis	**17**	**Prionospio**	**8**	**Abra prismatica**	**4**
Edwardsiidae	**15**	**Echinocyamus pusillus juvs**	**7**		
Peresiella clymenoides	**15**	**Echinocardium flavescens**	**7**	Siphonoecetes kroyeranus	3
Phoronis	**13**	**Moerella pygmaea**	**7**	Nephtys cirrosa	3
Chamelea striatula	**12**	**Pisione remota**	**7**	Nemertea	3
Dosinia lupinus	**11**	**Abra prismatica**	**7**	Nematoda	3
Myriochele danielsseni	**8**	**Polygordius**	**6**	Spiophanes bombyx	2
				Owenia	2
		Enchytraeidae	6		
No. of individuals	283	No. of individuals	168	No. of individuals	72
50% of individuals	141	50% of individuals	84	50% of individuals	36

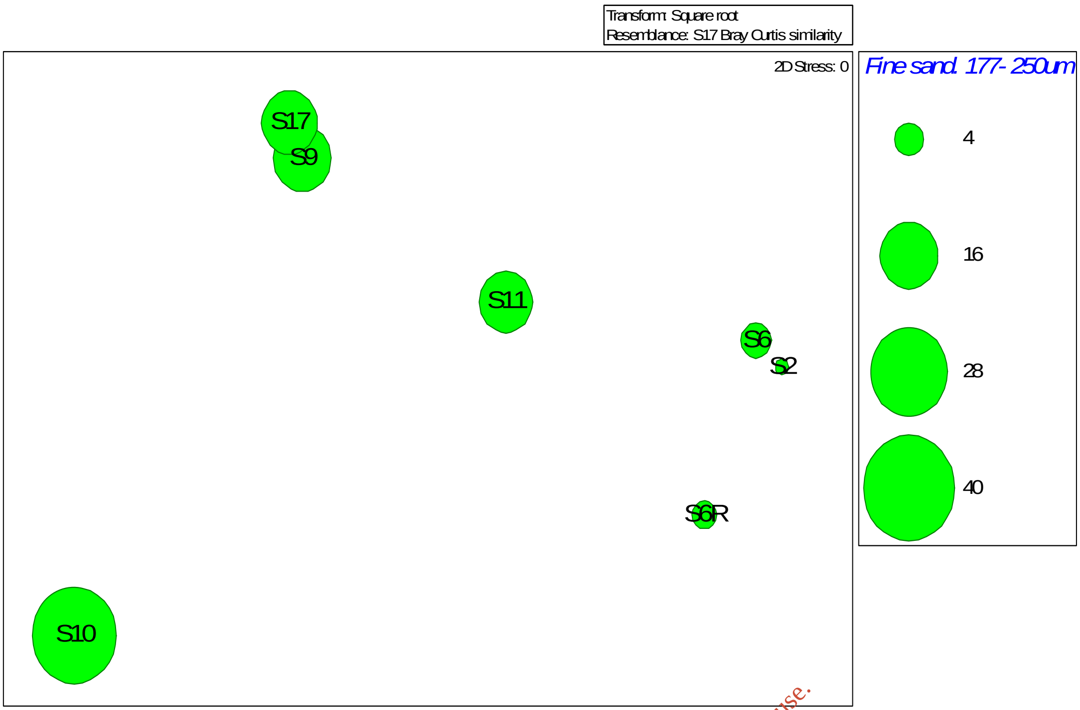
Top 10 ranked taxa for outfall sites in 2014. Taxa comprising the top 50% of the population are in bold. Abundances are per 0.1m^2 or part thereof

Appendix 3: Bray Curtis dendrogram showing within site (per replicate) faunal community clustering at SW-1

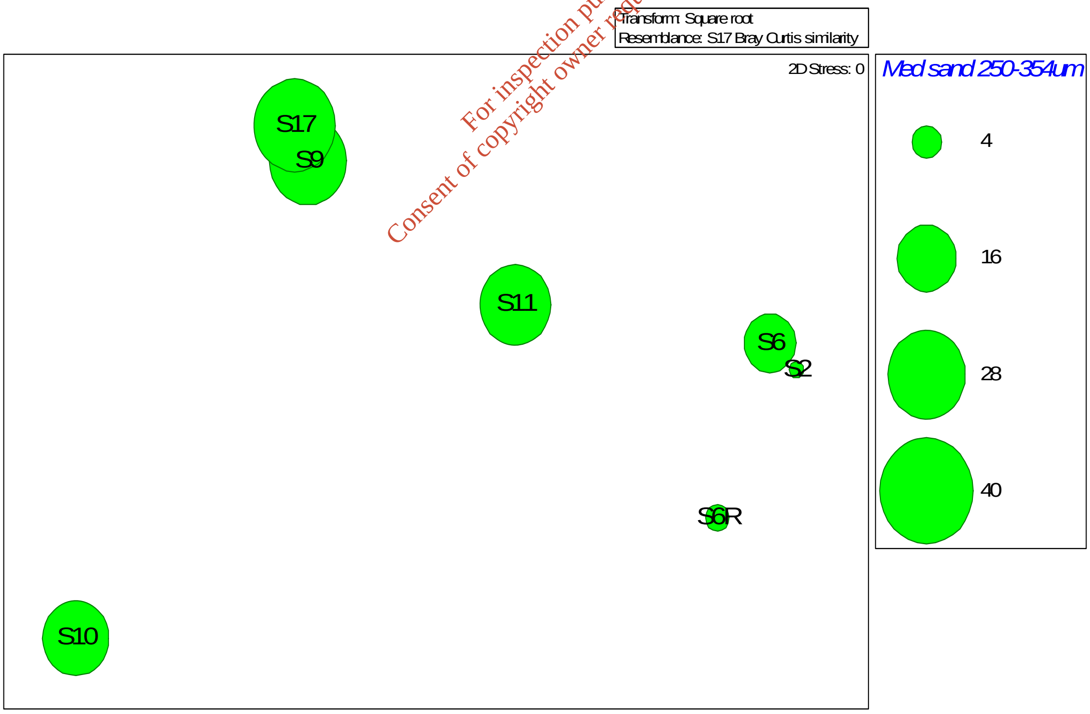


Dendrogram showing clustering of communities using per replicate sample data from outfall sites. Black lines indicate a significant difference between replicates.

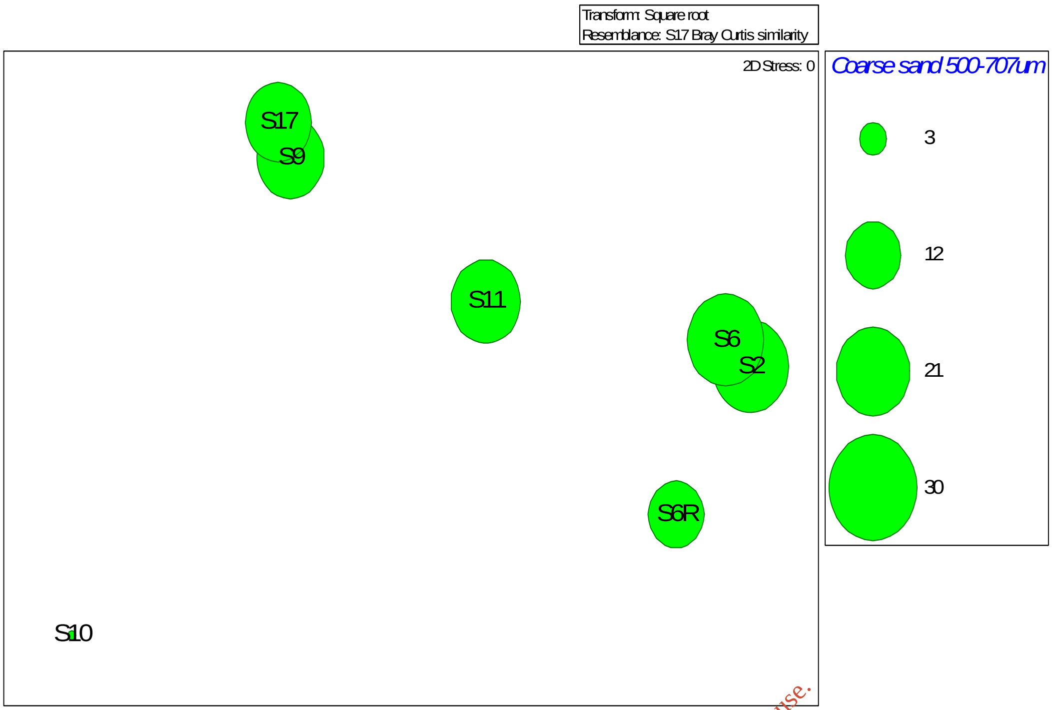
Appendix 4: MDS overlays of benthic faunal community clustering plotted against other environmental variables (particle size and concentrations of aluminium in seabed sediments) for stations at SW-1. The plots are graphical interpretation of the results of the BIO-ENV analysis



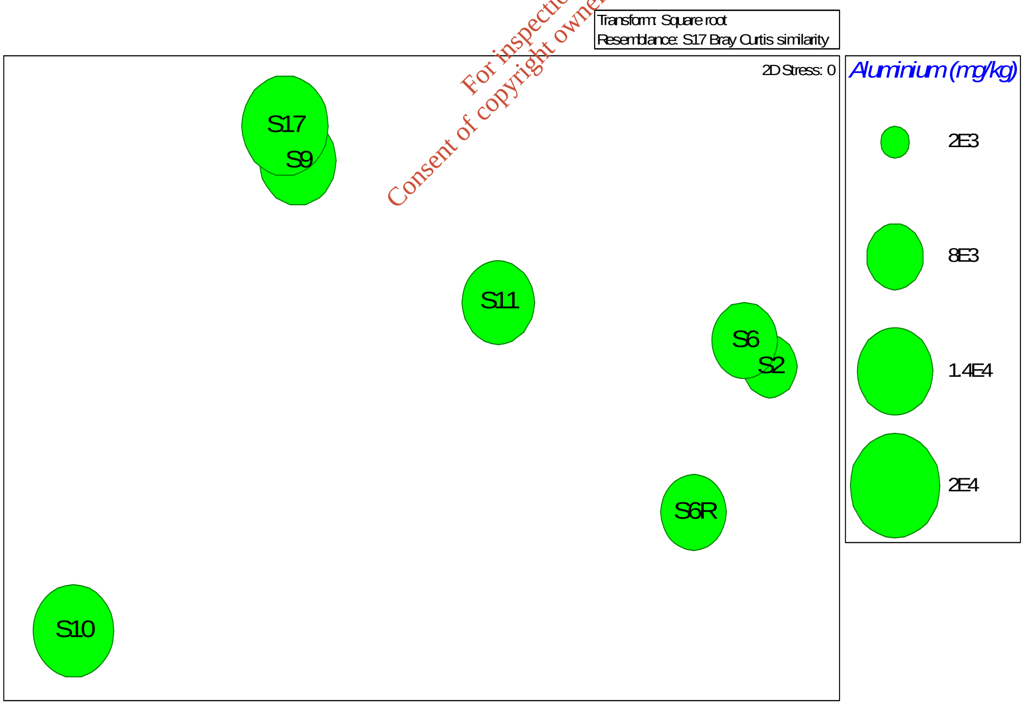
MDS plot of outfall sites in the study area with superimposed bubbles representing the percent particle size 177-250µm (fine sand) at each site.



MDS plot of outfall sites in the study area with superimposed bubbles representing the percent particle size 250-354µm (medium sand) at each site.



MDS plot of outfall sites in the study area with superimposed bubbles representing the percent particle size 500-707µm (coarse sand) at each site.



MDS plot of outfall sites in the study area with superimposed bubbles representing the concentration of Aluminium (mgkg-1) at each site.

Appendix 5: Osiris Projects Mobilisation Report

RSK, Shell E&P Ireland ltd

Corrib Offshore Manifold and Treated Surface Water Outfall (SW1 and SW3) Baseline Environment - Verification Survey

MOBILISATION REPORT

2014-030

Vessel: ILV Granuaile

26/09/2014

OSIRIS PROJECTS
SEABED MAPPING & COASTAL SURVEY

Maritime House
4 Brunel Road
Croft Business Park
Bromborough, Wirral
CH62 3NY
Tel. 0151 328 1120. Fax 0151 343 1057
e-mail: enquiries@osirisprojects.co.uk

Corrib Offshore Manifold and Treated Surface Water Outfall (SW1 and SW3) Baseline Environment - Verification Survey

MOBILISATION REPORT

Report Status: Issue 1

Issue Date: 06/10/2014

Project Manager: Gareth Stevens

Party Chief: Nick Bowley

Surveyors: Neil Davis
Rob Andrew

Report Author: Nick Bowley

Revision Number	Date of Issue	Comments
00	06/10/2014	Issue 1

Distribution:

RSK Environment Ltd
The Old School
Stillhouse Lane
Bedminster
Bristol
BS3 4EB

For the Attention of: David Watson, Director

CONTENTS

APPENDICES

1. Introduction

Osiris Projects were commissioned in September 2014 by RSK to provide a vessel and accurate positioning during a benthic environmental survey. The survey utilised a Camera, Grab and Water Sampler, which was positioned utilising a USBL system and RTG corrected GNSS interfaced into QPS QINSy navigation software.

1.1 Vessel

ILV Granuaile

ILV Granuaile is a buoy laying and maintenance vessel operated by the Commission for Irish Lights CIL registered in Dublin. The vessel was built in 2000 and is classed by Lloyds register as follows; 1001A, LMC, UMS, DP (DP Class 1) (AM). The vessel is 80m x 16.1m, with a draft of 4.6m, and has a gross tonnage of 2625 tonnes. The vessel has a maximum speed of 13kts with a cruising speed of 10kts. Propulsion is provided by 2 Schottel rudder propellers which, along with the Jet type bow thruster, provide the vessel with its DP capability.

Granuaile has accommodation for 30 personnel, in 22 single berth and 4 double berth cabins. The vessel has a minimum endurance of 45 days, which is limited by fuel consumption.

Granuaile is equipped with several systems which were utilised by OSIRIS for the duration of the survey, a prefabricated a moonpool and pole designed for the deployment of USBL equipment, and a Seapath 330+ INS system. Unfortunately the ELAC LAZ 5000 singlebeam echosounder had been lost at sea and was not replaced before mobilisation.

1.2 Geodetic Parameters

The GPS is referenced to the World Geodetic System, 1984 (WGS84).

All survey area coordinates are in terms of:

Datum:	WGS84
Conversion Factor to m	1.0
Spheroid	WGS 1984
Semi-Major Axis	6378137.00
Semi-Minor axis	6356752.314
Inverse Flattening (I/F)	298.25722356300

Projection	UTM 29
False Easting	500000.000m
False Northing	0.000m
Latitude of Origin	0;00;00.00
Central Meridian	09;00;00.00
UTM Zone	29
Scale Factor on CM	0.9996
Units:	Metres

1.2.1 Time

Raw Data	UTC
Survey Log Sheets	UTC
Reports	UTC

1.2.2 Units of Measurement

Linear	Metres (m)
Angular	Degrees (°, positive clockwise)

1.3 Equipment List

The specification sheets for the equipment listed can be viewed at the following address; http://www.osirisprojects.co.uk/spec-sheets/

Hardware		Asset Number
Global Positioning System 1	CNAV 3050 (RTG)	Rented S/N 12814
Global Positioning System 2	Seapath 330+	Vessel Owned
Gyro 1	Seapath 330+	Vessel Owned
Motion Reference Unit 1	Seapath 330+	Vessel Owned
USBL	Sonardyne Scout Plus	SUR0001/SUR0334
Sound Velocity Profiler	Valeport Mini SVP	SUR0282
Software		
Survey Acquisition	QINSy 8.1.2014.07.09	DON0301

2. Vessel Offsets

2.1 Central Reference Point

The central reference point for ILV Granuaile is defined from the 2004 dimensional survey as the MRU position. All offsets were relative to this position.

2.2 Main Offsets

Sign Convention	X axis	Y axis	Z axis
	Starboard: +ve	Bow: +ve	Up: +ve

Antennas	X (+ve Starboard)	Y (+ve Forward)	Z - CoG to Ant Base	Antenna	CoG to base of antenna	CoG to phase centre
			Z (+up)		Z (+up)	Z (+up)
CNAV 3050	5.384	-3.981	13.872	Navant3001R	13.872	
Seapath Ant1	-0.729	-2.695	25.961		25.961	
Seapath Ant2	-0.657	-0.19	25.906		25.905	
IMU	X	Y	Z (+up)	Comments		
Seapath MRU	0	0	0	Reference point		
USBL	X	Y	Z +up (CoG)	Comments		
Sonardyne Scout	-0.214	-12.636	-10.110	Moonpool		
Towpoints				Comments		
Drop Point	-7.814	-9.886	0	Launch and Recovery System		

Note: CoG - Centre of Gravity

2.3 INS/IMU Offsets

Sign Convention	X axis	Y axis	Z axis
	Stbd +	Forward +	Down +

3. Equipment

3.1 Global Positioning Systems

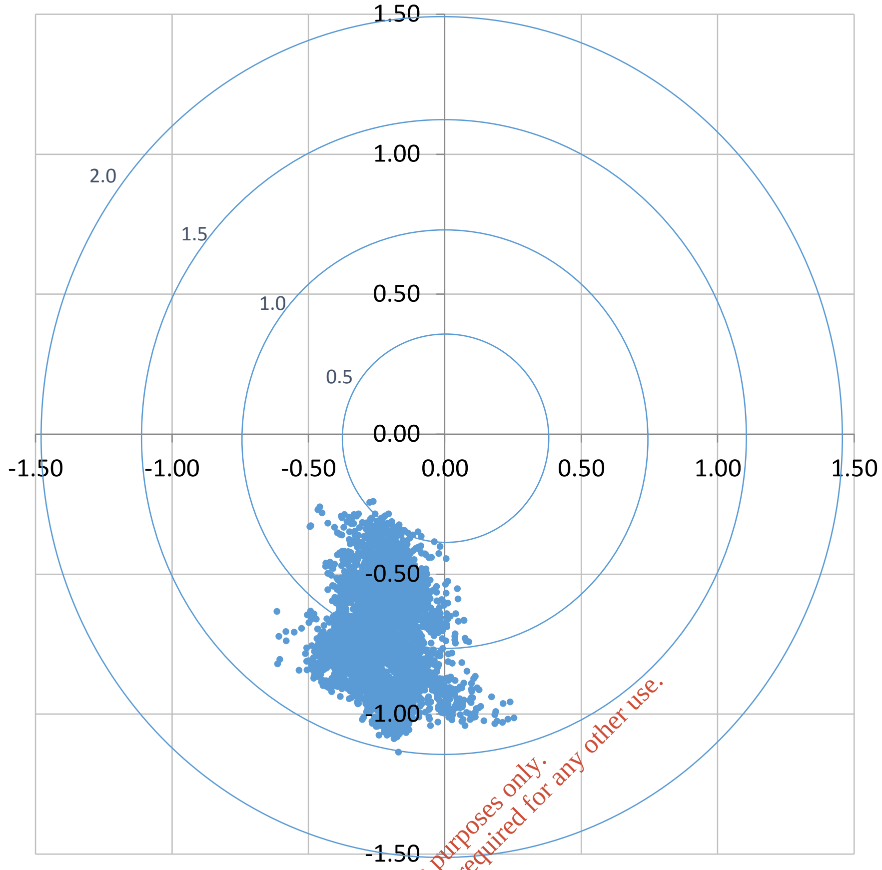
Position Navigation	Model	Serial No.	DGNSS Corrections	Antenna	Output Interval	Recorded Format
Primary	CNAV 3050	12814	RTG	NAVANT3001R	5Hz	Raw and QINSy
Secondary	Seapath 330	unknown	dGPS	unknown	20Hz	QINSy

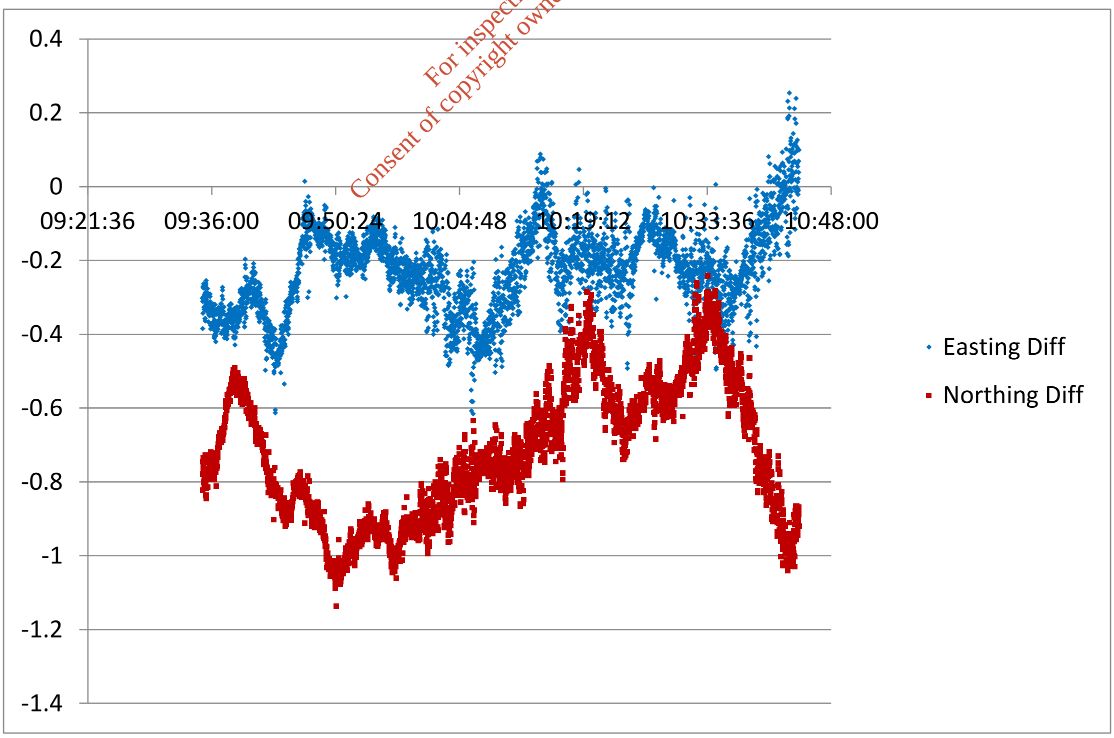
3.1.2 Primary and Secondary GPS System Comparison

A primary and secondary GPS system comparison was performed whilst at sea. The GPS data was subsequently logged within QPS QINSy, averaged and the Computed minus Observed (C-O) values are shown in the table below:

	Easting (m)	Northing (m)
Primary GPS	365390.5318	6020982.291
Secondary GPS	365390.3041	6020981.571
Difference (C-O)	0.22778216	0.719494585

Difference Between Primary and Secondary Nav over 1hr 10mins





3.2 Heading and Motion

Motion Reference	Model	Serial No.	Control Software	Recorded Format
Primary	Seapath 330+	Unknown	Seapath	QINSy

The Seapath 330+ INS was a pre-installed system within the vessel where Pitch, Roll and Heave are measured via the MRU, and heading calculated using two GNSS antenna. All three of these components were subject to a dimensional control survey prior to mobilisation, and any misalignments accounted for using this technique and entered into the control software. The output from the control software was therefore corrected to the vessel reference frame.

3.2.4 Timing Pulse (PPS)

	System	Positive/Negative
Pulse Source	CNAV 3050	Negative
Pulse Used by	QINSy	Negative

3.4 Subsurface Positioning

Subsurface Positioning System	Model	Control Software Version	Beacons	Recorded Format
	Sonardyne Scout Plus	Scout	Wideband	QINSy

3.4.1 USBL Calibration

The Sonardyne Scout was calibrated using a static calibration technique, which allows the user to correct the heading misalignment between the transducer and the vessel reference frame.

A beacon was lowered into the water at several points around the vessel. The bearings recorded in scout were compared to those expected in order to calculate the heading offset of the transducer.

Results:

Location	**Corrected for vessel heading**	**Expected result**	**Misalignment**	**Used Offset**
Stern	134.2	144.3	10.1	20 Degrees
Stbd	118	90	28	
Port	286	270	16	

3.8 Sound Velocity Profile and Sensors

Sound Velocity Measurement	Model	Serial No.	Calibration Date		Recorded Format
SVP1	Valeport Mini SVP	43265	18/06/2013		QINSy .db
SVP2	Valeport Monitor SVP	23727	19/05/2014	*Spare	QINSy .db

Sound velocity measurement systems are subject to a 24month factory calibration.

APPENDICES

APPENDIX 1

Vessel Specification

ILV GRANUAILE SPECIFICATION AND CAPABILITIES

General Particulars

Built by:	Damen Shipyards Holland
Date:	31st January 2000
Official Number:	403374
IMO Number:	9192947
MMSI:	250191000
Radio Call Sign:	EIPT
Class:	Lloyds 100A1, +LMC, +UMS + DP (AM)
IMO DP Notation:	Class 1

Dimensions

Length Overall:	79.69m
Breadth Moulded:	16.10m
Depth of Hold:	6.0m
Working Deck Width:	15.80m
Gross Registered Tonnage:	2625 tonnes
Net Registered Tonnage:	787 tonnes
Loaded Displacement:	3,903 tonnes
Operational Draft:	4.60m

Deck Equipment

1 x Liebherr Crane, 20 tonne SWL with constant tension capability, outreach 20 metres
2 x 15 tonne Chain capstans

1 x 26' wooden motor boat

1 x 8 metre RIB with inboard engine

2 x Karmform 'chain grabbers'

1 set of Hydraulic Towing Pins

Container Capability: 16 TEU Single Stack

Moonpool: diameter 0.5m, length 7.7m

Towing Equipment

1 x towing winch, 40 tonne bollard pull

1 x 32mm x 300m towing wire with 30cm soft eye.

60 tonnes breaking strain

1 x 200m 9" octoplait with large soft eye one end and wire tail with large eye other end.
Ancillary gear of slips, strops, shackles, etc.

Hydrographic Package

1 x Trac C Automatic Track Guidance

1 x CARIS Post Processing System

1 x ELAC LAZ 5000 echo sounder (single beam)

1 x Seatex MRU-5

1 x Marimatech SVP-HMS1820

1 x Kongsberg Seatex Seapath 200 attitude GPS

Integrated Bridge System

2 x DGPS Northstar MX500

1 x Loran C Furuno LC90

2 x 6 CH Motorola GPS receivers + MBX-3 Differential Receiver
2 x Simrad GC80 Gyro Compass

Kongsberg Dynamic Positioning (Class 1 DP)

Radars:	2 x Furuno FAR 2xx7 RPU-013 (1 S-band, 1 X-band)
Electronic Charts:	2 x Furuno FMD-3200-BB ECDIS system

Close Quarters DP Work

1 x Fan Beam Radar

Engine Configuration (Diesel Electric)

Power:	3,500 kW
Generator:	5 x 700 kW MAN B&W engines Type 8L 16/24 driving 690v AC AVK generators
Propulsion:	2 x 1,100 kW INDAR variable speed AC motors driving 2 x Schottel rudder propellers type SRP 1010 ZSFP
Bow Thruster:	1,100 kW INDAR variable speed AC motor driving Elliot White Gill Jet type 50T3S 360°
Stabilising:	Intering System (Passive)

Oil Recovery

Bilge Water Tank – 30 tonnes

Helicopter Operations

Daylight operations only

Pad:	Located forward – semi-circular with 13 metre diameter
Max weight:	3.2 tonnes
Fuel:	Direct pumped fuelling Jet A1 – 1700 litres
Underslinging:	Available from the afterdeck.

Liquids

Bunkers Maximum:	320 tonnes
Fresh Water:	457 tonnes
Water Making:	Not available
Maximum Speed:	13.00 knots
Endurance:	45 days @ cruising speed

MGO Consumption 24 hrs:
2 engines @ 80% = 6 tonnes per day
3 engines @ 80% = 10 tonnes per day

Accommodation

Crew:	Depending on contractual requirements and area of operations.
Others:	22 Single Berth and 4 Double Berth Cabins (including crew cabins) All cabins are air-conditioned

Security

CCTV External and Internal Monitoring (5 cameras and 3 monitors)
ISPS approved access control system

Note: All Details believed to be correct but without guarantee


GRANUAILE

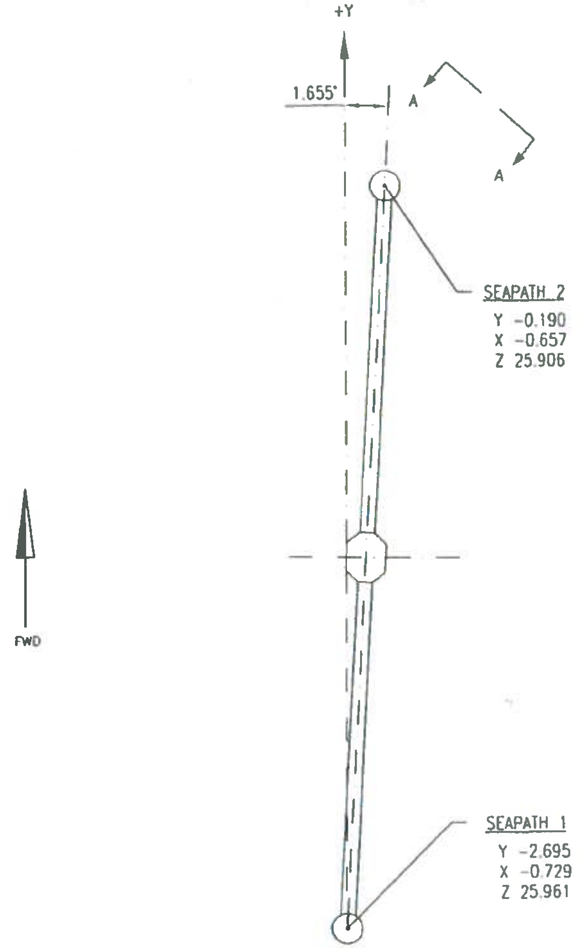
APPENDIX 2

Extracts from Granuaile Dimensional Control Survey 2004

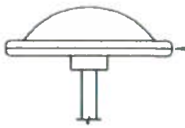
SEAPATH 1 (AFT)

SEAPATH 2 (FWD)

LOOKING TOWARDS PORT



SEAPATH AFT 1



SECTION A - A

NOTE:
ALL DIMENSIONS IN METER AND DEGREES

Blom

DIMENSIONAL CONTROL

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PROJECT: LAYBACK SURVEY ILV GRANUAILE	CONTRACT NO.	WO/CALL OFF NO.
LOCATION: HARLAND & WOLFF	REF. DRAWING NO.	REV.
TITLE: SEAPATH HEADING AND POSITION		

REV. NO.	REASON FOR ISSUE	DOC. NO.	FILE NO.	REV. DATE	DRAWN	PREPARED	CHECKED	APPROVED
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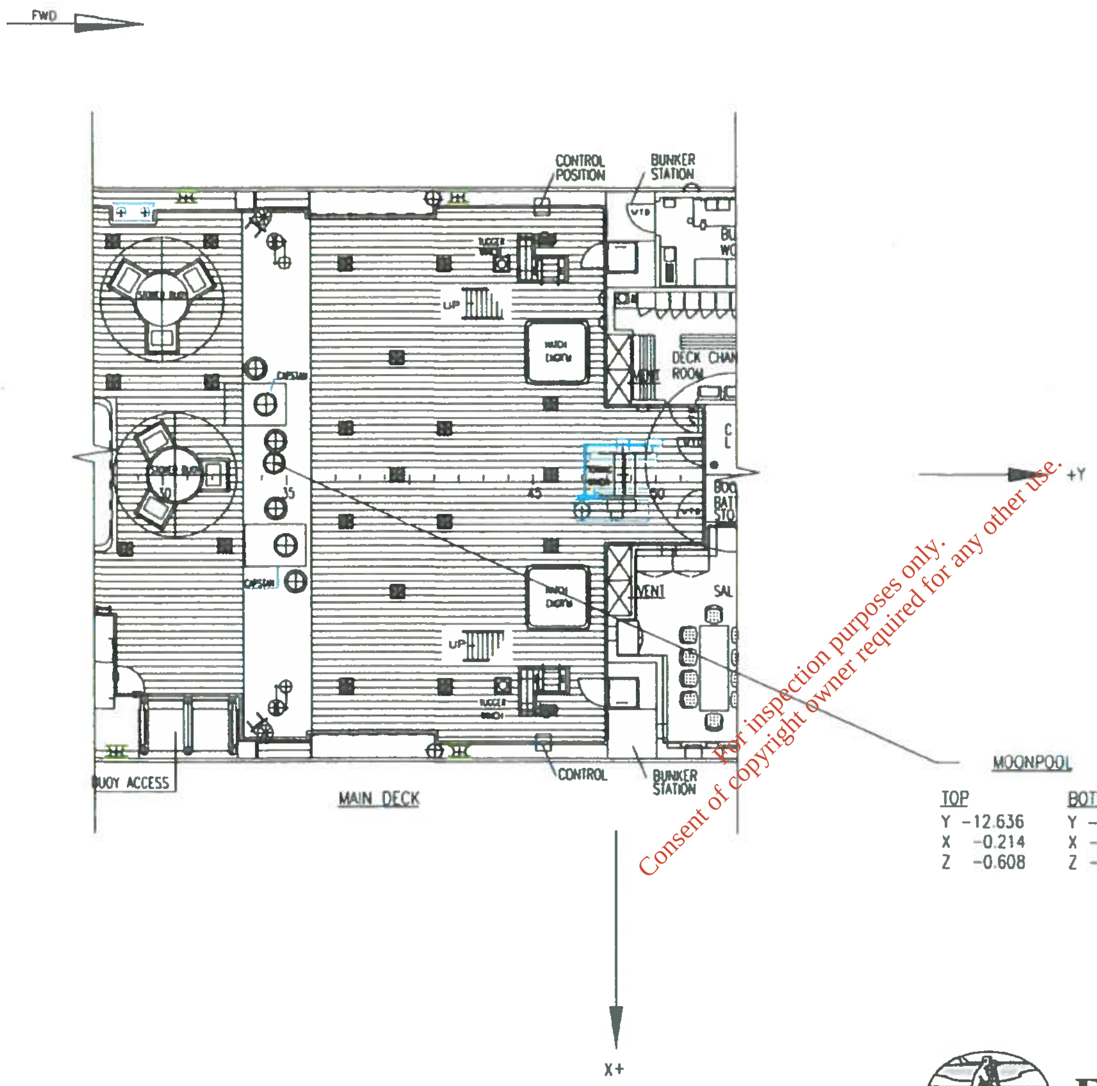
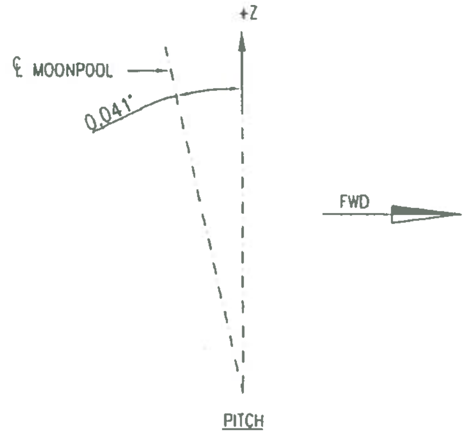
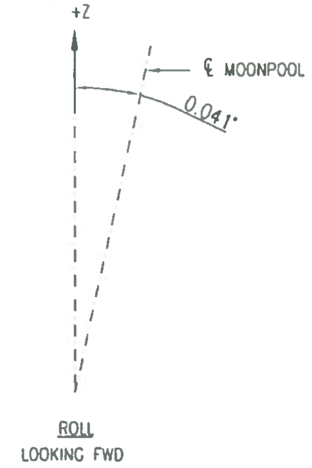


MOONPOOL

TOP		BOTTOM	
Y	-12.636	Y	-12.641
X	-0.214	X	-0.219
Z	-0.608	Z	-7.557





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DIMENSIONAL CONTROL

NOTE:
ALL DIMENSIONS ARE IN METER

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TITLE	POSITION OF MOONPOOL
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PAGE	9 of 15
CONTRACT NO.	
WO/CALL OFF NO.	
REF. DRAWING NO.	
REV.	

REV. NO.	REASON FOR ISSUE	DOC. NO.	FILE NO.	REV. DATE	DRAWN	PREPARED	CHECKED	APPROVED
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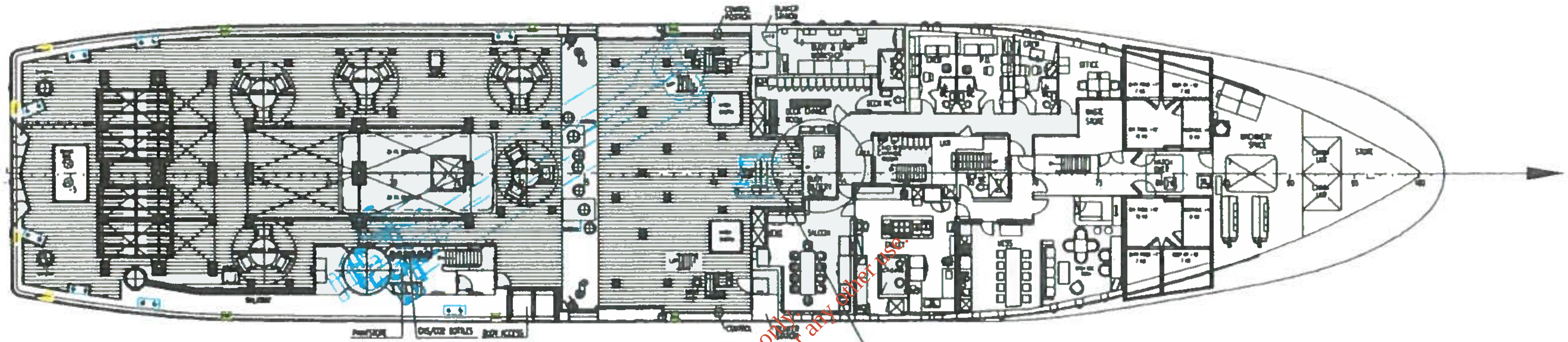
FWD

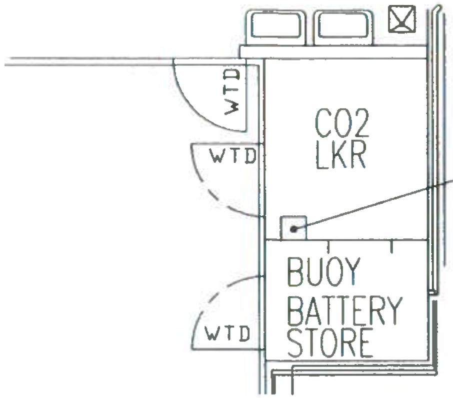


+Y

DETAIL

MAIN DECK

X+



MRU
Y 0.000
X 0.000
Z 0.000

DETAIL

Blom

DIMENSIONAL CONTROL

NOTE:

ALL DIMENSIONS ARE IN METER

CLIENT	INSPECTOR AND MARINE SUPERINTENDENT	DOCUMENT REFERENCE 0404107-04001098/ENCL. 1	PAGE 7 of 15
PROJECT	LAYBACK SURVEY ILV GRANUAILE	CONTRACT NO.	WO/CALL OFF NO.
LOCATION	HARLAND & WOLFF	REF. DRAWING NO.	REV.
TITLE	MRU 5, LOCATION		

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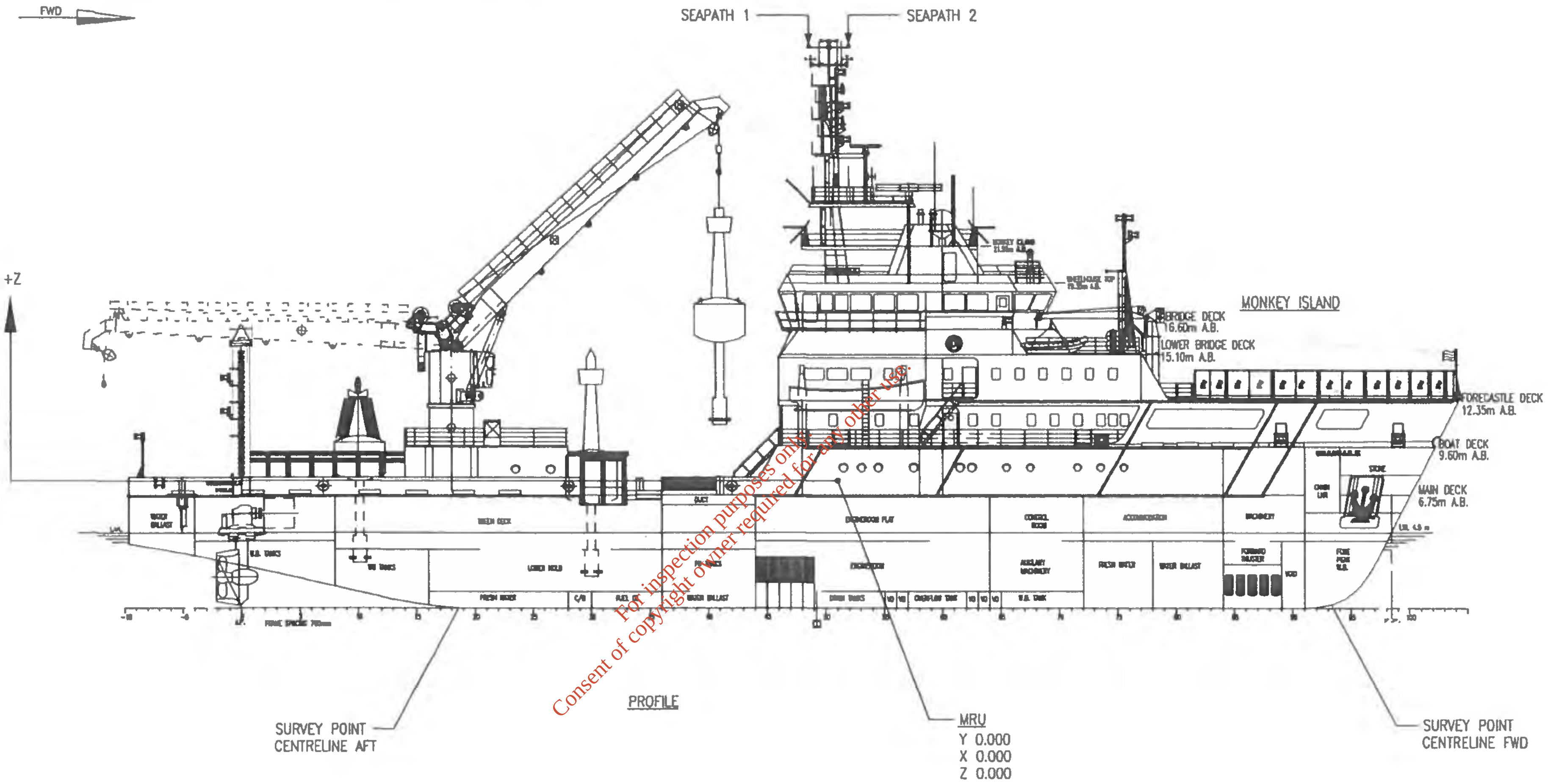

Blom

DIMENSIONAL CONTROL

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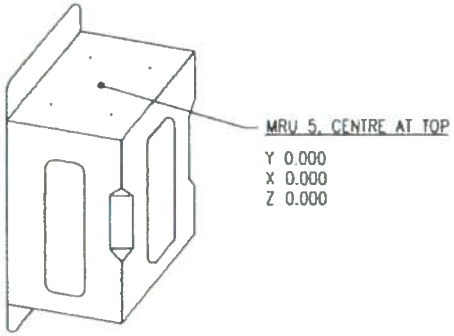
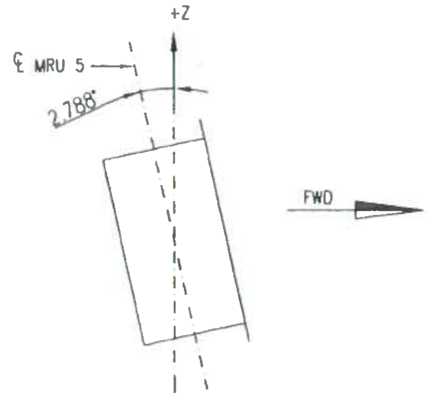
PROJECT	LAYBACK SURVEY ILV GRANUAILE
LOCATION	HARLAND & WOLFF
TITLE	SURVEY POINT KEEL, LOCATION OF SEAPATH
DOCUMENT REFERENCE	0404107-04001098/ENCL. 1
PAGE	1 of 15
CONTRACT NO.	
WO/CALL OFF NO.	
REF. DRAWING NO.	
REV.	

REV NO.	REASON FOR ISSUE	DOC. NO.	FILE NO.	REV DATE	DRAWN	PREPARED	CHECKED	APPROVED
0	FOR USE	04001098	01098011	22.09.04	TH	HK	EIF	KA

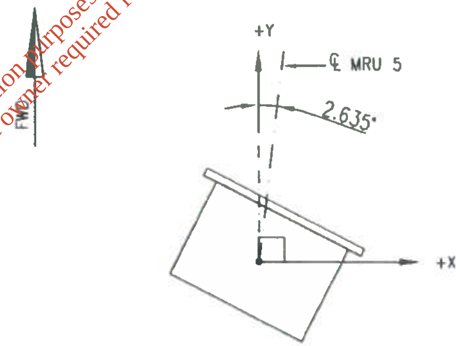
LOOKING FWD



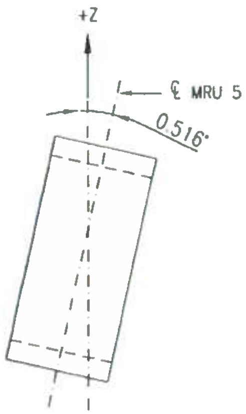
ISO VIEW MRU 5



PITCH
LOOKING TOWARDS STB.



HEADING
PLAN MRU 5



ROLL
LOOKING FWD

Blom

DIMENSIONAL CONTROL

NOTES:

- ALL DIMENSIONS IN METER
- ANGLES IN DEGREES
- MEASUREMENTS ARE TAKEN ON OUTSIDE PLASTIC CHASSIS

CLIENT	INSPECTOR AND MARINE SUPERINTENDENT	DOCUMENT REFERENCE 0404107-04001098/ENCL. 1	PAGE 8 of 15
PROJECT	LAYBACK SURVEY ILV GRANUAILE	CONTRACT NO.	WO/CALL OFF NO.
LOCATION	HARLAND & WOLFF	REF. DRAWING NO.	REV.
TITLE	MRU 5 POSITION, HEADING, ROLL AND PITCH		

REV. NO.	REASON FOR ISSUE	DOC. NO.	FILE NO.	REV. DATE	DRAWN	PREPARED	CHECKED	APPROVED
0	FOR USE	04001098	01098081	22.09.04	TH	HK	EIF	KA

APPENDIX 3

SVP Calibration Certificate

Calibration Certificate Number: 34602

This document certifies that the instrument detailed below has been calibrated according to Valeport Limited's Standard Procedures, using equipment with calibrations traceable to NAMAS or National Standards.

Instrument Type:	miniSVP
Instrument Serial Number:	43265
Calibrated By:	J.Harper
Date:	18/06/2013
Signed:	

Full details of the results from the calibration procedure applied to each fitted sensor are available in separate documents. This summary certificate should be kept with the instrument.

Valeport Limited, St. Peter's Quay, Totnes, Devon, TQ9 5EW. U.K.
Tel: +44 (0)1803 869292 Fax: +44 (0)1803 869293
E-mail: sales@valeport.co.uk Web: www.valeport.co.uk

Instrument type	miniSVP
Serial number	43265
Path Length, mm	100
Baud rate set ex factory	115200

Calibration History:	Certificate	Date
	34602	18/06/2013

System Components	Original Manufacture				Modification				Modification				Modification			
	Part	Iss	Serial Number	Range / Firmware	Part	Iss	Serial Number	Range / Firmware	Part	Iss	Serial Number	Range / Firmware	Part	Iss	Serial Number	Range / Firmware
Main Board	0650505	E	84871	0650713B5 0650714A												
SV Sensor			84872													
Pressure Board	0650506	A	84319													
Pressure Sensor			92961	500Dbar												
Temperature Board	0650506	A	84319													
Temperature Sensor			4929	5°C to +35°C												
Logger Board																
Power Supply Board	0660500	D	83896													
Micro Board	0660501	F	78995	0660700N1												
10Way connector Board	0660502	E	84085													
Battery connector Board	0660503	B	84150													
Bootloader Fitted	YES															

	Original Manufacture	Modification	Modification	Modification
Name	J.Horsell			
Date	18/06/2013			
Signed	[signature]			

Calibrated to Valeport's procedures using test equipment with calibrations traceable to NAMAS or national standards

Instrument Serial Number	43265
Transducer Type, mm	100
Transducer Ser No	84872
PCB Part No	0650505E
PCB Ser No	84871
Processor Firmware Version	0650713B5
FPGA Firmware Version	0650714A
Certificate Number	34602

Calibration Equipment used

Instrument	Type	Serial No
Temp Bridge	Micro K	311063/1
PRT	909L	15

Stage 1: First order fit

Temp °C90	SoS from Bilaniuk & Wong m/s	Measured ToF nsec*100	Coefficients	Calc SoS from coefficients m/s	Error (Calc - True) m/s	Acceptable Error m/s	Pass/Fail
2.1172	1412.797	14320985	2.016090E+05	1412.797	0.000	±0.001	Pass
15.8265	1468.807	13782577	5.013080E+06	1468.807	0.000	±0.001	Pass

Stage 2: Enter calibration string

#022;5013080;201609

Stage 3: Check point

Temp °C90	Actual SoS m/s	Measured SoS m/s	Error SoS Reading-Actual m/s	Acceptable Error m/s	Pass/Fail
15.8290	1468.815	1468.813	-0.002	±0.005	Pass

Name:	J.Harper
Date:	18/06/2013
Signature:	

Sensor Calibration Record

STRAIN GAUGE PRESSURE

Instrument Serial Number	43265
Sensor Type	Keller PAA10
Sensor Serial Number	92961
Sensor Range	500
Certificate Number	34602

Calibration Equipment used

Instrument	Type	Serial No
DWT	Budenburg	580DXA/28894/162K/A8640
Barometer	Fortin 54	4042

Stage 1: Determine Local pressure conditions

Air temperature	21.9	°C
Grid reference	280657 East, 059840 North	
Height above sea level	5	metres
Local Gravity	9.81125	M/sec²
Gravity std for barometer	9.80665	M/sec²
Atmospheric pressure	763.100	mmHg
	10.1423	dBar
Latitude (WGS84)	50.427429	

Stage 2: Set calibration codes

Units:	#018;D	Tare:	#009;0	Error msg:	#116;0		
Error Code:	#116;0	Latitude:	#016;50.427429	Init Tdr:	#904;0		
Tare off:	#011;ON	Dec pl 3:	#083;3	Output Pressure Data:	#904;2		

clear cal (new units): #085;0;1;0

Stage 2: Obtain Calibration data and Polynomial fit

Deadweight weight dBar	Deadweight pressure dBar	Atmospheric Pressure dBar	Counts (nnnn) nnnn	Total pressure absolute dBarA	Polynomial fit for raw data, Order 2: Parameter	Value	Polynomial calculations: Polynomial Result dBarA	Pressure Error [Calc - Actual] dBar	%FS	Acceptable Error	Pass/Fail
0	0.000	10.142	101756	10.142	a0	-2.496384E-02	10.157	0.015	0.003	±0.05	Pass
100	100.052	10.142	1101349	110.194	a1	1.000641E-04	110.170	-0.024	-0.005	±0.05	Pass
200	200.104	10.142	2101713	210.246	a2	-8.437267E-15	210.244	-0.003	-0.001	±0.05	Pass
300	300.156	10.142	3102102	310.298			310.303	0.004	0.001	±0.05	Pass
400	400.208	10.142	4102759	410.351			410.372	0.021	0.004	±0.05	Pass
500	500.260	10.142	5103063	510.403			510.389	-0.014	-0.003	±0.05	Pass

Stage 3: Enter calibration string etc:

#085;-8.437267E-15;1.000641E-04;-2.496384E-02

Turn on Tare Mode: #011;ON

Stage 4: Post Calibration Check

Deadweight weight dBar	Deadweight pressure dBar	Atmospheric Pressure dBar	Measured pressure dBarA	Total pressure dBarA	Error [Reading - Actual] dBar	%FS	Acceptable Error	Pass/Fail
0	0.000	10.142	10.155	10.142	0.013	0.003	±0.05	Pass
100	100.052	10.142	110.174	110.194	-0.020	-0.004	±0.05	Pass
200	200.104	10.142	210.244	210.246	-0.002	0.000	±0.05	Pass
300	300.156	10.142	310.306	310.298	0.008	0.002	±0.05	Pass
400	400.208	10.142	410.364	410.351	0.014	0.003	±0.05	Pass
500	500.260	10.142	510.395	510.403	-0.007	-0.001	±0.05	Pass

Name	M. Coleman
Date	18.06.13
Signed	VS

43265_CAL_130618

Calibrated to Valeport's procedures using test equipment with calibrations traceable to NAMAS or national standards

19/06/2013 08:45

Sensor Calibration Record **Temperature** **© Valeport Limited**

Instrument Serial Number	43265
Sensor Type	PRT
Sensor Serial Number	4929
Sensor Range	-5°C to +35°C
Certificate Number	34602

Calibration Equipment used

Instrument	Type	Serial No
Temp Bridge	Micro K	311063/1
PRT	909L	036

Stage 1: Obtain Calibration data and Polynomial fit

Counts nnnn	Bath temp °C [IPTS 90]	Polynomial fit for raw data Order Parameter	2 Value	Polynomial calculations Calc Temp °C [IPTS 90]	Temp Error °C [IPTS 90]	Acceptable Error	Pass/Fail
7224200	2.072	a0	-2.393308E+02	2.072	0.000	±0.01	Pass
7610025	15.825	a1	3.129794E-05	15.825	0.000	±0.01	Pass
8144761	35.031	a2	2.931591E-13	35.031	0.000	±0.01	Pass

Stage 2: Enter calibration string:

#087;2.931591E-13;3.129794E-05;-2.393308E+02

Stage 3: Post Calibration Check

Reading °C [IPTS 90]	Bath temp °C [IPTS 90]	Error [Reading-Actual] °C [IPTS 90]	Acceptable Error	Pass/Fail
35.029	35.030	-0.001	±0.01	Pass

Name	J.Harper
Date	18.06.13
Signed	

VALEPORT

Thank you for purchasing a Valeport instrument. Every care has been taken to ensure that the instrument has been manufactured to the highest possible standards, and as such it is covered under Valeport's Warranty Policy as detailed below:

Standard Warranty Policy

The instrument detailed below is supplied with a Limited 3 Year Warranty against defects in materials and workmanship, valid from the date of despatch from Valeport's premises, with the following exclusions, exceptions and limitations:

1) Sensors supplied by other manufacturers (including pressure sensors) are only warranted according to the warranty period provided by the original manufacturer (typically 1 year).
2) Consumable items (including, but not limited to: batteries, o-rings, zinc anodes and electrolytes) are not covered by warranty.
3) Reasonable wear and tear (as judged by Valeport) is not covered by warranty.
4) Valeport Limited shall be under no liability for any consequential loss or damage of any kind whatsoever.
5) Correctly performed standard maintenance procedures as described in the operating manual will not invalidate the warranty. Failures caused by improper care and handling, or by unskilled or poor quality repair and maintenance attempts are not covered under warranty. Modifications to the original design will invalidate the warranty, insofar as it relates to the modified part.
6) All warranty repairs must be performed by Valeport personnel or their authorized representatives.
7) Valeport Limited is the sole judge of the cause of any failure, and the validity of any warranty claim. Please refer to the "Spirit of the Warranty" section below.

- Goods for warranty assessment should be adequately packed (preferably in the original packing) and returned freight pre-paid to Valeport, complete with a description of the nature of the problem. It is preferable that an RMA (Returns Number) is obtained from us in advance, to allow us to schedule the repair.
- All warranty claims are assessed on a case-by-case basis. You will be informed as soon as possible as to the validity of the warranty claim.
- In the event of a valid warranty claim, the goods will be repaired or replaced as appropriate at the sole discretion of Valeport Limited. The repaired / replacement instrument will be returned to you at our cost, using our choice of shipping method.
- In the event of an invalid warranty claim, you will be informed of any repairs that are necessary, and if acceptable, the instrument will be repaired as if it had been returned for service, with appropriate costs and return freight charges payable by you.
- Any repairs made under warranty shall have no effect on the duration of the warranty period, i.e. the warranty shall continue as if no fault had occurred.
- Valeport may, at our discretion, opt to despatch a replacement part for fitting in the field, if it is deemed to be the most appropriate response. In such circumstances, the user will be required to return the faulty part to Valeport (at the user's cost) for assessment and confirmation that the failure is a valid warranty claim. Failure to return the faulty part, or if the fault is subsequently judged to fall outside the terms of the warranty, shall result in the user being invoiced for the replacement part and freight costs.

Spirit of the Warranty

This warranty is offered on the basis that Valeport fully expects the instrument to perform satisfactorily for many years. We have built a reputation on reliability, longevity and quality, and therefore the aim of this warranty is your satisfaction and peace of mind. The "rules" as detailed above are the framework within which we operate our warranty policy, and the minimum that you can expect from us in resolving any warranty issue. However, each case is considered on its own merit, and we may decide that in certain circumstances, alternative arrangements or solutions to a warranty issue are appropriate. Equally, we hope that our customers accept this warranty in the spirit in which it is given, and to respect that whilst our primary concern is always to try and ensure that any issues are resolved as quickly and as satisfactorily as possible, we do also have a responsibility to objectively assess the validity of any warranty claim, and to consider the interests of Valeport Limited in any actions taken.

M. Quartley

Matthew Quartley
Managing Director

Instrument Type miniSVP 50Bar

Serial Number(s) 43265

Date of Despatch 19th June 2013

Valeport Limited, St. Peter's Quay, Totnes, Devon, TQ9 5EW. U.K.
Tel: +44 (0)1803 869292 Fax: +44 (0)1803 869293
E-mail: sales@valeport.co.uk Web: www.valeport.co.uk

VAT No: GB 430 4453 84 Registered in England No: 1950444

Instrument Test Certificate

VALEPORT

Valeport Contract Number:	12130

System Description:	miniSVP 50Bar

Main Serial Number:	43265

Item	Serial Number	Assembly Completed		Service Completed		Calibration Completed		Functionality Test Completed		Pressure Test Completed 50 Bar		Immersion Test Completed		Post Immersion Functionality Test Completed	
		Inits:	Date:	Inits:	Date:	Inits:	Date:	Inits:	Date:	Inits:	Date:	Inits:	Date:	Inits:	Date:
miniSVP	43265	Jk	18/06/13	/	/	A	18/06/13 Certificate number 34602	Jk	18/06/13	Jk	19/06/13	/	/	Jk	19/06/13
							Certificate number								

This document certifies that, where indicated above, the specified instrument and accessory items have undergone assembly, service, calibration and test procedures according to Valeport Limited's standard procedural documentation, and are declared ready for shipment.

Signed: .... Contract Controller

Date: 19th June 2013

APPENDIX 4

QINSy Database

SURVEY DEFINITIONS

General Definitions

Line name	:	No line name
Line sequence number	:	1
Line description	:	
UTC to GPS time correction	:	16.000 s
Survey unit name	:	Meters
Conversion factor to metres	:	1.000000000000000

Geodetic Definitions

Magnetic Variation Information

Undefined

Datum Definitions

Survey Datum	:	WGS84
Spheroid name	:	WGS 1984
Conversion factor to metres	:	1.0000000000000
Semi-major axis (a)	:	6378137.000 m
Semi-minor axis (b)	:	6356752.314 m
Inverse flattening (1/f)	:	298.25722356300
First eccentricity squared (e**2)	:	0.0066943799901
Second eccentricity squared (e'**2)	:	0.0067394967422

Datum Shift Definitions

Undefined

Vertical Datum / Chart Datum Definition

Vertical datum	:	WGS84
Height file	:	N/A
Height level	:	No Level Correction
Height file	:	N/A
Height offset	:	0.000 m
MWL model	:	Horizontal Datum
MWL file	:	N/A
MWL level	:	No Level Correction
MWL file	:	N/A
MWL offset	:	0.000 m
MWL st.dev.	:	0.000 m
DTM mode	:	Absolute DTM's
DTM datum	:	WGS84
DTM file	:	N/A
DTM level	:	No Level Correction
DTM file	:	N/A
DTM offset	:	0.000 m

Projection Definition

Projection type	:	0001
Projection name	:	Universal Transverse Mercator (North Hemisphere)
Conversion factor to metres	:	1.0000000000000
UTM zone number	:	29
UTM central meridian	:	9;00;00.00000 W
Latitude of grid origin	:	0;00;00.00000 N
Longitude of grid origin	:	9;00;00.00000 W
Grid Easting at grid origin	:	500000.000 m
Grid Northing at grid origin	:	0.000 m
Scale factor at longitude of origin	:	0.999600000000

Local Construction Grid Definition

Not Applicable

Offset Convention

Offset mode	:	Rectangular
Offset distances units	:	Meters
Offset angles units	:	Degrees

OBJECT DEFINITIONS

General Summary Information

Number of survey vessels or objects	:	2
Number of relay vessels or buoys	:	0
Number of external network nodes	:	0
Number of datums/ellipsoids defined	:	1

Vessel Definitions

Granuaile

Streamers	:	0	Gun arrays	:	0
Buoys	:	0	Echosounders	:	0
Satellite receivers	:	0	USBL systems	:	1
Network nodes	:	7	Pitch/Roll/Heave sensors	:	Yes

Correction to GMT (UTC)	:	0.000 h
Correction to master vessel's time	:	0.000 s
Height above draft reference	:	4.500 m
Description of reference point	:	Granuaile CoG

Point	X	Y	Z	Pen	Fill	Style
1	0.000	39.845	0.000	Up	On	Solid
2	-6.000	30.000	0.000	Down	On	Solid
3	-8.000	15.845	0.000	Down	On	Solid
4	-8.000	-39.800	0.000	Down	On	Solid
5	8.000	-39.845	0.000	Down	On	Solid
6	8.000	15.845	0.000	Down	On	Solid
7	6.000	30.000	0.000	Down	On	Solid

Vessel Definitions (continued)

Deployed Benthic

Streamers	:	0	Gun arrays	:	0
Buoys	:	0	Echosounders	:	0
Satellite receivers	:	0	USBL systems	:	0
Network nodes	:	1	Pitch/Roll/Heave sensors	:	0

Correction to GMT (UTC)	:	0.000 h
Correction to master vessel's time	:	0.000 s
Height above draft reference	:	0.000 m
Description of reference point	:	Deployed Ben CoG

Gun Array Definitions

NETWORK DEFINITIONS

Fixed Node Definitions

Variable Node Definitions

Granuaile CoG

Object location	:	Granuaile
X (Stbd = Positive):	:	0.000 m
Y (Bow = Positive):	:	0.000 m
Z (Up = Positive):	:	0.000 m
A-priori SD	:	0.000 m

CNAV 3050 Ant

Object location	:	Granuaile
X (Stbd = Positive):	:	5.384 m
Y (Bow = Positive):	:	-3.981 m
Z (Up = Positive):	:	13.872 m
A-priori SD	:	0.010 m

Seapath Ant1

Object location	:	Granuaile
X (Stbd = Positive):	:	-0.729 m
Y (Bow = Positive):	:	-2.695 m
Z (Up = Positive):	:	25.961 m
A-priori SD	:	0.010 m

Seapath Ant2

Object location	:	Granuaile
X (Stbd = Positive):	:	-0.657 m
Y (Bow = Positive):	:	-0.190 m
Z (Up = Positive):	:	25.906 m
A-priori SD	:	0.010 m

Moonpool Top

Object location	:	Granuaile
X (Stbd = Positive):	:	-0.214 m
Y (Bow = Positive):	:	-12.636 m
Z (Up = Positive):	:	-0.600 m
A-priori SD	:	0.010 m

Scout TX

Object location	:	Granuaile
X (Stbd = Positive):	:	-0.214 m
Y (Bow = Positive):	:	-12.636 m
Z (Up = Positive):	:	-10.110 m
A-priori SD	:	0.010 m

Variable Node Definitions (continued)

Deployed Ben CoG

Object location	:	Deployed Benthic
X (Stbd = Positive):	:	0.000 m
Y (Bow = Positive):	:	0.000 m
Z (Up = Positive):	:	0.000 m
A-priori SD	:	0.000 m

Drop Point

Object location	:	Granuaile
X (Stbd = Positive):	:	-7.814 m
Y (Bow = Positive):	:	-9.886 m
Z (Up = Positive):	:	0.000 m
A-priori SD	:	0.010 m

Observation Definitions

COM5 Seapath [Gy	:	Bearing (True)
'At' node	:	Granuaile CoG
'To' node 1	:	Undefined
Measurement unit code	:	Degrees
System description	:	COM5 Seapath [Gyro Compass]
Propagation speed	:	0.0000000000 m/s
Lanewidth on baseline	:	0.0000000000 m/s
Scale factor	:	1.0000000000
Fixed system (C-O)	:	0.00000000 °
Variable (C-O)	:	0.000000 °
A-priori SD	:	0.50 °
Quality indicator	:	No quality info recorded

Reference Station Definitions

ATT Node Definitions

SYSTEM DEFINITIONS

Output System

Log Files

Interfacing

Type	:	Output System
Driver	:	Generic ASCII Data Logger (Controller)
Executable and Cmdlir	:	DrvGenericLogger.exe
Update rate	:	1.000 s

Pitch Roll Heave Sensor

COM5 Seapath

Interfacing

Type	:	Pitch Roll Heave Sensor			
Driver	:	Seapath MRU Binary Format 11			
Executable and Cmdlir	:	DrvSeapathMRU.exe 11 NOCS			
Port	:	5			
Baud rate	:	115200	Data bits	:	8
Parity	:	None	Stop bits	:	1
Update rate	:	0.000 s	Latency	:	0.000 s

Acquired by	:	[Directly into QINSy] (No additional time tags)
Observation time from	:	N/A

Number of slots	:	0

System Parameters

COM5 Seapath

Object	:	Granuaile
Location on object (Lever arm)	:	Granuaile CoG
PRH sensor reference number	:	1
Rotation convention pitch	:	Positive bow up
Rotation convention roll	:	Positive heeling to starboard
Angular variable measured	:	HPR (roll first)
Angular measurement units	:	Degrees
Sign convention heave	:	Positive upwards
Measurement units heave	:	Meters
Conversion factor to degrees decimal	:	1.0000000000000
Conversion factor to metres	:	1.0000000000000
Quality indicator type pitch and roll	:	No quality info recorded
Quality indicator type heave	:	No quality info recorded
Description of quality indicator type	:	
X (Stbd = Positive):	:	0.000 m
Y (Bow = Positive):	:	0.000 m
Z (Up = Positive):	:	0.000 m
A-priori SD	:	0.000 m
(C-O) pitch offset	:	0.000 °
(C-O) roll offset	:	0.000 °
(C-O) heave offset	:	0.000 m
Heave time delay	:	0.000 s
SD roll and pitch	:	0.050 °
SD heave (fixed)	:	0.050 m
SD heave (variable)	:	5.000 %
SD roll offset	:	0.050 °
SD pitch offset	:	0.050 °
SD heave offset	:	0.050 m

Description of pitch, roll and heave system

COM5 Seapath

Gyro Compass

COM5 Seapath [Gyro Compass]

Interfacing

Type	:	Gyro Compass			
Driver	:	Seapath Binary Format 11 (Heading)			
Executable and Cmdlir	:	DrvSeapathMRU.exe 11 NOCS			
Port	:	5			
Baud rate	:	115200	Data bits	:	8
Parity	:	None	Stop bits	:	1
Update rate	:	0.000 s	Latency	:	0.000 s

Acquired by	:	[Directly into QINSy] (No additional time tags)
Observation time from	:	N/A

Number of slots	:	0

Connected Observations

COM5 Seapath [Gy	:	Bearing (True)

Connected Nodes

Granuaile CoG	:	Granuaile

Position Navigation System

COM5 Seapath [Position Navigation System]

Interfacing

Type	:	Position Navigation System			
Driver	:	Seapath Binary Format 11			
Executable and Cmdlir	:	DrvSeapathMRU.exe 11 NOCS			
Port	:	5			
Baud rate	:	115200	Data bits	:	8
Parity	:	None	Stop bits	:	1
Update rate	:	0.000 s	Latency	:	0.000 s

Acquired by	:	[Directly into QINSy] (No additional time tags)
Observation time from	:	N/A

Number of slots	:	0

Satellite System Definition

Position datum	:	WGS84
Satellite system name	:	WGS84

Satellite Receiver Definition

Receiver number	:	1
Receiver description	:	
Node identifier	:	Granuaile CoG
Object location	:	Granuaile
X (Stbd = Positive):	:	0.000 m
Y (Bow = Positive):	:	0.000 m
Z (Up = Positive):	:	0.000 m
A-priori SD	:	0.000 m

SD latitude	:	0.500 m
SD longitude	:	0.500 m
SD height	:	1.000 m

Horizontal datum	:	WGS84	
Vertical datum	:	WGS84	N/A
Height level	:	No Level Correction	N/A
Height offset	:	0.000 m	

Connected Observations

Connected Nodes

Position Navigation System

CNAV 3050

Interfacing

Type	:	Position Navigation System			
Driver	:	NMEA Position (GPGGA)			
Executable and Cmdlir	:	DrvNMEA0183.exe MSL			
Port	:	2			
Baud rate	:	57600	Data bits	:	8
Parity	:	None	Stop bits	:	1
Update rate	:	0.000 s	Latency	:	0.000 s

Acquired by	:	[Directly into QINSy] (No additional time tags)
Observation time from	:	N/A
Number of slots	:	0

Satellite System Definition

Position datum	:	WGS84
Satellite system name	:	WGS84

Satellite Receiver Definition

Receiver number	:	0	
Receiver description	:		
Node identifier	:	CNAV 3050 Ant	
Object location	:	Granuaile	
X (Stbd = Positive):	:	5.384 m	
Y (Bow = Positive):	:	-3.981 m	
Z (Up = Positive):	:	13.872 m	
A-priori SD	:	0.010 m	
SD latitude	:	0.200 m	
SD longitude	:	0.200 m	
SD height	:	0.400 m	
Horizontal datum	:	WGS84	
Vertical datum	:	WGS84	N/A
Height level	:	No Level Correction	N/A
Height offset	:	0.000 m	

Connected Observations

Connected Nodes

Time Synchronization System

PPS

Interfacing

Type	:	Time Synchronization System			
Driver	:	NMEA ZDA			
Executable and Cmdlir	:	DrvPositionNMEA.exe			
Port	:	6			
Baud rate	:	57600	Data bits	:	8
Parity	:	None	Stop bits	:	1
Update rate	:	0.000 s	Latency	:	0.000 s

Acquired by	:	[Directly into QINSy] (No additional time tags)
Observation time from	:	N/A
Number of slots	:	0

PPS Pulse System

PPS Pulse System

Interfacing

Type	:	PPS Pulse System			
Driver	:	QPS PPS Adaptor			
Executable and Cmdlir	:	DrvPpsPulse.exe			
Port	:	1			
Baud rate	:	1200	Data bits	:	8
Parity	:	None	Stop bits	:	1
Update rate	:	0.000 s	Latency	:	0.000 s

Acquired by	:	[Directly into QINSy] (No additional time tags)
Observation time from	:	N/A

Number of slots	:	0

USBL System

COM 8 USBL

Interfacing

Type	:	USBL System			
Driver	:	Simrad HiPAP (NMEA $PSIMSSB Format)			
Executable and Cmdlir	:	DrvUsblTerminated.exe SIMRAD_HPR400_NMEA			
Port	:	8			
Baud rate	:	38400	Data bits	:	8
Parity	:	None	Stop bits	:	1
Update rate	:	0.000 s	Latency	:	0.000 s
Acquired by	:	[Directly into QINSy] (No additional time tags)			
Observation time from	:	N/A			
Number of slots	:	1			

System Parameters

COM 8 USBL

Object	:	Granuaile
USBL system reference number	:	1
Quality indicator type	:	No quality info recorded
Measurement units X,Y,Z	:	Meters
Sign convention for Z-axis data	:	Positive downward (depth)
Roll alignment	:	Corrected VRU
Pitch alignment	:	Corrected VRU
Horizontal alignment	:	Corrected gyro
Transducer alignment	:	Corrected
Turn around delays	:	Not corrected
Velocity of propagation	:	Assumed
Reduction to ship's reference point	:	Yes
Reference node	:	Granuaile CoG
Transducer	:	Scout TX
X (Stbd = Positive):	:	-0.214 m
Y (Bow = Positive):	:	-12.636 m
Z (Up = Positive):	:	-10.110 m
A-priori SD	:	0.010 m
Sign convention roll offset	:	Positive heeling to starboard
Sign convention pitch offset	:	Positive bow up
Sign convention heading offset	:	Positive to starboard
Roll alignment offset	:	0.000 °
Pitch alignment offset	:	0.000 °
Heading alignment offset	:	0.000 °
Velocity measurement units	:	Meters / Second
Assumed velocity of propagation	:	1485.000 m/s
Calibrated velocity of propagation	:	1485.000 m/s
Turn around delay	:	0.000 ms
SD horizontally	:	1.000 m
SD vertically	:	1.000 m
SD roll offset	:	0.050 °
SD pitch offset	:	0.050 °
SD heading offset	:	0.500 °

Connected Targets

Deployed Ben CoG	:	Deployed Benthic
Slot 1	:	B01

Output System

USBL Motion

Interfacing

Type	:	Output System			
Driver	:	Generic Output (User-defined ASCII)			
Executable and Cmdlir	:	DrvOutGenericUI.exe			
Port	:	7			
Baud rate	:	115200	Data bits	:	8
Parity	:	None	Stop bits	:	1
Update rate	:	1.000 s	Latency	:	0.000 s
Acquired by	:	[Directly into QINSy] (No additional time tags)			
Observation time from	:	N/A			
Number of slots	:	0			

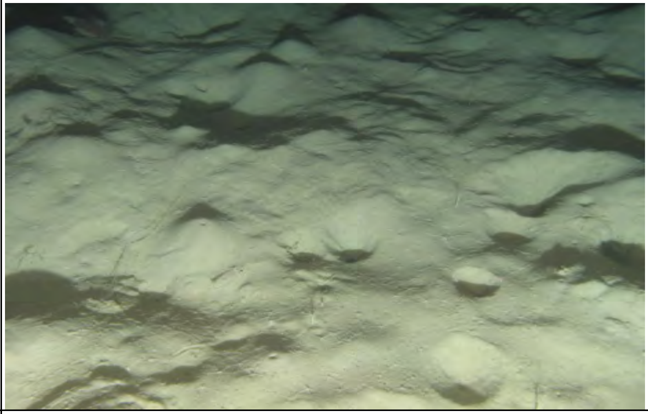
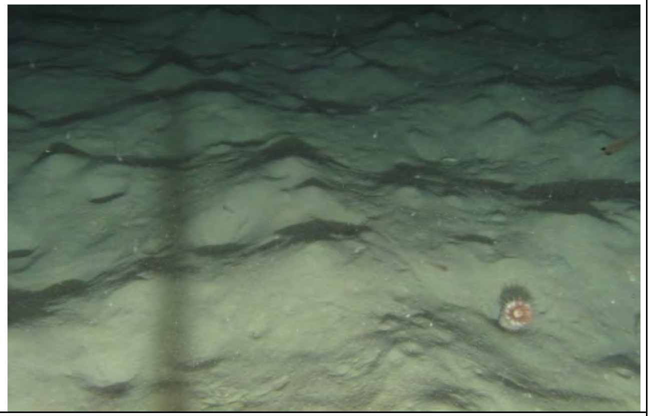
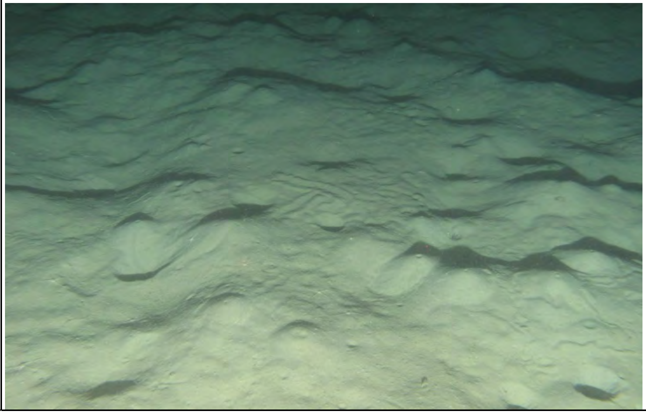
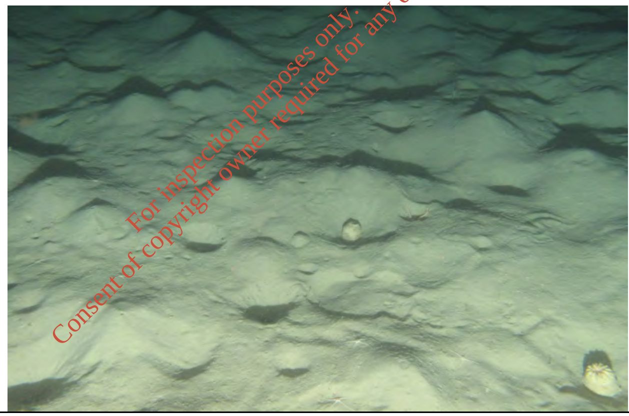
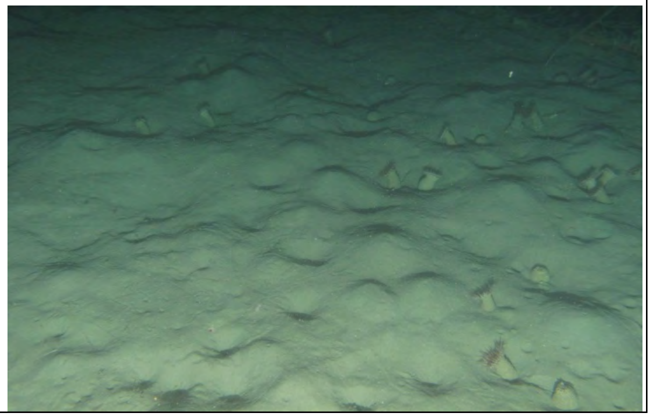
Output System

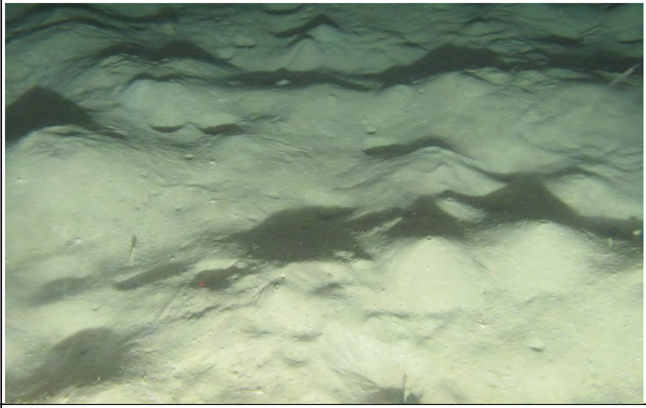
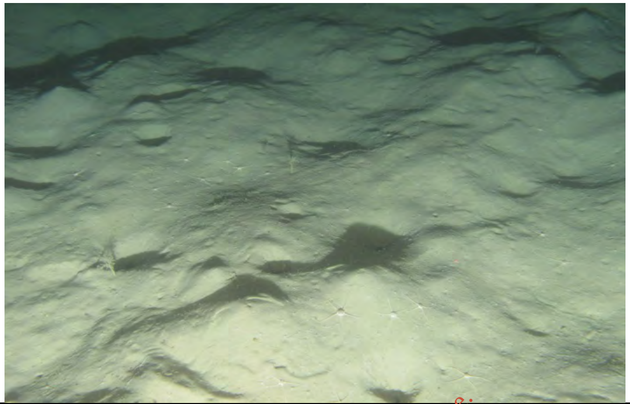
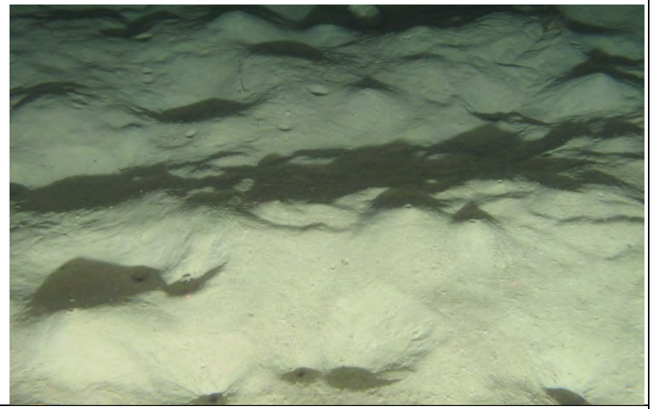
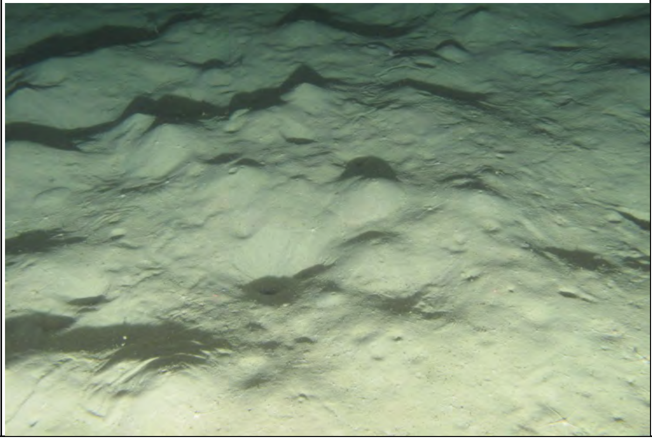
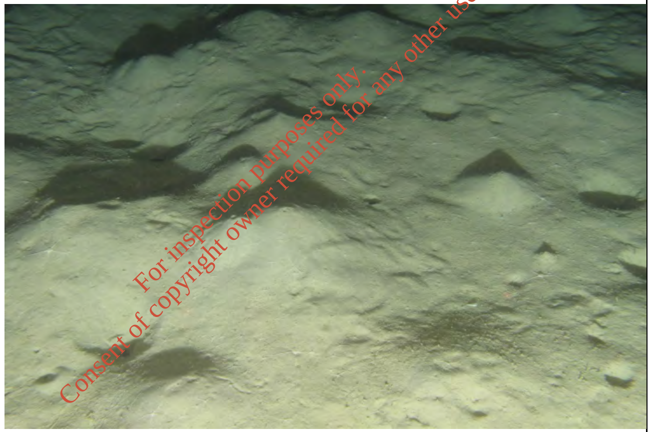
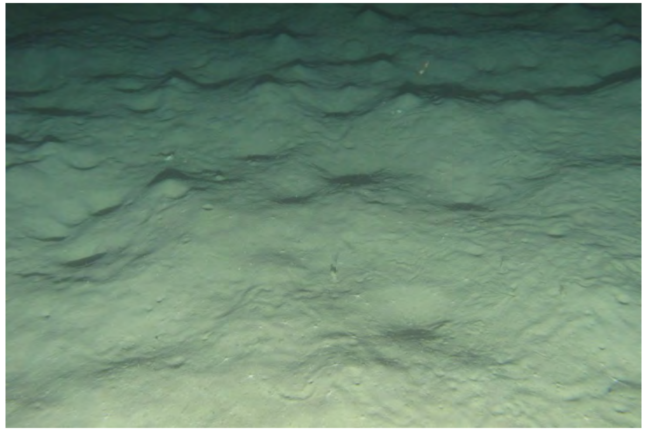
Video overlay

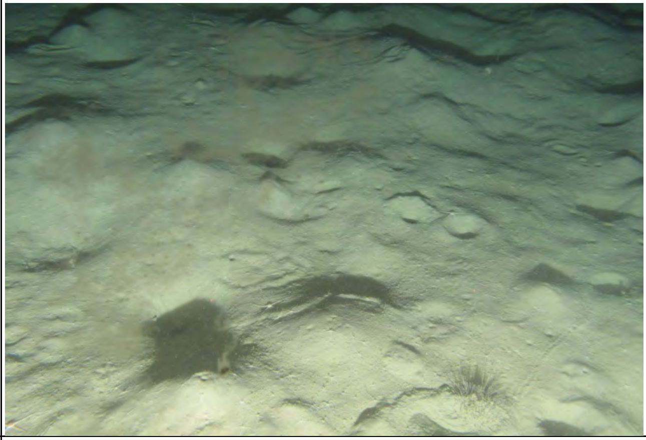
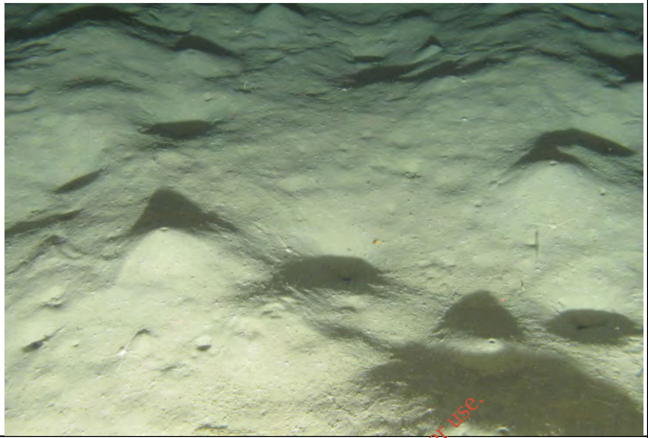
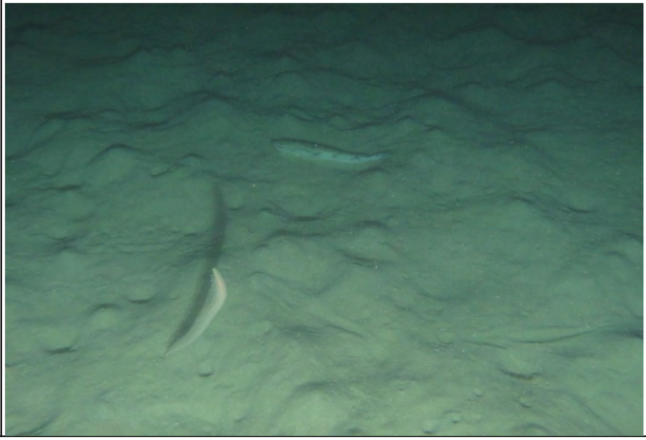
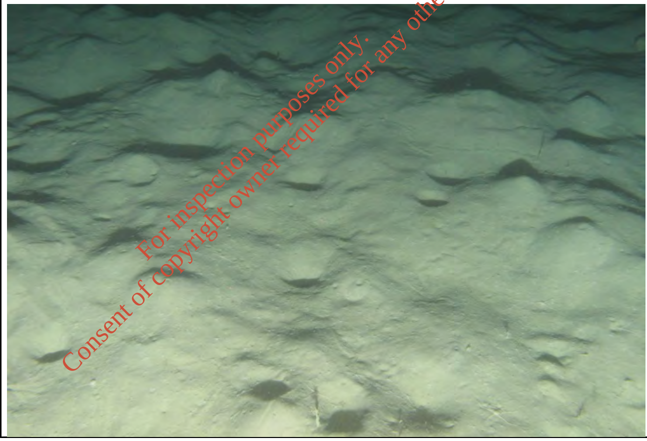
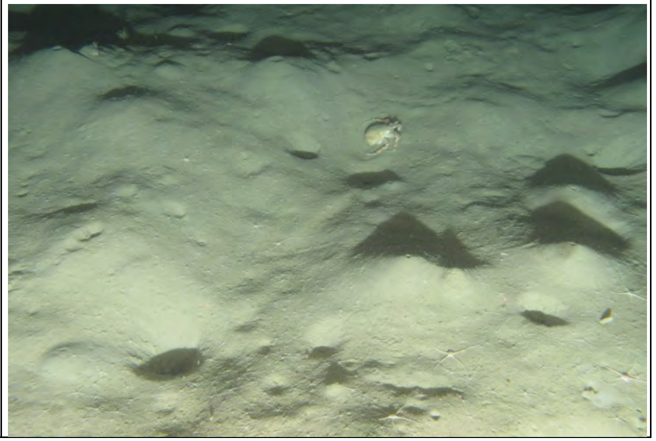
Interfacing

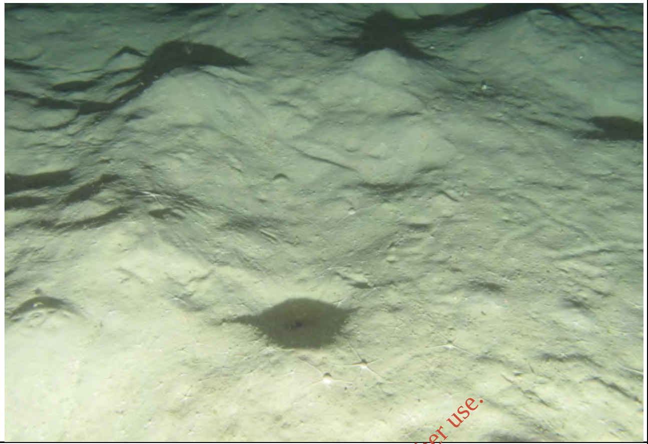
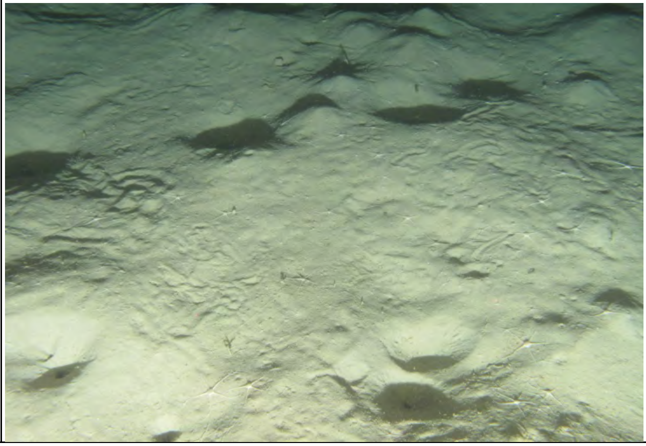
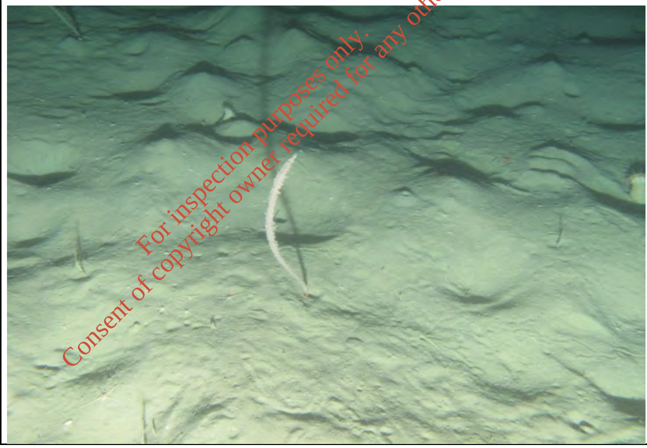
Type	:	Output System			
Driver	:	Generic Output (User-defined ASCII)			
Executable and Cmdlir	:	DrvOutGenericUI.exe			
Port	:	18			
Baud rate	:	9600	Data bits	:	8
Parity	:	None	Stop bits	:	1
Update rate	:	1.000 s	Latency	:	0.000 s
Acquired by	:	[Directly into QINSy] (No additional time tags)			
Observation time from	:	N/A			
Number of slots	:	0			

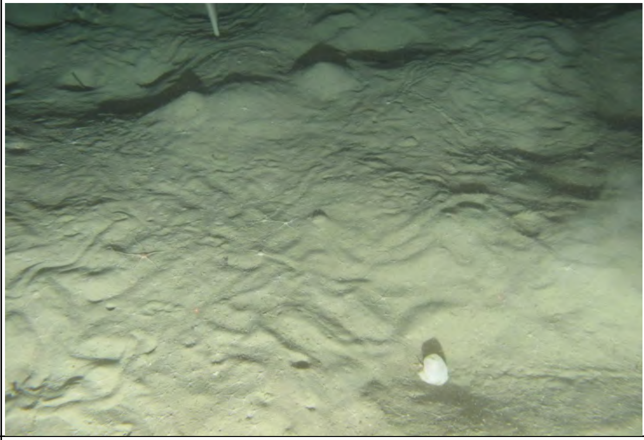
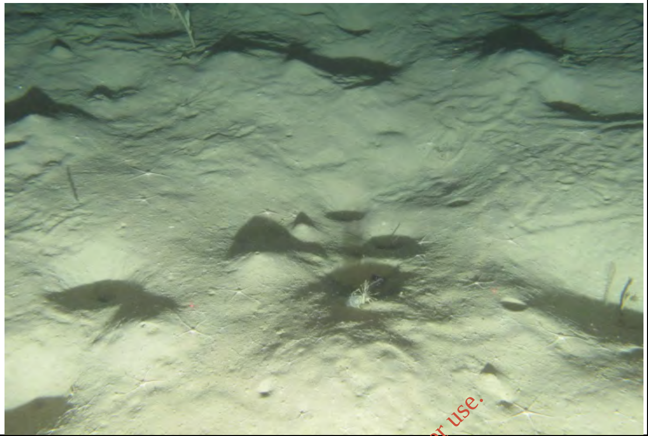
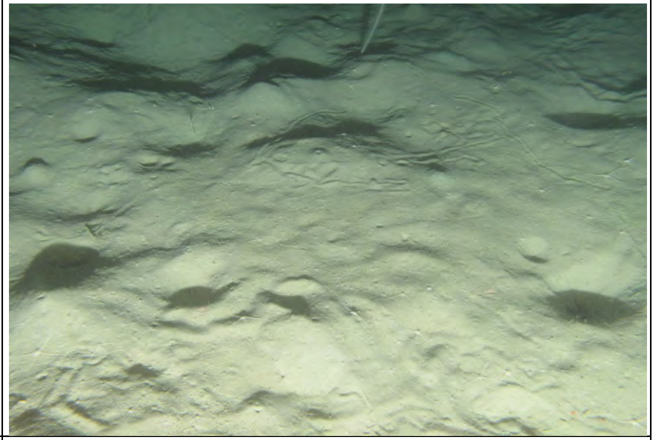
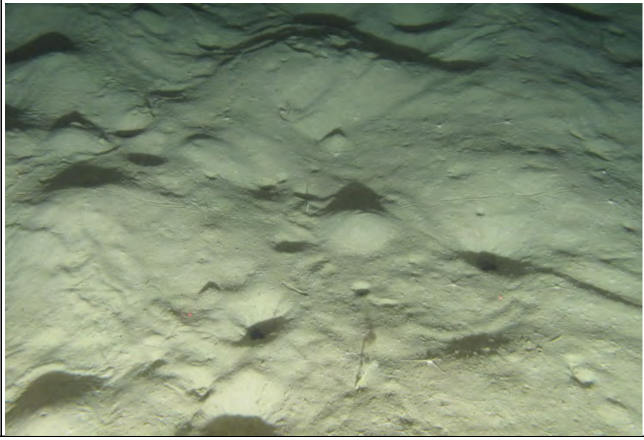
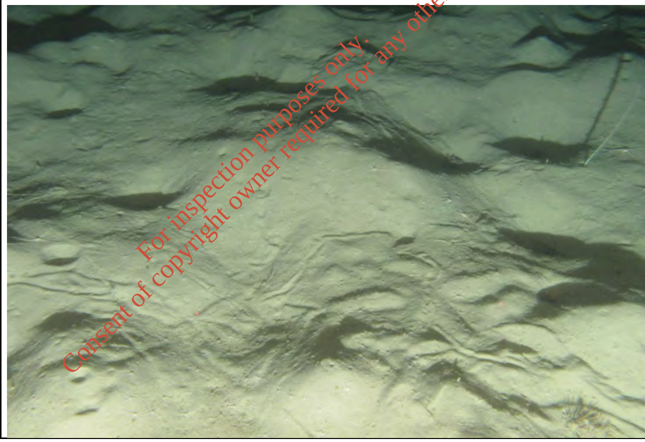
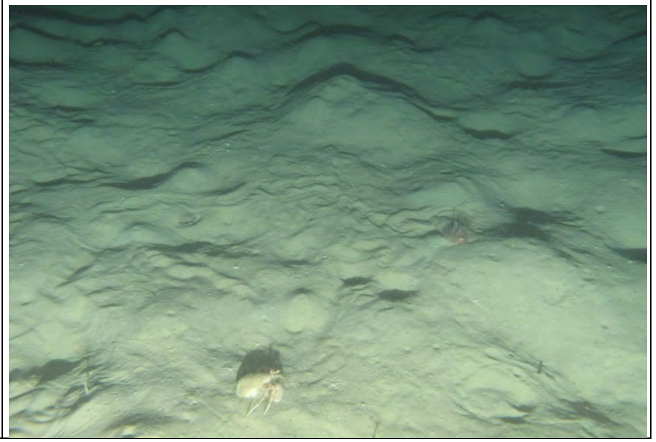
Appendix 6: Seabed photography by sampling station at SW-3

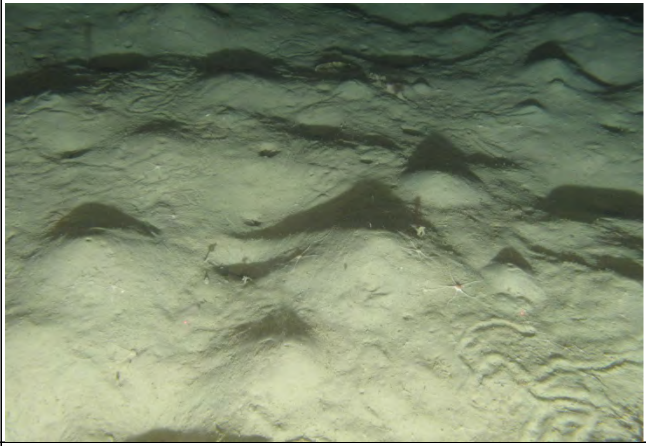
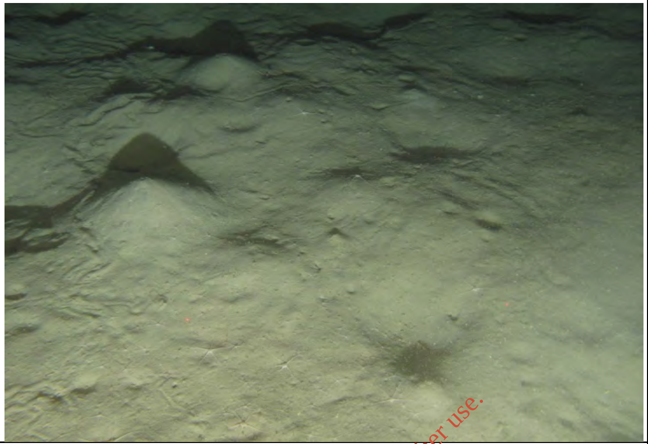
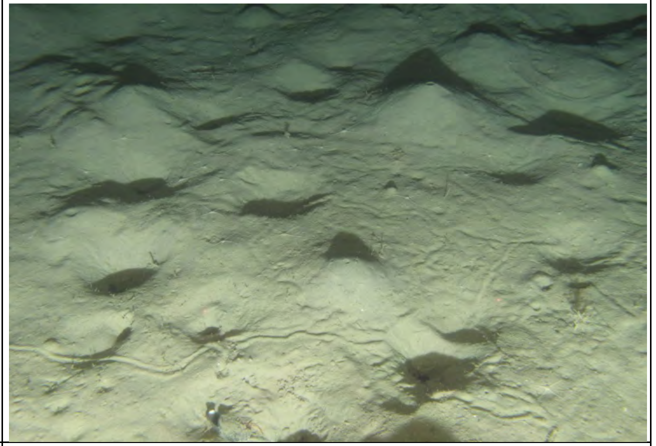
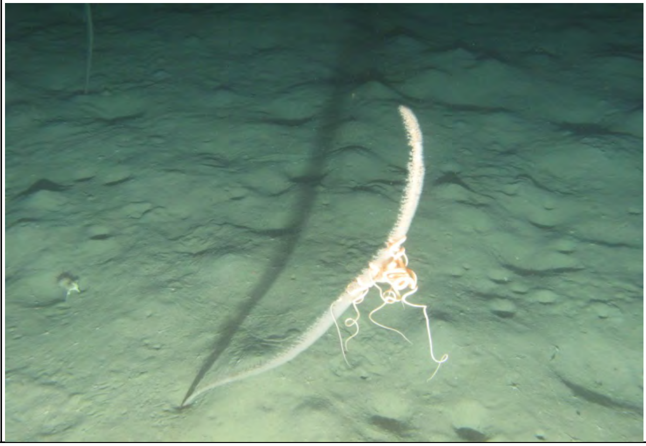
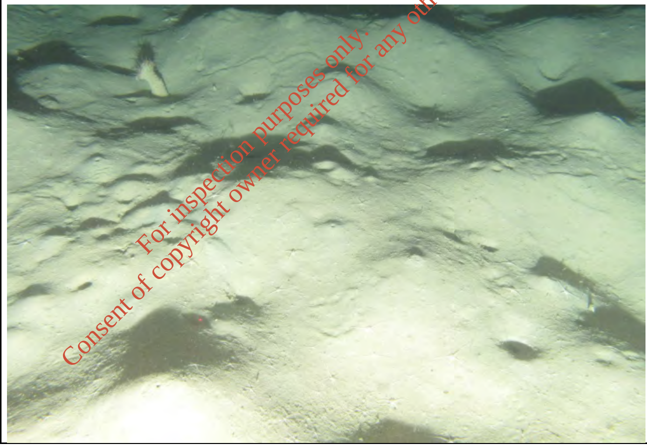
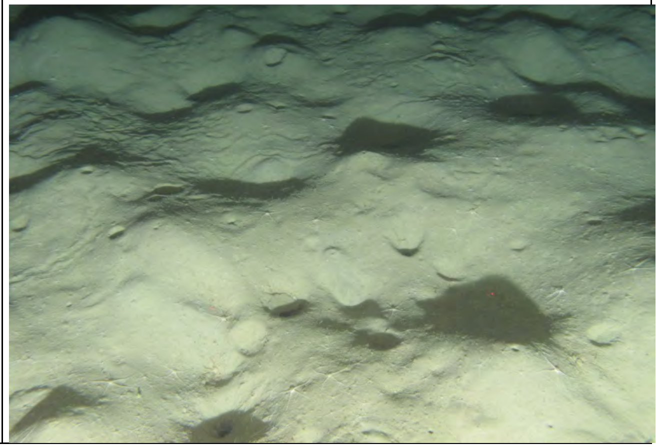
Station			
A4			
F5			

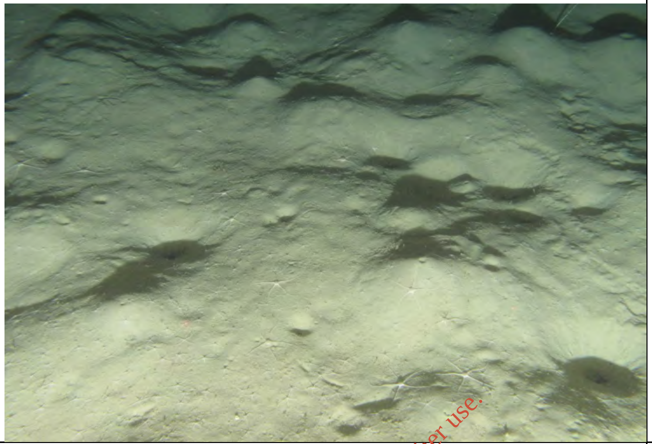
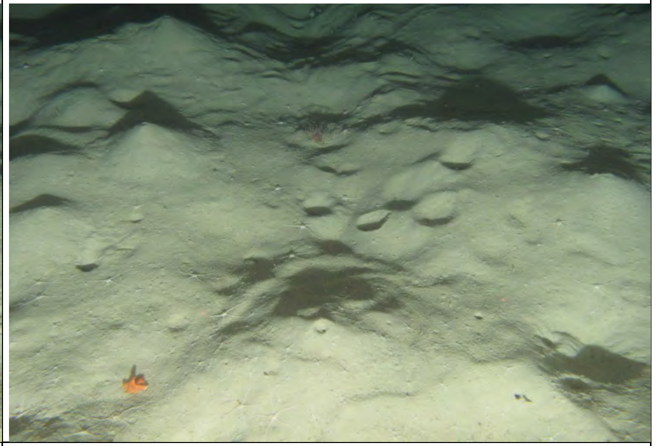
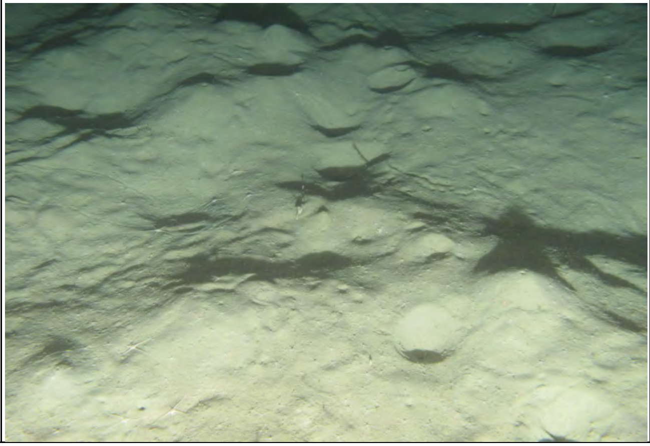
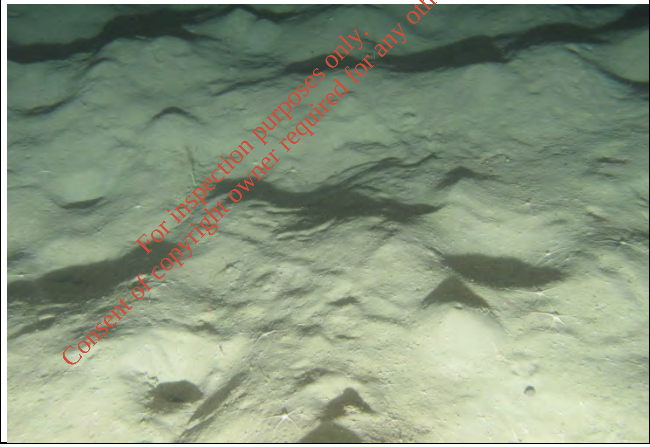
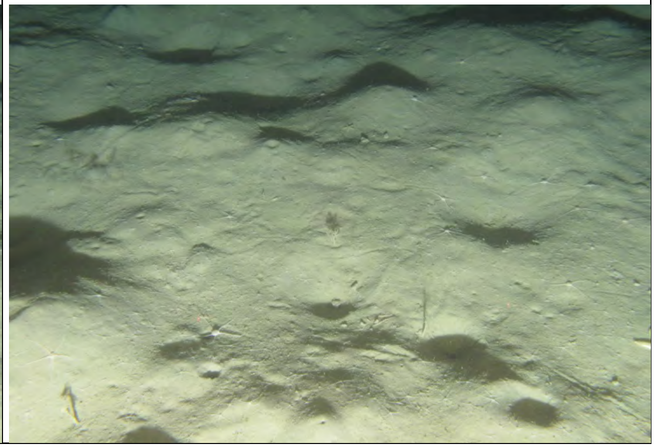
F4			
F6			

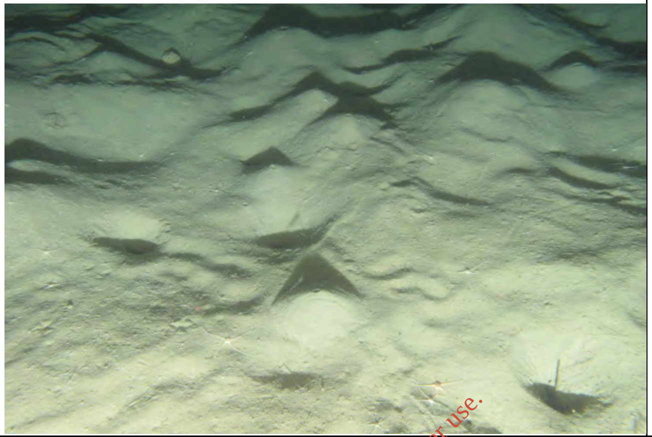
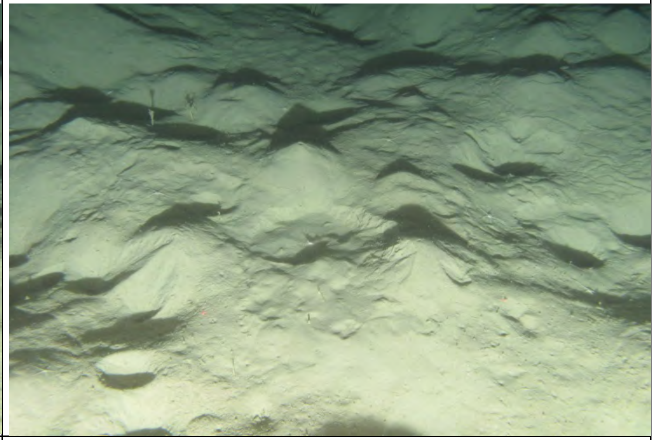
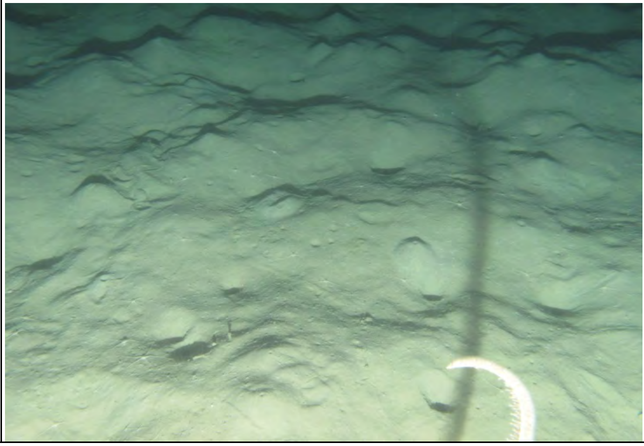
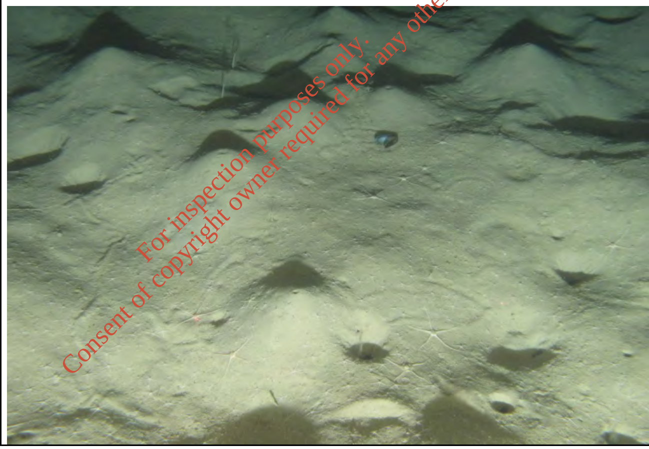
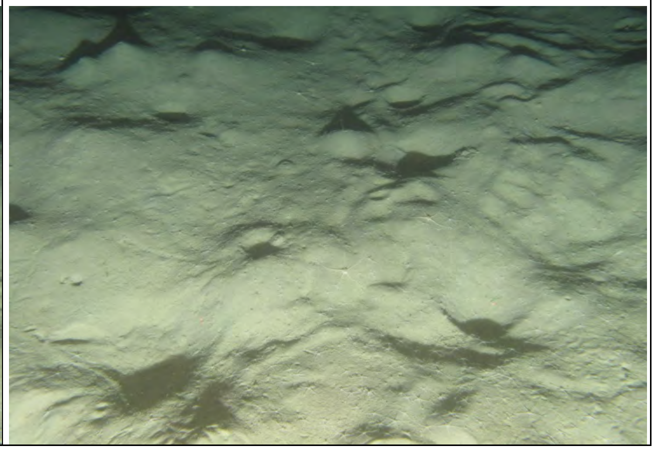
Z12			
F3			

Z11			
Z10			

Z9			
Z6			

Z5			
Z4			

Z3			
F8			

C4			
C1			

Appendix 7: Raw macrofaunal data from sampling stations in the vicinity of the Corrib Field (SW-3) –

Counts are individuals per $0.1m^2$ (per grab). P= present (colonial / encrusting species)

	A4-A	A4-B	A4-C	C1-A	C1-B	C1-C	C4-A	C4-B	C4-C
Cnidaria									
Anthoathecata		P							
Pandeiidae			P		P				
Bougainvillia britannica									
Modeeria rotunda									
Obelia	P		P						
Pennatulidae									
Actiniaria								P	
Actinauge richardi	1								
Edwardsiidae		1			1	2	1		
Scleractinia									
Platyhelminthes									
Platyhelminthes									
Nemertea									
Nemertea	2	2	1		2	1	1	1	
Tubulanus polymorphus	4	1	2	1		3		6	2
Cerebratulus			1						
Nematoda									
Nematoda	1								
Chaetognatha									
Chaetognatha									
Echiura									
Echiurus echiurus	25	14	8	13	7	11	15	7	11
Sipuncula									
Golfingiidae									
Golfingia elongata									
Thysanocardia procera									
Onchnesoma steenstrupi	1								
Annelida									
Aphroditidae									
Polynoidae									
Melaenis loveni						1	1		
Harmothoe glabra									
Lepidasthenia									
Sthenelais	1								
Sthenelais boa									
Sthenelais limicola	1			1		1			
Anaitides lineata									
Paranaitis uschakovi									
Glycera lapidum	3	3	4		1		3		1
Glycera rouxii									
Goniadidae									
Goniada maculata				2	1			1	
Goniada norvegica									
Commensodorum commensalis	1								
Gyptis									
Ophiodromus flexuosus									
Podarkeopsis capensis	1								
Ancistrosyllis groenlandica			1						
Glyphohesione klatti		1					1	1	
Litocorsa stremma									
Exogone hebes	1								
Exogone verugera									

	A4-A	A4-B	A4-C	C1-A	C1-B	C1-C	C4-A	C4-B	C4-C
Nephtys									
Nephtys									
Nephtys hombergii							1	1	
Nephtys hystricis	1								
Nephtys kersivalensis									
Paramphinome jeffreysii				1	1				
Lumbrineridae									
Lumbrineris cingulata				1	1		1		
Abyssoninoe scopa									
Notocirrus scoticus									
Aricidea				3					
Aricidea w assi	1	3	6		1	1	2		1
Aricidea suecica									
Aricidea catherinae		2		1				1	1
Aricidea laubieri			1	3	2	3			1
Aricidea roberti		1	2		1			1	
Levinsenia gracilis	1	2	2	3	1	2	5	3	
Paraonidae	1								
Paraonides myriamae									
Apistobranchus									
Apistobranchus tenuis									
Poecilochaetus serpens						1	1		
Aonides									
Aonides paucibranchiata									
Laonice					1				
Laonice bahusiensis						1			
Laonice sarsi					1				
Minuspio cirrifera	1		5			3			
Minuspio multibranchiata									
Dipolydora coeca									1
Prionospio			1			2	1	2	
Prionospio dubia						1		3	
Prionospio fallax		11	3	3	4	2		3	4
Pseudopolydora paucibranchiata					2				
Scolelepis									
Spiophanes				1	1				
Spiophanes bombyx		1							
Spiophanes kroyeri		1	2	1	1		2		2
Spiophanes w igleyi	1		1			4	1	1	8
Magelona minuta	2	3		1	1				
Chaetopteridae						1			1
Aphelochaeta									
Aphelochaeta									
Chaetozone "species D"									
Cirratulus caudatus									
Monticellina dorsobranchialis		1		1			1		
Tharyx									
Tharyx killariensis			1						1
Diplocirrus glaucus	1		1				1		2
Macrochaeta polyonyx							1		
Notomastus		3	2				1	1	3
Peresiella clymenoides	7	1		1	1	1		2	2
Maldanidae									

	A4-A	A4-B	A4-C	C1-A	C1-B	C1-C	C4-A	C4-B	C4-C
Micromaldane ornithochaeta									
Praxillura longissima		1							
Praxillella affinis		1			1				
Ophelina									
Ophelina abranchiata									
Ophelina cylindricaudata					2			2	1
Scalibregma celticum									
Scalibregma inflatum	1						1		
Galathowenia oculata	39	35	48	5	34	17	30	36	37
Myriochele danielsseni		1							
Owenia borealis									
Pectinariidae									
Amphictene auricoma									
Ampharetidae				1	2				
Amythasides macroglossus									
Anobothrus gracilis									
Eclysippe vanelli	3	4	6	2	1	3	2	3	3
Terebellides stroemi	1			1		1			
Trichobranchus roseus									
Loimia medusa									
Phisidia aurea									
Pista									
Pista cristata		1					1		1
Pista mediterranea									
Amaeana trilobata					1				
Polycirrus									
Amphicorina			1		2	1		1	
Chone collaris									
Dialychone dunerficta									
Dialychone longseta					1				
Euchone rosea									
Chelicerata									
Paranymphon spinosum									
Crustacea									
Ostracoda	1	1				5			
Lophogaster typicus									
Hypererythrops serriventer									
Pseudomma affine									
Perioculodes longimanus									
Synchelidium maculatum									
Leucothoe incisa	1								
Urothoe elegans	1	4	3	5	4	5	3	9	4
Harpinia									
Harpinia antennaria						2			
Harpinia crenulata									
Harpinia pectinata									
Harpinia laevis									
Acidostoma obesum (sensu Stoddart	1								
Hippomedon denticulatus			1						
Pardaliscidae									
Nicippe tumida					1	1	1	1	
Syrrhoe affinis									
Ampelisca					1				

	A4-A	A4-B	A4-C	C1-A	C1-B	C1-C	C4-A	C4-B	C4-C
Ampelisca gibba									
Ampelisca sarsi	1								
Ampelisca spinipes									
Cheirocratus									1
Eriopisa elongata									
Phtisica marina					12				
Natatolana borealis	1					1	1		
Eurydice truncata									
Eugerda tenuimana									
Tanaidacea		2	1		1				2
Eudorella truncatula								3	1
Leucon nasica						1			
Diastylis cornuta									
Diastyloides biplicatus									1
Caridea									
Alpheus glaber									
Processa	1								
Processa nouveli holthuisi									
Philocheras echinulatus									
Thalassinidae	1	1						1	
Callianassa subterranea			1						
Pagurus cuanensis									
Munida intermedia							1		
Atelecyclus rotundatus									
Macropipus tuberculatus									
Mollusca									
Chaetoderma nitidulum						1			
Falcidens crossotus				1	2	2		1	
Solenogastres									
Aporrhais serresianus									
Naticidae									1
Euspira fusca									
Aclis w alleri									
Eulima bilineata									
Acteon tornatilis							1		
Scaphander punctostriatus									
Philine catena									
Cylichna cylindracea			1						
Retusa									
Retusa obtusa									
Limacina retroversa						1			
Pulsellum affine			4		2				
Gadila subfusiformis						1			
Antalis agilis									
Pelecypoda				1					
Nuculidae			1		2				
Nuculoma tenuis					2			1	1
Yoldiella lenticula	1	1						1	
Limatula subovata									
Pectinoidea					2				
Similipecten similis									
Thyasira									
Thyasira									

	A4-A	A4-B	A4-C	C1-A	C1-B	C1-C	C4-A	C4-B	C4-C
Axinulus croulinensis	4	5	7	9	9	5	8	8	9
Mendicula ferruginosa				1	4	1			1
Adontorhina similis	5	10	8	3	11	4	3	10	10
Kelliella abyssicola	13	2	1	1	2	2		1	3
Kellia suborbicularis									
Tellimya ferruginosa			1						
Epilepton clarkiae									
Montacuta substriata									
Anomiidae									
Parvicardium minimum									1
Abra		1	1	1	1	1		2	2
Abra nitida									
Timoclea ovata	2						3	1	1
Thraciidae									
Poromya granulata									
Cuspidaria	1			1					
Cuspidaria abbreviata									1
Bryozoa									
Arachnidium simplex									
Nolella dilatata									
Schizoporella									
Schizoporella errata									
Phoronida									
Phoronis							1		
Echinodermata									
Asteroidea				1	1	1			
Astropecten irregularis						1			
Ophiuroidea					11				
Amphiura filiformis				1	1				
Ophiocten affinis	30	66	42	1	2	4	27		
Echinoidea	1	1		3	20		2		2
Echinocardium	1		3						
Echinocardium flavescens		1					1	1	
Spatangus purpureus									
Spatangus raschi									
Synaptidae									
Labidoplax				2					
Labidoplax buskii	1	3	1		2	1	5	1	6
Labidoplax digitata					2				
Oestergrenia thompsoni				1					
Hemichordata									
Hemichordata				1					
Glossobalanus sarniensis									

	F3-A	F3-B	F3-C	F6-A	F6-B	F6-C	F8-A	F8-B	F8-C
Cnidaria									
Anthoathecata									
Pandeiidae				P	P	P		P	
Bougainvillia britannica									
Modeeria rotunda									
Obelia									
Pennatulidae									
Actiniaria			P	P					
Actinauge richardi									
Edwardsiidae		1			1			1	
Scleractinia									
Platyhelminthes									
Platyhelminthes									
Nemertea									
Nemertea	5	1	1	1		2	1		5
Tubulanus polymorphus	4	6	8	5	4	2	2	2	5
Cerebratulus	1		4						
Nematoda									
Nematoda						1			
Chaetognatha									
Chaetognatha									
Echiura									
Echiurus echiurus	3	7	9	2	1	4			
Sipuncula									
Golfingiidae									
Golfingia elongata									
Thysanocardia procera			1						1
Onchnesoma steenstrupi									
Annelida									
Aphroditidae									
Polynoidae						1			
Melaenis loveni									
Harmothoe glabra					1				
Lepidasthenia									
Sthenelais									
Sthenelais boa									
Sthenelais limicola		1				1			1
Anaitides lineata				1					
Paranaitis uschakovi									
Glycera lapidum	2	2	4	2	3	1	2	1	5
Glycera rouxii									
Goniadidae									
Goniada maculata	1		2			1	1	1	1
Goniada norvegica									
Commensodorum commensalis									
Gyptis				1					
Ophiodromus flexuosus	1							1	
Podarkeopsis capensis									
Ancistrosyllis groenlandica									3
Glyphohesione klatti	3		2				1		1
Litocorsa stremma	1								2
Exogone hebes	2								
Exogone verugera			3						

	F3-A	F3-B	F3-C	F6-A	F6-B	F6-C	F8-A	F8-B	F8-C
Nephtys	1								
Nephtys	1								
Nephtys hombergii			1						
Nephtys hystricis									
Nephtys kersivalensis									
Paramphinome jeffreysii	5								2
Lumbrineridae	1								
Lumbrineris cingulata			2						
Abyssoninoe scopa	2								1
Notocirrus scoticus									
Aricidea	2	2				1	1		
Aricidea w assi	2	5	5	1	2	2		2	8
Aricidea suecica						1			
Aricidea catherinae	7		1	3	1		1		3
Aricidea laubieri	4	2	3		1	2	1		2
Aricidea roberti			2			1	2	1	1
Levinsenia gracilis	9	6	6	1	3	3	2	1	7
Paraonidae									
Paraonides myriamae					1				
Apistobranchus						1			
Apistobranchus tenuis		1	1						
Poecilochaetus serpens									
Aonides						1			
Aonides paucibranchiata									
Laonice									
Laonice bahusiensis	1								
Laonice sarsi	3	1		1	1		1		
Minuspio cirrifera	17	2	6	6	7	3	1	3	5
Minuspio multibranchiata									
Dipolydora coeca			3						
Prionospio		3	3		1		2		
Prionospio dubia		1	4				1		2
Prionospio fallax		2	3	2	4	5	4	4	2
Pseudopolydora paucibranchiata	1								
Scolelepis						1			1
Spiophanes						1			
Spiophanes bombyx		1							
Spiophanes kroyeri	3	1	2			3	3	2	4
Spiophanes w igleyi	1	1	4			1	2		2
Magelona minuta	2		1	1		1	1		2
Chaetopteridae		2							1
Aphelochaeta									1
Aphelochaeta									
Chaetozone "species D"									
Cirratulus caudatus									
Monticellina dorsobranchialis							1		
Tharyx									
Tharyx killariensis					1				
Diplocirrus glaucus	1	2		1	1				
Macrochaeta polyonyx	1		1		4				1
Notomastus		1	4			1			2
Peresiella clymenoides	1	3	2	1	2		3	2	4
Maldanidae					1				

	F3-A	F3-B	F3-C	F6-A	F6-B	F6-C	F8-A	F8-B	F8-C
Micromaldane ornithochaeta			2						
Praxillura longissima				1			1		
Praxillella affinis									1
Ophelina									
Ophelina abranchiata									
Ophelina cylindricaudata	3	2		3		1	1	3	1
Scalibregma celticum									
Scalibregma inflatum									
Galathowenia oculata	124	43	49	44	1	30	119	30	105
Myriochele danielsseni				1					
Owenia borealis									1
Pectinariidae					1				
Amphictene auricoma									
Ampharetidae					1	1			
Amythasides macroglossus					1				
Anobothrus gracilis									
Eclysippe vanelli	8	10	14	3	4	2	1		10
Terebellides stroemi		1							2
Trichobranchus roseus						1			
Loimia medusa									
Phisidia aurea									
Pista			1					1	
Pista cristata		1							
Pista mediterranea									
Amaeana trilobata									
Polycirrus				1					
Amphicorina	1	5	5	1	3	1	1	1	5
Chone collaris									
Dialychone dunerficta	2	1	3						
Dialychone longseta						1			
Euchone rosea									1
Chelicerata									
Paranymphon spinosum									
Crustacea									
Ostracoda	2		1		2		1	1	
Lophogaster typicus									
Hypererythrops serriventer									
Pseudomma affine									1
Perioculodes longimanus					1	2	1		1
Synchelidium maculatum	1					1			
Leucothoe incisa						1			
Urothoe elegans		5	3	9	5	9	8	7	11
Harpinia						1			
Harpinia antennaria					1		2		1
Harpinia crenulata	1								
Harpinia pectinata									
Harpinia laevis									
Acidostoma obesum (sensu Stoddart & Lowry		1	1	1					
Hippomedon denticulatus			1						1
Pardaliscidae									
Nicippe tumida			1						
Syrrhoe affinis								1	
Ampelisca				1				1	

	F3-A	F3-B	F3-C	F6-A	F6-B	F6-C	F8-A	F8-B	F8-C
Ampelisca gibba			1						
Ampelisca sarsi									
Ampelisca spinipes									
Cheirocratus									
Eriopisa elongata									
Phtisica marina									
Natatolana borealis				1	3			1	
Eurydice truncata									
Eugerda tenuimana									
Tanaidacea	2		4			2		1	
Eudorella truncatula	1		1						
Leucon nasica									
Diastylis cornuta									
Diastyloides biplicatus		1					1		1
Caridea									
Alpheus glaber									
Processa									
Processa nouveli holthuisi							1		
Philocheras echinulatus								1	
Thalassinidae		1	1					1	
Callianassa subterranea									
Pagurus cuanensis				1					
Munida intermedia									
Atelecyclus rotundatus			1						
Macropipus tuberculatus									
Mollusca									
Chaetoderma nitidulum	2		3				2	1	
Falcidens crossotus		2		1				1	1
Solenogastres									
Aporrhais serresianus									
Naticidae									
Euspira fusca									
Aclis w alleri									
Eulima bilineata									
Acteon tornatilis									
Scaphander punctostriatus									
Philine catena									
Cylichna cylindracea									2
Retusa									
Retusa obtusa									
Limacina retroversa									
Pulsellum affine			1	1					
Gadila subfusiformis									
Antalis agilis			1						
Pelecypoda									
Nuculidae									
Nuculoma tenuis									1
Yoldiella lenticula					1				
Limatula subovata									
Pectinoidea									
Similipecten similis									
Thyasira					1				
Thyasira		1							

	F3-A	F3-B	F3-C	F6-A	F6-B	F6-C	F8-A	F8-B	F8-C
Axinulus croulinensis	6	6	13	5	4	5	16	13	5
Mendicula ferruginosa	3		2				1		
Adontorhina similis	14	8	10	3	2	4	8	8	9
Kelliella abyssicola	3	2	3		3		6	2	1
Kellia suborbicularis									
Tellimya ferruginosa						1			
Epilepton clarkiae									
Montacuta substriata									1
Anomiidae									
Parvicardium minimum				1				1	
Abra	2	6	9	1	4	3	3	2	1
Abra nitida									
Timoclea ovata	1	1				1	1	1	1
Thraciidae			1						
Poromya granulata									
Cuspidaria		3				1			1
Cuspidaria abbreviata		1	1						
Bryozoa									
Arachnidium simplex									
Nolella dilatata									
Schizoporella									
Schizoporella errata								P	
Phoronida									
Phoronis	1			1		4		1	
Echinodermata									
Asteroidea									
Astropecten irregularis			3				1	1	2
Ophiuroidea						2	1		1
Amphiura filiformis				1					
Ophiocten affinis	23	33	9	24	6	1	18		4
Echinoidea	12	4			4	3	4	2	5
Echinocardium		1	10						1
Echinocardium flavescens	2						3		3
Spatangus purpureus								1	
Spatangus raschi									
Synaptidae			2						
Labidoplax									
Labidoplax buskii	6			3	2	3	1	2	3
Labidoplax digitata			1					1	
Oestergrenia thompsoni									
Hemichordata									
Hemichordata	1								
Glossobalanus sarniensis		1							

	Z3-A	Z3-B	Z3-C	Z4-A	Z4-B	Z4-C	Z5-A	Z5-B	Z5-C
Cnidaria									
Anthoathecata									
Pandeiidae		P			P	P			
Bougainvillia britannica	P								
Modeeria rotunda									
Obelia								P	
Pennatulidae									
Actiniaria								P	
Actinauge richardi									
Edwardsiidae	3	5	2	2	1	4		4	1
Scleractinia									
Platyhelminthes									
Platyhelminthes									2
Nemertea									
Nemertea	1		1		1	3	2	6	
Tubulanus polymorphus	3	9	3	3	2	6	3		4
Cerebratulus			3						3
Nematoda									
Nematoda			1						
Chaetognatha									
Chaetognatha									
Echiura									
Echiurus echiurus		1	1	5	1	3	11	1	1
Sipuncula									
Golfingiidae		1							
Golfingia elongata									
Thysanocardia procera	1								1
Onchnesoma steenstrupi	1					1			
Annelida									
Aphroditidae					1				
Polynoidae		1							
Melaenis loveni			1				2		
Harmothoe glabra									
Lepidasthenia									
Sthenelais									
Sthenelais boa		1							
Sthenelais limicola						1	1		
Anaitides lineata									
Paranaitis uschakovi									1
Glycera lapidum	1	2	2	4	5	4	2		5
Glycera rouxii							1		
Goniadidae					1				
Goniada maculata	1	1				1			1
Goniada norvegica						1			
Commensodorum commensalis									
Gyptis									
Ophiodromus flexuosus				1					
Podarkeopsis capensis									
Ancistrosyllis groenlandica			3	1				2	
Glyphohesione klatti		1				1			
Litocorsa stremma		1		9					
Exogone hebes			1	2				1	1
Exogone verugera									

	Z3-A	Z3-B	Z3-C	Z4-A	Z4-B	Z4-C	Z5-A	Z5-B	Z5-C
Nephtys							1		
Nephtys									
Nephtys hombergii									
Nephtys hystricis	1	1	1					1	
Nephtys kersivalensis									
Paramphinome jeffreysii	1		1	1	1	2	2	1	1
Lumbrineridae									
Lumbrineris cingulata			1						
Abyssoninoe scopa									
Notocirrus scoticus				1					
Aricidea			2	2	1		1		
Aricidea wassi		3		2	2	3	1		5
Aricidea suecica									
Aricidea catherinae	1	3	3	1		4			3
Aricidea laubieri				1		3	4		4
Aricidea roberti									
Levinsenia gracilis	8	7	9	9	6	8	4	3	6
Paraonidae		3							
Paraonides myriamae									
Apistobranchus						1			
Apistobranchus tenuis		1		2	1				
Poecilochaetus serpens	1								
Aonides									
Aonides paucibranchiata									
Laonice					2				
Laonice bahusiensis	1				1				
Laonice sarsi	1					1			
Minuspio cirrifera		2	5	3	3	1	1		2
Minuspio multibranchiata									
Dipolydora coeca			1	1					
Prionospio		1			3				
Prionospio dubia	5		1		2	2		5	
Prionospio fallax	2	10	12		2	9	3		4
Pseudopolydora paucibranchiata									
Scolelepis									
Spiophanes									
Spiophanes bombyx			1	1			1		
Spiophanes kroyeri	1	1	1	3	1		1	1	3
Spiophanes wigleyi	2	3	1	3	3		3	3	3
Magelona minuta			3		1	1		1	1
Chaetopteridae	1	1							
Aphelochaeta									
Aphelochaeta							1		
Chaetozone "species D"			2						
Cirratulus caudatus		1							
Monticellina dorsobranchialis									
Tharyx									
Tharyx killariensis									
Diplocirrus glaucus	2	1		1			1		
Macrochaeta polyonyx			5		2	1			
Notomastus	3			1					
Peresiella clymenoides	3	1	3	6		2	4	2	2
Maldanidae									

	Z3-A	Z3-B	Z3-C	Z4-A	Z4-B	Z4-C	Z5-A	Z5-B	Z5-C
Micromaldane ornithochaeta									
Praxillura longissima				1					
Praxillella affinis	2								
Ophelina									
Ophelina abranchiata									
Ophelina cylindricaudata	2	2	2	1	4	3	2	1	1
Scalibregma celticum					1				
Scalibregma inflatum	1					1			
Galathowenia oculata	39	23	50	16	43	34	20	57	40
Myriochele danielsseni									
Owenia borealis									
Pectinariidae									
Amphictene auricoma				1					
Ampharetidae		6			1	3			2
Amythasides macroglossus		1							
Anobothrus gracilis									
Eclysippe vanelli	6	7	5	8	9	5	2	13	13
Terebellides stroemi	1	1				1			
Trichobranchus roseus									
Loimia medusa									
Phisidia aurea	1								
Pista									
Pista cristata		1							
Pista mediterranea									
Amaeana trilobata					1			1	
Polycirrus									
Amphicorina	4	3	10	2	1	1	2	1	1
Chone collaris									
Dialychone dunerficta		1				1			1
Dialychone longseta			1						
Euchone rosea									
Chelicerata									
Paranymphon spinosum									
Crustacea									
Ostracoda		4	2			2		1	
Lophogaster typicus								1	
Hypererythrops serriventer									1
Pseudomma affine									
Perioculodes longimanus									
Synchelidium maculatum									
Leucothoe incisa		1		1	1	1			
Urothoe elegans	3	9	5	2	3	9	3	5	12
Harpinia									1
Harpinia antennaria					1	1		1	1
Harpinia crenulata									
Harpinia pectinata				2			2	3	2
Harpinia laevis						1			
Acidostoma obesum (sensu Stoddart & Lowry)					1				
Hippomedon denticulatus									
Pardaliscidae									
Nicippe tumida		1		2					
Syrrhoe affinis									
Ampelisca		1	1						

	Z3-A	Z3-B	Z3-C	Z4-A	Z4-B	Z4-C	Z5-A	Z5-B	Z5-C
Ampelisca gibba				1		1			
Ampelisca sarsi									
Ampelisca spinipes									1
Cheirocratus									
Eriopisa elongata			2			1			
Phtisica marina									
Natatolana borealis	1					1			
Eurydice truncata	1								
Eugerda tenuimana	1								
Tanaidacea			3			1	1		1
Eudorella truncatula	1			4			1	2	1
Leucon nasica									
Diastylis cornuta						1			
Diastyloides biplicatus			1			1			1
Caridea									
Alpheus glaber				1					
Processa									
Processa nouveli holthuisi									
Philocheras echinulatus									
Thalassinidae							1	2	1
Callianassa subterranea									
Pagurus cuanensis									
Munida intermedia									
Atelecyclus rotundatus	1						1		
Macropipus tuberculatus					1				
Mollusca									
Chaetoderma nitidulum		2	1	3				3	
Falcidens crossotus	1	1		3	1				2
Solenogastres			1						
Aporrhais serresianus									
Naticidae									
Euspira fusca	1								
Aclis w alleri			2						
Eulima bilineata							1	1	
Acteon tornatilis									
Scaphander punctostriatus					1				
Philine catena									1
Cylichna cylindracea	1		1			1			2
Retusa									
Retusa obtusa						1			
Limacina retroversa									
Pulsellum affine									
Gadila subfusiformis									
Antalis agilis									
Pelecypoda						1			
Nuculidae									
Nuculoma tenuis			1	1					2
Yoldiella lenticula									
Limatula subovata						1			
Pectinoidea									
Similipecten similis									
Thyasira		1							
Thyasira									

	Z3-A	Z3-B	Z3-C	Z4-A	Z4-B	Z4-C	Z5-A	Z5-B	Z5-C
Axinulus croulinensis	8	4		5	3	8	2	9	3
Mendicula ferruginosa	1			1				1	
Adontorhina similis	18	4	4	7	5	12	5	9	15
Kelliella abyssicola	6	1	1	3			4	5	2
Kellia suborbicularis									
Tellimya ferruginosa			1						
Epilepton clarkiae						1			
Montacuta substriata									
Anomiidae									
Parvicardium minimum	2	1				3		1	
Abra	5	4		1	3	3		1	1
Abra nitida						1			
Timoclea ovata	1		1				1	1	1
Thraciidae									
Poromya granulata									
Cuspidaria		2		2	1	1			
Cuspidaria abbreviata		2					2		2
Bryozoa									
Arachnidium simplex									
Nolella dilatata							P	P	
Schizoporella				P					
Schizoporella errata									
Phoronida									
Phoronis			1	1		1			1
Echinodermata									
Asteroidea									
Astropecten irregularis	1		1						
Ophiuroidea	1	3				12			2
Amphiura filiformis									
Ophiocten affinis	46	9	24	19	14	15	25	6	14
Echinoidea	4	4	4			4	5	2	1
Echinocardium				4					
Echinocardium flavescens		2		1		1	1		
Spatangus purpureus									
Spatangus raschi					1				
Synaptidae									
Labidoplax									
Labidoplax buskii	3	4	2	1	3	1	4	3	
Labidoplax digitata		2							
Oestergrenia thompsoni									
Hemichordata									
Hemichordata			1						
Glossobalanus sarniensis									

	Z6-A	Z6-B	Z6-C	Z9-A	Z9-B	Z9-C	Z10-A	Z10-B	Z10-C
Cnidaria									
Anthoathecata									
Pandeiidae				P		P	P		
Bougainvillia britannica									
Modeeria rotunda									
Obelia									
Pennatulidae							P		P
Actiniaria									
Actinauge richardi									
Edwardsiidae	1	2		3	2		5	4	1
Scleractinia					P				
Platyhelminthes									
Platyhelminthes							1		
Nemertea									
Nemertea		2	2		1				2
Tubulanus polymorphus		1			2	1	1	1	6
Cerebratulus				1		1		1	
Nematoda									
Nematoda									
Chaetognatha									
Chaetognatha						1			
Echiura									
Echiurus echiurus	8		5	11	4	4	3	15	25
Sipuncula									
Golfingiidae									
Golfingia elongata						1			
Thysanocardia procera									
Onchnesoma steenstrupi								2	
Annelida									
Aphroditidae				1				1	
Polynoidae								1	2
Melaenis loveni								1	
Harmothoe glabra									
Lepidasthenia				1					
Sthenelais									
Sthenelais boa									
Sthenelais limicola	1					2			
Anaitides lineata									
Paranaitis uschakovi									
Glycera lapidum		1	1	1	3	2	1	5	4
Glycera rouxii							1		
Goniadidae				1					
Goniada maculata		1	1						
Goniada norvegica									
Commensodorum commensalis									
Gyptis									
Ophiodromus flexuosus						1		2	
Podarkeopsis capensis									
Ancistrosyllis groenlandica									1
Glyphohesione klatti						1			2
Litocorsa stremma									
Exogone hebes									1
Exogone verugera									

	Z6-A	Z6-B	Z6-C	Z9-A	Z9-B	Z9-C	Z10-A	Z10-B	Z10-C
Nephtys									
Nephtys	1								
Nephtys hombergii								1	
Nephtys hystricis									
Nephtys kersivalensis						1			
Paramphinome jeffreysii		1	1	1		2			2
Lumbrineridae									
Lumbrineris cingulata				1		1			
Abyssoninoe scopa									
Notocirrus scoticus									
Aricidea		1		1			2		4
Aricidea w assi		1		2	1		1	1	1
Aricidea suecica									
Aricidea catherinae		1	2			1		2	2
Aricidea laubieri						1		2	3
Aricidea roberti									1
Levinsenia gracilis	1	1	2	2	2		1	3	2
Paraonidae									
Paraonides myriamae		1							
Apistobranchus									1
Apistobranchus tenuis									
Poecilochaetus serpens								1	
Aonides									
Aonides paucibranchiata					2				
Laonice									
Laonice bahusiensis							2		
Laonice sarsi	1								
Minuspio cirrifera		1	1	3		4		3	
Minuspio multibranchiata									
Dipolydora coeca									
Prionospio			1		1				
Prionospio dubia						1			
Prionospio fallax	1	2	1	10	3		4		3
Pseudopolydora paucibranchiata					2				
Scolelepis					1				
Spiophanes									
Spiophanes bombyx									1
Spiophanes kroyeri	1	1	1					2	2
Spiophanes w igleyi	1	1			3			2	1
Magelona minuta			1			1			1
Chaetopteridae									
Aphelochaeta									
Aphelochaeta									
Chaetozone "species D"									
Cirratulus caudatus									
Monticellina dorsobranchialis								1	
Tharyx									
Tharyx killariensis									
Diplocirrus glaucus				1		1	1		1
Macrochaeta polyonyx				1					
Notomastus					1	1		1	1
Peresiella clymenoides			1	1		4	4	2	3
Maldanidae					1				

	Z6-A	Z6-B	Z6-C	Z9-A	Z9-B	Z9-C	Z10-A	Z10-B	Z10-C
Micromaldane ornithochaeta									
Praxillura longissima									
Praxillella affinis									
Ophelina									1
Ophelina abranchiata									
Ophelina cylindricaudata			1	2		1		2	
Scalibregma celticum									
Scalibregma inflatum								1	
Galathowenia oculata	8	44	2	34	7	15	7	9	12
Myriochele danielsseni									
Owenia borealis									
Pectinariidae									
Amphictene auricoma						1			
Ampharetidae			1	1	1				4
Amythasides macroglossus			2						1
Anobothrus gracilis									
Eclysippe vanelli		4	5	4	1	4	2	4	1
Terebellides stroemi				1		1			
Trichobranchus roseus									
Loimia medusa				1					
Phisidia aurea									
Pista									
Pista cristata									
Pista mediterranea								1	
Amaeana trilobata									
Polycirrus									
Amphicorina	3	1	1				2	1	3
Chone collaris									
Dialychone dunerficta				1					
Dialychone longseta									
Euchone rosea									
Chelicerata									
Paranymphon spinosum	1								
Crustacea									
Ostracoda						2	1		1
Lophogaster typicus									
Hypererythrops serriventer									
Pseudomma affine									
Perioculodes longimanus						1		1	
Synchelidium maculatum		1							
Leucothoe incisa									
Urothoe elegans	5	5	6	6	5	12	8	4	9
Harpinia									1
Harpinia antennaria			1		1	2			
Harpinia crenulata									
Harpinia pectinata	1		1						
Harpinia laevis									1
Acidostoma obesum (sensu Stoddart & Lowry)									
Hippomedon denticulatus	1			1		2		1	
Pardaliscidae									
Nicippe tumida	3						1		
Syrrhoe affinis									
Ampelisca									3

	Z6-A	Z6-B	Z6-C	Z9-A	Z9-B	Z9-C	Z10-A	Z10-B	Z10-C
Ampelisca gibba			1			1			
Ampelisca sarsi									
Ampelisca spinipes									
Cheirocratus	1								
Eriopisa elongata									
Phtisica marina									
Natatolana borealis				1	1		1		
Eurydice truncata									
Eugerda tenuimana									
Tanaidacea			1	1				1	1
Eudorella truncatula						1			
Leucon nasica									
Diastylis cornuta								1	2
Diastyloides biplicatus		1					1		1
Caridea						1			
Alpheus glaber									
Processa									
Processa nouveli holthuisi									
Philocheras echinulatus									
Thalassinidae			1						1
Callianassa subterranea									
Pagurus cuanensis									
Munida intermedia	1								
Atelecyclus rotundatus									
Macropipus tuberculatus									
Mollusca									
Chaetoderma nitidulum	1			2	1			2	1
Falcidens crossotus		1						2	
Solenogastres		1							
Aporrhais serresianus					1				
Naticidae									
Euspira fusca									
Aclis walleri								1	1
Eulima bilineata							1	1	2
Acteon tornatilis									
Scaphander punctostriatus									
Philine catena									
Cylichna cylindracea					1		3		
Retusa									
Retusa obtusa									
Limacina retroversa									
Pulsellum affine			1					1	
Gadila subfusiformis					1				
Antalis agilis									
Pelecypoda									
Nuculidae							1		
Nuculoma tenuis	5	1		2	4				2
Yoldiella lenticula		1							
Limatula subovata									
Pectinoidea									
Similipecten similis									
Thyasira									
Thyasira									

	Z6-A	Z6-B	Z6-C	Z9-A	Z9-B	Z9-C	Z10-A	Z10-B	Z10-C
Axinulus croulinensis	5	5	11	14	9	4	9	11	18
Mendicula ferruginosa	1							1	1
Adontorhina similis	10	22	11	24	11	18	18	16	14
Kelliella abyssicola	6	4	2	3	1		2	3	4
Kellia suborbicularis									
Tellimya ferruginosa							1	1	
Epilepton clarkiae									
Montacuta substriata				1					
Anomiidae		2							
Parvicardium minimum			1					2	
Abra	1		2	2	3		1		
Abra nitida									2
Timoclea ovata				1	2		1		
Thraciidae									
Poromya granulata	1								
Cuspidaria	1	1	1			1	2		
Cuspidaria abbreviata									1
Bryozoa									
Arachnidium simplex					P				
Nolella dilatata									
Schizoporella									
Schizoporella errata									
Phoronida									
Phoronis						3			
Echinodermata									
Asteroidea		1		1					
Astropecten irregularis									
Ophiuroidea	1	5	3	1		1	3		9
Amphiura filiformis								1	
Ophiocten affinis	7	4	2	21	2			8	2
Echinoidea		2	3	2					1
Echinocardium						1		1	
Echinocardium flavescens		1	1	3	2	2	1	1	2
Spatangus purpureus						1			
Spatangus raschi									
Synaptidae									
Labidoplax					1				
Labidoplax buskii		2	5	2	3	4	1		1
Labidoplax digitata							1		
Oestergrenia thompsoni									
Hemichordata									
Hemichordata							1		
Glossobalanus sarniensis									

	Z11-A	Z11-B	Z11-C	Z12-A	Z12-B	Z12-C
Cnidaria						
Anthoathecata						
Pandeiidae				P		
Bougainvillia britannica						
Modeeria rotunda			P			
Obelia						
Pennatulidae						
Actiniaria						
Actinauge richardi						
Edwardsiidae		3			1	
Scleractinia						
Platyhelminthes						
Platyhelminthes						
Nemertea						
Nemertea		1	2			
Tubulanus polymorphus		2			1	1
Cerebratulus			1	1		1
Nematoda						
Nematoda						
Chaetognatha						
Chaetognatha						
Echiura						
Echiurus echiurus		3	2			
Sipuncula						
Golfingiidae						
Golfingia elongata						
Thysanocardia procera						
Onchnesoma steenstrupi			1			
Annelida						
Aphroditidae	1	1				
Polynoidae						1
Melaenis loveni	1					
Harmothoe glabra						
Lepidasthenia						
Sthenelais						
Sthenelais boa						
Sthenelais limicola		1				1
Anaitides lineata						
Paranaitis uschakovi						
Glycera lapidum		4	1		2	1
Glycera rouxii						
Goniadidae						
Goniada maculata		1			1	
Goniada norvegica						
Commensodorum commensalis						
Gyptis						
Ophiodromus flexuosus					1	
Podarkeopsis capensis						
Ancistrosyllis groenlandica						
Glyphohesione klatti			1		1	
Litocorsa stremma				1		
Exogone hebes						
Exogone verugera						

	Z11-A	Z11-B	Z11-C	Z12-A	Z12-B	Z12-C
Nephtys						
Nephtys						
Nephtys hombergii	1					
Nephtys hystricis						
Nephtys kersivalensis					1	
Paramphinome jeffreysii		3	1	2	1	
Lumbrineridae						
Lumbrineris cingulata						
Abyssoninoe scopa						
Notocirrus scoticus						
Aricidea						
Aricidea wassi		1			1	1
Aricidea suecica						
Aricidea catherinae				1	1	
Aricidea laubieri		2			1	
Aricidea roberti					1	
Levinsenia gracilis			1		1	1
Paraonidae						1
Paraonides myriamae						
Apistobranchus						
Apistobranchus tenuis						1
Poecilochaetus serpens						
Aonides						
Aonides paucibranchiata						
Laonice						
Laonice bahusiensis						
Laonice sarsi				1		
Minuspio cirrifera	1	1			1	1
Minuspio multibranchiata		1				
Dipolydora coeca						
Prionospio				2		
Prionospio dubia						1
Prionospio fallax		4	1		3	3
Pseudopolydora paucibranchiata						
Scolelepis						
Spiophanes						
Spiophanes bombyx		1				
Spiophanes kroyeri					1	2
Spiophanes wigleyi		2	1			1
Magelona minuta		2				1
Chaetopteridae			1			
Aphelochaeta						
Aphelochaeta						
Chaetozone "species D"						
Cirratulus caudatus						
Monticellina dorsobranchialis			1			
Tharyx					1	
Tharyx killariensis						
Diplocirrus glaucus	1		1		1	
Macrochaeta polyonyx						
Notomastus						1
Peresiella clymenoides		7	4		1	4
Maldanidae						

	Z11-A	Z11-B	Z11-C	Z12-A	Z12-B	Z12-C
Micromaldane ornithochaeta						
Praxillura longissima						
Praxillella affinis						
Ophelina						
Ophelina abranchiata						
Ophelina cylindricaudata		2		1	1	3
Scalibregma celticum						
Scalibregma inflatum						
Galathowenia oculata	5	95	76	15	26	21
Myriochele danielsseni					1	
Owenia borealis						1
Pectinariidae						
Amphictene auricoma						
Ampharetidae			1	1	1	
Amythasides macroglossus	1					
Anobothrus gracilis		1				
Eclysippe vanelli		3		2		3
Terebellides stroemi	2		1			
Trichobranchus roseus						
Loimia medusa						
Phisidia aurea						
Pista						
Pista cristata			1			
Pista mediterranea						
Amaeana trilobata						
Polycirrus						
Amphicorina		1		1	2	
Chone collaris			1			
Dialychone dunerficta						
Dialychone longseta						
Euchone rosea						
Chelicerata						
Paranymphon spinosum						
Crustacea						
Ostracoda	1					
Lophogaster typicus						
Hypererythrops serriventer						
Pseudomma affine						
Perioculodes longimanus						
Synchelidium maculatum						
Leucothoe incisa						
Urothoe elegans	3	6	9	3	5	8
Harpinia						
Harpinia antennaria						
Harpinia crenulata						
Harpinia pectinata						
Harpinia laevis						
Acidostoma obesum (sensu Stoddart & Lowry)						1
Hippomedon denticulatus		2	1	2		
Pardaliscidae				1		
Nicippe tumida						
Syrrhoe affinis						
Ampelisca					1	2

	Z11-A	Z11-B	Z11-C	Z12-A	Z12-B	Z12-C
Ampelisca gibba						
Ampelisca sarsi						
Ampelisca spinipes			1			
Cheirocratus						
Eriopisa elongata						
Phtisica marina						
Natatolana borealis	5				1	1
Eurydice truncata						
Eugerda tenuimana						
Tanaidacea						
Eudorella truncatula						
Leucon nasica				1		
Diastylis cornuta						
Diastyloides biplicatus	4					
Caridea						
Alpheus glaber						
Processa						1
Processa nouveli holthuisi		1				
Philocheras echinulatus						
Thalassinidae			1			
Callianassa subterranea						
Pagurus cuanensis						1
Munida intermedia						
Atelecyclus rotundatus						
Macropipus tuberculatus						
Mollusca						
Chaetoderma nitidulum		3				
Falcidens crossotus			1			
Solenogastres						
Aporrhais serresianus						
Naticidae			1		1	
Euspira fusca						
Aclis walleri						
Eulima bilineata						
Acteon tornatilis		1				
Scaphander punctostriatus						
Philine catena						
Cylichna cylindracea				1		
Retusa						2
Retusa obtusa						
Limacina retroversa						
Pulsellum affine				1		
Gadila subfusiformis						
Antalis agilis		1				
Pelecypoda						
Nuculidae						
Nuculoma tenuis			1			
Yoldiella lenticula	1					
Limatula subovata						
Pectinoidea						
Similipecten similis				1		
Thyasira						
Thyasira						

	Z11-A	Z11-B	Z11-C	Z12-A	Z12-B	Z12-C
Axinulus croulinensis	3	4	5	1	3	3
Mendicula ferruginosa	2					
Adontorhina similis	11	6	11	8	1	3
Kelliella abyssicola	1	1	1	2		1
Kellia suborbicularis				1		
Tellimya ferruginosa				1		
Epilepton clarkiae						
Montacuta substriata						
Anomiidae						
Parvicardium minimum						
Abra	3	1	1	2	4	2
Abra nitida						
Timoclea ovata		1		2		
Thraciidae						
Poromya granulata						
Cuspidaria				1	1	2
Cuspidaria abbreviata			1			
Bryozoa						
Arachnidium simplex						
Nolella dilatata						
Schizoporella						
Schizoporella errata					P	
Phoronida						
Phoronis		1	3	1		
Echinodermata						
Asteroidea						1
Astropecten irregularis			1	2		
Ophiuroidea	1	1		1	11	1
Amphiura filiformis						
Ophiocten affinis	29	15	8	5	1	15
Echinoidea		7	1		2	3
Echinocardium	1		6	1	2	
Echinocardium flavescens		1		3		3
Spatangus purpureus						
Spatangus raschi						
Synaptidae						
Labidoplax						
Labidoplax buskii	4	3	4	3		5
Labidoplax digitata			1			
Oestergrenia thompsoni						
Hemichordata						
Hemichordata						
Glossobalanus sarniensis						

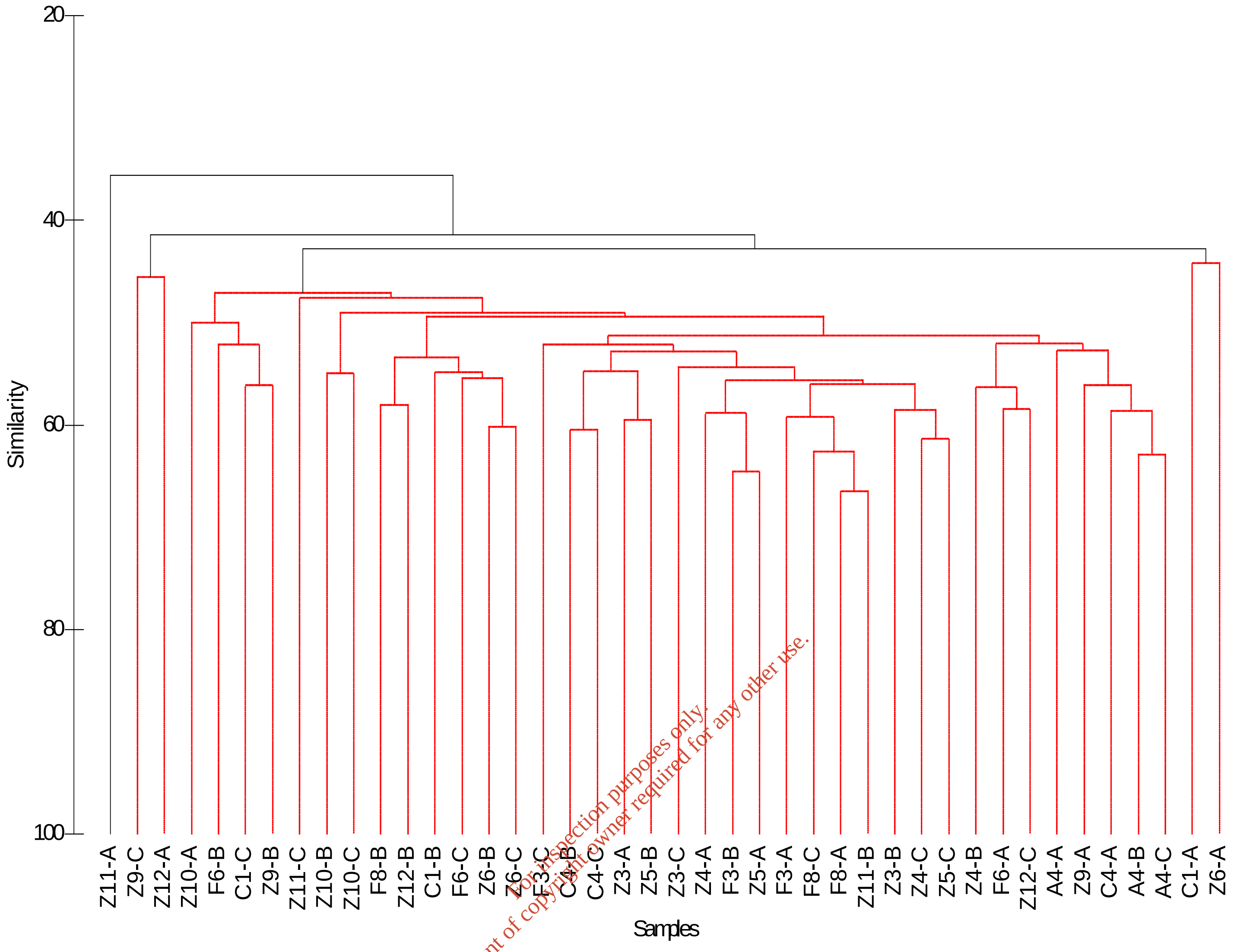
Appendix 8: Ranked macrofaunal taxa data from sampling stations in the vicinity of the Corrib Field (SW-3) – Top 10 ranked taxa for Corrib Field sites in 2014. Taxa comprising the top 50% of the population are shown in bold. Abundances are per 0.1m^2 (per grab)

A4		C1		C4		F3		F6		F8	
Ophiocten affinis	**46**	**Galathowenia oculata**	**19**	**Galathowenia oculata**	**34**	**Galathowenia oculata**	**72**	**Galathowenia oculata**	**25**	**Galathowenia oculata**	**85**
Galathowenia oculata	**41**	**Echiurus echiurus**	**10**	**Echiurus echiurus**	**11**	**Ophiocten affinis**	**22**	**Ophiocten affinis**	**10**	**Axinulus croulinensis**	**11**
Echiurus echiurus	**16**	**Axinulus croulinensis**	**8**	**Ophiocten affinis**	**9**	**Eclysippe vanelli**	**11**	**Urothoe elegans**	**8**	**Urothoe elegans**	**9**
		Echinoidea	**8**	**Axinulus croulinensis**	**8**	**Adontorhina similis**	**11**	**Minuspio cirrifera**	**5**		
Adontorhina similis	8	**Adontorhina similis**	**6**	**Adontorhina similis**	**8**	**Minuspio cirrifera**	**8**	**Axinulus croulinensis**	**5**	Adontorhina similis	8
Axinulus croulinensis	5	**Urothoe elegans**	**5**			**Axinulus croulinensis**	**8**	**Tubulanus polymorphus**	**4**	Ophiocten affinis	7
Kelliella abyssicola	5	**Phtisica marina**	**4**	Urothoe elegans	5			**Prionospio fallax**	**4**	Eclysippe vanelli	4
Prionospio fallax	5	**Ophiuroidea**	**4**	Labidoplax buskii	4	Levinsenia gracilis	7			Echinoidea	4
Eclysippe vanelli	4			Spiophanes wigleyi	3	Echiurus echiurus	6	Eclysippe vanelli	3	Aricidea wassi	3
Glycera lapidum	3	Prionospio fallax	3	Tubulanus polymorphus	3	Tubulanus polymorphus	6	Adontorhina similis	3	Levinsenia gracilis	3
Aricidea wassi	3	Aricidea laubieri	3	Levinsenia gracilis	3	Abra	6	Abra	3	Prionospio fallax	3
				Eclysippe vanelli	3			Labidoplax buskii	3		
No. of individuals	179	No. of individuals	117	No. of individuals	126	No. of individuals	250	No. of individuals	116	No. of individuals	200
50% of individuals	89	50% of individuals	59	50% of individuals	63	50% of individuals	125	50% of individuals	58	50% of individuals	100

Z3		Z4		Z5		Z6	
Galathowenia oculata	**37**	**Galathowenia oculata**	**31**	**Galathowenia oculata**	**39**	**Galathowenia oculata**	**18**
Ophiocten affinis	**26**	**Ophiocten affinis**	**16**	**Ophiocten affinis**	**15**	**Adontorhina similis**	**13**
Adontorhina similis	**9**	**Adontorhina similis**	**8**	**Adontorhina similis**	**10**	**Axinulus croulinensis**	**6**
Levinsenia gracilis	**8**	**Levinsenia gracilis**	**8**	**Eclysippe vanelli**	**9**	**Urothoe elegans**	**5**
Prionospio fallax	**8**	**Eclysippe vanelli**	**7**	**Urothoe elegans**	**7**	**Echiurus echiurus**	**4**
Eclysippe vanelli	**6**	**Axinulus croulinensis**	**5**			**Kelliella abyssicola**	**4**
Amphicorina	**6**	**Urothoe elegans**	**5**	Axinulus croulinensis	5	**Ophiocten affinis**	**4**
Urothoe elegans	**6**	**Glycera lapidum**	**4**	Echiurus echiurus	4		
		Ophiuroidea	**4**	Levinsenia gracilis	4	Eclysippe vanelli	3
Tubulanus polymorphus	5	**Tubulanus polymorphus**	**4**	Kelliella abyssicola	4	Ophiuroidea	3
Axinulus croulinensis	4	**Prionospio fallax**	**4**	Spiophanes wigleyi	3	Labidoplax buskii	2
Echinoidea	4						
No. of individuals	191	No. of individuals	167	No. of individuals	160	No. of individuals	94
50% of individuals	96	50% of individuals	83	50% of individuals	80	50% of individuals	47

Z9		Z10		Z11		Z12	
Galathowenia oculata	**19**	**Adontorhina similis**	**16**	**Galathowenia oculata**	**59**	**Galathowenia oculata**	**21**
Adontorhina similis	**18**	**Echiurus echiurus**	**14**	**Ophiocten affinis**	**17**	**Ophiocten affinis**	**7**
Axinulus croulinensis	**9**	**Axinulus croulinensis**	**13**			**Urothoe elegans**	**5**
Urothoe elegans	**8**	**Galathowenia oculata**	**9**	Adontorhina similis	9	**Ophiuroidea**	**4**
Ophiocten affinis	**8**	**Urothoe elegans**	**7**	Urothoe elegans	6	**Adontorhina similis**	**4**
		Ophiuroidea	**4**	Axinulus croulinensis	4	**Abra**	**3**
Echiurus echiurus	6	**Edwardsiidae**	**3**	Peresiella clymenoides	4	**Labidoplax buskii**	**3**
Prionospio fallax	4	**Glycera lapidum**	**3**	Labidoplax buskii	4		
Eclysippe vanelli	3	**Ophiocten affinis**	**3**	Echinoidea	3	Axinulus croulinensis	2
Labidoplax buskii	3	**Peresiella clymenoides**	**3**	Echinocardium	2	Prionospio fallax	2
Minuspio cirrifera	2	**Kelliella abyssicola**	**3**	Echiurus echiurus	2	Echinocardium flavescens	2
Echinocardium flavescens	2			Glycera lapidum	2		
				Prionospio fallax	2		
				Natatolana borealis	2		
				Abra	2		
No. of individuals	124	No. of individuals	135	No. of individuals	145	No. of individuals	88
50% of individuals	62	50% of individuals	67	50% of individuals	73	50% of individuals	44

Appendix 9: Results of Bray Curtis test for similarity (Community Clustering) on averaged per replicate data for sampling stations in the vicinity of the Corrib Field (SW-3)



Dendrogram showing clustering of communities using per replicate sample data from field sites. Black lines indicate a significant difference between replicates (generated by a SIMPROF test).

Appendix 10: Results of an Analysis of Similarity Test (SIMPER) comparing macrofaunal assemblage data at the Corrib Field between 2008 and 2014

Cluster 1 (all 2008 sites)	Average similarity: 52.96			
Species	**Av. Abund**	**Av. Sim**	**% Contrib**	**Cum %**
Galathowenia oculata	10.90	13.18	24.88	24.88
Prionopsio fallax	2.74	2.91	5.50	30.38
Abra	2.28	2.54	4.81	35.19
Axinulus crouliensis	1.97	2.11	3.98	39.17
Adontorhina similis	1.92	2.01	3.79	42.96

Cluster 2 (all 2014 sites)	Average similarity: 48.52			
Species	**Av. Abund**	**Av. Sim**	**% Contrib**	**Cum %**
Galathowenia oculata	5.54	6.31	13.00	13.00
Adontorhina similis	2.92	3.70	7.62	20.62
Axinulus crouliensis	2.46	3.10	6.39	27.01
Urothoe elegans	2.29	3.01	6.21	33.22
Ophiocten affinis	3.11	2.87	5.91	39.13
Eclysippe vanelli	1.83	1.87	3.86	42.98

Between Clusters 1 and 2	Average dissimilarity: 62.11			
Species	**Av. Abund (2008)**	**Av. Abund (2014)**	**Av Diss**	**Cum%**
Galathowenia oculata	10.90	5.54	4.07	6.56
Ophiocten affinis	0.10	3.11	2.19	10.08
Urothoe elegans	0.32	2.29	1.48	12.46
Echiurus echiurus	0.00	1.93	1.41	14.72
Owenia borealis	1.71	0.05	1.22	16.68
Prionopsio fallax	2.74	1.50	1.11	18.48

SIMPER output of those species that contribute to the similarity between clusters of Corrib Field sites in 2008 and 2014 using Bray-Curtis similarity on standardised square root transformed data. The columns shown give the average abundance, the average contribution to the similarity (or dissimilarity), the percentage contribution to overall similarity and the cumulative contribution to similarity (or dissimilarity).