Appendix D

Benthic Subtidal and Intertidal Ecology Supporting Information

C1 – Public

ORIEL WIND FARM PROJECT

Natura Impact Statement

Appendix D: Benthic Subtidal and Intertidal Ecology – Supporting Information

MDR1520B
NIS– Appendix D
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1 BENTHIC SUBTIDAL AND INTERTIDAL ECOLOGY

1.1 Introduction

This report describes the potential impacts of the Oriel Wind Farm Project (hereafter referred to as "the Project") on benthic, subtidal and intertidal ecology. It considers the potential impact of the offshore infrastructure [offshore wind farm and offshore cable] of the Project below the High-Water Mark (HWM) during the construction, operational and maintenance, and decommissioning phases.

1.2 Purpose

The primary purpose of this report is to provide supporting information on the potential impacts of the Project on benthic, subtidal and intertidal ecology, which is used to inform the assessment of adverse effects in the NIS. In particular, it:

- Identifies European sites which have relevant benthic, subtidal and intertidal qualifying features and presents the existing environmental baseline established from desk studies and consultation (section 1.4 and section 3); and

- Identifies potential impacts, their magnitude and their sensitivity on relevant benthic, subtidal and intertidal qualifying features, based on the information gathered (section 6). An assessment of potential in-combination effects is provided in section 7.

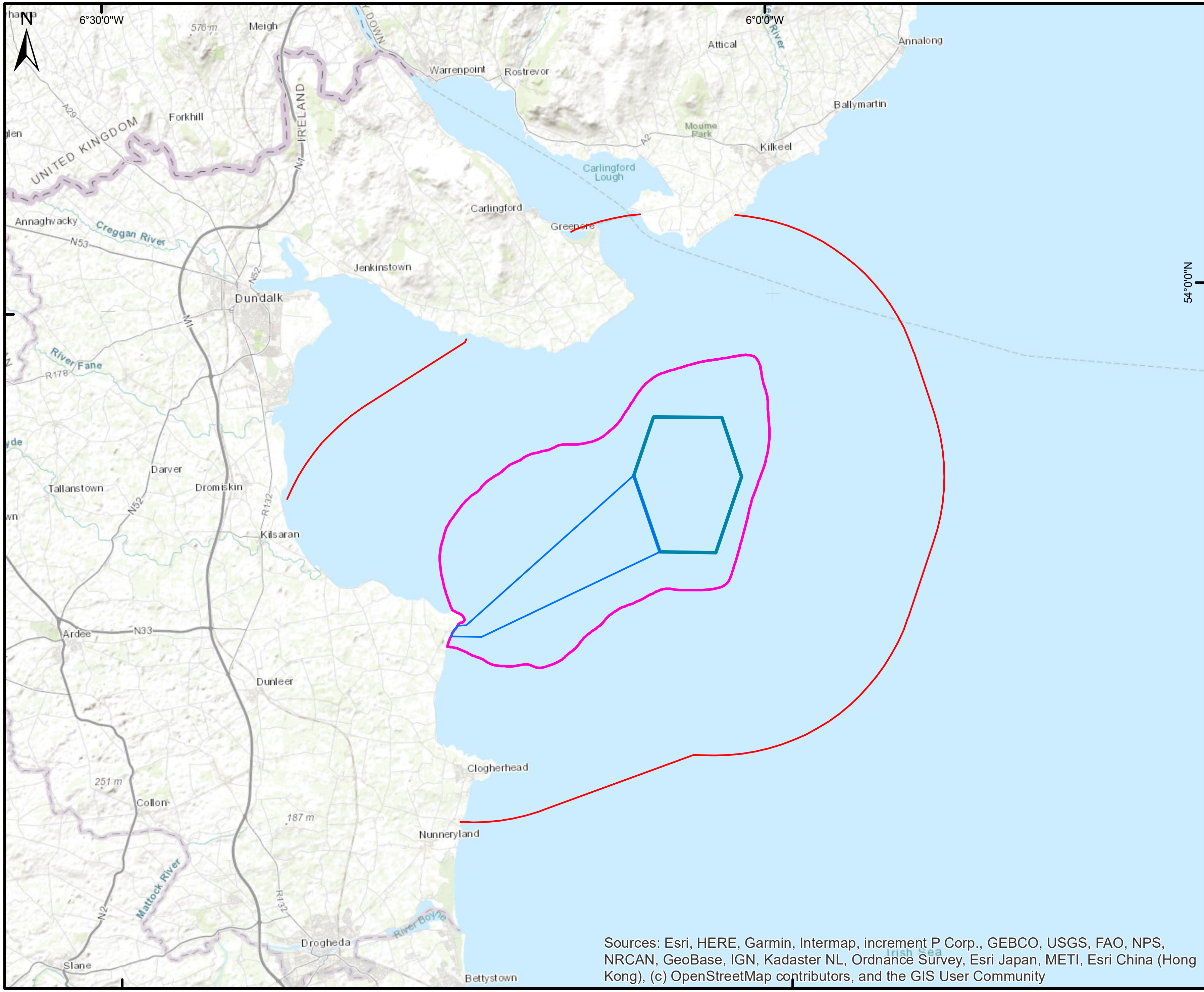
1.3 Zone of Influence

The Zone of Influence (ZoI) varies with each impact source and receptor interaction. The ZoI is contained within the study area, described below.

The Benthic Subtidal and Intertidal Ecology Study Area is shown in Figure 1-1 and has been chosen to include all areas that are within the ZoI of the Project that have benthic subtidal or intertidal ecological features.

The Benthic Subtidal and Intertidal Ecology Study Area encompasses the offshore wind farm area, offshore cable corridor (including intertidal habitats up to the HWM) plus a buffer of 10 km. The benthic, subtidal and intertidal ecology ZoI is up to one tidal excursion from the offshore wind farm area and offshore cable corridor (i.e. the extent within which plume effects would be expected to occur) and the outputs of the assessment provided in appendix B: Marine Processes Technical Report has indicated a maximum tidal excursion of 3.5 km (Figure 1-1-). The 10 km buffer from the offshore wind farm area and offshore cable corridor contains representative habitats from the wider area, encompasses one tidal excursion and is therefore, considered to be precautionary.

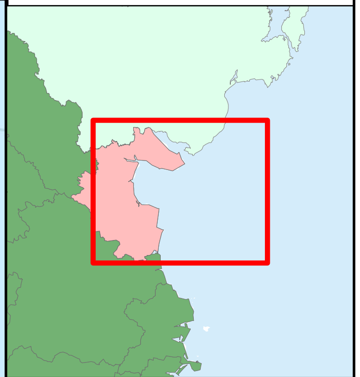
The Benthic Subtidal and Intertidal Ecology characterisation also considers benthic subtidal habitats and communities within the wider west Irish Sea region, to provide a wider context.



Legend

- Offshore Wind Farm Area
- Offshore Cable Corridor
- Typical Tidal Excursion (based on Figure 7-1, chapter 7: Marine Processes)
- Benthic Subtidal and Intertidal Ecology Study Area

Data Sources: Client, Ordnance Survey Ireland, RPS



Client

ORIEL WINDFARM
OFFSHORE RENEWABLE ENERGY

Project

Oriel Wind Farm Project

Title

Figure 1-1
Benthic Subtidal and Intertidal Ecology Study Area

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1.4 Consultation

Table 1-1 summarises the issues raised relevant to benthic subtidal and intertidal ecology which have been identified during consultation activities undertaken to date, together with how these issues have been considered in the production of this appendix.

Table 1-1: Summary of key issues raised during consultation on benthic subtidal and intertidal ecology.

Date	Consultee and type of response	Issues raised	Response to issue raised and/or where considered in this appendix
September 2019	Inland Fisheries Ireland	Identified that Dundalk Bay is promoted as an angling venue for a range of species and the bay receives waters from a number of rivers in the Neagh International River Basin District. These include species which are valuable from a fisheries perspective and contain a number of migrating species which include Annex II species under the European Habitats Directive such as salmon and sea lamprey. Highlighted importance of mitigation measures to ensure protection and conservation of the aquatic habitats.	Qualifying Interest (QI) fish and shellfish receptors have been identified through a desktop study and are discussed in section 6 and the NIS.
October 2019	Department of Culture, Heritage and the Gaeltacht – Email and telephone	Provided details of intertidal survey methodology via Scoping Report and email correspondence for agreement to agree survey scope with DCHG in advance of the survey.	As the landfall does not intersect with or interfere with any Special Areas of Conservation (SACs), the intertidal survey of the landfall is not relevant to the NIS.
January 2021	Environmental Protection Agency - Email	Discussion regarding the potential requirement for a dumping at sea permit.	If activities require a dumping at sea permit an application will be made following award of consent and confirmation of the offshore installation methodologies supported by data from the detailed Phase 2 geotechnical survey.
March 2021	Marine Institute- Email	Provided additional data sets to be used to characterise the baseline including Marine Institute data and monitoring reports from offshore wind parks in Belgium. The Marine Institute recommended the consideration of ecosystem service provision of habitats assessed. Suggested it would be useful to provide a list of the sites and conservation designated to be considered.	Additional data sets have been included in the benthic ecology baseline characterisation. Designated sites considered are listed in Table 3-1.
April 2021	NPWS- Meeting	Discussion regarding the baseline data sources, the results of the benthic validation survey, assessment methodology, important ecological receptors and impacts scoped in/out.	The results of the benthic validation survey report are presented in annex 1: Benthic Survey Report.
August 2021	Louth County Council - Email	Query regarding presence of seagrass beds in the offshore wind farm area and offshore cable corridor.	No seagrass beds were identified during baseline surveys.

2 METHODOLOGY TO INFORM THE BASELINE

2.1 Desktop study

An evidence-based approach has been used to inform the baseline for benthic subtidal and intertidal ecology. This involved utilising existing data and information from sufficiently similar studies. This evidence-based approach means that it is not always necessary for new data to be collected, or new modelling studies to be undertaken, to characterise potential impacts with sufficient confidence for the purposes of this report.

The baseline characterisation has been carried out in accordance with the Guidance on Marine Baseline Ecological Assessments and Monitoring Activities for Offshore Renewable Energy Projects from DCCAE (DCCAE, 2018).

Data has been acquired through relevant historical data, previous studies and surveys (including from the offshore wind farm area), to characterise the Benthic Subtidal and Intertidal Ecology Study Area. The EMODnet and Ireland's Marine Atlas provide data on an interactive map of the seabed habitats within the west Irish Sea.

Other sources of information within the west Irish Sea include studies on muddy habitats in the northwestern Irish Sea (Hensley, 1996; Clements *et al.,* 2018; Lundy *et al.,* 2019), regional studies of offshore benthic communities of the Irish Sea (Mackie, 1990) and studies on communities associated with Irish Sea sandbank habitats. These have also been used to inform the baseline characterisation.

The key sources (i.e. data and reports) used to inform the baseline characterisation of the Benthic Subtidal and Intertidal Ecology Study Area are summarised in Table 2-1 below.

Table 2-1: Summary of key sources

Title	Source	Year	Author
Oriel Windfarm Limited Offshore Wind Farm, Environmental Impact Statement, Chapter 9: Marine and Terrestrial Ecology.	Oriel Windfarm Limited	2007	Aquafact
Ireland's Marine Atlas: • Designated Sites	Marine Institute	2019	N/A
National Parks and Wildlife Service website: • Designated Sites	National Parks and Wildlife Service	2020	N/A
EMODnet Seabed habitats.	EMODnet	2019	N/A
A preliminary survey of benthos from the *Nephrops norvegicus* mud grounds in the north-western Irish Sea.	Estuarine, Coastal and Shelf Science	1996	Hensley
Western Irish Sea Nephrops Grounds (FU15) 2018 UWTV Survey report and catch options for 2019.	Marine Institute	2018	Clements *et al*.
Western Irish Sea Nephrops Grounds (FU15) 2019 UWTV Survey report and catch options for 2020.	Marine Institute	2019	Lundy *et al.*
Diversity of demersal and megafaunal assemblages inhabiting sandbanks of the Irish Sea.	Scientific publication – Marine Biodiversity	2013	Atalah *et al.*

Title	Source	Year	Author
Offshore benthic communities of the Irish Sea.	Scientific publication – Nature conservation	1990	Mackie
Marine Institute provided benthic survey raw data from Dundalk Bay and the western Irish Sea	Marine Institute	April 2021	Marine Institute

2.2 Field study

Field surveys were limited to the Project boundaries. Therefore, they did not extend into any SAC, as none are located closer than 7.49 km to the offshore wind farm area, or closer than 4.38 km to the offshore cable corridor.

2.3 Identification of relevant European sites and features (species and habitats)

All designated European sites within the Benthic Subtidal and Intertidal Ecology Study Area and qualifying interests (QIs) that could be affected by the construction, operational and maintenance, and decommissioning phases of the Project were identified using the three-step process described below:

- Step 1: All European sites within the Benthic Subtidal and Intertidal Ecology Study Area were identified using a number of sources. These included the National Parks and Wildlife Service website and the Atlas of Marine Protection website;
- Step 2: Information was compiled on the relevant benthic subtidal and intertidal ecology QIs for each of these sites.
- Step 3: Using the above information and expert judgement, sites were included for further consideration if:
  - A designated site with benthic subtidal and intertidal ecology qualifying features directly overlaps with the offshore wind farm area or offshore cable corridor, and therefore has the potential to be directly affected by the Project; or
  - A designated site and associated qualifying features are located within the potential ZoI for impacts associated with the Project, and therefore have the potential to be indirectly affected by the Project.

3 BASELINE ENVIRONMENT

3.1 Relevant European sites

Relevant European sites which have benthic, subtidal and intertidal ecology qualifying features, and which have been considered in the benthic, subtidal and intertidal ecology report for the Project are described in Table 3-1 below.

Table 3-1: Designated European sites and relevant qualifying features for the Benthic Subtidal and Intertidal Ecology assessment.

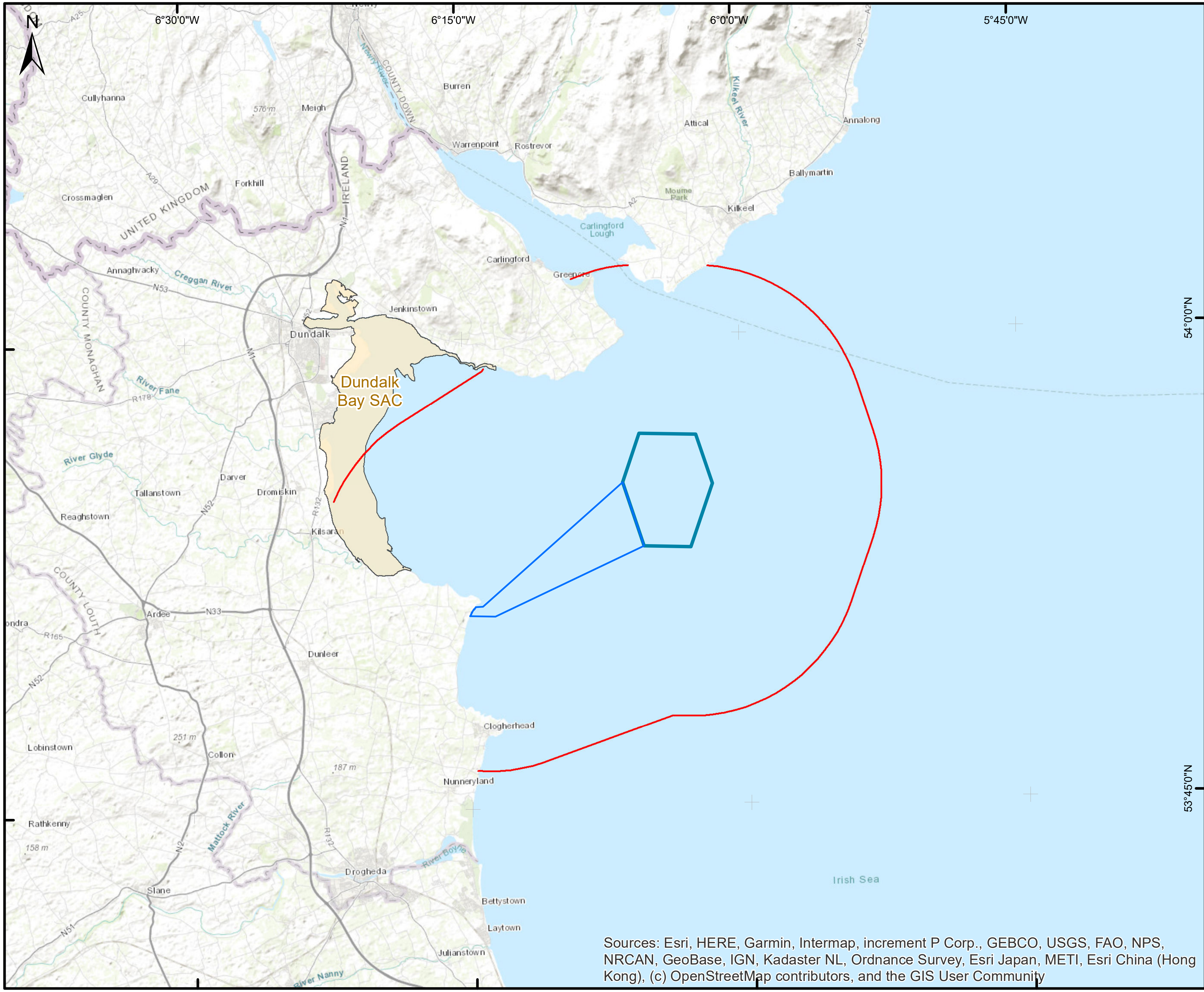
European site (code)	Closest distance to offshore wind farm area (km)	Closest Distance to offshore cable corridor (km)	Relevant Qualifying Feature(s)
Dundalk Bay SAC (IE000455)	9.3	4.4	**Annex I Habitats** • Estuaries [1130] • Mudflats and sandflats not covered by seawater at low tide [1140] • Salicornia and other annuals colonising mud and sand [1310] • Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*) [1330] • Mediterranean salt meadows (*Juncetalia maritimi*) [1410]

A Note: other qualifying features, including habitats above high water are not presented here.

Dundalk Bay SAC is designated under the Habitats Directive as a Site of Community Importance for a range of marine and coastal habitats (NPWS, 2011a). A list of the Dundalk Bay SAC Annex I habitats relevant to this assessment are presented in Table 3-1 and described below.

The conservation objectives are to maintain the favourable conservation status of the Estuaries, Mudflats and sandflats not covered by seawater at low tide, Atlantic salt meadows and Mediterranean salt meadows, and to restore the favourable conservation status of Salicornia and other annuals colonising mud and sand (NPWS, 2011b).

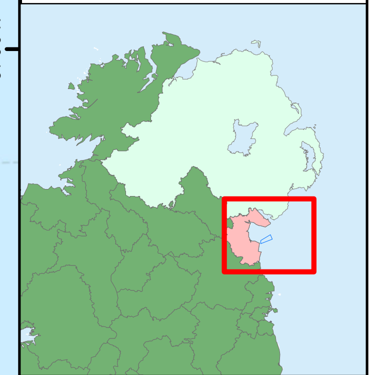
In addition, Dundalk Bay SAC also encompasses the Annex I habitat Perennial vegetation of stony banks [1220], which has an objective to maintain favourable conservation condition.



Legend

- Project Offshore Wind Farm Area
- Project Offshore Cable Corridor
- Benthic Subtidal and Intertidal Ecology Study Area
- Dundalk Bay SAC

Data Sources: Client, NPWS



Client

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Project

Oriel Wind Farm Project

Title **Figure 3-1**

Relevant European sites within the Benthic and Intertidal Ecology Study Area

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Date:	27/03/2024		Geographic Co-ordinates: ETRS89

3.2 Relevant qualifying features

3.2.1 Estuaries

Typically, estuaries are the seaward parts of river valleys which experience reduced salinities (i.e. <30 practical salinity units) (NPWS, 2023). NPWS (2023) provides a description of this habitat within Ireland. Estuarine habitats are typically composed of soft muds as a result of the sheltered nature of the system and the fresh water input. Where stones or shells are present green and brown algae as well as fucoids are likely to be present. Infaunal species numbers are generally low with oligochaetes dominating. Estuaries are located on all parts of the Irish coastline. The largest is located in the mid-west of Ireland (Shannon Estuary) and constitutes approximately 50% of the national resource. Estuaries are often home to various species of birds, in Ireland these can include little tern, cormorant, brent goose, oystercatcher, dunlin and bar-tailed godwit among many others. Invertebrate communities present across estuaries can include species of mollusca, polychaete, oligochaete and crustacea. Estuaries can also be home to some marine mammals such as harbour seals, grey seal and otters.

The estuarine habitat within the Dundalk Bay SAC is estimated to cover 2799 ha and occur across the north of the site, extending to the sites furthest inland extent (NPWS, 2011c).

3.2.2 Mudflats and sandflats not covered by seawater at low tide

Intertidal mudflats and sandflats are submerged at high tide and exposed at low tide and are normally associated with inlets, estuaries or shallow bays (NPWS, 2007). NPWS (2007) provides a description of this habitat within Ireland. The sedimentary structure of these habitats can vary based on the conditions experienced at each site, exposed coasts may experience coarse mobile sand beach where as sheltered estuaries may experience stable fine sediment mud flats. Mudflats tend to be located in sheltered coastal areas with large inputs of silt from river deposition. Sandflats tend to occur on more exposed coastlines with strong wave and tidal currents which prevent the deposition of silt. These habitats support diverse communities including invertebrates, algae and eel grass. Mudflats tend to be dominated by polychaetes and molluscs, whereas sandflats may have lower biodiversity with communities dominated by crustacea and amphipods. Where eel grass occurs biodiversity and biomass are likely to be higher. The communities in this habitat provide an important food source for wading birds and wildfowl such as knot, dunlin and sanderling. The area of mudflats and sandflats in Ireland encompasses 566.3 km^2. The two largest sites are located in the mid-west (Shannon Estuary) and north-east (Dundalk Bay).

The mudflats and sandflats not covered by seawater at low tide habitat is a permanent feature within the Dundalk Bay SAC is estimated to cover 4375 ha and occur across the majority of the SACs extent (NPWS, 2011c). This habitat is largely composed of a complex of muddy fine sand and intertidal fine sand communities (NPWS, 2011c).

3.2.3 *Salicornia* and other annuals colonising mud and sand

This vegetation is a pioneering species of saltmarshes in sheltered coastal habitats composed of intertidal mud and sandflats (JNCC, 2023a). The UK Joint Nature Conservation Committee (JNCC) (2023a) provides a description of this habitat in Europe. This habitat is characterised by a small number of species including *Arthrocnemum perenne*, Annual *Salicornia*, *Salicornia perennis*, *Suaeda maritima* and *Sagina maritima*. The density of these plants can vary and may be lower on sites with sandier substrates. These species often develop in the lower reaches of saltmarshes where the vegetation is frequently flooded by the tide, but it can also be found in disturbed areas of upper saltmarshes. This habitat is a precursor to the development of more stable saltmarsh vegetation.

The *Salicornia* and other annuals colonising mud and sand habitat is a stable or increasing habitat within the Dundalk Bay SAC and is estimated to cover 35 ha, making it one of the largest examples of this habitat in Ireland (NPWS, 2011c).

3.2.4 Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)

Atlantic salt meadows develop vegetation with high salinity tolerance colonise soft intertidal sediments on sheltered coastlines (JNCC, 2023b). The JNCC (2023b) provides a description of this habitat in Europe. This vegetation forms in the middle and upper reaches of saltmarshes, where tidal inundation still occurs but at low frequency and durations. Due to the specific conditions required for this habitat the vegetation may vary due to climatic conditions affecting the frequency and duration of tidal inundation. Access by grazing by domestic livestock to this habitat is especially important in determining the structure and species composition of the habitat type and in determining its relative value for plants, for invertebrates and for wintering or breeding waterfowl. This Annex I habitat type is predominantly found on Atlantic coasts in western Europe.

The Atlantic salt meadow habitat occurs in a few distinct patches across the Dundalk Bay SAC which covers approximately 380 ha of the site (although further surveyed areas have been identified from aerial surveys) (NPSW, 2011c). Within the Dundalk Bay SAC Atlantic salt meadows the most common form of salt meadow and are characterised by sea-purslane (*Halimione portulacoides*), common cord-grass (*Spartina anglica*) and common saltmarsh-grass (*Puccinellia maritima*) (Department of the Arts, Heritage and the Gaeltacht, 2014).

3.2.5 Mediterranean salt meadows (*Juncetalia maritimi*)

Mediterranean salt meadows occupy the upper reaches of saltmarsh, near the boundary with terrestrial habitats (Brophy *et al*, 2019). This habitat is wide spread across the Irish coastline however their distribution is not as extensive as Atlantic salt meadows. This habitat is distinct from Atlantic salt marshes due to the presence of sea rush (*Juncus maritimus*) and/or, less commonly, sharp rush (*Juncus acutus*) (Brophy *et al*, 2019).

The Mediterranean salt meadow habitat occurs only in a very small area of the Dundalk Bay SAC, with an extent of approximately 0.045 ha (NPSW, 2011c). Within the Dundalk Bay SAC Mediterranean salt meadows are mostly confined to the upper levels of the saltmarshes or along stream sides where they merge with grassland habitats (though the transitional zone is now absent in many places) (Department of the Arts, Heritage and the Gaeltacht, 2014). The habitat contains sea rush (*Juncus maritimus*), sea arrowgrass (*Triglochin maritima*) and sea aster (*Aster tripolium*) (Department of the Arts, Heritage and the Gaeltacht, 2014).

3.3 Data validity and limitations

The data sources used in this report are detailed in Table 2-1 above. The desktop data used are the most up to date publicly available information which can be obtained from the applicable data sources as cited. There is potential for the benthic communities to have developed and evolved since the desktop data sources were collected. However, the communities associated with this part of the west Irish Sea are generally stable over time, with consistency in the communities recorded over time.

As mentioned above in section 2.2, field surveys did not cover Annex I habitats of European sites.

4 KEY PARAMETERS FOR ASSESSMENT

4.1 Project design parameters

The project description is provided in section 2 of the NIS. Table 4-1 outlines the project design parameters that have been used to inform the assessment of potential impacts of the construction, operational and maintenance and decommissioning phases of the Project on benthic, subtidal and intertidal ecology.

Table 4-1: Project design parameters used for the assessment of potential impacts on Benthic, Subtidal and Intertidal Ecology.

Potential impact	Phase[1]			Project Design Parameters	Justification
	C	O	D		
Temporary subtidal habitat loss/disturbance	✓	✓	✓	**Construction Phase** 709,500 m^2 of temporary habitat loss/disturbance due to: • Use of jack-up vessels during foundation installation, with two jack-up events per WTG and four jack-up events for the OSS; • Installation of 41 km inter-array cables and 16 km offshore cable with seabed disturbance width of 10 m; and • Sand wave clearance for 10% of inter-array cables and 10% of the offshore cable. Offshore construction phase duration up to 15 months. **Operational and Maintenance Phase** 387,000 m^2 of temporary habitat loss/disturbance due to: • Component replacement activities using jack-up vessel associated with 25 WTGs (average of two major component replacements per year); • Inter-array cables: seven repair events and seven reburial events over the lifetime of the Project; and • Offshore cable: three subtidal repair events and three subtidal reburial events over the lifetime of the Project. Operational phase of 40 years. **Decommissioning Phase** 624,000 m^2 of temporary habitat loss/disturbance. Parameters are assumed to be the same as for the construction phase however seabed preparation and seabed clearance (prior to foundation installation) will not take place during the decommissioning phase.	These values accounts for project specific WTG and OSS foundation types, and maximum length of cables resulting in greatest extent of temporary habitat loss. Maximum proportion of cables requiring seabed clearance prior to cable installation.
Temporary intertidal habitat loss/disturbance	✓	✓	✓	**Construction Phase** Cable installation at the landfall via open trenching: • Installation of one cable in one trench between HWM and LWM with dimensions 5 m x 800 m x 3 m (width x length x depth), with 15 m working area either side of trench, leading to 28,000 m^2 of temporary intertidal habitat loss/disturbance; and	These values account for the footprint within intertidal zone due to offshore cable installation at the landfall. The project design parameters are based on open cut trenching. Disturbance corridor includes: cable trenching, vehicle movements and vessel grounding.

				• Vessel grounding and vehicle movements across the foreshore (within the 30 m wide working area). Installation duration of 3 months. **Operational Phase** Cable repair and reburial at the landfall via open trench • Offshore cable in the intertidal area: three intertidal repair events and three intertidal reburial events, leading to temporary habitat loss/disturbance of 126,000 m^2. Operational phase of 40 years. **Decommissioning Phase** • Removal of one cable leading to 28,000 m^2 of temporary intertidal habitat loss/disturbance. Decommissioning duration of 3 months.	
Increased suspended sediment concentrations and associated sediment deposition	✓	✓	✓	**Construction Phase** WTGs and OSS installed on monopile foundations: • Drilled installation of 9.6 m diameter pile. • Installation of inter-array and offshore cables: – Disturbance of seabed material from a 3 m wide and 3 m deep trench for offshore cable and 1 m wide and 3 m deep for inter-array cables; and – Modelled cable lengths over areas of sand and muddy sand. **Operational and Maintenance Phase** Cable repair/reburial activities: • Inter-array cables: seven repair events and seven reburial events over the lifetime of the project; and • Offshore cable: three repair events and three reburial events over the lifetime of the project. **Decommissioning Phase** WTGs and OSS on monopile foundations: • Cutting and removal of monopile foundations to approximately 2 m below seabed; Removal of inter-array and offshore cables: • Disturbance of seabed material from a 3 m wide and 3 m deep trench for offshore cable and 1 m wide and 3 m deep for inter-array cables.	Greatest volume of sediment released into the water column. See appendix B: Marine Processes Technical Report for further justification.
Seabed disturbance leading to the potential release of sediment contaminants and resulting potential effects on benthic ecology	✓	✓	✓	**Construction Phase** WTGs and OSS installed on monopile foundations: • Installation of inter-array and offshore cables: – Disturbance of seabed material from a 3 m wide and 3 m deep trench for offshore cable and 1 m wide and 3 m deep for inter-array cables.	Greatest volume of sediment released into the water column. Therefore, the highest potential for release of sediment contaminants.

				– Sand wave clearance for 10% of inter-array cables and 10% of the offshore cable. **Operational and Maintenance Phase** Cable repair/reburial activities: • Inter-array cables: seven repair events and seven reburial events over the lifetime of the Project; and • Offshore cable: three subtidal repair events and three subtidal reburial events over the lifetime of the Project. **Decommissioning Phase** WTGs and OSS on monopile foundations: • Removal of inter-array and offshore cables: • Disturbance of seabed material from a 3 m wide and 3 m deep trench for offshore cable and 1 m wide and 3 m deep for inter-array cables.	
Long-term subtidal habitat loss	✗	✓	✗	**Operational and Maintenance Phase** 332,121 m^2 of long-term habitat loss due to: • Presence of 26 (i.e. 25 x WTG + 1 x OSS) monopile foundations with a diameter of 9.6 m and associated scour protection; and • Presence of cable protection associated with 41 km inter-array cables and 16 km offshore cable. Assumes 50% of inter-array cable route and 50% of offshore cable route may require cable protection. Operational phase of 40 years.	These values account for the WTG and OSS foundation types and associated scour protection, maximum length of cables and cable protection resulting in greatest extent of habitat loss.
Colonisation of foundations, scour protection and cable protection	✗	✓	✗	**Operational and Maintenance Phase** Long-term habitat creation of 356,807 m^2 due to: • Presence of 26 (i.e. 25 x WTG + 1 x OSS) monopile foundations, including scour protection; and • Presence of cable protection associated with 41 km inter-array cables and 16 km offshore cable. Operational phase of 40 years.	These values account for the WTG and OSS foundation types and associated scour protection, maximum length of cables and cable protection resulting in greatest surface area for colonisation.
Alteration of seabed habitats arising from effects of physical processes	✗	✓	✗	**Operational and Maintenance Phase** WTGs and OSS installed on monopile foundations: • Presence of 25 WTG foundations and 1 OSS foundation of 9.6 m diameter each; • Minimum spacing 944 m; • Inclusion of approximately 1,810 m^2 of scour protection for each foundation; 47,060 m^2 of scour protection across the site. Operational phase of 40 years.	Obstruction to flow in the water column. See appendix B: Marine Processes Technical Report.
Increased risk of introduction and spread of invasive and non-native species	✓	✓	✓	**Construction Phase** Increased risk of invasive and non-indigenous species (INIS) due to: • 475 vessel round trips during the construction phase. Offshore construction phase duration of 15 months. **Operational and Maintenance Phase**	These values account for the surface area created by offshore infrastructure and maximum number of vessel movements during construction, operational and maintenance and decommissioning phases.

	Increased risk of INIS due to: • The long-term creation of 359,807 m^2 of hard substrates due to foundations, associated scour protection and cable protection (see previous impact); and • 352 vessel round trips per year during the operational and maintenance phase. Operational phase of 40 years. **Decommissioning Phase** Increased risk of INIS due to: • 475 vessel round trips during the decommissioning phase. Decommissioning duration assumed to be similar to that for construction.	

1 C= Construction, O = Operation, D = Decommissioning

4.2 Measures included in the Project

As part of the project design process, a number of measures have been proposed to reduce the potential for impacts on benthic, subtidal and intertidal ecology (see Table 4-2). These measures include designed-in and management measures (controls). These measures were not taken into account in section 4 of the Stage 1 screening appraisal to inform screening for appropriate assessment (see appendix A: Report to Inform Screening for Appropriate Assessment) in accordance with guidance and prevailing case law but can lawfully be taken into account for the Stage 2 appraisal.

As there is a commitment to implementing these measures, they are considered inherently part of the design of the Project and have therefore been considered in the assessment of potential impacts presented in section 6 below (i.e. the determination of magnitude assumes implementation of these measures). These measures are considered standard industry practice for this type of development.

Table 4-2: Measures included in the Project.

Measures included in the Project	Justification
An Environmental Management Plan (EMP) (see appendix K: Management Plans) has been prepared and will be implemented during the construction, operational and maintenance and decommissioning phases of the Project. The EMP will include Project specific measures and commitments and a Marine Pollution Contingency Plan (MPCP) (see appendix K: Management Plans). Measures also include: designated areas for refuelling where spillages can be easily contained, storage of chemicals in secure designated areas in line with appropriate regulations and guidelines, double skinning of pipes and tanks containing hazardous substances, and storage of these substances in impenetrable bunds.	To ensure that the potential for release of pollutants from construction, operational and maintenance, and decommissioning plant is minimised. In this manner, accidental release of contaminants from vessels will be strictly controlled, thus providing protection for marine life across all phases of the Project development.
A pre-construction survey will be undertaken within the offshore wind farm area and offshore cable corridor to identify any areas of reef habitat (particularly *Modiolus* beds and *S. spinulosa* reef habitats). This will include a drop-down video survey to determine the extent, distribution and quality/condition of any reef. Should reef areas be identified during pre-construction surveys, appropriate measures will be agreed with regulatory and nature conservation bodies to avoid direct impact on these features. Where possible, features will be avoided by layout refinement of foundations and cables.	Biogenic reef habitats have been identified as having the potential to occur in the offshore wind farm area however no evidence of these have been recorded during site-specific surveys. As these are OSPAR habitats and/or Annex I habitats protected under the Habitats Directive, direct impacts on these habitats should be avoided wherever possible. Pre-construction surveys to determine extent, distribution and quality/condition of reef habitats will inform appropriate mitigation measures (e.g. layout refinement) to avoid such impacts.
A Marine Invasive Non-native Species Management Plan (see appendix K: Management Plans) will be produced and agreed in consultation with statutory consultees. The plan will outline measures to ensure vessels comply with the	To manage and minimise the risk of potential introduction and spread of Invasive Non-Indigenous Species.

International Maritime Organisation (IMO) ballast water management guidelines, it will consider the origin of vessels and contain standard housekeeping measures for such vessels as well as measures to be included in the event that a high alert species is recorded.	
Reinstatement of rock in the intertidal zone following cable installation. Any cut rock will be placed back on top of the cable to backfill the trench.	To promote recovery of associated communities within the area affected.

4.3 Impacts scoped out of the assessment

On the basis of the baseline environment and the project description outlined in section 2 of the NIS, a number of impacts are proposed to be scoped out of the assessment for benthic subtidal and intertidal ecology. These impacts are outlined, together with a justification for the scoping out decision, in Table 4-3.

There will be no direct impact on the features of interest of the Natura 2000 sites within the Benthic Subtidal and Intertidal Ecology Study Area (i.e. Dundalk Bay SAC) as no infrastructure will be installed within this protected area. No indirect impacts will occur as this site is greater than one tidal excursion (3.5 km) away therefore there is no impact receptor pathway. As there is no route for impact, qualifying features of the Dundalk Bay SAC within the Benthic Subtidal and Intertidal Ecology Study Area have not been considered further.

Table 4-3: Impacts scoped out of the assessment for benthic subtidal and intertidal ecology.

Potential impact	Justification
Accidental release of pollutants	The measures set out in the EMP (see appendix K: Management Plans) will minimise the likelihood of accidental release of pollutants (e.g. spillage of chemicals) and in the unlikely event that such an incident occurs, they will limit the severity of any such release. The offshore wind farm area is relatively close to the operational port facilities therefore offshore refuelling is unlikely. All offshore operations will be subject to the measures set out in an EMP and MPCP (see appendix K: Management Plans). As such, there is no potential for effects on benthic subtidal and intertidal ecology receptors from this impact and this impact has therefore been scoped out from the assessment.
Long-term intertidal habitat loss	There is no proposed cable protection within the intertidal area and the installed offshore cable will run beneath the intertidal habitats. Therefore, there will be no long-term habitat loss and this impact has been scoped out from the assessment.
Temporary intertidal habitat loss/disturbance	There is no overlap between the Project and any European sites with Annex I habitats and this impact has therefore been scoped out from the assessment.
Long-term subtidal habitat loss	There is no overlap between the Project and any European sites with Annex I habitats and this impact has therefore been scoped out from the assessment.
Temporary subtidal habitat loss/disturbance	There is no overlap between the Project and any European sites with Annex I habitats and this impact has therefore been scoped out from the assessment.

5 IMPACT METHODOLOGY

5.1 Overview

This report takes account of the following guidance documents and legislation:

- CIEEM (2019) Guidelines for Ecological Impact Assessment (EcIA) in the UK and Ireland. Terrestrial, Freshwater and Coastal;
- Guidance on Environmental Considerations for Offshore Wind Farm Development (OSPAR, 2008); and
- Marine Evidence-based Sensitivity Assessment – A Guide (Tyler-Walters *et al.,* 2018);
- The Habitats Directive 92/43/EEC; and
- European Communities (Birds and Natural Habitats) Regulations 2011, as amended.

5.2 Impact assessment criteria

This section describes the criteria applied in this assessment to assign values to the magnitude of potential impacts and the sensitivity of the receptors.

The criteria for defining impact magnitude in this report are outlined in Table 5-1 below.

Table 5-1: Definition of terms relating to the magnitude of an impact.

Magnitude of impact	Definition
High	Loss of resource and/or quality and integrity of resource; severe damage to key characteristics, features or elements (Adverse)
	Large scale or major improvement or resource quality; extensive restoration or enhancement; major improvement of attribute quality (Beneficial)
Medium	Loss of resource, but not adversely affecting integrity of resource; partial loss of/damage to key characteristics, features or elements (Adverse)
	Benefit to, or addition of, key characteristics, features or elements; improvement of attribute quality (Beneficial)
Low	Some measurable change in attributes, quality or vulnerability, minor loss of, or alteration to, one (maybe more) key characteristics, features or elements (Adverse)
	Minor benefit to, or addition of, one (maybe more) key characteristics, features or elements; some beneficial impact on attribute or a reduced risk of negative impact occurring (Beneficial)
Negligible	Very minor loss or detrimental alteration to one or more characteristics, features or elements (Adverse)
	Very minor benefit to, or positive addition of one or more characteristics, features or elements (Beneficial)

The sensitivity of benthic subtidal and intertidal ecology receptors has been defined by the Marine Evidence based Sensitivity Assessment (MarESA), as a product of the likelihood of damage (resistance) due to a pressure and the rate of recovery (recoverability) once the pressure has been removed. Recoverability is the ability of a habitat to return to the state of the habitat that existed before the activity or event which caused change. Full recovery does not necessarily mean that every component species has returned to its prior condition, abundance or extent but that the relevant functional components are present, and the habitat is structurally and functionally recognisable as the initial habitat of interest.

The MarESA has been drawn upon to support the assessment of sensitivity of the benthic subtidal and intertidal ecology receptors within the Benthic Subtidal and Intertidal Ecology Study Area. The MarESA is a database which has been developed through the Marine Life Information Network (MarLIN) of Britain and

Ireland and is maintained by the Marine Biological Association (MBA). This database comprises a detailed review of available evidence on the effects of pressures on marine species or habitats, and a subsequent scoring of sensitivity against a standard list of pressures, and their benchmark levels of effect. The evidence base presented in the MarESA is peer reviewed and represents the largest review undertaken to date on the effects of human activities and natural events on marine species and habitats. It is considered to be one of the best available sources of evidence relating to recovery of seabed species and habitats. The benchmarks for the relevant MarESA pressures which have been used to inform each impact assessment have also been referenced under each impact assessment in section 6.

The process for defining receptor sensitivity in this report follows that defined by the MarESA sensitivity assessment, which correlates resistance and recoverability to categorise sensitivity, as set out in Table 5-2.

Table 5-2: Definition of terms relating to the sensitivity of the receptor (reproduced from MarESA sensitivity assessment).

		Resistance			
		None	**Low**	**Medium**	**High**
Recoverability	Very Low	High sensitivity	High sensitivity	Medium sensitivity	Low sensitivity
	Low	High sensitivity	High sensitivity	Medium sensitivity	Low sensitivity
	Medium	Medium sensitivity	Medium sensitivity	Medium sensitivity	Low sensitivity
	High	Medium sensitivity	Low sensitivity	Low sensitivity	Not sensitive (Negligible)

5.3 European sites

Where Natura 2000 sites (i.e. internationally designated European sites) are considered, this report summarises the potential impacts on the QIs of internationally designated sites as described within section 3.1. The complete assessment of adverse effects is contained in the NIS for the Project.

6 POTENTIAL IMPACTS

The potential impacts arising from the construction, operational and maintenance and decommissioning phases of the Project are listed in Table 4-1, along with the project design parameters against which each impact has been assessed.

A description of the potential effect on benthic, subtidal and intertidal ecology receptors caused by each identified impact is given below.

6.1 Increased suspended sediment concentrations and associated sediment deposition

Increases of suspended sediments and associated sediment deposition are predicted to occur during the construction and decommissioning phases of the Project as a result of the installation/removal of monopile foundations, installation/removal of inter-array and offshore cables and sand wave clearance for inter array and offshore cables. Increases of suspended sediments and associated sediment deposition are also predicted to occur during the operational and maintenance phase due to inter-array and offshore cable repair and reburial events. The appendix B: Marine Processes Technical Report provides a full description of the physical assessment, including numerical modelling used to inform the predictions made with respect to increases in suspended sediment and subsequent deposition.

The benchmarks for the relevant MarESA pressures which have been used to inform this impact assessment are as follows:

- Changes in suspended solids (water clarity): the benchmark for which is a change in one rank on the Water Framework Directive (WFD) scale (e.g. from clear to intermediate for one year), caused by activities disturbing sediment or organic particulate material and mobilising it into the water column such as dredging, disposal at sea, cable and pipeline burial; and

- Smothering and siltation rate changes (light): the benchmark for light deposition is up to 5 cm of fine material added to the habitat in a single discrete event.

The CEFAS Climatology Report 2016 shows the spatial distribution of average non-algal Suspended Particulate Matter (SPM) for the majority of the UK continental shelf. For 1998-2005 the largest plumes are associated with large rivers such as the Thames estuary, the Wash and Liverpool Bay, which show mean values of SPM above 30 mg/l. Using this study, it is estimated that the average SPM associated with Dundalk Bay is approximately 2 mg/l to 3 mg/l (Silva *et al*., 2016) (see appendix B: Marine Processes Technical Report).

6.1.1 Construction phase

Magnitude of impact

The installation of Project infrastructure within the offshore wind farm area and offshore cable corridor may lead to increases in suspended sediment concentrations and associated sediment deposition. The project design parameters for foundation installation assume all WTG and offshore substation foundations will be installed by drilling 9.6 m diameter monopiles (Table 4-1).

Modelling of suspended sediments associated with the foundation installation showed low levels of suspended sediments with peaks of 100 mg/l extending beyond the offshore wind farm area in all modelled scenarios. The average suspended sediment concentrations beyond the immediate vicinity of the offshore wind farm area are generally less than 30mg/L with most of the sediment plume envelope having a suspended sediment concentration of less than 10mg/L. Sediment deposition is predicted to be indiscernible from the background due to the limited quantity of material released, with the exception of directly at the drill site where cuttings fall to the seabed. Further detail can be found in appendix B: Marine Processes Technical Report.

Installation of inter-array cables through ploughing/jetting would involve disturbance of seabed material from 1 m wide and 3 m deep trenches. Modelling of suspended sediment concentrations associated with the installation of inter-array cables showed a peak concentration of 2,000 mg/l in the immediate vicinity of cable installation, with averages less than 3 mg/l. The sediment plume will only persist for a maximum of 2 to3 hours in any location; following completion of the works, turbidity will return to normal within a couple of tidal cycles (see appendix B: Marine Processes Technical Report). Sedimentation will occur in the immediate vicinity of the inter-array cable installation activities, with no discernible levels of sedimentation modelled to occur beyond the offshore wind farm area. Further detail can be found in appendix B: Marine Processes Technical Report.

Installation of the offshore cable through ploughing/jetting would involve disturbance of seabed material from 3 m wide and 3 m deep trenches. Modelling of suspended sediment associated with the installation of the offshore cable showed general peak concentrations of 300 mg/l which is equivalent to turbidity levels during storm conditions, although this level of increase would only be recorded in very localised areas towards the landfall location, due to the shallow waters. Average concentrations were predicted to be less than 50 m/l. The sediment plume will only persist for a maximum of 3 to4 hours in any location (see appendix B: Marine Processes Technical Report). Sedimentation will occur in the immediate vicinity of the offshore cable installation activities. The distribution of the sediment which is released during the operation is typically less than 20 mm in depth. The final settled depth being less than 5 mm outside the offshore cable corridor. Further detail can be found in appendix B: Marine Processes Technical Report.

Modelling of the installation of inter-array and offshore cables was carried out on the basis of a number of trenching techniques. Sand wave clearance activities would use ploughing techniques. The volume of material relocated per metre of bed preparation is of the same order of magnitude as the trenching, however the mobilisation of sediments into suspension would be less significant as the trenching lifts material off the bed whilst plough would move material along it. The sand wave clearance constitutes up to 10% of the cable lengths therefore the operations would be less extensive than cable burial. It may therefore be concluded that the magnitude of impacts arising from seabed clearance would be less than for cable trenching and therefore was not modelled and the conclusion for this impact is considered to be the same as for cable installation.

The increased suspended sediment concentrations and associated sediment deposition is predicted to be of localised spatial extent, short term duration, intermittent and high reversibility due to site hydrodynamics. It is predicted that the impact will affect subtidal and intertidal benthic ecology receptors directly. The magnitude is therefore, considered to be low.

Sensitivity of the receptor

The species and communities associated with the Annex I qualifying features of the Dundalk Bay SAC (Table 3-1) are not sensitive to the relatively low increases in suspended sediment concentrations associated with construction activities outlined above. At a distance of over 4 km from any European protected sites, the suspended sediment concentrations would be much lower than those within the immediate proximity of construction operations (as outlined above) and therefore imperceptible against the baseline levels of suspended sediment concentration in the area. Similarly, sediment deposition will be imperceptible from the background sediment transport regime at this distance. Based on the above information it can be concluded that the relevant qualifying features of the Dundalk Bay SAC will not be sensitive to increases of suspended sediments and associated sediment deposition as a result of the Project.

6.1.2 Operational and maintenance phase

Magnitude of impact

Operational and maintenance activities within the offshore wind farm area and offshore cable corridor may lead to increases in suspended sediment concentrations and associated sediment deposition. The project design includes for seven inter-array cable repair and seven reburial events and three offshore cable repair and three reburial events over the Project lifetime (Table 4-1). This work would be undertaken using similar methods as those for cable installation activities (i.e. trenching/jetting).

Any suspended sediments and associated deposition will be of the same magnitude, or lower as for the construction phase. For the purposes of this assessment, the impacts of the operational and maintenance phase activities are predicted to be similar to those for construction, as set out above.

The increased suspended sediment concentrations and associated sediment deposition is predicted to be of localised spatial extent, short term duration, intermittent and high reversibility due to site hydrodynamics. It is predicted that the impact will affect benthic ecology receptors directly. The magnitude is therefore, considered to be low.

Sensitivity of the receptor

The sensitivity of the receptors can be found in the construction phase assessment above (section 6.1.1).

6.1.3 Decommissioning phase

Magnitude of impact

The decommissioning phase of Project infrastructure within the offshore wind farm area and offshore cable corridor may lead to increases in suspended sediment concentrations and associated sediment deposition. The Project will incur the cutting and removal of monopile foundations to approximately 2 m below seabed, and the removal of inter-array and offshore cables.

Decommissioning of the foundations, inter-array cables and offshore cables are assumed to result in similar increases in suspended sediments and associated deposition as that during the construction phase. For the purposes of this assessment, the impacts of the decommissioning phase activities are therefore predicted to be similar to those for construction, as set out above.

The increased suspended sediment concentrations and associated sediment deposition is predicted to be of localised spatial extent, short term duration, intermittent and high reversibility due to site hydrodynamics. It is predicted that the impact will affect subtidal benthic ecology receptors directly. The magnitude is therefore, considered to be low.

Sensitivity of the receptor

The sensitivity of the receptors can be found in the construction phase assessment above (section 6.1.1).

6.2 Seabed disturbance leading to the potential release of sediment contaminants

Seabed disturbance leading to the potential release of sediment contaminants may occur during the construction and decommissioning phases as a result of the installation/removal of foundations and the installation/removal of inter-array and offshore cables. Seabed disturbance leading to the potential release of sediment contaminants may occur during the operational and maintenance phases due to inter-array and offshore cable repair and reburial events.

The benchmarks for the relevant MarESA pressures which have been used to inform this impact assessment are as follows:

- Transition elements & organo-metal contamination: The benchmark is compliance with all average annual environmental quality standards (AA EQS), conformance with Permissible Exposure Limits (PELs), Environment Assessment Criteria (EACs) and Effects Range Lows (ER-Ls);
- Hydrocarbon & Polycyclic Aromatic Hydrocarbons (PAH) contamination: The benchmark is compliance with all AA EQS, conformance with PELs, EACs, ER-Ls; and
- Synthetic compound contamination: The benchmark is compliance with all AA EQS, conformance with PELs, EACs, ER-Ls.

Site specific sediment sampling for contaminants will be carried out at the detailed design phase for the Project. Although site specific sediment contamination levels are unknown at this time, it is considered unlikely that transition elements, organo-metals, hydrocarbons, PAH compounds and synthetic compounds will be present in any greater concentrations than trace amounts. They are very likely to all be in compliance with the Marine Institute sediment quality guidance levels which are similar to the levels in the MarESA benchmark listed above (Cronin *et al*., 2006). It is therefore likely that any contaminants will be below the MarESA benchmark levels. There are few large infrastructure projects and no oil and gas exploration activities in this part of the western Irish Sea, with activities further limited in the immediate vicinity of the offshore wind farm area and offshore cable corridor. Therefore, there is currently no identified source of contamination. In addition, sediments within large parts of the offshore wind farm area and offshore cable corridor are composed of sand and coarse sediment, with low levels of fine sediments (i.e. muds) onto which contaminants would adhere. This further reduces the risk of contamination in these areas.

6.2.1 Construction phase

Magnitude of impact

The installation of Project infrastructure within the offshore wind farm area and offshore cable corridor will cause seabed disturbance which may lead to the release of sediment bound contaminants. The project design parameters for foundation installation assume installation of array and offshore cables as well as sand wave clearance for 10% of inter array cables and 10% of the offshore cable (Table 4-1).

Modelled levels of disturbed and suspended sediments can be found under the impact ‘Increased suspended sediment concentrations and associated sediment deposition’ above. However, it is considered that levels of contamination will be negligible to low as there is no identified source of contamination and the coarse nature of the sediments with minimal fine content over much of the offshore wind farm area and offshore cable corridor will limit the risk further. In the unlikely event that sediment bound contaminants are present, the volumes of sediment disturbed will be small and any contaminants will be quickly diluted to levels which would not cause harm to benthic ecology receptors.

Should dredged material resulting from seabed preparations be found to be significantly contaminated, such that it cannot be disposed of at sea, they will be appropriately disposed of based on the levels of contamination recorded (e.g. an onshore licenced disposal site). The presence of contaminants will be established as part of the permitting process for the Dumping at Sea permit application.

The seabed disturbance leading to the potential release of sediment bound contaminants is predicted to be of localised spatial extent, short term duration, intermittent and of high reversibility due to site hydrodynamics. It is predicted that the impact will affect subtidal and intertidal benthic ecology receptors directly. The magnitude is therefore, considered to be negligible.

Sensitivity of the receptor

The MarESA has not concluded on the sensitivity to sediment contamination for any of the benthic subtidal and intertidal ecology receptors. The sensitivity however has been described based on the MarESA sensitivity review of each habitat. It should be noted that the sensitivities assessed here are those associated with low levels of contamination, as would be expected within the sediments within the Benthic Subtidal and Intertidal Ecology Study Area.

Characterising bivalve species of the Annex I qualifying features of the Dundalk Bay SAC (Table 3-1) are opportunistic species that have high dispersal potential (Larsen *et al*., 2007; Josefson, 1982) therefore can colonise areas where disturbance has occurred, assuming contamination has been adequately diluted so that it does not cause toxic effects. Some species are also considered to be fast growing with a lifespan of 5-6 years therefore can quickly recover a stable population (Künitzer, 1989).

Species may also recover from damage or disturbance through the migration of adults of mobile species such as the polychaetes *Glycera lapidum* and *Nephtys cirrosa*, amphipods and urchins. Many of the characterising species are mobile and therefore would be able to rapidly colonise affected areas from the surrounding habitat. This includes opportunistic species (e.g. *Spiophanes bombyx*, *Spio filicornis* and *Spirobranhchus lamarckii)*, which are likely to be the first to recolonise an area after damage or disturbance (Tillin *et al*., 2016, Tillin, 2016a, Tillin, 2016b). Communities associated with these habitats can also recover through larval dispersal of the venerid bivalves; the venerid bivalves in the biotope reach sexual maturity within two years and spawn at least once a year, therefore recruitment is likely to be high in areas of suitable habitat (Guillou & Sauriau, 1985; Dauvin, 1985).

Characterising species of the intertidal sandy sediments (e.g. *Lanice conchilega*, *Limecola balthica* and *Arenicola marina*) are sessile and larval colonisation are therefore the most important recovery mechanism however adult migration is also possible (McQuillan & Tillin, 2016). Strasser & Pielouth (2001) reported that *L. conchilega* larvae were observed to settle in areas where there were no adults and the population was subsequently re-established in three years. Beukema (1990) reported that following removal of entire intertidal populations (following a cold winter), *L. conchilega* populations recovered rapidly (within 1 and 2 years).

As described in section 6.1.1, at a distance of over 4 km from any European sites, the suspended sediment concentrations (and therefore sediment bound contaminants) would be much lower than within the Project boundaries and therefore would result in imperceptible increases in contaminant concentrations. In addition, as outlined above, contaminant levels within sediments in the Project boundaries are expected to be minimal. Based on the above information it can be concluded that the relevant qualifying features of the Dundalk Bay SAC will have a sensitivity of negligible to low in relation to seabed disturbance leading to the potential release of sediment contaminants as a result of the Project.

6.2.2 Operational and maintenance phase

Magnitude of impact

Operational and maintenance phase activities within the offshore wind farm area and offshore cable corridor will cause seabed disturbance which may lead to the release of sediment contaminants. The project design includes for seven inter-array cable repair and seven reburial events, three offshore cable repair and three reburial events over the 40 year Project lifetime (Table 4-1), using similar methods as those for cable installation activities (i.e. trenching/jetting).

Any disturbed or suspended sediments will be of the same magnitude, or lower as for the construction phase. For the purposes of this assessment, the impacts of the operational and maintenance phase activities are predicted to be similar to those for construction, as set out above.

The seabed disturbance leading to the potential release of sediment bound contaminants is predicted to be of localised spatial extent, short term duration, intermittent and high reversibility due to site hydrodynamics. It is predicted that the impact will affect benthic ecology receptors directly. The magnitude is therefore, considered to be negligible.

Sensitivity of the receptor

The sensitivity of the receptors can be found in the construction phase assessment above (section 6.2.1).

6.2.3 Decommissioning phase

Magnitude of impact

Decommissioning of Project infrastructure within the offshore wind farm area and offshore cable corridor will cause seabed disturbance which may lead to the release of sediment contaminants. The project design parameters are represented by the removal of foundations, inter-array and offshore cables.

Decommissioning of the foundations, inter-array cables and offshore cables are assumed to result in similar increases in disturbed and suspended sediments as that during the construction phase. For the purposes of this assessment, the impacts of decommissioning phase activities are therefore predicted to be similar to those for construction phase, as set out above.

The seabed disturbance leading to the potential release of sediment bound contaminants is predicted to be of localised spatial extent, short term duration, intermittent and high reversibility due to site hydrodynamics. It is predicted that the impact will affect benthic ecology receptors directly. The magnitude is therefore, considered to be negligible.

Sensitivity of the receptor

The sensitivity of the receptors can be found in the construction phase assessment above (section 6.2.1).

6.3 Colonisation of foundations, scour protection and cable protection

Within the offshore wind farm area, sediments are dominated by mud and sand sediment with a smaller proportion of coarse sediments, while the offshore cable corridor is dominated by circalittoral mud and coarse sediment. As such, the introduction of hard substrates due to installation of foundation structures and associated scour protection, and any cable protection, will have a direct effect on benthic ecology receptors through the colonisation of these hard substrates. There is not an applicable MarESA pressure therefore sensitivity has been discussed qualitatively below.

6.3.1 Operational and maintenance phase

Magnitude of impact

The presence of Project infrastructure within the offshore wind farm area and offshore cable corridor may result in the colonisation of foundations, scour protection and cable protection. The project design includes for 356,043 m^2 of habitat created due to the installation of monopile foundations, associated scour protection and cable protection associated with inter-array cables and offshore cable (Table 4-1). It is expected that the foundations and scour and cable protection will be colonised by species already occurring in the Benthic Subtidal and Intertidal Ecology Study Area (e.g. Tunicates, *Spriobranchus* sp., mussels and barnacles which are typical of the western Irish Sea). Colonisation of WTG foundations occurs as a short pioneer stage (above two years), a diverse intermediate stage (two to nine years) and a possible climax stage (about nine years for monopile structures). This climax stage has been described as likely to be a *M. senile*-*M.edulis* co-dominated assemblage, both species have been found in the vicinity of the offshore wind farm area (Degraer *et al*., 2019).

Activities resulting in the long-term colonisation of foundations, scour protection and cable protection will be continuous throughout the operational and maintenance phase. The operational and maintenance phase will occur over a period of 40 years.

Colonisation of WTG foundations, scour protection and cable protection is predicted to be of localised spatial extent (restricted to the new areas of hard substrate), long-term duration, continuous and medium reversibility following the decommissioning phase. It is predicted that the impact will affect benthic ecology receptors directly. However, any effects are expected to be limited in extent, would be unlikely to extend beyond the Project boundaries and will not extend more than 4 km from the Project boundary, and therefore will not affect any European sites. The magnitude is therefore, considered to be low.

Sensitivity of the receptor

The introduction of new hard substrate will represent a shift from the baseline conditions from soft substrate areas (i.e. sands, muds and gravels) to hard substrate in the areas where infrastructure is present. This may produce some potentially beneficial effects, for example the likely increase in biodiversity and biomass, as has been observed at the Egmond aan Zee offshore wind farm in The Netherlands (Lindeboom *et al*., 2011). Species which are typical of rocky and intertidal habitats are likely to be the ones to colonise the new hard substrate.

Post-construction monitoring of the foundations at Egmond aan Zee offshore wind farm recorded colonisation of hard substrate in two distinct zones. The upper zone (7-10 m) was dominated by *M. edulis* and other fauna including barnacles and starfish. The lower zone (10 m to seabed) was dominated by anemones and the small crustacean *Jassa* spp. (Lindeboom *et al*., 2011). Colonisation by these species represented an increase in biodiversity and was a significant change compared to the situation if no hard substrates were present (Lindeboom *et al*., 2011).

The installation of scour protection may also have beneficial effects as it will increase the structural complexity of the substrata which will provide refuge and niche habitats as well as increasing feeding opportunities for larger and more mobile species. Studies at the Horns Rev offshore wind farm in Denmark have shown that offshore wind farm structures can be used as nursery habitats for the edible crab *Cancer pagurus* (BioConsult, 2006).

Colonisation of the WTG foundations, associated scour protection and cable protection may have indirect effects on the baseline communities and habitats due to increased predation on and competition with the existing soft sediment species. These effects are difficult to predict, especially as monitoring to date has focused on the colonisation and aggregation of species close to the foundations rather than broad scale studies. Where scour and cable protection are deployed, use of smaller rock sizes, where possible, may facilitate the colonisation of rock protection by epifaunal species typical of coarse sediment which are found within the offshore wind farm area. Previous studies have shown that for artificial hard substrate to be colonised by a benthic community similar to that of the baseline, its structure should resemble that of the baseline habitat as far as possible (Coolen, 2017). The addition of smaller grained material to scour/cable protection will benefit the native colonising communities (Van Duren *et al*., 2017; Lengkeek *et al.,* 2017).

Based on the above information it can be concluded that the relevant qualifying features of the Dundalk Bay SAC will have a sensitivity of negligible to low in relation to the colonisation of foundations, scour protection and cable protection as a result of the Project.

6.4 Alteration of seabed habitats arising from effects of physical processes

6.4.1 Operational and maintenance phase

Alteration of seabed habitats may arise from the effects of physical processes, including scour effects and changes in the sediment transport and wave regimes resulting in potential effects on marine ecology. Appendix B: Marine Processes Technical Report provides a full description of the assessment used to inform this report.

The relevant MarESA pressures used to inform this impact assessment are changes in local water flow (tidal current) and local wave exposure changes. The benchmarks for these pressures are:

- Changes in local water flow (tidal current): change in peak mean spring bed flow velocity between 0.1 m/s to 0.2 m/s for more than one year. The pressure is associated with activities that have the potential to modify hydrological energy flows. This pressure corresponds to the impacts associated with the presence of WTG and OSS foundations and cable protection; and

- Local wave exposure changes: change in nearshore significant wave height >3% but <5% for one year. This pressure corresponds to the impacts associated with the presence of WTG and OSS foundations and scour protection.

It is important to note that the predicted changes in wave and tidal regime (see appendix B: Marine Processes Technical Report) are lower than the MarESA benchmarks used to inform the assessment therefore potential effects on communities are not likely to occur.

Magnitude of impact

The presence of Project infrastructure within the offshore wind farm area will obstruct tidal flow and alter the wave climate within the offshore wind farm area. The project design includes for the installation of 25 WTGs and one offshore substation on monopile foundations and associated scour protection (Table 4-1). The modelling carried out presented the impact of 25 WTGs and one offshore substation on monopile foundations and associated scour protection. Therefore, the results presented below are considered precautionary and beyond the realistic project design parameters.

Tidal flow is accelerated in the immediate vicinity of each structure as it is redirected around the foundation and there is a zone of reduced speed in the lee of the structure. These alterations in current speed are generally <0.004 m/s in the immediate vicinity of the structure, with lesser changes occurring across the wider offshore wind farm area. These changes are also limited to the immediate offshore wind farm area (appendix B: Marine Processes Technical Report).

Examination of the one in two year wave climate showed a reduction in significant wave height of around 40 mm which is typically less than 2%. This is limited to the immediate vicinity of the structures. For a more severe one in 50 year storm the level of change is less than the one in two year scenario, as the baseline wave height is increased. The combined effect of wave and tidal currents was also investigated. During the flood tide the tidal flow is in concert with the wave climate and the difference in littoral currents was both limited in magnitude (change of approximately 0.03 m/s) and also spatially (alteration in flow would be limited to the offshore wind farm area). The changes in littoral currents due to the structures were found to be imperceptible from the background levels within the modelling (appendix B: Marine Processes Technical Report).

Alteration of seabed habitats arising from the effects of physical processes is predicted to be of localised spatial extent, long-term duration, continuous and high reversibility following the decommissioning phase. It is predicted that the impact will affect benthic ecology receptors indirectly. However, any effects are localised in the vicinity of the turbines, and even within the wind farm itself the effects will be much lower than the numbers presented. Beyond 4 km (i.e. the distance to the nearest European site) the effects will be imperceptible against the background. The magnitude is therefore, considered to be negligible.

Sensitivity of the receptor

As outlined above, the changes to the hydrodynamic regime (i.e. wave regime and tidal flow) will occur only in the immediate vicinity of Project infrastructure and the Project boundary. At a distance of over 4 km from the Project boundaries, any changes in the hydrodynamic regime will be imperceptible against the background. As such, there is no pathway for effects on Annex I qualifying features of the Dundalk Bay SAC (Table 3-1) or any other designated features greater distances from the Project boundary. Based on the above information it can be concluded that the relevant qualifying features of the Dundalk Bay SAC will not be sensitive to alteration of seabed habitats may arise from the effects of physical processes as a result of the Project.

6.5 Increased risk of introduction and spread of invasive and non-indigenous species

The risk of introduction and spread of INIS during the construction, operational and maintenance and decommissioning phases has been considered in this assessment. Magnitude has been considered for all three phases combined as the increased risk of introduction and spread of INIS is as a result of all phases combined. The relevant MarESA pressure that has been used for this assessment is:

- Introduction or spread of invasive non-indigenous species. The benchmark for this MarESA pressure is the direct introduction of one or more INIS.

6.5.1 All phases

Magnitude of impact

The installation of hard substrates and the presence of construction, operational and maintenance and decommissioning phase vessels may lead to an increased risk of introduction and spread of INIS. The project design parameters are represented by the introduction of 475 vessel round trips during the construction phase, 352 vessel round trips per year during the 40 year operational and maintenance phase and 475 vessel round trips during the decommissioning phase (Table 4-1).

There were approximately 1300 vessels movements over two months (January and July 2019) occurring within the Benthic Subtidal and Intertidal Ecology Study Area, including cargo vessels, tankers, fishing vessels, recreational vessels and service vessels (see section 2: Project Description of the main NIS document for vessel movements) therefore the additional Project vessels, which represents a 27% increase in vessel traffic within the Benthic Subtidal and Intertidal Ecology Study Area during the operational and maintenance phase, and will not significantly add to the risk of introduction and spread of INIS.

As presented in Table 4-1, the risk of introduction and spread of INIS will be increased due to the creation of 359,807 m^2 of hard substrate from the installation of monopile foundations, associated scour protection and any cable protection. There are already natural hard substrates within the vicinity of the offshore wind farm area and offshore cable corridor (e.g. circalittoral rock or other hard substrata). Therefore, the introduction of new hard substrates would not be a substantial change in the baseline and would not substantially increase the risk of introduction and spread of non-indigenous species.

Marine invasive species established in Ireland include carpet sea squirt *Didemnum vexillum* and the slipper limpet *Crepidula fornicata*, both of which are already found in the vicinity of the offshore wind farm area and offshore cable corridor (Invasive Species Ireland, 2019). There are several species which are of concern as potential marine invasive species for Ireland. These are the Asian rapa whelk *Rapana venosa*, oyster drill *Ceratostoma inornatum* and *Urosalpinx cinereal*, red king crab *Paralithodes camtschaticus* and striped eel catfish *Plotosus lineatus* (Invasive Species Ireland, 2019). Of these, the Asian rapa whelk is the only one thought to have a potential pathway to Ireland through ballast water (Invasive Species Ireland, 2019). The Project includes a Marine Invasive Non-Indigenous Species Management Plan (MINIS) and an EMP (see appendix K: Management Plans).as the measures included in the abovementioned plans, such as, *inter alia*, ensuring any new infrastructure coming from another marine environment is cleaned and checked prior to installation and that vessels comply with the IMO ballast water management guidelines will ensure that the risk of potential introduction and spread of INIS will be minimised.

Risk of introduction and spread of INIS is predicted to be of regional spatial extent, long term duration, continuous and low reversibility. It is predicted that the impact will affect benthic ecology receptors indirectly. The magnitude is therefore, considered to be negligible.

Sensitivity of the receptor

As with the colonisation of foundations impact assessment (section 6.3), effects of introduction and spread of INIS are expected to be limited to the Project boundaries and would not be expected to extend to 4 km from the Project boundary (i.e. the closest distance between the Project boundary and the Dundalk Bay SAC). However, as outlined above, the implementation of a MINIS Management Plan and an EMP (see appendix K: Management Plans) will minimise any risk introduction or spread of these species, further reducing the potential for effects on Annex I qualifying features of the Dundalk Bay SAC (Table 3-1). Based on the above information it can be concluded that the sensitivity of the relevant qualifying features of the Dundalk Bay SAC will have a sensitivity of negligible in relation to the risk of introduction and spread of INIS as a result of the Project.

7 IN-COMBINATION EFFECTS

The in-combination assessment (ICA) takes into account the impact associated with the Project together with other projects within the ZoI of the Project. The projects selected as relevant to the ICA have based upon the results of a screening exercise (see appendix J: Screening – In-combination Effects). Each project has been considered on a case-by-case basis for screening in or out of this assessment based upon data confidence, effect-receptor pathways and the spatial/temporal scales involved.

The approach to in-combination examines the potential for effects associated with the Project alongside the following projects if they fall within the ZoI for relevant European sites:

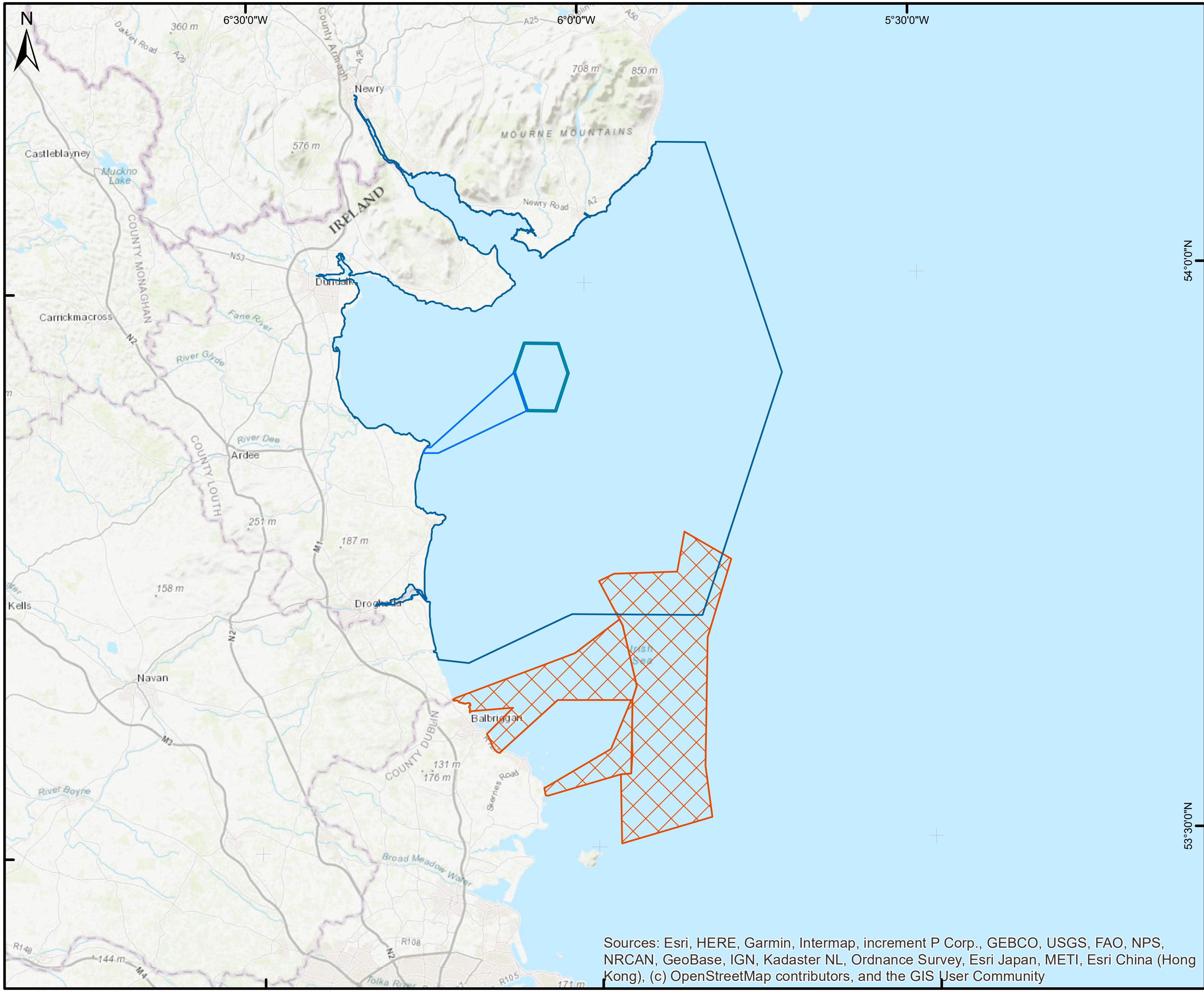
- Other projects with consent but not yet constructed/construction not completed;
- Other projects in a consent application process but not yet determined (including planning applications, foreshore lease/licence applications, Dumping at Sea Permit applications);
- Other projects currently operational that were not operational when baseline data were collected, and/or those that are operational but have an ongoing impact; and
- Projects, which satisfy the definition of 'relevant maritime usage' under the Maritime Area Planning Act (2021) (i.e. wind farm projects designated as 'Relevant Projects' or 'Phase 1 Projects') including Arklow Bank II, Bray Bank and Kish Bank; North Irish Sea Array, Codling Wind Park (I and II).

Only one project has been screened into this ICA; the NISA offshore wind farm project (Table 7-1).

Table 7-1: List of other projects considered within the in-combination assessment.

Project	Status	Approximate Distance from offshore wind farm area (km)	Approximate Distance from Offshore cable corridor (km)	Description of Project/Plan	Dates of construction (if applicable)	Dates of operation (if applicable)	Overlap with Project
Offshore Wind Farms							
North Irish Sea Array (NISA)	Maritime Area Consent	16.2	18.1	Scoping Report (2021) refers to the construction of an offshore wind farm of up to 500 MW, consisting of 36 turbines with a maximum height of 320 m and rotor diameter of up to 290 m. Offshore substation platforms may be required[1].	Unknown	Unknown (Design life minimum 35 years)	Potential for construction and operational phases to overlap with the Project. Potential for overlap for impacts such as SSC, habitat loss (temporary and long term) and colonisation of hard substrates.

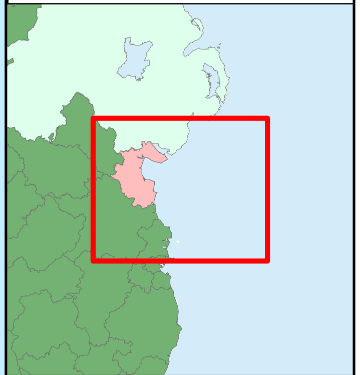
[1] Project website https://northirishseaarray.ie/: states that wind farm will consist of 35 to 46 turbines.



Legend

- Offshore Wind Farm Area
- Offshore Cable Corridor
- Cumulative Benthic Subtidal and Intertidal Ecology Study Area
- Statkraft North Irish Sea Array (NISA)

Data Sources: Client, Ordnance Survey Ireland, RPS



Client

ORIEL WINDFARM
OFFSHORE RENEWABLE ENERGY

Project

Oriel Wind Farm Project

Title **Figure 7-1**

Other projects screened into the in-combination assessment - benthic

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Issue Details

Drawn By: NG	**Project No.** EOR0822 (MDR1520B)
Checked By: NG	**File Ref:**
Approved By: AOS	EOR0822_BEN_E_1108_FINAL
Scale: 1:500,000 @ A4	**Projection:** ITM (IRENET95)
Date: 12/03/2024	Geographic Co-ordinates: ETRS89

Table 7-2 presents the relevant project design parameters from Table 4-1, which are used to assess the potential in-combination effects of the Project with the other projects identified in Table 7-1 (where information is available).

For the purposes of this appendix, in-combination effects have been assessed within the Benthic Subtidal and Intertidal Ecology Study Area. Those impacts scoped out of the assessment for benthic subtidal and intertidal ecology in section 4.3 above have also been scoped out of the ICA.

Table 7-2: Project design parameters considered for the assessment of potential in-combination effects on benthic subtidal and intertidal ecology.

Potential impact	Phase			Project design parameter	Justification
	C	O	D		
Increase in suspended sediment concentrations and associated sediment deposition	✓	✓	✓	Project design parameter as described for the Project (Table 4-1) assessed in-combination with NISA Offshore Wind Farm.	Maximum potential for in-combination effects from an increase in suspended sediment concentrations and associated deposition from construction, operational and decommissioning phase activities within the Benthic Subtidal and Intertidal Ecology Study Area.
Seabed disturbance leading to the potential release of sediment contaminants	✓	✓	✓		Maximum potential for in-combination effects from seabed disturbance leading to the potential release of sediment contaminants from construction, operational and decommissioning phase activities within the Benthic Subtidal and Intertidal Ecology Study Area.
Colonisation of foundations, scour protection and cable protection	×	✓	×		Maximum potential for in-combination effects from colonisation of foundations, scour protection and cable protection within the Benthic Subtidal and Intertidal Ecology Study Area.
Alteration of seabed habitats arising from effects of physical processes	×	✓	×		Maximum potential for in-combination effects from Alteration of seabed habitats arising from effects of physical processes from the installation of infrastructure within the Benthic Subtidal and Intertidal Ecology Study Area.
Increased risk of introduction and spread of invasive and non-indigenous species	✓	✓	✓		Maximum potential for in-combination effects from increased risk of introduction and spread of invasive and non-indigenous species from new infrastructure and vessel movements within the Benthic Subtidal and Intertidal Ecology Study Area.

7.1 Increased suspended sediment concentrations and associated sediment deposition

7.1.1 Construction Phase

Magnitude of impact

The installation of foundations within the offshore wind farm area, together with the NISA Offshore Wind Farm project, may lead to increase in suspended sediment concentrations and associated deposition as a result of disturbance to the seabed.

Sediment disturbance arising from construction phase activities at the NISA Offshore Wind Farm, such as cable laying and foundation installation, may result in potential effects on benthic communities through smothering (North Irish Sea Array Windfarm Ltd., 2021). Currently only a scoping report is available for this project which does not quantify the area likely to be impacted or the suspended sediment concentrations which may be associated with the relevant activities. The scale of this impact associated with the NISA Offshore Wind Farm however is likely to be similar to the increase in suspended sediment concentrations and the associated deposition which will be expected as a result of the Project.

The impact is predicted to be of local spatial extent, short term duration, intermittent and high reversibility It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be low.

Sensitivity of the receptor

Sensitivities of the relevant benthic subtidal and intertidal ecology receptors to increases in suspended sediment concentrations and associated deposition are as per the impact assessment above (section 6.1.1).

7.1.2 Operational and maintenance phase

Magnitude of impact

Maintenance activities, including remedial burial of cables, within the offshore wind farm area, together with the NISA Offshore Wind Farm project, may lead to increase in suspended sediment concentrations and associated deposition as a result of disturbance to the seabed.

Sediment disturbance arising from operational phase activities at the NISA Offshore Wind Farm, such as cable remedial works, may result in potential effects on benthic communities through smothering (North Irish Sea Array Windfarm Ltd., 2021). Currently only a scoping report is available for this project which does not quantify the area likely to be impacted or the suspended sediment concentrations which may be associated with the relevant activities. The scale of this impact associated with the NISA Offshore Wind Farm however is likely to be similar to the increase in suspended sediment concentrations and the associated deposition which will be expected as a result of the Project.

The impact is predicted to be of local spatial extent, short term duration (individual maintenance operations would occur over a period of days to weeks), intermittent and high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be low.

Sensitivity of the receptor

Sensitivities of the relevant benthic subtidal and intertidal ecology receptors to increases in suspended sediment concentrations and associated deposition are as per the impact assessment above (section 6.1.1).

7.1.3 Decommissioning phase

Magnitude of impact

The installation of foundations within the offshore wind farm area, together with the NISA Offshore Wind Farm project may lead to increase in suspended sediment concentrations and associated deposition as a result of disturbance to the seabed.

Sediment disturbance arising from the decommissioning phase activities at the NISA Offshore Wind Farm, such as cable or turbine foundation removal, may result in potential effects on benthic communities through smothering (North Irish Sea Array Windfarm Ltd., 2021). Currently only a scoping report is available for this project which does not quantify the area likely to be impacted or the suspended sediment concentrations which may be associated with the relevant activities. The scale of this impact associated with the NISA Offshore Wind Farm however is likely to be similar to the increase in suspended sediment concentrations and the associated deposition which will be expected as a result of the Project.

The impact is predicted to be of local spatial extent, short term duration, intermittent and high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be low.

Sensitivity of the receptor

Sensitivities of the relevant benthic subtidal and intertidal ecology receptors to increases in suspended sediment concentrations and associated deposition are as per the impact assessment above (section 6.1.1).

7.2 Seabed disturbance leading to the potential release of sediment contaminants

7.2.1 Construction Phase

Magnitude of impact

The installation of foundations within the offshore wind farm area, together with the NISA Offshore Wind Farm project, may lead to potential release of sediment contaminants as a result of disturbance to the seabed.

Seabed disturbance arising from construction phase activities at the NISA Offshore Wind Farm, such as cable laying and foundation installation, may result in potential effects on benthic communities through release of contaminated sediments and/or accidental contamination (North Irish Sea Array Windfarm Ltd., 2021). Currently only a scoping report is available for this project which does not quantify the area likely to be impacted or concentrations of contaminants associated with the seabed within the NISA array area and offshore cable corridor. The scale of this impact associated with the NISA Offshore Wind Farm however is likely to be similar to potential for contaminant release from the seabed associated with the Project.

The impact is predicted to be of local spatial extent, short term duration, intermittent and high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be low.

Sensitivity of the receptor

Sensitivities of the relevant benthic subtidal and intertidal ecology receptors to seabed disturbance leading to the potential release of sediment contaminants are as per the impact assessment above (section 6.2.1).

7.2.2 Operational and maintenance phase

Magnitude of impact

Maintenance activities, including remedial burial of cables within the offshore wind farm area, together with the NISA Offshore Wind Farm project, may lead to potential release of sediment contaminants as a result of disturbance to the seabed.

Seabed disturbance arising from operational phase activities at the NISA Offshore Wind Farm, such as cable remedial works, may result in potential effects on benthic communities through release of contaminated sediments and/or accidental contamination (North Irish Sea Array Windfarm Ltd., 2021). Currently only a scoping report is available for this project which does not quantify the area likely to be impacted or concentrations of contaminants associated with the seabed within the NISA array area and offshore cable corridor. The scale of this impact associated with the NISA Offshore Wind Farm however is likely to be similar to potential for contaminant release from the seabed associated with the Project.

The seabed disturbance leading to the potential release of sediment bound contaminants is predicted to be of localised spatial extent, short term duration, intermittent and high reversibility due to site hydrodynamics. It is predicted that the impact will affect benthic ecology receptors directly. The magnitude is therefore, considered to be negligible.

Sensitivity of the receptor

Sensitivities of the relevant benthic subtidal and intertidal ecology receptors to seabed disturbance leading to the potential release of sediment contaminants are as per the impact assessment above (section 6.2.1).

7.2.3 Decommissioning phase

Magnitude of impact

The removal of foundations within the offshore wind farm area, together with the NISA Offshore Wind Farm project, may lead to potential release of sediment contaminants as a result of disturbance to the seabed.

Seabed disturbance arising from the decommissioning phase activities at the NISA Offshore Wind Farm, such as cable and foundation removal activities, may result in potential effects on benthic communities through release of contaminated sediments and/or accidental contamination (North Irish Sea Array Windfarm Ltd., 2021). Currently only a scoping report is available for this project which does not quantify the area likely to be impacted or concentrations of contaminants associated with the seabed within the NISA array area and offshore cable corridor. The scale of this impact associated with the NISA Offshore Wind Farm however is likely to be similar to potential for contaminant release from the seabed associated with the Project.

The seabed disturbance leading to the potential release of sediment bound contaminants is predicted to be of localised spatial extent, short term duration, intermittent and high reversibility due to site hydrodynamics. It is predicted that the impact will affect benthic ecology receptors directly. The magnitude is therefore, considered to be negligible.

Sensitivity of the receptor

Sensitivities of the relevant benthic subtidal and intertidal ecology receptors to seabed disturbance leading to the potential release of sediment contaminants are as per the impact assessment above (section 6.2.1).

7.3 Colonisation of foundations, scour protection and cable protection

7.3.1 Operational and maintenance phase

Magnitude of impact

The placement of infrastructure such as wind turbine foundations, scour protection and cable protection within the offshore wind farm area, together with the NISA Offshore Wind Farm project, may lead to colonisation of this new hard substrate.

Colonisation of foundations, scour protection and cable protection as a result of the NISA Offshore Wind Farm, may result in potential effects on benthic communities due an increase in local biodiversity and alterations to the prevailing benthic habitats and communities (North Irish Sea Array Windfarm Ltd., 2021). Currently only a scoping report is available for this project which does not quantify the area likely to be impacted by colonisation. The scale of this impact associated with the NISA Offshore Wind Farm however is likely to be similar to the colonisation which will be expected as a result of the Project.

The impact is predicted to be of localised spatial extent (restricted to the new areas of hard substrate), long-term duration, continuous and medium reversibility following the decommissioning phase. It is predicted that the impact will affect benthic ecology receptors directly. The magnitude is therefore, considered to be low.

Sensitivity of the receptor

Sensitivities of the relevant benthic subtidal and intertidal ecology receptors to colonisation of foundations, scour protection and cable protection are as per the impact assessment above (section 6.3.1).

7.4 Alteration of seabed habitats arising from effects of physical processes

7.4.1 Operational and maintenance phase

Magnitude of impact

The placement of infrastructure such as wind turbine foundations within the offshore wind farm area, together with the NISA Offshore Wind Farm project, may lead to alteration of seabed habitats arising from effects of physical processes as a result of the placement of infrastructure on the seabed.

Alteration of seabed habitats arising from effects of physical processes arising from the placement of infrastructure as a result of the NISA Offshore Wind Farm, such as cable protection and turbine foundations, may result in potential effects on benthic communities through smothering (North Irish Sea Array Windfarm Ltd., 2021). Currently only a scoping report is available for this project which does not quantify the likely scale of the alteration of physical process which could be expected as a result of the NISA Offshore Wind Farm. The scale of this impact associated with the NISA Offshore Wind Farm however is likely to be similar to the long term habitat loss or alteration which will be expected as a result of the Project.

The impact is predicted to be of localised spatial extent, long-term duration, continuous and high reversibility following the decommissioning phase. It is predicted that the impact will affect benthic ecology receptors indirectly. The magnitude is therefore, considered to be low.

Sensitivity of the receptor

Sensitivities of the relevant benthic subtidal and intertidal ecology receptors to alteration of seabed habitats arising from effects of physical processes are as per the impact assessment above (section 6.4.1).

7.5 Increased risk of introduction and spread of invasive and non-indigenous species

7.5.1 All phases

Magnitude of impact

The installation, maintenance and decommissioning of hard substrates and the presence of vessels to undertake this work, together with the NISA Offshore Wind Farm project, may lead to an increased risk of introduction and spread of INIS.

An increased risk of introduction and spread of INIS from the installation of hard substrates and the presence of construction, operational and maintenance and decommissioning phase vessels at the NISA Offshore Wind Farm, may result facilitate the spread of non-native species and may subsequently impact biodiversity and benthic ecology of the area (North Irish Sea Array Windfarm Ltd., 2021). Currently only a scoping report is available for this project which does not quantify the number of vessel movements or the amount of new hard substrate which may be installed. The scale of this impact associated with the NISA Offshore Wind Farm however is likely to be similar to the increased risk of introduction and spread of INIS which will be expected as a result of the Project.

Risk of introduction and spread of INIS is predicted to be of regional spatial extent, long term duration, continuous and low reversibility. It is predicted that the impact will affect benthic ecology receptors indirectly. The magnitude is therefore, considered to be negligible.

Sensitivity of the receptor

Sensitivities of the relevant benthic subtidal and intertidal ecology receptors to increased risk of introduction and spread of INIS are as per the impact assessment above (section 6.5.1).

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Tillin, H.M. & Budd, G., (2016) [Porphyra purpurea] and [Ulva] spp. on sand-scoured mid or lower eulittoral rock. In Tyler-Walters H. and Hiscock K. (eds) Marine Life Information Network: Biology and Sensitivity Key Information Reviews, [on-line]. Plymouth: Marine Biological Association of the United Kingdom. [cited 18-02-2021]. Available from: https://www.marlin.ac.uk/habitat/detail/288.

ANNEX 1: BENTHIC SURVEY REPORT

Oriel Wind Farm
Benthic Studies

Produced by

AQUAFACT International Services Ltd

On behalf of

Parkwind

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AQUAFACT

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1. Introduction

Parkwind commissioned AQUAFACT to carry out a marine benthic survey of the Oriel wind farm site and proposed cable route in order to characterise the baseline environment in terms of its sediment composition and faunal communities.

An infaunal grab sampling survey and underwater drop down video survey was carried out at the station location illustrated in Figure 1.1 below.

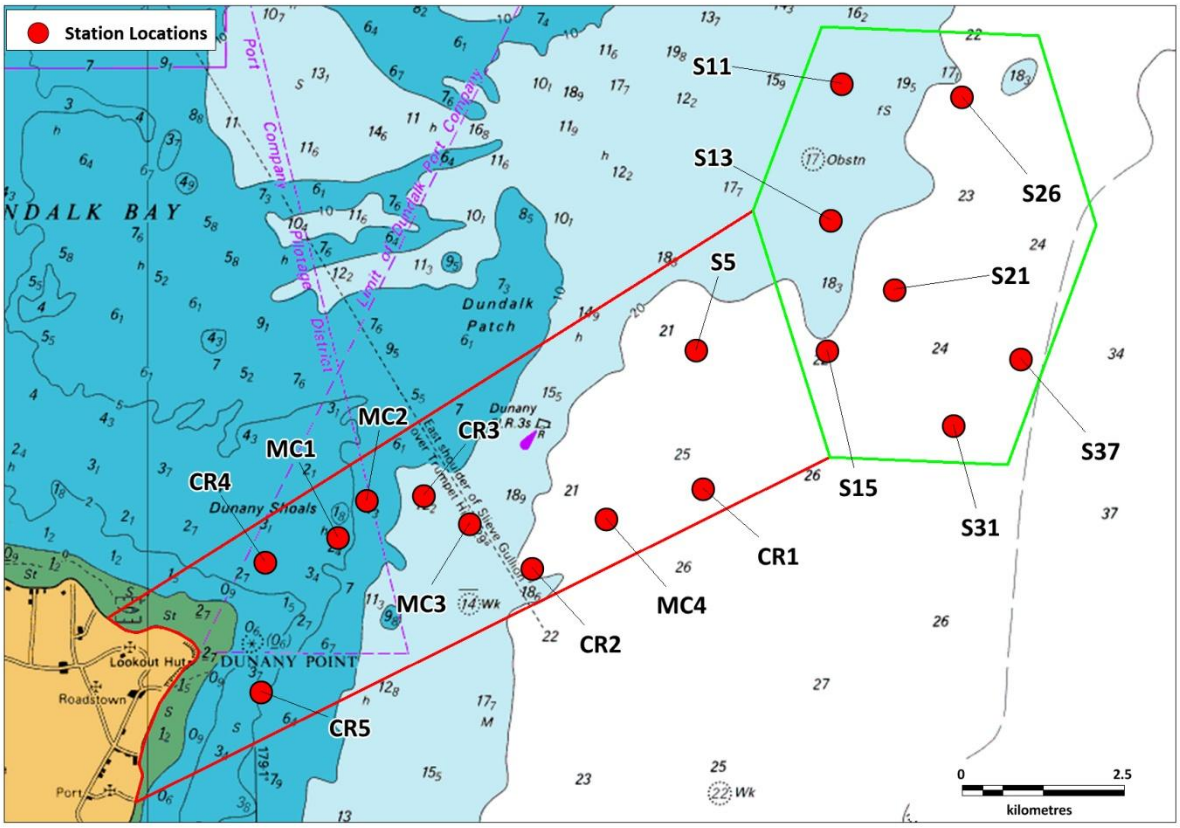

Figure 1.1: Location of the stations surveyed at Oriel Wind Farm (green outline) and cable route area (red outline).

2. Benthic Grab Survey

2.1. Materials & Methods

2.1.1. Sampling Procedure

To carry out the subtidal benthic assessment of the Oriel Wind farm and cable route, AQUAFACT grab sampled a total of 10 stations and surveyed a further 9 locations with drop down video camera. Sampling took place on the 21st October and 3rd December 2019 from Fastnet Shipping's vessel *Petrel.* Sea state was calm with a slight (5kt) northwesterly breeze in the October survey. Sea state was choppy with an 11kt southwesterly breeze. Figure 2.1 shows the location of the grab stations and video stations surveyed and Table 2.1 shows the station coordinates and depths.

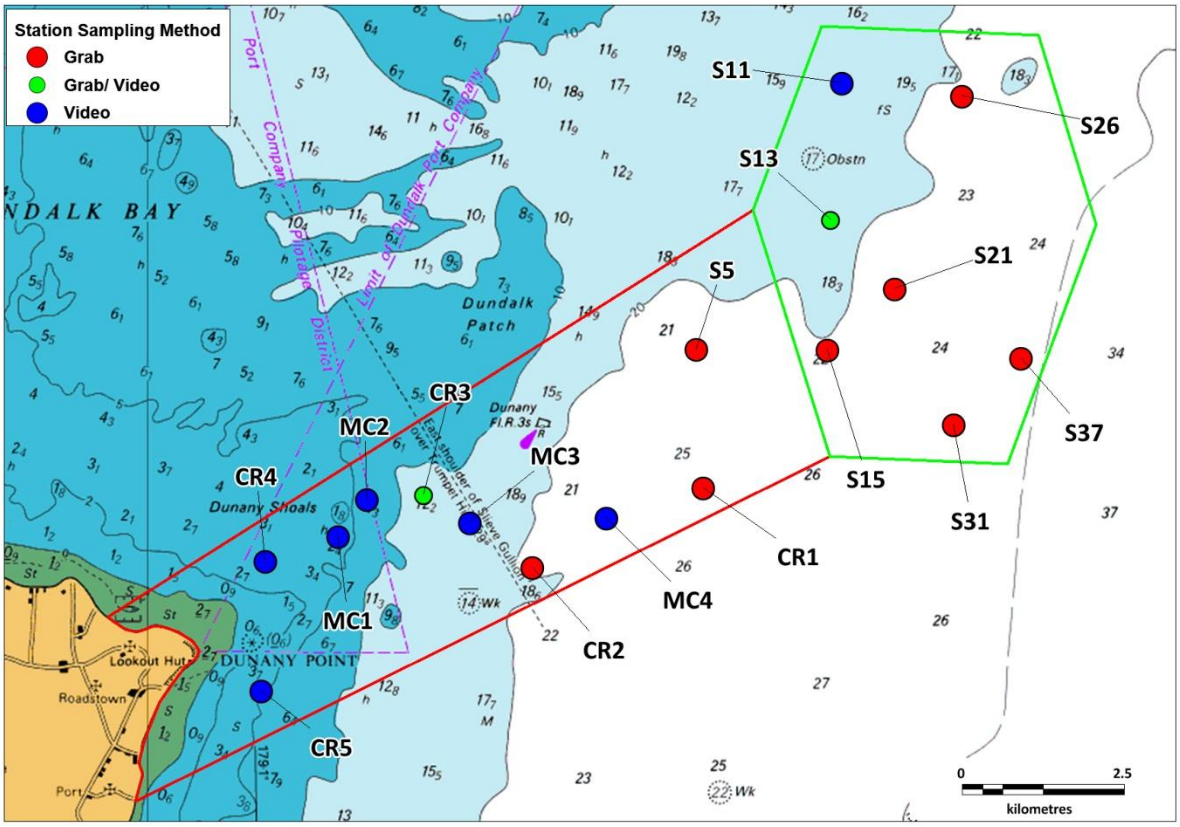

Figure 2.1: Location of the grab stations and video transect locations surveyed on the 12th October and 3rd December 2019.

Table 2.1: Station coordinates and depths at the grab stations and video transect locations.

Station	Latitude	Longitude	Depth (m)	Survey method
CR1	53.8836°	-6.1203°	27	Video
CR2	53.8725°	-6.1605°	21	Video
CR3	53.88269°	-6.18616°	15	Grab & Video
CR3	53.8824°	-6.1864°	15	Video
CR4	53.8734°	-6.2235°	5	Video
CR5	53.85533°	-6.2244°	6	Video
S5	53.9030°	-6.1218°	25	Grab
S11	53.9400°	-6.0875°	19	Video
S13	53.9210°	-6.0901°	18	Grab & Video
S15	53.9029°	-6.0910°	27	Grab
S21	53.9113°	-6.0751°	27	Grab
S26	53.9382°	-6.05929°	19	Grab & Video
S31	53.8925°	-6.0613°	31	Grab
S37	53.9017°	-6.0454°	34	Grab
MC1	53.8769°	-6.2063°	7	Video
MC2	53.8820°	-6.1995°	8	Video
MC3	53.8788°	-6.1753°	18	Video
MC4	53.8795°	-6.1431°	25	Video

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

A 0.1m^2 Day grab was used to sample the grab sites. On arrival at each sampling station, the vessel location was recorded using DGPS (latitude/longitude). Additional information such as date, time, site name, sample code and depth were recorded in a data sheet.

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

A digital image of each sample (including sample label) was taken and these images can be seen in Appendix 1. The grab sampler was cleaned between stations to prevent cross contamination.

The samples collected for faunal analysis were carefully and gently sieved on a 1mm mesh sieve as a sediment water suspension for the retention of fauna. Great care was taken during the sieving process in order to minimise damage to taxa such as spionids, scale worms, phyllodocids and amphipods. The sample residue was carefully flushed into a pre-labelled (internally and externally) container from below. Each label contained the sample code and date. The samples were stained with Eosin-briebrich scarlet and fixed in 4% w/v buffered formaldehyde solution upon returning to the laboratory. These samples were ultimately preserved in 70% alcohol prior to processing.

2.1.2. Sample Processing

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

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

The sediment granulometric analysis was carried out by AQUAFACT using the traditional granulometric approach. Traditional analysis involved the dry sieving of approximately 100g of sediment using a series of Wentworth graded sieves. The process involved the separation of the sediment fractions by passing them through a series of sieves. Each sieve retained a fraction of the sediment, which were later weighed and a percentage of the total was calculated. Table 2.2 shows the classification of sediment particle size ranges into size classes. Sieves, which corresponded to the range of particle sizes (Table 2.2), were used in the analysis. Appendix 2 provides the detailed granulometric methodology.

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

Range of Particle Size	Classification	Phi Unit
<63µm	Silt/Clay	>4 Ø
63-125 µm	Very Fine Sand	4 Ø, 3.5 Ø
125-250 µm	Fine Sand	3 Ø, 2.5 Ø
250-500 µm	Medium Sand	2 Ø, 1.5 Ø
500-1000 µm	Coarse Sand	1 Ø, 1.5 Ø
1000-2000 µm (1 – 2mm)	Very Coarse Sand	0 Ø, -0.5 Ø
2000 – 4000 µm (2 – 4mm)	Very Fine Gravel	-1 Ø, -1.5 Ø
4000 -8000 µm (4 – 8mm)	Fine Gravel	-2 Ø, -2.5 Ø
8 -64 mm	Medium, Coarse & Very Coarse Gravel	-3 Ø to -5.5 Ø
64 – 256 mm	Cobble	-6 Ø to -7.5 Ø
>256 mm	Boulder	< -8 Ø

The additional sediment samples collected from the faunal stations had their organic carbon analysis performed by ALS Laboratories in Loughrea using the Loss on Ignition method. Appendix 2 provides the methodology.

2.1.3. Data Analysis

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

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

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

where: N is the number of individuals

S is the number of species

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

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

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

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

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

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

4) Effective number of species (ENS) (Hill, 1973; Jost, 2006)

$$H = \exp(H')$$

Where H’ is the Shannon-Weiner diversity index.

Species richness is a measure of the total number of species present for a given number of individuals. Evenness is a measure of how evenly the individuals are distributed among different species. The Shannon-Wiener index incorporates both species richness and the evenness component of diversity (Shannon & Weaver, 1949). The diversity index is then converted to effective numbers of species to reflect ‘true diversities’ (Hill, 1973, Jost, 2006) that can then be compared across communities (MacArthur, 1965; Jost, 2006). The effective number of species (ENS) is equivalent to the number of equally abundant species that would be needed in each sample to give the same value of a diversity index, *i.e.* Shannon-Weiner Diversity index. The ENS behaves as one would intuitively expect when diversity is doubled or halved, while other standard indices of diversity do not (Jost, 2006). If the ENS of one community is twice that of another then it can be said that that community is twice as diverse as the other.

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

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

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

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

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

In order to assess the benthic ecological quality of the community, the AZTI Marine Biotic Index (AMBI) was calculated. AMBI offers a 'pollution or disturbance classification' which represents the benthic community health (*sensu* Grall & Glémarec, 1997). Individuals are put into one of five ecological sensitivity groups (Group I - very sensitive to disturbance/pollution; Group II - indifferent to disturbance/pollution; Group III - tolerant to disturbance/pollution; Group IV - second-order opportunists and Group V - first order opportunists) and the AMBI score is calculated as a weighted average of the sensitivity scores of each replicate sample. Assemblages with high proportions of sensitive taxa are indicative of areas with low levels of disturbance and stations dominated by opportunistic taxa reflect impacted areas.

2.1.4. Underwater drop down video survey.

The drop down video stations can be seen in Figure 2.1 above. Nine stations are shown and they have been selected to cover the areas where hard ground would prevent grab sampling for benthic faunal survey.

Offshore still and video seabed photographic data were acquired using a high resolution underwater camera. A drop down camera (manufactured by LH-Camera) was be used for this survey. This is an upgraded version of their standard unit. Its specification include a high resolution, 560 line colour PAL camera with 0.1 lux sensitivity. Footage will be digitized and captured using a Getac B300 rugged notebook and backed up to writeable DVD media. A video overlay unit allows position (dGPS) to be inserted and recorded continually on screen, streamlining the incorporation of footage into GIS for ground truthing and mapping purposes. The underwater camera is combined with a dedicated still camera that captures in real time

A minimum of ten (10) clear images were obtained from each survey location. The video photography data was reviewed in conjunction with the still photographs. The locations of habitats and/or associated flora and faunal communities were noted.

The physical characteristics of the seabed was recorded, estimated or classified (as appropriate), including: minimum & maximum depth, underwater visibility. Should suitable geophysical data be available, this will be interpreted in conjunction with the video data.

2.2. Results

2.2.1. Fauna

The taxonomic identification of the benthic infauna across all 10 grab stations sampled at Oriel Wind Farm and cable route yielded a total count of 148 taxa ascribed to 9 phyla. The 148 taxa consisted of 1,464 individuals. Of the 148 taxa recorded, 115 were identified to species level. The remaining 33 could not be identified to species level as they were juveniles (14 taxa), partial/damaged (13 taxa) or indeterminate (6 taxa). Appendix 3 shows the faunal abundances from the sampled sites.

Of the 148 taxa present, 3 were cnidarians (hydroids, anemones etc.), 1 was a nematode (roundworm), 4 were nemerteans (ribbon worms), 3 were sipunculids (acorn worm), 64 were annelids (segmented worms), 24 were crustaceans (crabs, prawns, amphipods), 37 were molluscs (mussels, cockles, snails), 1 was a phoronid (horseshoe worm), 11 were echinoderms (brittlestars, starfish.

2.2.1.1. Univariate Analysis

Univariate statistical analyses were carried out on station-by-station faunal data. In addition all colonial, epifaunal, parasitic and fish species were removed prior to analysis. The following parameters were calculated and can be seen in Table 2.3: taxon numbers, number of individuals, richness, evenness, Shannon-Weiner diversity and Effective species numbers (Hill numbers based on the Shannon-Weiner diversity). Taxon numbers ranged from 9 (CR3) to 46 (S26). Number of individuals ranged from 23 (CR3) to 349 (S31). Richness ranged from 3.63 (CR1) to 8.91 (S26). Evenness ranged from 0.53 (S31) to 0.97 (CR2). Shannon-Weiner diversity ranged from 1.97 (CR3) to 3.1 (S26). Effective species numbers (exponential of Shannon-Weiner diversity) ranged from 7.18 (CR3) to 22.24 (S26) indicating the station S26 is effectively over three times as diverse as station CR3. Figure 2.2 shows these community indices in graphical form.

Table 2.3: Univariate measures of community structure.

Station	No. Taxa	No. Individuals	Richness	Evenness	Shannon-Weiner Diversity	Effective Species No.
	S	N	d	J'	H'(loge)	exp(H')
CR1	14	36	3.63	0.88	2.33	10.28
CR2	20	34	5.39	0.97	2.89	18.06
CR3	9	23	2.55	0.90	1.97	7.18
S5	25	155	4.76	0.66	2.13	8.37
S13	33	121	6.67	0.82	2.88	17.79
S15	40	310	6.80	0.77	2.84	17.16
S21	45	217	8.18	0.81	3.09	21.88
S26	46	156	8.91	0.81	3.10	22.24
S31	45	349	7.51	0.53	2.02	7.56
S37	25	63	5.79	0.89	2.88	17.76

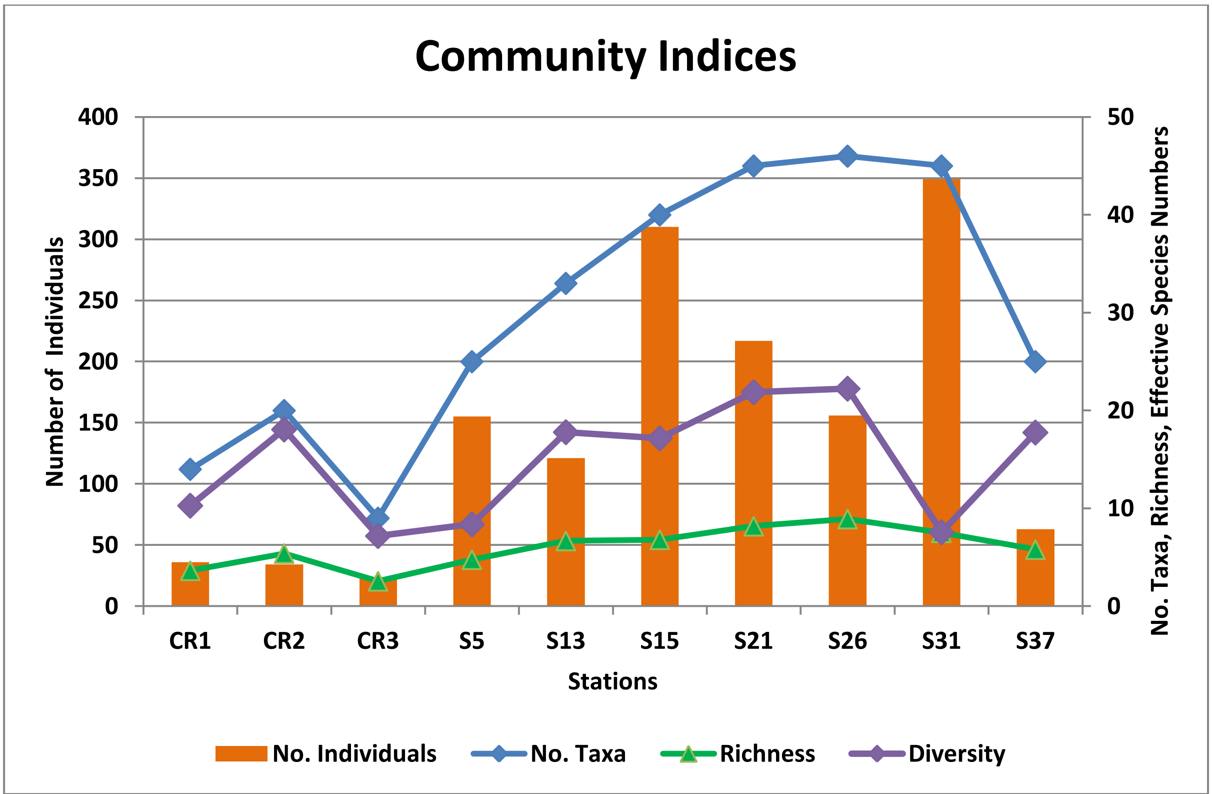

Figure 2.2: Community indices. Diversity is expressed in effective species numbers.

2.2.1.2. Multivariate Analysis

The same data set used above for the univariate analyses was also used for the multivariate analyses. The dendrogram and the MDS plot can be seen in Figures 2.3 and 2.4 respectively. The stress level of 0.09 on the MDS plot indicates an excellent representation of the data with no prospect of misinterpretation. SIMPROF analysis revealed 4 statistically significant groupings between the 10 stations (the stations connected by red lines cannot be significantly differentiated).

- Group a: Station CR3
- Group b: Stations CR1, CR2 and S37
- Group c: Stations S5, S15 and S31
- Group d: Stations S13, S21 and S26

Group a contained station CR3 and separated from all other groups at a similarity level of 5.34%. This group contained 9 taxa comprising 23 individuals. Of the 9 taxa, 5 were present twice or less. Four species accounted for just almost 74% of the faunal abundance of this group; the bivalves *Nucula* sp. (juv.) (6 individuals, 26.09% abundance), *Fabulina fabula* (5 individuals, 21.74%) and *Nucula nitidosa* (3 individuals, 13.04% abundance) and the polychaete *Nephtys cirrosa* (3 individuals, 13.04% abundance. SIMPER analysis could not be carried out on this group as it only contained one station. *Nucula* sp. (juv), *Nucula nitidosa* and *Fabulina fabula* are very sensitive to organic enrichment and present under unpolluted conditions. *Nephtys cirrosa* are indifferent to enrichment, typically present in low densities with non-significant variations over time. The number of taxa and individuals, species richness and diversity were lowest in this group. This group (station CR3) broadly conforms to the JNCC biotope SS.SSa.IMuSa.FfabMag *Fabulina fabula* and *Magelona mirabilis* with venerid bivalves and amphipods in infralittoral compacted fine muddy sand and the EUNIS biotope A5.242. This Shallow *Venus* community [the 'Boreal offshore sand association' of Jones 1950] is present in shallow (5 m to 40 m) nearshore sands.

Group b contained stations CR1, CR2 and S37 and had a within group similarity of 52.98% and separated from group c at a 26.24% similarity level. This group contained 35 taxa comprising 133 individuals. Of the 35 taxa, 19 were present twice or less. Five species accounted for almost 52% of the faunal abundance of this group; the polychaetes *Prionospio* sp. (19 individuals, 14.29% abundance), *Magelona minuta* (18 individuals, 13.53% abundance), *Nephtys incisa* (13 individuals, 9.77% abundance) and *Levinsenia gracilis* (10 individuals, 7.52% abundance) and the bivalve molluscs *Abra nitida* (9 individuals, 6.77% abundance). SIMPER analysis revealed *Prionospio* sp., *Magelona minuta, Nephtys incisa, Levinsenia gracilis, Abra nitida, Eudorella truncatula* and *Goneplax rhomboides* as the characterizing species of this group. SIMPER results are presented in Appendix 4.

Magelona minuta, Eudorella trucatula and *Goneplax rhomboides* are very sensitive to organic enrichment and present under unpolluted conditions. *Nephtys incisa* is indifferent to enrichment, typically present in low densities with non-significant variations over time. *Abra nitida* and *Levinsenia gracilis* are tolerant to excess organic enrichment, they occur under normal conditions but their populations are stimulated by organic enrichment. *Prionospio* sp. is a second order opportunistic species which are adapted to slight to pronounced unbalanced conditions. The number of taxa and individuals were below average. Diversity was medium to high within this group. The stations within this group broadly conform to the biotope SS.SMu.OMu.LevHet *Levinsenia gracilis* and *Heteromastus filiformis* in offshore circalittoral mud and sandy mud and the EUNIS biotope A5.375.

Group c contained the stations S5, S15 and S31 and had a within group similarity of 42.39%. This group contained 74 taxa comprising 814 individuals. Of the 74 taxa, 37 were present twice or less. Four species accounted for almost 59% of the faunal abundance of this group; the gastropod *Turritella communis* (327 individuals, 40.17%), the bivalve *Abra nitida* (43 individuals, 5.28% abundance), the brittlestar *Amphiura filiformis* (66 individuals, 8.11% abundance) and the amphipod *Abludomelita obtusata* (41 individuals, 5.04% abundance). SIMPER analysis revealed *Diplocirrus glaucus, Abludomelita obtusata, Nephtys* sp. (juv), *Cylichna cylindracea, Chamelea striatula, Abra nitida* and *Turritella communis* as the characterizing species of this group. SIMPER results are presented in Appendix 4. *Diplocirrus glaucus* and *Chamelea striatula* are very sensitive to organic enrichment and present under unpolluted conditions. *Nephtys* sp. (juv), *Turritella communis*, *Cylichna cylindracea* and *Amphiura filiformis* are indifferent to enrichment, typically present in low densities with non-significant variations over time. *Abludomelita obtusata* and *Abra nitida* are tolerant to excess organic enrichment, they occur under normal conditions but their populations are stimulated by organic enrichment. The number of taxa and individuals were high in this group. Diversity ranged from low to high. The stations within this group broadly conform to the JNCC biotope SS.SMu.CSaMu.AfilKurAnit *Amphiura filiformis, Kurtiella bidentata* and *Abra nitida* in circalittoral sandy mud and the EUNIS biotope A5.351. This *Amphiura* community [the 'Boreal offshore muddy sand association' of Jones 1950] is present in offshore sandy muds at shallow to moderate depths (15 m to 100 m) and typically including the brittle-star *Amphiura filiformis*, the urchin *Echinocardium cordatum* and the tower shell *Turritella communis*.

Group d contained the stations S13, S21 and S26 and had a within group similarity of 26.04% and separated from Groups b and c at a 16.66% similarity level. This group contained 97 taxa comprising

4,949 individuals. Of the 97 taxa, 50 were present twice or less. Seven species accounted for just under 49% of the faunal abundance of this group; the polychaetes *Scoloplos armiger* (53 individuals, 10.73% abundance), *Lumbrineris cingulata* aggregate (35 individuals, 7.09% abundance), *Diplocirrus glaucus* (27 individuals, 5.47% abundance), the brittlestar *Ophiura* sp. (juv) (42 individuals, 8.5% abundance), the bivalve *Thracia phaseolina* (37 individuals, 7.49% abundance), Nemertea (indet)(24 individuals, 4.86% abundance) and Nematoda (22 individuals, 4.45% abundance). SIMPER analysis revealed *Ampelisca typica, Euspira nitida, Lumbrineris cingulata* aggregate, Nemertea (indet) and Veneridae (juv) are the characterising species of this group. SIMPER results are presented in Appendix 4. *Ampelisca typica* and Veneridae (juv) are very sensitive to organic enrichment and present under unpolluted conditions. *Euspira nitida* and *Lumbrineris cingulata* aggregate are indifferent to enrichment, typically present in low densities with non-significant variations over time. Nemertea are tolerant to excess organic enrichment, they occur under normal conditions but their populations are stimulated by organic enrichment. Numbers of taxa and individuals in this group were medium to high. The diversity was highest in this group with stations S26 highest, followed by station S21. Effective species numbers indicate that these two stations are more than 3 times more diverse than the least diverse station (CR3). Although the stations within this grouping only had a within group similarity level of 26.04%, they can be broadly said to exhibit elements of the JNCC biotope SS.SCS.CCS.MedLumVen *Mediomastus fragilis, Lumbrineris* spp. and venerid bivalves in circalittoral coarse sand or gravel and the EUNIS biotope A5.142.

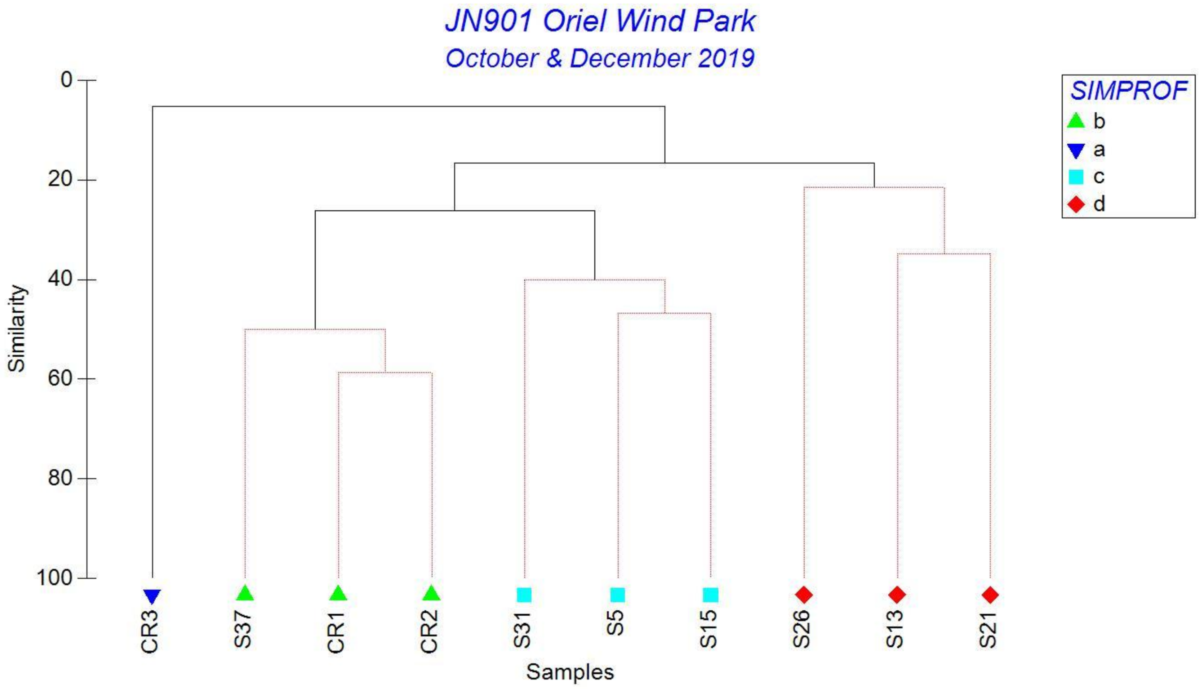

Figure 2.3: Dendrogram produced from Cluster analysis.

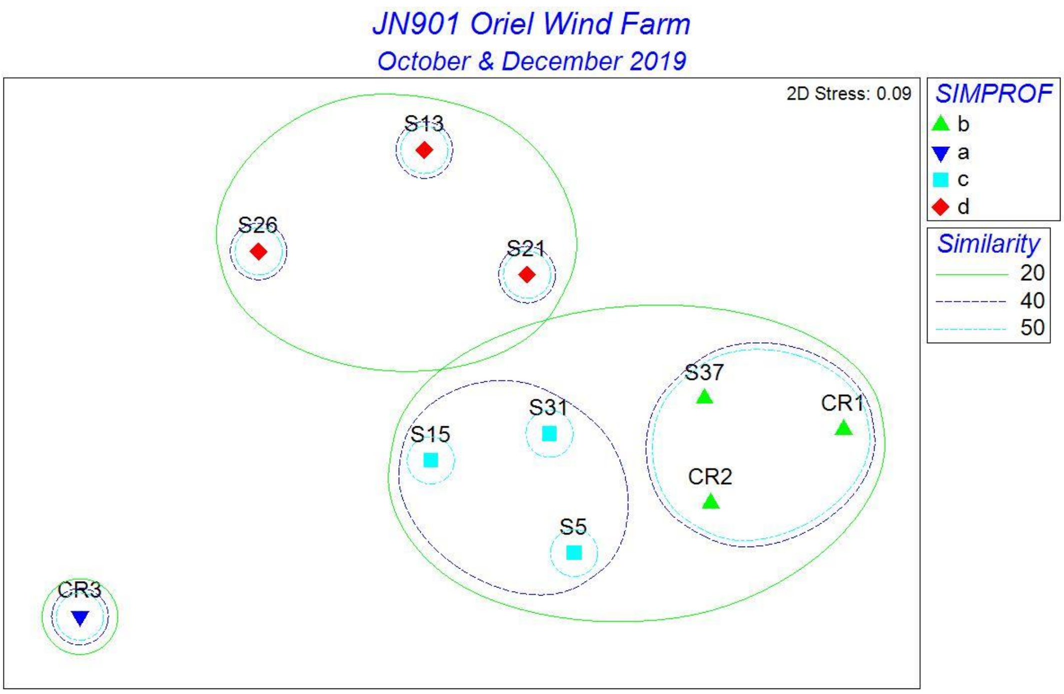

Figure 2.4: MDS plot.

2.2.1.3. AMBI analysis

Table 2.4 shows the AMBI results from the analysis of faunal samples. Stations CR3 was classified as undisturbed. All other stations were classified as slightly disturbed. Figure 2.6 presents histograms of the AMBI results indicating the relative abundance of species based on sensitivities.

Table 2.4: AMBI Results

Stations	I (%)	II (%)	III (%)	IV (%)	V (%)	Not assigned (%)	AMBI	BI from Mean AMBI	Disturbance Classification
CR1	22.22	22.22	19.44	36.11	0	0.00	2.54	2	Slightly disturbed
CR2	29.41	26.47	26.47	17.65	0	0.00	1.99	2	Slightly disturbed
CR3	69.57	17.39	13.04	0.00	0	0.00	0.65	1	Undisturbed
S5	18.07	65.16	16.77	0.00	0	0.00	1.48	2	Slightly disturbed
S13	50.41	15.70	32.23	1.65	0	0.00	1.28	2	Slightly disturbed
S15	17.10	61.29	21.61	0.00	0	0.00	1.57	2	Slightly disturbed
S21	35.02	26.27	36.41	2.30	0	0.00	1.59	2	Slightly disturbed
S26	16.77	64.52	18.07	0.65	0	0.60	1.54	2	Slightly disturbed
S31	8.93	68.88	22.19	0.00	0	0.60	1.70	2	Slightly disturbed
S37	41.27	20.64	28.57	9.52	0	0.00	1.60	2	Slightly disturbed

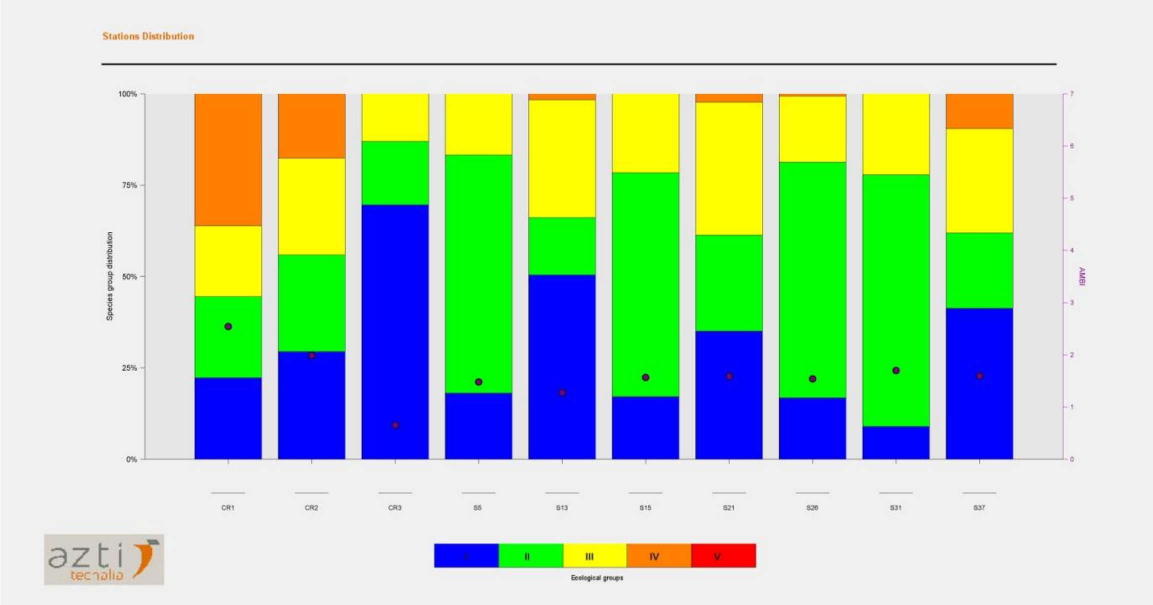

Figure 2.5: AMBI results histogram

2.2.2. Underwater drop down video analysis

<u>Station MC1</u>

Date/ Time: 03/12/2019, 11.22

Video Coordinates: 53.87686°N 6.2063°W

Water Depth: 7m

Station Description: Boulder, cobble and gravel seafloor with canopy of red and brown algae attached to the boulders. The sea urchin, *Echinus esculentus* and the starfish *Asterias rubens* as well as calcareous tube worms and sponges were noted. Figure 2.6 displays the still images of the video transect. The biotope at this station can be broadly classified as IR.MIR.KR Kelp with red seaweeds (moderate infralittoral rock).

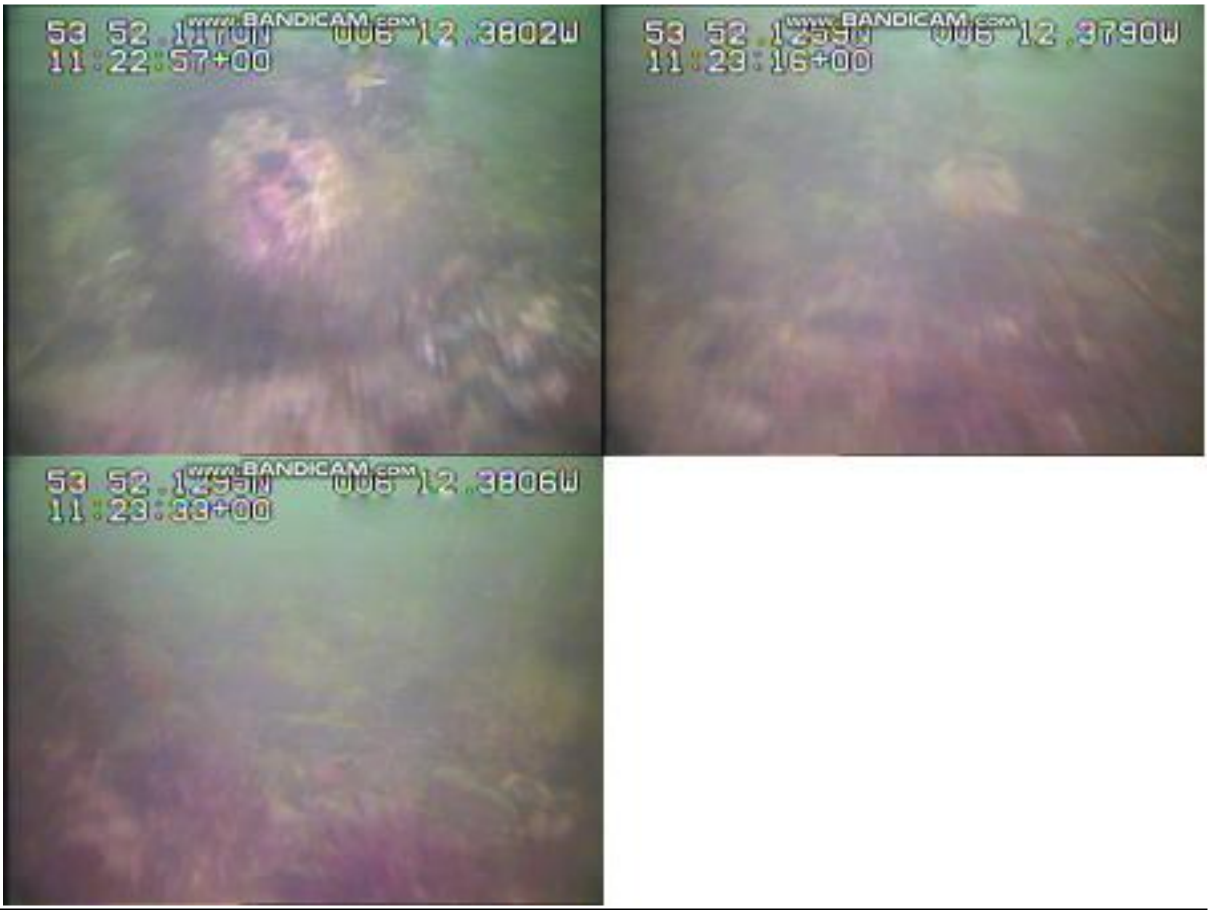

Figure 2.6: Still images from drop down video transect at Station MC1.

Station MC2

Date/ Time: 03/12/2019, 11.50

Video Coordinates: 53.8820°N 6.1995°W

Water Depth: 8m

Station Description: Boulder, cobble and gravel seafloor with canopy of red and brown algae attached to the boulders. The sea urchin, *Echinus esculentus*, the starfish *Asterias rubens,* calcareous tubeworms and sponges were noted as was a shoal of small fish. Figure 2.7 displays the still images of the video transect. The biotope at this station can be broadly classified as IR.MIR.KR Kelp with red seaweeds (moderate infralittoral rock).

Figure 2.7: Still images from drop down video transect at Station MC2.

Station MC3

Date/ Time: 03/12/2019, 11.59

Video Coordinates: 53.8778°N 6.1753°W

Water Depth: 18m

Station Description: Sea floor consists of fine sand formed into small waves. Numerous starfish (*Asterias rubens*) were recorded as were a number of small fish (Gurnard and Cod). Figure 2.8 displays the still images of the video transect.

Figure 2.8: Still images from drop down video transect at Station MC3.

<u>Station MC4</u>

Date/ Time: 03/12/2019, 12.10

Video Coordinates: 53.8795°N 6.1431°W

Water Depth: **25**m

Station Description: Sea floor consists of fine sand formed into small waves. Numerous starfish (*Asterias rubens*) were recorded and a sea pen, *Virgularia mirabilis,* was imaged protruding from the sand. The biotope at this station can be broadly classified as SS.SMu.CSaMu Circalittoral sandy mud. Figure 2.9 displays the still images of the video transect.

Figure 2.9: Still images from drop down video transect at Station MC4.

Station CR4

Date/ Time: 03/12/2019, 11.10

Video Coordinates: 53.8734°N 6.2235°W

Water Depth: 5m

Station Description: A seafloor of fine sand formed into small waves with a light scattering of shell across the surface. No macrofauna or megafauna were observed along this transect. Figure 2.10 displays the still images of the video transect.

Figure 2.10: Still images from drop down video transect at Station CR4.

Station CR3

Date/ Time: 03/12/2019, 11.10

Video Coordinates: 53.8824°N 6.1864°W

Water Depth: 15m

Station Description: Boulder, cobble and gravel seafloor with light sediment cover. Hydroids (*Halecium halecium*), tunicates (*Ascidiella aspersa*), anemones (*Metridium senile*), calcareous tubeworms and sponges were noted attached to suitable substrates. A number of starfish (*Asterias rubens*) were also observed. The biotope observed here has elements of the JNCC SS.SCS.CCS.SpiB *Spirobranchus triqueter* with barnacles and bryozoans crusts on unstable circalittoral cobbles and pebbles (EUNIS A5.141) and SS.SMx.CMx.FluHyd *Flustra foliacea* and *Hydrallmania falcata* on tide-swept circalittoral mixed sediment (EUNIS A5.444). The bottom composition transitioned from coarse stone and cobble to fine sand at 53.8829°N*,* 6.1860°W, where the infaunal grab station CR3 was located. Figure 2.11 displays the still images of the video transect.

Figure 2.11: Still images from drop down video transect at Station CR3

Station CR5

Date/ Time: 03/12/2019, 11.35

Video Coordinates: 53.8533°N 6.2244°W

Water Depth: 6m

Station Description: Seafloor consisting of boulder, cobble and gravel with a canopy of red and brown algae and crustose reds attached to the boulders. The sea urchin, *Echinus esculentus,* and the starfish, *Asterias rubens,* were noted. The biotope at this station can be broadly classified as IR.MIR.KR Kelp with red seaweeds (moderate infralittoral rock). Figure 2.12 displays the still images of the video transect.

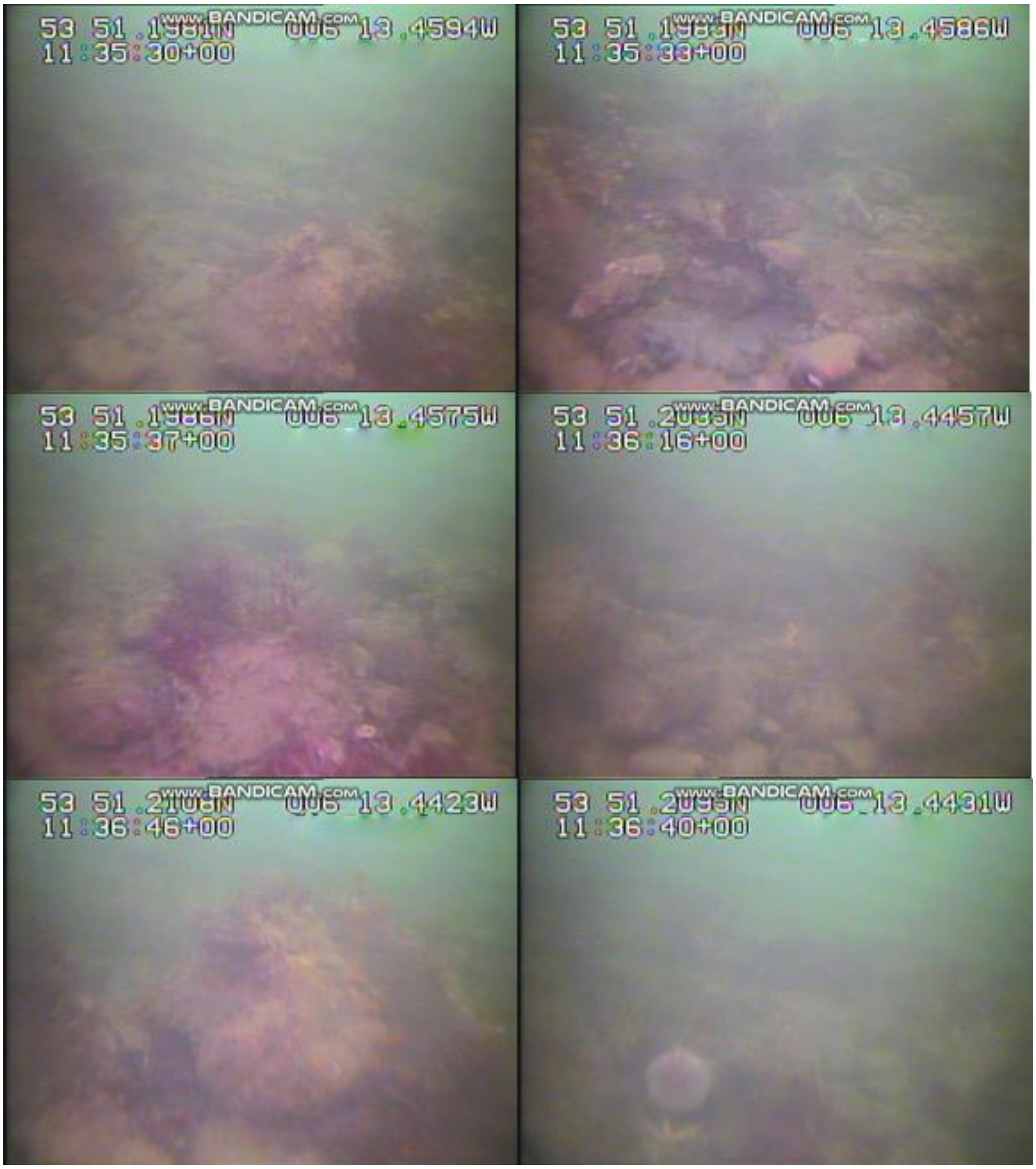

Figure 2.12: Still images from drop down video transect at Station CR5.

Station 26

Date/ Time: 03/12/2019, 09.32

Video Coordinates: 53.9391°N 6.0581°W

Water Depth: 20m

Station Description: A seafloor of fine muddy sand with a scattering of shell and gravel over its surface. No macrofauna or megafauna were observed along this transect. Figure 2.13 displays the still images of the video transect.

Figure 2.13: Still images from drop down video transect at Station 26.

Station 11

Date/ Time: 03/12/2019, 09:20

Video Coordinates: 53.9400°N 6.0875°W

Water Depth: 19m

Station Description: Seafloor with gravel, cobble and boulders with sparse flora or faunal attached. Brittle stars (*Ophiothrix fragilis*) were common. Boulders with cover of crustose corallines. A large starfish (*Luidia ciliaris*) and sea urchin (*Echinus esculentus*) were also imaged. Figure 2.14 displays still images of the video transect. The biotope at this station can be broadly classified as SS.SMx.CMx.Oph.Mx *Ophiothrix fragilis* and/or *Ophiocomina nigra* brittlestar beds on sublittoral mixed sediment (EUNIS classification A5.445).

Figure 2.14: Still images from drop down video transect at Station 11.

Station 13

Date/ Time: 03/12/2019, 10.07

Video Coordinates: 53.9210°N 6.0100°W

Water Depth: 18m

Station Description: A seafloor of fine sand formed into small waves with a light scattering of shell over its surface. No macrofauna or megafauna were observed along this transect. Figure 2.15

displays the still images of the video transect.

Figure 2.15: Still images from drop down video transect at Station 13.

2.2.3. Sediment

Table 2.6 shows the sediment characteristics of the faunal stations in Oriel Wind Farm and cable route. A digital image of each sediment sample can be seen in Appendix 1.

The sediment sampled at Oriel Wind Farm and along the cable route was classified as muddy sand, sand, slightly gravelly sand, slightly gravelly muddy sand and sandy gravel according to Folk (1954). No medium gravel-boulders were recorded. Highest levels of fine gravel, very fine gravel, very coarse sand and coarse sand were observed at S26 (21.3%, 26.5%, 21.6% and 24.6% respectively). Highest levels of medium sand were found at S13 (55.9%). Highest levels of fine sand were found at S15 (74.3%). Highest levels of very fine sand were found at CR1 and CR2 (50.4%) and highest levels of silt-clay at CR1 (28.7%). Figure 2.16 illustrates the sediment type according to Folk (1954) including the sediment type observed along the video transects. Figure 2.17 shows the breakdown of sediment composition at each grab station.

Table 2.6 also displays the organic matter values recorded at each station. Organic matter values ranged from 1.02 (CR3) to 6.01 (S26).

Table 2.5: Sediment characteristics of the faunal stations at Oriel Wind Farm and cable route. LOI refers to the % organic carbon loss on ignition.

Station	>8mm	Fine Gravel (>4mm)	Very Fine Gravel (2-4mm)	Very Coarse Sand (1-2mm)	Coarse Sand (0.5-1mm)	Medium Sand (0.25-0.5mm)	Fine Sand (125-250mm)	Very Fine Sand (62.5-125mm)	Silt-Clay (<63mm)	Folk (1954)	LOI
CR1	0	0	0	0.3	0.9	3	16.8	50.4	28.7	Muddy sand	3.84
CR2	0	0.8	2.2	1.5	0.5	1.4	16.3	50.4	26.9	Slightly gravelly muddy sand	3.99
CR3	0	0	0	0.2	0.4	1.5	54	43.6	0.3	Sand	1.02
S5	0	0	0.3	1.2	5.6	7.6	29.3	37.6	18.3	Muddy sand	3.31
S13	0	0.1	0.5	1.1	8.7	55.9	33.5	0.2	0	Sand	1.05
S15	0	1.7	0.3	0.3	0.5	6.7	74.3	11.9	4.1	Slightly gravelly sand	3.76
S21	0	0.3	1.1	1.7	8.4	0.2	87	0.6	0.7	Slightly gravelly sand	1.64
S26	0	21.3	26.5	21.6	24.6	3.3	1.6	0.6	0.5	Sandy gravel	6.01
S31	0	0.9	0.6	2.2	7.9	14.5	32.4	29	12.4	Slightly gravelly muddy sand	1.25
S37	0	0	0	0.2	0.1	0.8	37.6	40.9	20.3	Muddy sand	2.92

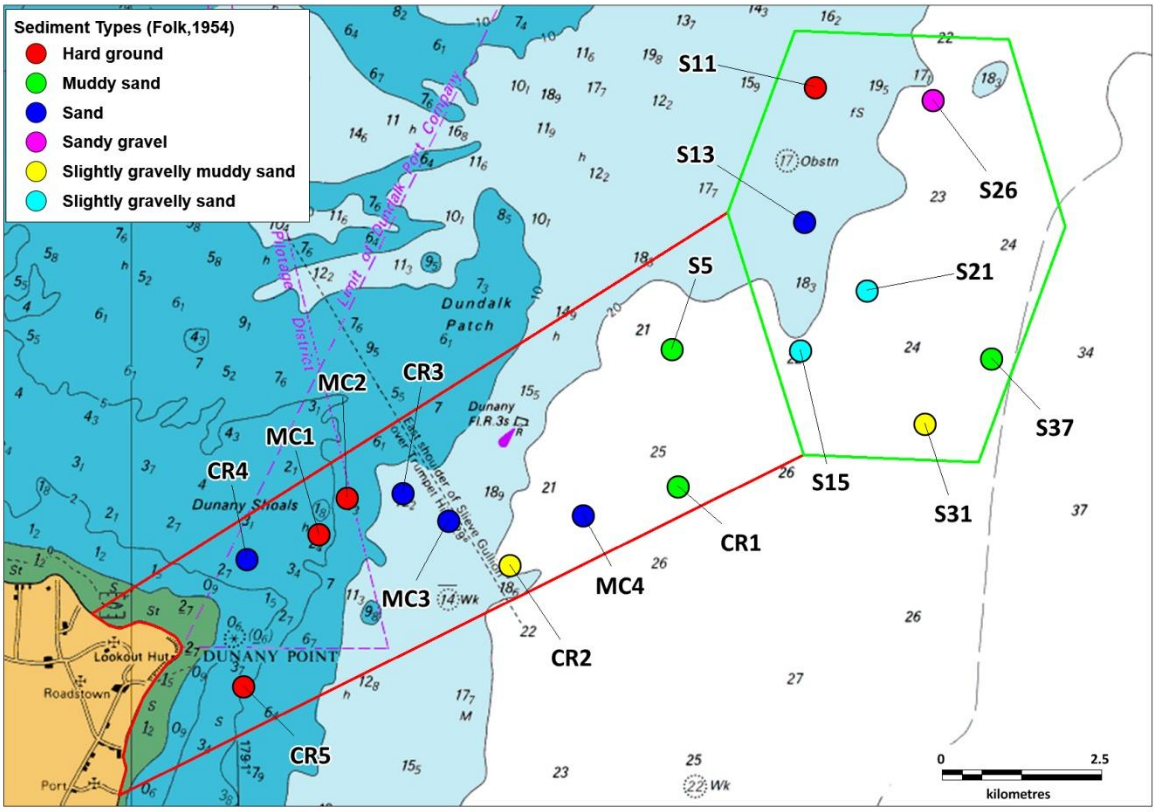

Figure 2.16: Sediment type according to Folk (1954) at Oriel Wind Farm and along the cable route.

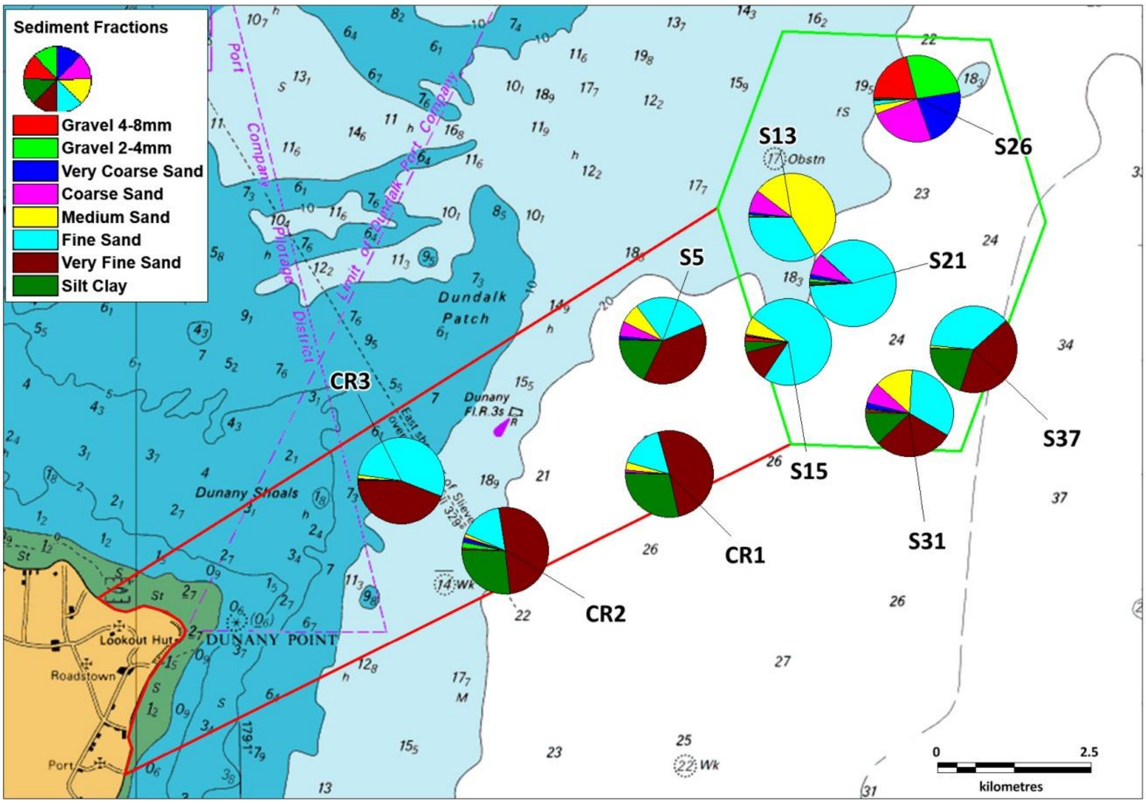

Figure 2.17: A breakdown of sediment type at each grabs station at Oriel Wind Farm and along the cable route.

2.2.4. 2006 Benthic Survey

Table 2.6 below lists the community habitats identified in the stations surveyed in 2006 and re-surveyed during present investigation. Sediment types are categorised according to Folk (1954). A full breakdown of the particle size analysis and % organic carbon from the 2019 survey is presented in section 2.2.3. Stations surveyed along the current proposed cable route were not previously surveyed as alternative cable routes were investigated.

Table 2.6: Comparison of benthic community results from 2006 and 2019 surveys.

Station	2006 Survey			2019 Survey		
	Community	Sediment type (Folk, 1954)	Organic carbon (%)	Community	Sediment type (Folk, 1954)	Organic carbon (%)
S5	*Amphiura* community	Muddy sand	3.8	SS.SMu.CSaMu.AfilKurAnit (*Amphiura* community)	Muddy sand	3.31
S11	Hard Ground	Not sampled	N.A.	SS.SMx.CMx.Oph.Mx Hard Ground (video survey)	Boulders and cobbles	N.A.
S13	Hydroids, *Edwardsia*, *Thracia* sp., *Lumbrineris* sp.	Sand	1.92	SS.SCS.CCS.MedLumVen (including *Lumbrineris, Thracia, Edwardsia*)	Sand	1.05
S15	*Abra* community	Sandy mud	3.91	SS.SMu.CSaMu.AfilKurAnit (*Amphiura* community)	Slightly gravelly sand	3.76
S21	Hydroids, *Edwardsia*, *Thracia*, *Lumbrineris*	Not sampled	1.66	SS.SCS.CCS.MedLumVen (including *Lumbrineris, Thracia, Edwardsia*)	Slightly gravelly sand	1.64
S26	Hydroids, *Edwardsia*, *Thracia*, *Lumbrineris*	Sand	1.85	SS.SCS.CCS.MedLumVen (including *Lumbrineris*)	Sandy gravel	6.01
S31	*Abra* community	Muddy sand	5.96	SS.SMu.CSaMu.AfilKurAnit (*Amphiura* community)	Slightly gravelly muddy sand	1.25
S37	*Amphiura* community	Gravelly muddy sand	3.9	SS.SMu.OMu.LevHet (broad *Amphiura* community)	Muddy sand	2.92

Stations that have changed their community composition in the intervening years since the 2006 survey include S15 and S31. Stations S15 and S31 have changed from an *Abra* community to an

Amphiura community. This is expected considering the change in sediment type recorded – from sandy mud to slightly gravelly sand in the case of S15 and from muddy sand to slightly gravelly sand in the case of S31. The reduction in the silt-clay content and increase in coarse material has an impact on the species composition favouring an *Amphiura* community and reducing the suitability for an *Abra* dominated community.

3. Discussion

Detailed faunal analysis of grab samples within the Oriel Wind Farm site and proposed cable route showed a statistical divide of 4 groups between the stations surveyed. Group a (station CR3) can be classified as SS.SSa.IMuSa.FabMag *Fabulina fabula* and *Magelona mirabilis* with venerid bivalves and amphipods in infralittoral compacted fine muddy sand. This community, the Shallow *Venus* community [the 'Boreal offshore sand association' of Jones 1950] has been previously recorded in this area by Mackie (1990). Group b (stations CR1, CR2 and S37) can be classified as SS.SMu.OMu.LevHet *Levinsenia gracilis* and *Heteromastus filiformis* in offshore circalittoral mud and sandy mud, and its sensitivity to disturbance is considered by MarLIN (The Marine Life Information Network – www.marlin.ac.uk) in conjunction with a broad array of *Amphiura* dominated biotopes. Group c (stations S5, S15 and S31) can be classified as SS.SMu.CSaMu.AfilKurAnit *Amphiura filiformis, Kurtiella bidentata* and *Abra nitida* in circalittoral sandy mud. This community, the *Amphiura* community [the 'Boreal offshore muddy sand association' of Jones 1950] is present in offshore sandy muds and has been previously recorded in this area by Mackie (1990) as well as the previous Oriel Benthic survey (2006). Group d (stations S13, S21 and S26) did not form a statistically meaningful group but can be broadly considered as belong to a community similar to SS.SCS.CCS.MedLumVen *Mediomastus fragilis, Lumbrineris* spp. and venerid bivalves in circalittoral coarse sand or gravel.

MarLIN classifies the sensitivity of the SS.SSa.IMuSa.FabMag community to smothering and siltation rate change to be low with a high recoverability. The broad *Amphiura* communities are classified as not sensitive to smothering and siltation. SS.SCS.CCS.MedLumVen community is also classified as having low sensitivity and high recoverability to smothering and siltation.

Species richness and diversity were highest in the stations with the higher gravel content and lowest in CR3 which had the highest fine sand and very fine sand content. AMBI results from the analysis of the faunal classified stations CR3 as undisturbed. All of the remaining grab stations were classified as slightly disturbed.

The underwater drop down video survey was carried out in areas it was suspected that hard ground would hinder a grab survey. These included seven stations within the cable route area and four stations within Oriel Wind Farm boundaries. Five video station transects revealed hard ground: MC1, MC2, CR3, CR5 and S11. Stations MC1, MC2 and CR5 can be broadly classified as IR.MIR.KR Kelp with red seaweeds (moderate energy infralittoral rock). This biotope is classified by MarLIN as not sensitive to smothering and siltation with a high recoverability. Station CR3 transect is classified as having elements of SS.SCS.CCS.SpiB *Spirobranchus triqueter* with barnacles and bryozoans crusts on unstable circalittoral cobbles and pebbles (EUNIS A5.141) and SS.SMx.CMx.FluHyd *Flustra foliacea a*nd *Hydrallmania falcata* on tide-swept circalittoral mixed sediment and transitions into the SS.SSa.IMuSa.FfabMag *Fabulina fabula* and *Magelona mirabilis* with venerid bivalves and amphipods in infralittoral compacted fine muddy sand where the grab station for CR3 was taken. These are classified by MarLIN as having a no sensitivity and high recoverability to smothering and siltation. S11 transect is classified as SS.SMx.CMx.Oph.Mx *Ophiothrix fragilis* and/or *Ophiocomina nigra* brittlestar beds on sublittoral mixed sediment. MarLIN classifies this biotope as having a medium sensitivity and recoverability to smothering and siltation indicating a low resilience to impact.

The last benthic survey of the Oriel Wind Farm site was conducted in 2006. At that time, 44 grab stations both inside and outside of the wind farm boundaries were surveyed. In addition, two potential cable routes which followed different routes to the current proposed route were surveyed. The findings of the benthic survey indicated that “While all the wind farm faunal groups identified differed with respect to their dominant species, they all contained characteristics of assemblages documented from the Irish Sea. Two communities from Jones (1950) “Boreal Offshore Muddy Sand Association’, the *Amphiura* community and the *Abra* community. The *Amphiura* community occurs in offshore muddy sands at shallow to moderate depths (5-30m). Typical species include the brittlestar *Amphiura filiformis*, the urchin *Echinocardium cordatum* and the tower shell *Turritella communis.* This group is common in the Irish Sea between Ireland and the Isle of Man. The *Abra* community occurs in small pockets in shallow (5-30m) nearshore muddy sands/muds with rich organic contents. Typical species include the bivalve mollusc *Abra alba* and the polychaete *Lagis koreni.* Elements of Jones (1950) “Boreal Offshore Sand Association’ were also observed. This community occurs in shallow (5-40m) nearshore sands. Dominants of this community range from the bivalve molluscs *Chamelea gallina* and *Fabulina fabula* to the polychaetes *Magelona mirabilis and*

Nephtys cirrosa. This community is widely distributed around the Irish Sea coastline. Mackie (1990) also described these communities from this area." (AQUAFACT, 2007).

Since the 2006 survey, two stations have change in their sediment composition and benthic community types – stations S15 and S31. Both of these stations have experienced an increase in coarse sediment and a reduction in silt-clay content. As a result, these stations have switched from an *Abra* community to an *Amphiura* community. In the 2006 survey, 9 stations were identified as having an *Abra* community (S15, S16, S17, S30, S31, S32, S38, S39 and S43). These stations were located in the south east of the wind farm site. It is unknown whether the stations other than S15 and S31 have also experienced changes in granulometry and community type but both *Abra* and *Amphiura* communities are common throughout the Irish Sea.

4. Conclusions

The communities and biotopes identified in the infaunal and video surveys are widely distributed around the Irish Sea coastline and have been identified previously from the area. Diversity and abundance of fauna was higher in the wind farm area than in the area surrounding the proposed cable route. The Marine Life Information Network (MarLIN) initiative in the UK considers the characterising species of the majority of the biotopes identified in the present study as having a low to no sensitivity to smothering. Recovery will either be immediate or within a few weeks to six months. Sensitivity to substratum loss is moderate (the habitat or species is very adversely affected by an external factor arising from human activities or natural events, but is expected to take more than 1 year or up to 10 years to recover). The SS.SMx.CMx.Oph.Mx community at S11 identified as having a medium sensitivity to smothering and siltation indicating a likely return to pre-impact conditions within 2-10 years.

The species recorded in the study area are commonly found along the east coast of Ireland. None of the species recorded in the proposed wind farm area or proposed cable routes are uncommon, rare or protected.

5. References

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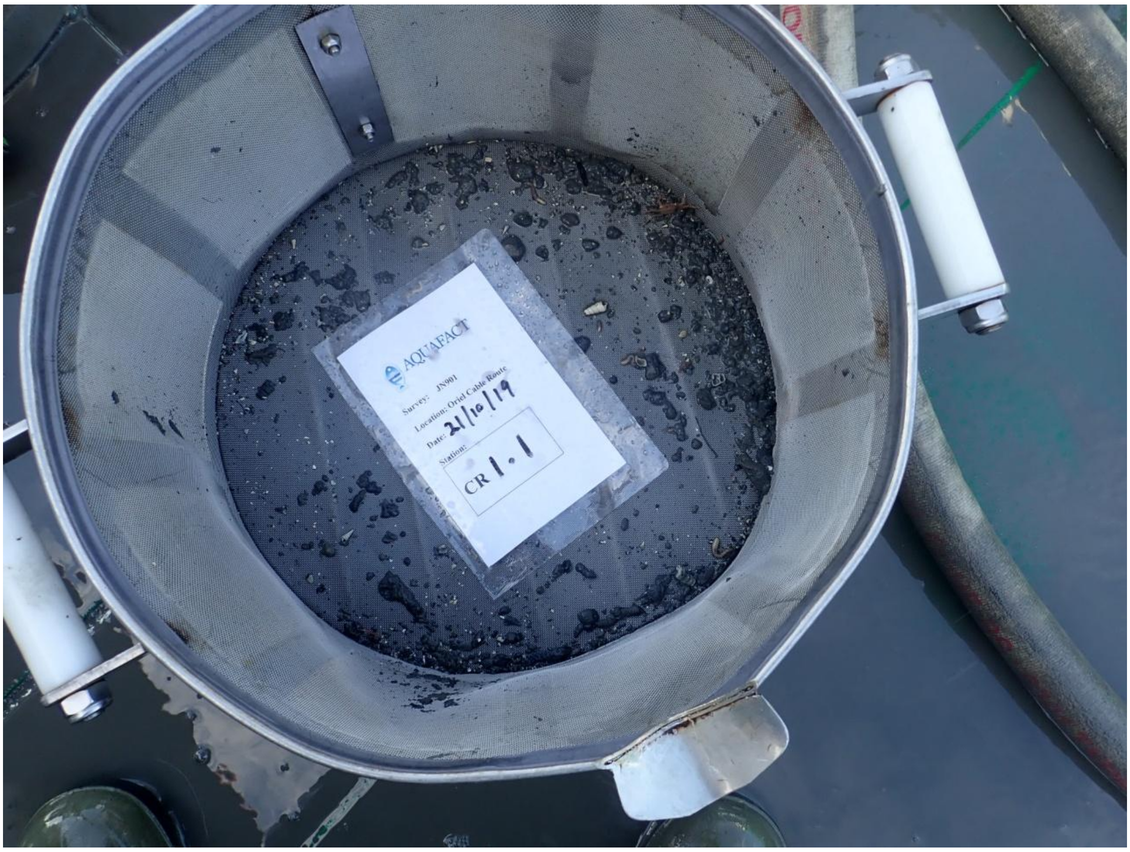
APPENDIX 1 PHOTOGRAPHIC LOG

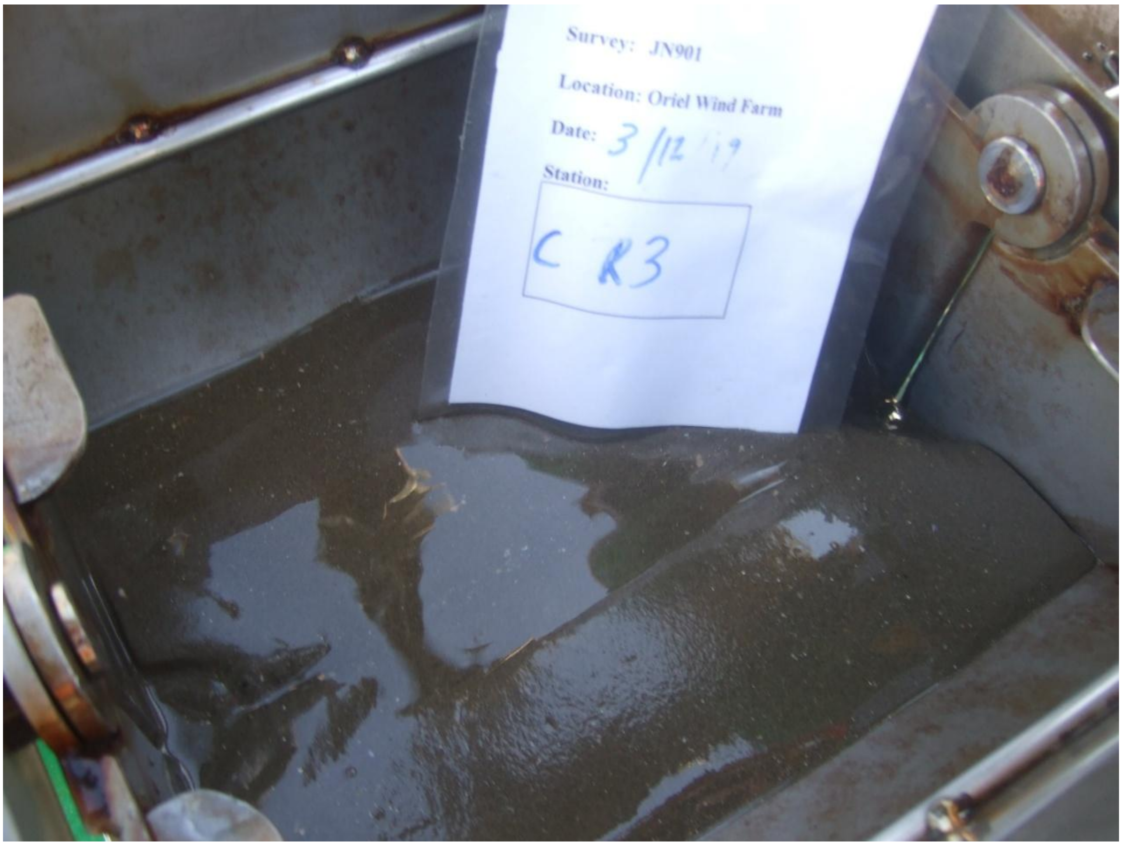
CR1- Grab



CR1 – Sieve

CR2 – Grab

CR2 – Sieve



CR3 – Grab

CR3 – Sieve

Stn 5 – Grab

Stn 5 – Sieve

Stn 11 – Grab

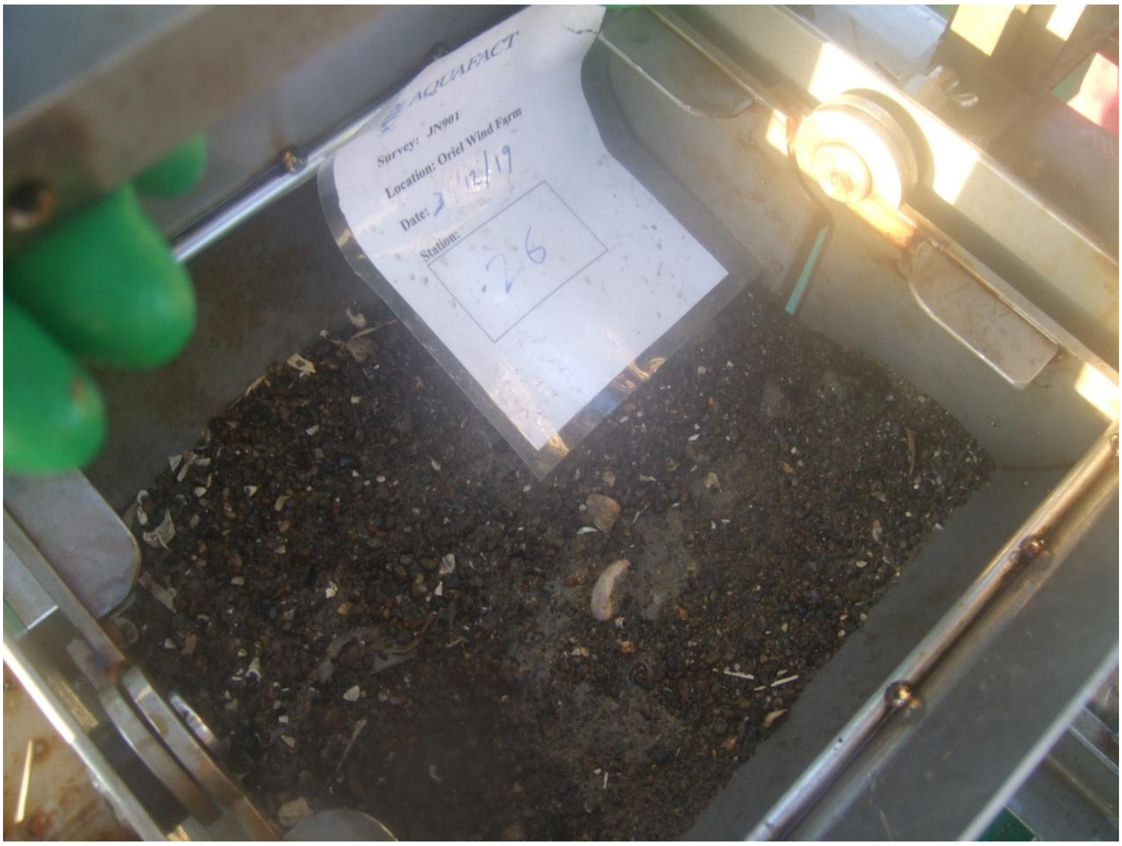
Stn 13 – Sieve

Stn 15 – Grab

Stn 15 – Sieve

Stn 21 – Grab

Stn 21 – Sieve



Stn 26 – Grab

Stn 31 – Grab

Stn 31 – Sieve

Stn 37 – Grab


AQUAFACT
Survey: JN901
Location: Oriel Wind Farm
Date: 21/10/19
Station:
Stn 37.1

Stn 37 – Sieve

APPENDIX 2 SEDIMENT ANALYSIS

AQUAFACT carry out the granulometric analysis using the traditional granulometric technique. We have all of the necessary equipment required *e.g.* Wentworth graded sieves, Easysize computer software, hydrogen peroxide, sodium hexametaphosphate, drying oven, beakers, mixers, electronic scales. We have carried out sediment analysis for all subtidal sampling programmes that we have been involved in.

AQUAFACT employ the following methodology for the granulometric analysis:

1. Approximately 100g of dried sediment (previously washed in distilled water and dried) is weighed out and placed in a labelled 1L glass beaker to which 100ml of a 6 percent hydrogen peroxide solution is then added. This is allowed to stand overnight in a fume hood.
2. The beaker is placed on a hot plate and heated gently. Small quantities of hydrogen peroxide are added to the beaker until there is no further reaction. This peroxide treatment removes any organic material from the sediment which can interfere with grain size determination.
3. The beaker is then emptied of sediment and rinsed into a 63µm sieve. This is then washed with distilled water to remove any residual hydrogen peroxide. The sample retained on the sieve is then carefully washed back into the glass beaker up to a volume of approximately 250ml of distilled water.
4. 10ml of sodium hexametaphosphate solution is added to the beaker and this solution is stirred for ten minutes and then allowed to stand overnight. This treatment helps to dissociate the clay particles from one another.
5. The beaker with the sediment and sodium hexametaphosphate solution is washed and rinsed into a 63µm sieve. The retained sampled is carefully washed from the sieve into a labelled aluminium tray and placed in an oven for drying at 100ºC for 24 hours.
6. The dried sediment should then be passed through a Wentworth series of analytical sieves (>8,000 to 63µm; single phi units). The weight of material retained in each sieve is weighed and recorded. The material passing through the 63µm sieve is also weighed and the value added to the value measured in Point 5 above.
7. The total silt/clay fraction is determined by subtracting all weighed fractions from the initial starting weight of sediment as the less than 63µm fraction was lost during the various washing stages.
8. The reporting of sediment samples will be as percentages within the following range of particle sizes:

- PSA % <63
- PSA % 63<125
- PSA % 125<250
- PSA % 250<500
- PSA % 500<1000
- PSA % 1000<2000
- PSA % 2000<4000
- PSA % 4000<8000
- PSA % ≥8000

The grain size data will be used to determine Folk (1954) classification, which is standard in all AQUAFACT's reports.

The organic matter (Loss on Ignition) is carried out by ALS Labs in Loughrea using the following methodology:

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

APPENDIX 3 SPECIES INVENTORY

JN 901 Oriel Nov Dec 2019											
Station	**AphiaID**	**CR1**	**CR2**	**CR3**	**STN 5**	**STN 13**	**STN 15**	**STN 21**	**STN 26**	**STN 31**	**STN 37**
CNIDARIA	1267										
ANTHOZOA	1292										
Cerianthidae	100684										
Cerianthus lloydii	283798					1					
ACTINIARIA	1360										
Actiniaria (indet)	1360				6		6			5	
Edwardsiidae	100665										
Edwardsia claparedii	100880					2		5			
NEMATODA	799										
Nematoda	799				1			14	8	3	3
NEMERTEA	152391										
Nemertea (indet)	152391					3	1	19	2	3	1
Nemertea sp. B	152391					1					
Tubulanidae	122321										
Tubulanus polymorphus	122637	1	2					2		2	
Lineidae	122314										
Cerebratulus sp. (damaged)	122348						3	1			
SIPUNCULA	1268										
Golfingiidae	2032										
Golfingia sp. (juv)	1648				1						
Thysanocardia procera	136063									2	
Phascolionidae	1647										
Phascolion (Phascolion) strombus strombus	410749						1				
ANNELIDA	882										
POLYCHAETA	883										
PHYLLODOCIDA	892										

JN 901 Oriel Nov Dec 2019											
Station	**AphiaID**	**CR1**	**CR2**	**CR3**	**STN 5**	**STN 13**	**STN 15**	**STN 21**	**STN 26**	**STN 31**	**STN 37**
Aphroditidae	938										
Aphrodita aculeata	129840								3		
Polynoidae	939										
Harmothoe sp. (damaged)	129491								1	2	
Pholoidae	941										
Pholoe inornata	130601	2			1						1
Pholoe baltica (sensu Petersen)	130599		1				23	1	13	10	
Sigalionidae	943										
Sthenelais limicola	131077							2			
Phyllodocidae	931										
Eteone longa aggregate	130616					2	1		2		
Eumida bahusiensis	130641								1		
Pseudomystides limbata	130683								1		
Phyllodoce mucosa	334512							1			
Phyllodoce rosea	334514								1		
Glyceridae	952										
Glycera sp. (damaged)	129296								2		
Glycera lapidum aggregate	130123					1			7		
Glycera tridactyla	130130			1					1		
Glycera unicornis	130131									1	
Goniadidae	953										
Goniada maculata	130140									1	
Goniadella gracilis	130145								6		
Sphaerodoridae	957										
Ephesiella abyssorum	131081								1		
Hesionidae	946										

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Station	**AphiaID**	**CR1**	**CR2**	**CR3**	**STN 5**	**STN 13**	**STN 15**	**STN 21**	**STN 26**	**STN 31**	**STN 37**
Hesionidae (damaged)	946									1	
Oxydromus flexuosus	710680						1				
Podarkeopsis helgolandicus	130197									1	2
Pilargidae	15009										
Litocorsa stremma	130697							1		6	1
Syllidae	948										
Syllis cornuta	157583								1		
Syllis mauretanica	766393								1		
Streptosyllis websteri	131402							2			
Exogone naidina	327985						3				
Nephtyidae	956										
Nephtys sp. (juv)	129370		1		6		1	1		1	1
Nephtys cirrosa	130357			3		3		1			
Nephtys hombergii	130359				2		6	2			
Nephtys incisa	130362	3	2		1					1	8
Nephtys kersivalensis	130363								1		
EUNICIDA	895										
Lumbrineridae	967										
Lumbrineris cingulata aggregate	130240					8		20	7	6	
Lumbrineris latreilli	130248								7		
Abyssoninoe hibernica	146469										1
Dorvilleidae	971										
Protodorvillea kefersteini	130041								3		
ORBINIIDA	884										
Orbiniidae	902										
Scoloplos armiger	130537					22	1	31			

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Station	**AphiaID**	**CR1**	**CR2**	**CR3**	**STN 5**	**STN 13**	**STN 15**	**STN 21**	**STN 26**	**STN 31**	**STN 37**
Paraonidae	903										
Levinsenia gracilis	130578	3	2							3	5
Paradoneis lyra	130585							1	1	1	
SPIONIDA	889										
Spionidae	913										
Spionidae (damaged)	913		1								
Aonides oxycephala	131106					2			4		
Laonice cirrata	131128								1		
Prionospio sp. (damaged)	129620	10	3					1			6
Prionospio fallax	131157	3	3					1			
Prionospio multibranchiata	131160										1
Scolelepis sp. (damaged)	129623	1									1
Spio symphyta	596189			1							
Magelonidae	914										
Magelona alleni	130266									4	
Magelona filiformis	130268							2			1
Magelona minuta	130270	5	3		1					3	10
Magelona johnstoni	130269			1							
CAPITELLIDA	890										
Capitellidae	921										
Mediomastus fragilis	129892					2			2	1	
Notomastus latericeus	129898									1	1
OPHELIIDA	891										
Opheliidae	924										
Ophelia borealis	130491					3					
Scalibregmatidae	925										

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Station	**AphiaID**	**CR1**	**CR2**	**CR3**	**STN 5**	**STN 13**	**STN 15**	**STN 21**	**STN 26**	**STN 31**	**STN 37**
Scalibregma inflatum	130980								3	16	
TEREBELLIDA	900										
Cirratulidae	919										
Chaetozone setosa	129955							2			
Flabelligeridae	976										
Diplocirrus glaucus	130100		1		1		2	27		3	2
Acrocirridae	920										
Macrochaeta clavicornis	129745								1		
Pectinariidae	980										
Lagis koreni	152367								1		
Ampharetidae	981										
Melinna palmata	129808		1								
Ampharete lindstroemi aggregate	129781							1			
Trichobranchidae	983										
Terebellides stroemii	131573					1					
Terebellidae	982										
Terebellidae (damaged)	982								1		
Polycirrus sp. (damaged)	129710							1			
SABELLIDA	901										
Oweniidae	975										
Galathowenia oculata	146950						5	1		2	
Owenia borealis	329882					1		14			
ARTHROPODA	1065										
CRUSTACEA	1066										
AMPHIPODA	1135										
Oedicerotidae	101400										

JN 901 Oriel Nov Dec 2019											
Station	**AphiaID**	**CR1**	**CR2**	**CR3**	**STN 5**	**STN 13**	**STN 15**	**STN 21**	**STN 26**	**STN 31**	**STN 37**
Monoculodes carinatus	102882								1		
Perioculodes longimanus	102915					1					
Phoxocephalidae	101403										
Harpinia antennaria	102960							3			
Harpinia crenulata	102963										2
Lysianassidae	101395										
Acidostoma obesum	102497					3					
Ampeliscidae	101364										
Ampelisca sp. (damaged)	101445									1	
Ampelisca typica	101933					5		4	4		
Pontoporeiidae	101406										
Bathyporeia elegans	103058					1					
Melitidae	101397										
Abludomelita obtusata	102788				10		17			14	
Photidae	148558										
Photis longicaudata	102383				15			1			
Aoridae	101368										
Autonoe longipes	102021								2		
Leptocheirus hirsutimanus	102036					1					
Caprellidae	101361										
Pariambus typicus	101857							1			
ISOPODA	1131										
Arcturidae	118280										
Astacilla dilatata	295579						3				
CUMACEA	1137										
Bodotriidae	110378										

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Station	**AphiaID**	**CR1**	**CR2**	**CR3**	**STN 5**	**STN 13**	**STN 15**	**STN 21**	**STN 26**	**STN 31**	**STN 37**
Iphinoe serrata	110460						1			1	1
Leuconidae	110382										
Eudorella truncatula	110535	1	1								1
Diastylidae	110380										
Diastylis sp. (damaged)	110398									1	
Diastylis laevis	110481						2		1		
DECAPODA	1130										
Decapoda larvae	1130									1	
Caridea	106674										
Processidae	106791										
Processa nouveli holthuisi	108344		1								
Nephropidae	106741										
Nephrops norvegicus	107254									1	
Laomediidae	106802										
Jaxea nocturna	107737									2	
PAGUROIDEA	106687										
Porcellanidae	106734										
Pisidia longicornis	107188									1	
BRACHYURA	106673										
Goneplacidae	106757										
Goneplax rhomboides	107292	2	1		3					2	2
MOLLUSCA	51										
GASTROPODA	101										
Turritellidae	127										
Turritella communis	141872				74		50	1		203	
LITTORINIMORPHA	382213										

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Station	**AphiaID**	**CR1**	**CR2**	**CR3**	**STN 5**	**STN 13**	**STN 15**	**STN 21**	**STN 26**	**STN 31**	**STN 37**
Rissoidae	123										
Alvania sp. (damaged)	138439									1	
Iravadiidae	122										
Hyala vitrea	140129									5	
Naticidae	145										
Euspira nitida	151894					1	1	1	1		
Eulimidae	135										
Eulima glabra	139805						7				
Nassariidae	151										
Tritia sp. (juv)	246140									1	
Mangeliidae	153853										
Sorgenfreispira brachystoma	847930						3				4
Pyramidellidae	162										
Odostomia sp. (juv)	138413				2					3	
Acteonidae	155										
Acteon tornatilis	138691					2		5			
CEPHALASPIDEA	154										
Cylichnidae	159										
Cylichna cylindracea	139476		1		1		7	3		1	
Philinidae	161										
Philine quadripartita	574582					1					
Diaphanidae	1750										
Diaphana minuta	139557								2		
SCAPHOPODA	104										
DENTALIIDA	200										
Dentallidae	202										

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Station	**AphiaID**	**CR1**	**CR2**	**CR3**	**STN 5**	**STN 13**	**STN 15**	**STN 21**	**STN 26**	**STN 31**	**STN 37**
Antalis entalis	150534						2				
BIVALVIA	105										
NUCULIDA	382247										
Nuculidae	204										
Nucula sp. (juv)	138262			6			8				
Nucula nitidosa	140589			3	2	1	4			1	
Nucula nucleus	140590							4		2	
MYTILIDA	210										
Mytilidae	211										
Mytilidae (juv)	211			2							
Musculus subpictus	506128							1			
Lucinidae	218										
Lucinoma borealis	140283							1			
Thyasiridae	219										
Thyasira sp. (juv)	138552							1			
Thyasira flexuosa	141662		2		3		1		2	2	1
IMPARIDENTIA	869600										
Lasaeidae	222										
Kurtiella bidentata	345281				2		30		3		
Mactridae	230										
Spisula subtruncata	140302		1								
Tellinidae	235										
Fabulina fabula	146907			5					1		
Moerella donacina	147021								1		
Psammobiidae	237										
Gari fervensis	140870					5					

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Station	**AphiaID**	**CR1**	**CR2**	**CR3**	**STN 5**	**STN 13**	**STN 15**	**STN 21**	**STN 26**	**STN 31**	**STN 37**
Semelidae	1781										
Abra sp. (juv)	138474	1									
Abra alba	141433										
Abra nitida	141435	2	3		10	4	8	2		25	4
VENERIDA	217										
Veneridae	243										
Veneridae (juv)	243		2			14	2	2	1		2
Chamelea striatula	141908			1	1		14	2		1	
Clausinella fasciata	141909								3		
Dosinia sp. (juv)	138636				1		4	6	1		
Dosinia lupinus	141912					1	1				
MYIDA	245										
Corbulidae	248										
Corbula gibba	139410					2					
Hiatellidae	251										
Hiatella arctica	140103				2		1				
ANOMALODESMATA	254										
Thraciidae	256										
Thracia sp. (juv)	138549						1				
Thracia phaseolina	152378					21		16			
PHORONIDA	1789										
Phoronidae	148378										
Phoronis sp.	128545	1	2		6		17		1	1	
ECHINODERMATA	1806										
ASTEROIDEA	123080										
Asteroidea (juv)	123080					1	1				

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Station	**AphialD**	**CR1**	**CR2**	**CR3**	**STN 5**	**STN 13**	**STN 15**	**STN 21**	**STN 26**	**STN 31**	**STN 37**
FORCIPULATIDA	123086										
Asteriidae	123121										
Asterias rubens	123776								1		
OPHIUROIDEA	123084										
OPHIURIDA	123117										
Amphiuridae	123206										
Amphiuridae (juv)	123206	1				1	5	5			1
Amphiura filiformis	125080				2		64	3			
Ophiuridae	123200										
Ophiura sp. (juv)	123574								42		
ECHINOIDEA	123082										
CLYPEASTEROIDA	123100										
Echinocyamidae	510679										
Echinocyamus pusillus	124273					3					
SPATANGOIDA	123106										
Loveniidae	123175										
Echinocardium cordatum	124392						1				
Echinocardium flavescens	124394					1					
HOLOTHUROIDEA	123083										
DENDROCHIROTIDA	123111										
Phyllophoridae	123188										
Thyone fusus	124670							1	5		
Cucumariidae	123187										
Oncus planci	124647				1						
APODIDA	123108										
Synaptidae	123182										

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Station	**AphiaID**	**CR1**	**CR2**	**CR3**	**STN 5**	**STN 13**	**STN 15**	**STN 21**	**STN 26**	**STN 31**	**STN 37**
Leptosynapta sp. (damaged)	123449						1		1		
CHORDATA	1821										
TUNICATA	146420										
ASCIDIACEA	1839										
Ascidiidae	103443										
Ascidiella aspersa	103718							1			
PISCES	11676										
PERCIFORMES	11014										
Ammodytidae	125516										
Ammodytes tobianus	126752					1					

APPENDIX 4 SIMPER ANALYSIS

Table 1: SIMPER analysis of Group b fauna.

Group b Average similarity: 52.98					
Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Prionospio sp. (damaged)	1.55	6.17	6.4	11.66	11.66
Magelona minuta	1.53	6.07	6.84	11.47	23.12
Nephtys incisa	1.4	5.44	7.02	10.27	33.39
Levinsenia gracilis	1.33	5.44	7.02	10.27	43.65
Abra nitida	1.31	5.42	9.6	10.23	53.88
Goneplax rhomboides	1.13	4.69	6.4	8.86	62.74
Eudorella truncatula	1	4.42	6.95	8.34	71.08
Prionospio fallax	0.88	2.24	0.58	4.23	75.31
Tubulanus polymorphus	0.73	1.7	0.58	3.21	78.52
Phoronis sp.	0.73	1.7	0.58	3.21	81.73
Veneridae (juv)	0.79	1.52	0.58	2.88	84.61
Pholoe inornata	0.73	1.44	0.58	2.71	87.32
Scolelepis sp. (damaged)	0.67	1.44	0.58	2.71	90.03

Table 2: SIMPER analysis of Group c fauna.

Group c Average similarity: 42.39					
Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Turritella communis	3.12	5.69	6.08	13.42	13.42
Abludomelita obtusata	1.91	3.76	11.52	8.87	22.29
Abra nitida	1.9	3.54	6.74	8.36	30.65
Actiniaria (indet)	1.54	3.14	6.8	7.4	38.05
Phoronis sp.	1.53	2.48	2.74	5.86	43.91
Nucula nitidosa	1.2	2.2	4.86	5.2	49.12
Thyasira flexuosa	1.17	2.2	5.03	5.2	54.31
Diplocirrus glaucus	1.17	2.17	26.64	5.13	59.44
Nephtys sp. (juv)	1.19	2.06	7.59	4.87	64.31
Cylichna cylindracea	1.21	2.06	7.59	4.87	69.18
Chamelea striatula	1.31	2.06	7.59	4.87	74.05
Pholoe baltica (sensu Petersen)	1.32	1.04	0.58	2.45	76.49
Nephtys hombergii	0.92	0.89	0.58	2.09	78.58
Kurtiella bidentata	1.18	0.89	0.58	2.09	80.67
Amphiura filiformis	1.34	0.89	0.58	2.09	82.76
Goneplax rhomboides	0.84	0.88	0.58	2.06	84.83
Odostomia sp. (juv)	0.84	0.88	0.58	2.06	86.89
Dosinia sp. (juv)	0.8	0.74	0.58	1.76	88.65
Hiatella arctica	0.73	0.74	0.58	1.76	90.4

Table 2: SIMPER analysis of Group d fauna.

Group d Average similarity: 26.04					
Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Lumbrineris cingulata aggregate	1.81	3.2	10.63	12.29	12.29
Ampelisca typica	1.44	2.75	11.64	10.56	22.85
Nemertea (indet)	1.53	2.4	8.35	9.21	32.06
Veneridae (juv)	1.37	2.07	6.45	7.96	40.02
Euspira nitida	1	1.94	11.64	7.47	47.48
Scoloplos armiger	1.51	1.45	0.58	5.59	53.07
Thracia phaseolina	1.38	1.34	0.58	5.16	58.23
Nematoda	1.21	0.98	0.58	3.78	62
Eteone longa agg.	0.79	0.82	0.58	3.14	65.15
Aonides oxycephala	0.87	0.82	0.58	3.14	68.29
Mediomastus fragilis	0.79	0.82	0.58	3.14	71.44
Edwardsia claparedii	0.89	0.8	0.58	3.07	74.5
Acteon tornatilis	0.89	0.8	0.58	3.07	77.57
Abra nitida	0.87	0.8	0.58	3.07	80.64
Glycera lapidum agg.	0.88	0.69	0.58	2.64	83.28
Nephtys cirrosa	0.77	0.67	0.58	2.58	85.86
Owenia borealis	0.98	0.67	0.58	2.58	88.44
Amphiuridae (juv)	0.83	0.67	0.58	2.58	91.02