Environmental Impact
Assessment Report

NISA

North Irish Sea Array

Volume 3: Offshore Chapters

Chapter 12

Benthic Subtidal and Intertidal Ecology

Statkraft CIP Copenhagen Infrastructure Partners GoBe APEM Group ARUP

Contents

Tables

12. Benthic Subtidal and Intertidal Ecology

12.1 Introduction

This chapter of the Environmental Impact Assessment Report (EIAR) presents of an assessment of likely significant effects from the North Irish Sea Array (NISA) Offshore Wind Farm (hereafter referred to as the 'proposed development') in relation to benthic subtidal and intertidal ecology during the construction, operation, and decommissioning phases.

This chapter sets out the methodology followed (Section 12.2), describes the baseline environment (Section 12.3) and summarises the main characteristics of the proposed development which are of relevance to benthic subtidal and intertidal ecology (Section 12.4) including any embedded mitigation. Potential impacts and relevant receptors are identified, and an assessment of likely significant effects on subtidal and intertidal benthic ecology is undertaken, details of which are provided in Section 12.5.

Additional measures are proposed to mitigate and monitor these effects if required (Section 12.6) and any residual likely significant effects are then described (Section 12.7). Transboundary effects are considered (Section 12.8), and cumulative effects are assessed in Section 12.9 and are summarised in Volume 6, Chapter 38 Cumulative and Inter-Related Effects (hereafter referred to as the 'Cumulative and Inter-Related Effects Chapter'). The chapter then provides a reference section (Section 12.10).

The EIAR also includes the following:

- Detail on the competent experts that have prepared this chapter is provided in Appendix 1.1 in Volume 8;
- Detail on the extensive consultation that has been undertaken with a range of stakeholders during the development of the EIAR is set out in Appendix 1.2; and
- A glossary of terminology, abbreviations and acronyms is provided at the beginning of Volume 2 of the EIAR.

A detailed description of the proposed development including construction, operation and decommissioning is provided in Volume 2, Chapter 6: Description of the Proposed Development – Offshore (hereafter referred to as the 'Offshore Description Chapter') and Volume 2, Chapter 8: Construction Strategy – Offshore (hereafter referred to as the 'Offshore Construction Chapter').

The assessment should be read in conjunction with the following linked EIAR chapters within Volume 3:

- Chapter 10: Marine Geology, Oceanography and Physical Processes (hereafter referred to as the Physical Processes Chapter)
- Chapter 11: Marine Water and Sediment Quality (MW&SQ; hereafter referred to as the MW&SQ Chapter); and
- Chapter 13: Fish and Shellfish Ecology.

This chapter should also be read alongside the following appendices:

- Volume 9, Appendix 12.1: Array Area Benthic Survey Report; and
- Volume 9, Appendix 12.2: Cable Route Benthic Survey Report.

All figures within this Chapter are provided in Volume 7A.

12.2 Methodology

12.2.1 Introduction

The assessments of benthic subtidal and intertidal ecology are consistent with the EIA methodology presented in Volume 2, Chapter 2: EIA and Methodology for the preparation of an EIAR (hereafter referred to as the EIAR Methodology Chapter).

12.2.2 Study Area

The study area defined for the benthic subtidal and intertidal ecology assessment was initially identified at the proposed development scoping stage, in line with Department of Communications, Climate Action and Environment (DCCAE) (now the Department of the Environment, Climate and Communications; DECC) Guidance (DCCAE, 2017) (See Appendix 2.1: Scoping Report). It comprises both subtidal and intertidal components. A risk assessment is needed for each benthic feature that may be impacted by the proposed development. Appropriate data characterising these features are required to establish if impact pathways exist.

The extent of the study area has been determined by reference to the modelled tidal ellipse and sediment plume modelling. This describes the greatest distance over which suspended sediments at concentrations above background levels may be displaced as 12km i.e. the distance at which no elevation above background suspended solids concentrations are observed (see the Physical Processes Chapter).

The offshore elements of the proposed development consist of the array area and offshore export cable corridor (ECC) seaward of the high-water mark (HWM) and are collectively referred to as the 'offshore development area'. The study area (Figure 12.1) has been set with reference to this modelled greatest excursion distance and encompasses both the array area and ECC (as indicated by the offshore development area) and a Zone of Influence (ZoI) extending 12km from the offshore development area. This approach is precautionary and likely to encompass all potential impacts to subtidal and intertidal receptors from the proposed development.

For the purposes of this chapter the benthic study area includes a subtidal component encompassing the offshore development area and a surrounding 12km ZOI, and an intertidal component encompassing the area between HWM to the low water mark (LWM) within the ECC (see Figure 12.6).

12.2.3 Relevant Guidance and Policy

This section outlines guidance and policy specific to benthic subtidal and intertidal ecology, including best practice guidelines. Overarching guidance on EIA is presented in the EIAR Methodology Chapter. Furthermore, policy applicable to the proposed development is detailed in Volume 2, Chapter 3: Legal and Policy Framework.

Site-specific benthic surveys and the assessment of likely significant effects upon benthic subtidal and intertidal ecology has been made with specific reference to the following identified relevant legislation and guidance:

- Guidance on Assigning Benthic Biotopes using EUNIS or the Marine Habitat Classification of Britain and Ireland (Joint Nature Conservation Committee (JNCC), Revised 2019)
- Guidance on Marine Baseline Ecological Assessment and Monitoring Activities for Offshore Renewable Energy Projects Part 1 and 2 (DCCAE, 2018)
- Guidance from the Marine Life Information Network (MarLIN) on assessing habitat sensitivity using Marine Evidence based Sensitivity Assessment (MarESA) and Integrated Mapping for the Sustainable Development of Ireland's Marine Resource (INFOMAR) (MarLIN, 2018)
- Guidelines for Ecological Impact Assessment in the UK and Ireland. Marine and Coastal, Final Document (Chartered Institute of Ecology and Environmental Management (CIEEM), 2018)
- Guidance on Environmental Impact Statement (EIS) and Natura Impact Statements (NIS) Preparation for Offshore Renewable Energy Projects (Barnes, 2017)
- MMO Guidance. Marine Licensing: sediment analysis and sample plans https://www.gov.uk/guidance/marine-licensing-sediment-analysis-and-sample-plans###Suitability%20of%20material;
- Guidelines for data acquisition to support marine environmental assessments of offshore renewable energy projects (Centre for Environment, Fisheries and Aquaculture (Cefas), 2012)
- Guidelines for the Conduct of Benthic Studies at Marine Aggregate Extraction Sites (2nd Edition). (Ware & Kenny, 2011)

- Guidance on Survey and Monitoring in Relation to Marine Renewables Deployments in Scotland Volume 5: Benthic Habitats (Saunders et al., 2011)
- Guidance on Environmental Considerations for Offshore Wind Farm Development (Oil Spill Prevention, Administration and Response (OSPAR, 2008)
- BGS guidance on the similarities between the Folk sediment classification system and EUNIS sediment habitat classification (Long, 2006)
- Guidelines for the assessment of dredge material for disposal in Irish water (Cronin et al., 2006).
- Guidance note for EIA in respect of Food and Environment Protection Act (FEPA) and Coast Protection Act (CPA) requirements (Cefas), 2004)
- Cefas Guidelines for the conduct of benthic studies at aggregate dredging sites https://www.marbef.org/qa/documents/ConductofsurveysatMAEsites.pdf;
- Guidance from the British Geological Survey (BGS) on sediment classification used within BGS sediment maps using the Folk (1954) triangular diagram
- JNCC Marine Monitoring Handbook (Davies et al., 2001); and
- Canadian Sediment Quality Guidelines for the Protection of Aquatic Life https://ccme.ca/en/current-activities/canadian-environmental-quality-guidelines [Accessed September 2023].

The key National Marine Planning Framework (NMPF) policy that is applicable to the assessment of benthic subtidal and intertidal ecology is summarised in Table 12.1. NMPF policies are addressed in their entirety in Appendix 3.1: NMPF Compliance Report.

Table 12.1 Key NMPF policies relevant to the assessment

Policy name	Policy description	Where addressed
National Marine Policy Framework (2021)	Biodiversity Policy 2 Proposals that protect, maintain, restore and enhance the distribution and net extent of important habitats and distribution of important species will be supported, subject to the outcome of statutory environmental assessment processes and subsequent decision by the competent authority, and where they contribute to the policies and objectives of this NMPF. Proposals must avoid significant reduction in the distribution and net extent of important habitats and other habitats that important species depend on, including avoidance of activity that may result in disturbance or displacement of habitats.	Likely significant effects of relevance to Biodiversity Policy 2 are addressed in: • Section 12.5.2.3 Impact 3: Temporary habitat disturbance in array area and ECC. • Section 12.5.3.1 Impact 6: Long-term or permanent subtidal habitat loss/ change from the presence of foundations, scour protection and cable protection. • Section 12.5.4.1 Impact 12: Temporary increase in SSC and sediment deposition; and • Section 12.5.4.2 Impact 13: Temporary habitat disturbance in the array area and ECC.
	Water Quality Policy 1 Proposals that may have significant adverse impacts upon water quality, including upon habitats and species beneficial to water quality, must demonstrate that they will, in order of preference and in accordance with legal requirements: a) avoid, b) minimise, or c) mitigate significant adverse impacts.	Likely significant effects of relevance to Water Quality Policy 1 are addressed in: • Section 12.5.2.1 Impact 1: Temporary increase in SSC and sediment deposition in subtidal habitats. • Section 12.5.2.3 Impact 3: Temporary habitat disturbance in array area and ECC. • Section 12.5.2.4 Impact 4: Reduction in water and sediment quality through release of contaminated sediments and/or accidental contamination; and • Section 12.5.4.1 Impact 12: Temporary increase in SSC and sediment deposition. Marine pollution contingency measures will be implemented as part of Appendix 6.1: Offshore Environmental Management Plan (EMP; hereafter Offshore EMP) to manage the risk of accidental

Policy name	Policy description	Where addressed
		spillages from construction equipment or collision incidents. This would include a chemical risk review with information regarding how and when chemicals are to be used, stored and transported in accordance with recognised best practice guidance. This measure would reduce the likelihood of potentially harmful pollutants to be released into the marine environment which may then impact on fish and shellfish receptors.
	Sea floor and Water Column Integrity Policy 1 Proposals that incorporate measures to support the resilience of marine habitats will be supported, subject to the outcome of statutory environmental assessment processes and subsequent decision by the competent authority and where they contribute to the policies and objectives of this NMPF. Proposals which may have significant adverse impacts on marine, particularly deep sea, habitats must demonstrate that they will, in order of preference and in accordance with legal requirements: a) avoid, b) minimise, or c) mitigate significant adverse impacts on marine habitats, or d) if it is not possible to mitigate significant adverse impacts on marine habitats must set out the reasons for proceeding.	Likely significant effects of relevance to Sea Floor and Water Column Integrity Policy 1 are addressed in: • Section 12.5.2.3 Impact 3: Temporary habitat disturbance in array area and ECC. • Section 12.5.3.1 Impact 6: Long-term or permanent subtidal habitat loss/ change from the presence of foundations, scour protection and cable protection; and • Section 12.5.4.2 Impact 13: Temporary habitat disturbance in the array area and ECC. Mitigation in respect to likely effects is considered in Section 12.4.5.
	Sea floor and Water Column Integrity Policy 2 Proposals, including those that increase access to the maritime area, must demonstrate that they will, in order of preference and in accordance with legal requirements: a) avoid, b) minimise, or c) mitigate adverse impacts on important habitats and species.	Likely significant effects of relevance to Sea Floor and Water Column Integrity Policy 2 are addressed in: • Section 12.5.2.3 Impact 3: Temporary habitat disturbance in array area and ECC • Section 12.5.3.1 Impact 6: Long-term or permanent subtidal habitat loss/ change from the presence of foundations, scour protection and cable protection; and • Section 12.5.4.2 Impact 13: Temporary habitat disturbance in the array area and ECC. Mitigation in respect to likely effects is considered in Section 12.6
	Sea floor and Water Column Integrity Policy 3 Proposals that protect, maintain, restore, and enhance coastal habitats for ecosystem functioning and provision of ecosystem services will be supported, subject to the outcome of statutory environmental assessment processes and subsequent decision by the competent authority, and where they contribute to the policies and objectives of this NMPF. Proposals must take account of the space required for coastal habitats, for ecosystem functioning and provision of ecosystem services, and demonstrate that they will, in order of preference and in accordance with legal requirements: a) avoid, b) minimise, or c) mitigate for net loss of coastal habitat.	Likely significant effects of relevance to Sea Floor and Water Column Integrity Policy 3 are addressed in: • Section 12.5.2.3 Impact 3: Temporary habitat disturbance in array area and ECC • Section 12.5.3.1 Impact 6: Long-term or permanent subtidal habitat loss/ change from the presence of foundations, scour protection and cable protection; and • Section 12.5.4.2 Impact 13: Temporary habitat disturbance in the array area and ECC. Mitigation in respect to likely effects is considered in Section 12.6.

12.2.4 Data Collection and Collation

Information on the benthic subtidal and intertidal communities within the study area was collected through a detailed desktop review of existing literature and data sources, and site-specific surveys. These data have provided comprehensive coverage across large parts of the benthic subtidal and intertidal ecology study area and wider region.

12.2.5 Site-specific Surveys

Site-specific surveys for the proposed development have been undertaken to provide an up-to-date characterisation of the benthic subtidal and intertidal habitats and species occurring within the study area, the survey areas are referred to as 'intertidal survey area', 'ECC subtidal survey area' and 'array subtidal survey area' hereafter (Figure 12.3). All survey methodologies were in line with the relevant guidance documentation (Cefas, 2002; Cefas et al., 2004; Davies et al., 2001; Ware and Kenny, 2011).

The surveys are summarised in Table 12.2 below. The full detailed methodologies and analyses of the site-specific surveys are available within Volume 9 Appendices 12.1: Array Area Benthic Survey Report and 12.2: Cable Route Benthic Survey Report.

Table 12.2 Site-specific benthic subtidal and intertidal survey data

Title	Summary	Spatial coverage
NISA Benthic Ecology Baseline Cable Route Benthic Survey Report (Natural Power Consultants Ltd, 2023).	An Intertidal Phase I walkover survey was undertaken on the 26th of September 2022 and was carried out between MHW and MLW to determine the composition and distribution of intertidal biotopes and the extent of sub-features. In areas of soft substrate, sediment characteristics were assessed with material collected from eight sites for particle size analysis (PSA) and Total Organic Carbon (TOC) content determination. Sediment samples were also collected from ten sites for infaunal analysis with sediment taken to a depth of 20-25cm and washed over a 1mm sieve with all retained fauna identified and enumerated. Biotopes/habitats were assigned and mapped by reference to the benthic community data collected and by reference to aerial imagery. The subtidal benthic survey campaign was carried out between the 27th of September – 1st October 2022 with 30 sites surveyed, of which 24 were within the ECC with the remainder directly to the south. Drop Down Video (DDV) transects were conducted at all sites to inform seabed habitat classification. Similarly, samples for infaunal analysis were collected at all 30 sites using a 0.1m2 Day Grab. Material was washed over a 1mm sieve with all retained fauna identified and enumerated. Additional sediment was collected at ten sites for PSA and TOC determination while surficial sediments were collected for chemical analyses. Turbidity measurements were collected at various depths at three sites, one measurement per site; located near shore, mid-way along the ECC assessment area and near the array area. Sample sites are indicated on Figure 12.2.	Intertidal survey area
NISA Benthic Ecology Baseline Array Area Benthic Survey Report (Natural Power Consultants Ltd, 2022).	A total of 40 sampling stations were selected in the vicinity of the array area and the adjacent subtidal environment, of which 11 sites were within the array area. Sites were selected with reference to existing habitat and geophysical data to ensure that all habitats present within the survey area were represented. At each station sediment was collected for physiochemical analyses (PSA, TOC, chemistry) and a single 0.1m2 Day Grab sample was taken for faunal analysis. DDV samples were collected from 12 sampling stations, five of which were within the array area distributed throughout the array. In addition, DDV data were acquired at 20 sites located to the southwest of the array area where historical data indicated the prevalence of hard substrate unsuitable for grab sampling.	Array subtidal survey area

Title	Summary	Spatial coverage
	All survey sites were within the area covered by the Marine Area Consent (MAC)1 for the proposed development, which has been refined since the survey was undertaken in 2022 through design development to the offshore development area. Sample location is indicated on Figure 12.2.	

12.2.6 Desk-based Review

A detailed desktop review was carried out to establish a baseline of information describing the benthic subtidal and intertidal ecology of the study area. The baseline characterisation utilises a broad combination of datasets and provides a robust temporal analysis and validation of regional monitoring datasets. In addition, the benthic subtidal and intertidal ecology characterisation is informed through site specific surveys undertaken across the offshore development area (see Section 12.2.5). The key desk-based data sources used in the assessment are shown below in Table 12.3.

[1] the MAC is a State consent, awarded to the Developer in December 2022 which allows the right to occupy a part of the maritime area and the ability to subsequently apply for development consent within that maritime area.

Table 12.3 Desk-based data sources relevant to benthic subtidal and intertidal ecology

Data sources / publications	Reference / source location, data type and summary	Temporal coverage	Spatial coverage in relation to the study area
EMODnet broad-scale seabed habitat map of Europe (EUSeaMap, 2021).	https://www.emodnet-seabedhabitats.eu/ Interactive map of benthic data and habitat maps.	Latest data from 2021	Covers the entire subtidal component of the study area.
Integrated Mapping for the Sustainable Development of Ireland's Marine Resources (INFOMAR, 2021).	https://www.infomar.ie/maps/interactive-maps/seabed-and-sediment A joint project between the Marine Institute and Geological Survey of Ireland using multibeam echosounder and seabed survey data providing sediment mapping.	2006-2016	Covers the entire subtidal component of the study area.
Habitats Directive Annex I habitat maps.	https://www.emodnet-seabedhabitats.eu/access-data/launch-map-viewer/ Habitat data from EMODnet Seabed Habitat maps that contains data on habitats described in Annex I of the EU's Habitats Directive.	2016	Covers the entire subtidal component of the study area.
JNCC Mid Irish Sea Reefs habitat mapping report (Dalkin, 2008).	https://data.jncc.gov.uk/data/c74e7820-b959-4d2a-b235-a2a187a5fbae/JNCC-Report-411-FINAL-WEB.pdf Report written with the aim of improving the understanding of the benthic habitats and communities within the Irish Sea.	2006 – 2007	Covers the entire subtidal component of the study area.
Distribution of Coastal Habitats in Ireland 2013-2018 (Marine Institute, 2019).	https://data.marine.ie/geonetwork/srv/eng/catalog.search#/metadata/ie.marine.data:dataset.3993 Specific habitats identified in the EU Habitats Directive including subtidal sandbanks, sea cliffs, estuaries and sand dunes.	1983 - 2018	Covers the entire study area.
Offshore Benthic Communities of the Irish Sea. In: The Irish Sea: An Environmental Review, Part 1 (Mackie, 1990).	https://gis.ices.dk/geonetwork/srv/api/records/4908b026-1ee4-4921-9a9c-ce53f802864e Data collected for Irish Sea benthic habitats were digitised into a map by JNCC. Specific habitats identified in the EU Habitats Directive including subtidal sandbanks, sea cliffs, estuaries and sand dunes.	1990	Covers the entire subtidal component of the study area.
Dublin Port Maintenance Dredging 2022 – 2029 Benthic and Fisheries Assessment (Aquatic Services Unit, 2020)	https://www.dublinport.ie/information-centre/dredging/ Data and information on Maintenance Dredging campaigns. Benthic and fisheries assessment of the subtidal area of Dublin Port to support the ongoing maintenance dredging operations of the port from 2022 to 2029.	2020	Surveys carried out subtidally to south of the study area in Dublin Bay.
Greater Dublin Drainage Scheme: Hydrographic Survey Report GEO13_GDD (Tech Works Marine, 2013)	https://assets.gov.ie/109918/2501a74e-c4af-48a9-a598-44d9026d7355.pdf Near-shore seabed surveys in two areas North of Dublin to investigate the seabed properties to ascertain their suitability for location of a marine to serve the new wastewater treatment plant (WWTP) of the greater Dublin area.	2013	Two subtidal survey areas off Dublin located south of the study area.

12.2.7 Data Limitations

Grab sampling and DDV surveys, while providing detailed information on the infauna and epifauna present, cannot cover wide swathes of the seabed and consequently represent point samples that must be interpreted in combination with the geophysical datasets (Fugro, 2022) which indicate broad habitat types present to produce benthic maps that provide comprehensive cover. These limitations apply to the general application of acoustic devices and ground-truthing to map marine habitats and are not specific to this survey (e.g. Kenny et al., 2003).

Classification of subtidal and intertidal survey data into habitats and the production of habitat maps based on the survey data, while highly useful for assessment purposes, has two main limitations:

- Difficulties in defining the precise extents of each biotope, even when using site-specific geophysical survey data to characterise the seabed; and
- There is generally a transition from one sedimentary biotope to another, rather than fixed limits and therefore, the boundaries of where one biotope ends, and another starts often cannot be precisely defined.

Consequently, the biotope maps presented in this chapter should not be considered as definitive, nor should the habitat boundaries be considered to be fixed, they do however represent a robust characterisation of the receiving environment.

The MarESA methodology is based on scientific evidence that has been used to inform assessments on biotope sensitivity to pressures. Confidence in the assessment is based on the robustness of the underlying evidence, which ranges from peer reviewed literature (high confidence) to expert judgement (low confidence). While there are limitations of the scientific evidence on the biology of features and their responses to environmental pressures on which the sensitivity assessments been based the MarESA assessments have been adopted as good practice in determining the sensitivity of species and features to pressures.

12.2.8 Methodology for the Assessment of Effects

EIA significance criteria for benthic subtidal and intertidal ecology follows Environmental Protection Agency (EPA) guidance:

- EPA (2022) Guidelines on the information to be contained in Environmental Impact Assessment Reports.

The assessment includes determination of the magnitude of potential impacts on benthic subtidal and intertidal ecology receptors which considers the extent and duration of the impact, its reversibility and the timing and frequency of the causative activity. The sensitivity of different receptors is also considered as part of the impact assessment. The sensitivity of benthic species developed as part of MarESA[2] is recognised as standard practice for this process and represents the key resource in determining receptor sensitivity for the benthic subtidal and intertidal assessment. The sensitivity assessment of the species takes into account the current status of the species, and its importance (locally, regionally, nationally or internationally).

The criteria for determining the sensitivity of the receiving environment and the magnitude of impacts for the benthic subtidal and intertidal ecology assessment are defined in Table 12.4 and Table 12.5 respectively. A matrix was used for the determination of significance of effect in EIA terms (Table 12.6). The combination of the magnitude of the impact with the sensitivity of the receptor determines the assessment of significance of effect.

12.2.8.1 Sensitivity criteria

The sensitivities of different biotopes have been classified by MarLIN[3] on the MarESA four-point scale (high, medium, low and not sensitive). This methodology is applied to ecological groups, which are found in the Irish Sea, and is based on species characteristic of offshore, circalittoral biotopes (Tillin and Tyler-Walters, 2014) and to biogenic habitats.

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[2] https://www.marlin.ac.uk/evidence
[3] http://www.marlin.ac.uk/species/sensitivity_rationale

The scale takes account of the intolerance (resistance) and recoverability (resilience) of a species or biotope in response to a stressor. Specific benchmarks (duration and intensity) are defined for the different impact pathways for which sensitivity has been assessed (e.g. smothering, abrasion, habitat alteration etc.). Detailed information on the benchmarks used and further information on the definition of resistance and resilience can be found on the MarLIN website, while the benchmarks have been included in the assessments.

The MarESA methodology is based on scientific evidence that has been used to inform assessments on biotope sensitivity to pressures. This has therefore been deemed the most appropriate method to assess biotope sensitivities.

The MarESA methodology has been applied in various analogous projects around the UK, Ireland and Europe to define the sensitivities of biotopes. Specific examples of the application of this method include the Arklow Bank Offshore Wind Park, Hornsea Four, Awel y Môr, Norfolk Boreas Offshore Wind Farm EIA, Hornsea Three Offshore Wind Farm EIA, Moray West Offshore Windfarm EIA, Dudgeon Offshore Wind Farm, Sheringham Shoal Offshore Wind Farm and Norfolk Vanguard Offshore Wind Farm.

For the purposes of this assessment, four sensitivity categories have been defined in Table 12.4, each reflecting one of the four MarESA categories.

Table 12.4 Sensitivity of the receiving environment

Receptor sensitivity	Definition
High	Equivalent to MarLIN MarESA sensitivity category 'High'. The habitat or species is noted as exhibiting 'None' or 'Low' resistance (tolerance) to an external factor, whether that arises from natural events or human activities, and is expected to recover only over very extended timescales i.e. >25 years or not at all (resilience is 'Very Low'); or The habitat or species is noted as exhibiting 'None' or 'Low' resistance (tolerance) to an external factor, whether that arises from natural events or human activities, and is expected to recover only over very extended timescales i.e. >10 or up to 25 years (resilience is 'Low').
Medium	Equivalent to MarLIN MarESA sensitivity category 'Medium'. The habitat or species is noted as exhibiting 'None' or 'Low' resistance (tolerance) to an external factor, whether that arises from natural events or human activities, and is expected to recover over medium timescales i.e. >2 or up to ten years (resilience is 'Medium'); or The habitat or species is noted as exhibiting 'None' resistance (tolerance) to an external factor, whether that arises from natural events or human activities, and is expected to recover over <2 years (resilience is 'High'); or The habitat or species is noted as exhibiting 'Medium' resistance (tolerance) to an external factor, whether that arises from natural events or human activities, and is expected to recover over medium to very long timescales, i.e. >2 years or up to 25 years or not at all (resilience is 'Medium', 'Low' or 'Very Low').
Low	Equivalent to MarLIN MarESA sensitivity category 'Low'. The habitat or species is noted as exhibiting 'Low' or 'Medium' resistance (tolerance) to an external factor, whether that arises from natural events or human activities, and is expected to recover over <2 years (resilience is 'High'); or The habitat or species is noted as exhibiting 'High' resistance (tolerance) to an external factor, whether that arises from natural events or human activities, and is expected to recover over medium to very long timescales, i.e. >2 years or up to 25 years or not at all (resilience is 'Medium', 'Low' or 'Very Low').
Negligible	Equivalent to MarLIN MarESA sensitivity category 'Not Sensitive'. The habitat or species is noted as exhibiting 'High' resistance (tolerance) to an external factor, whether that arises from natural events or human activities, and is expected to recover over short timescales, i.e. <2 years (resilience is 'High').

12.2.8.2 Magnitude of impact criteria

A distinction is made throughout the assessment between the magnitude - as defined by the extent, duration, frequency, and probability and consequences of the impact - and the resulting significance of the 'effects' upon benthic subtidal and intertidal receptors.

The descriptions of magnitude are specific to the assessment of benthic subtidal and intertidal impacts and are considered against the magnitude descriptions presented in Table 12.5. Potential impacts have been considered in terms of whether they are adverse or beneficial.

Where an impact could reasonably be assigned to more than one level of magnitude, professional judgement has been used to determine which level is the most appropriate for the impact. The level has been assigned based on the most appropriate potential consequences of the impact as defined for each level of magnitude (see Table 12.5). For example, an impact may occur constantly throughout the operational phase but is not discernible or measurable in practice, therefore it would be concluded to be of a negligible magnitude despite the frequency of the impact.

For the purposes of the definitions below: near-field has been defined as within the array area and ECC boundary; and far-field has been defined as extending beyond these boundaries.

Table 12.5 Magnitude of the impact

Magnitude	Definition
High	**Extent:** Impact across the near-field and far-field areas beyond the study area. **Duration:** The impact is anticipated to be permanent (i.e., over 60 years). **Frequency:** The impact will occur constantly throughout the relevant project phase. **Consequences:** Permanent changes to key characteristics or features of the particular environmental aspect's character or distinctiveness.
Medium	**Extent:** The greatest extent of the impact is restricted to the near-field and far-field (i.e., the defined study area). **Duration:** The impact is anticipated to medium-term (i.e., seven to 15 years) to long-term (15 – 60 years). **Frequency:** The impact will occur constantly throughout a relevant project phase. **Consequences:** Noticeable change to key characteristics or features of the particular environmental aspect's character or distinctiveness.
Low	**Extent:** The greatest extent of the impact is restricted to the near-field and adjacent far-field areas. **Duration:** The impact is anticipated to be temporary (i.e., lasting less than one year) to short-term (i.e., one to seven years). **Frequency:** The impact will occur frequently throughout a relevant project phase. **Consequences:** Barely discernible to noticeable change to key characteristics or features of the particular environmental aspect's character or distinctiveness.
Negligible	**Extent:** The greatest extent of the impact is restricted to the near-field and immediately adjacent far-field areas. **Duration:** The impact is anticipated to be momentary (seconds to minutes) to brief (lasting less than one day). **Frequency:** The impact will occur once or infrequently throughout a relevant project phase. **Consequences:** No discernible to barely discernible change to key characteristics or features of the particular environmental aspect's character or distinctiveness.

12.2.8.3 Defining the significance of effect

The significance of effect associated with an impact will be dependent upon the sensitivity of the receptor and the magnitude of the impact. The assessment methodology for determining the significance of likely significant effects is described in Table 12.6. Predictions of impact will be based on the best available data and using a combination of professional judgement, specialist knowledge and modelling where appropriate; this is especially true for the determination between whether an effect is profound or very significant. Effects defined as significant, very significant or profound are considered significant in EIA terms. An effect that has a significance of moderate, slight, not significant, or imperceptible is not considered significant in EIA terms.

Table 12.6 Significance of likely significant effects upon benthic ecology

Description of Impact Magnitude			Existing Environment – Sensitivity			
			High	**Medium**	**Low**	**Negligible**
	Adverse impact	**High**	Profound or very significant	Significant	Moderate	Imperceptible
		Medium	Significant	Moderate	Slight	Imperceptible
		Low	Moderate	Slight	Slight	Imperceptible
		Negligible	Not significant	Not significant	Not significant	Imperceptible
	Beneficial impact	**Negligible**	Not significant	Not significant	Not significant	Imperceptible
		Low	Moderate	Slight	Slight	Imperceptible
		Medium	Significant	Moderate	Slight	Imperceptible
		High	Profound or very significant	Significant	Moderate	Imperceptible

Where relevant, mitigation measures that are incorporated as part of the proposed development design process and/ or can be considered to be industry standard practice (referred to as 'embedded mitigation') are considered throughout the chapter and are reflected in the outcome of the assessment of effects, described in Section 12.4.5. Additional mitigation measures that are not embedded and are considered as part of the residual effects assessment are described separately (Section 12.6).

12.3 Baseline Environment

12.3.1 Introduction

The benthic subtidal and intertidal ecology study area is defined in Section 12.2.2. A summary of the existing baseline is presented within this section.

12.3.2 Receiving Environment

This characterisation of the receiving benthic environment incorporates key information collected during site-specific surveys encapsulating the offshore development area, and elements of the wider MAC boundary, as well as from a desk-based review of the data and literature covering the wider region surrounding the study area.

Existing data on benthic subtidal and intertidal habitats collected during previous studies have been classified using different systems. Sediments with the same granulometric profiles can be classified using different systems. A classification system designed by Folk (1954) is commonly used and groups sediments based on grain diameter, while more recent data have been grouped into a simplified Folk system in order to categorise habitats using the European Nature Information System (EUNIS) (Long, 2006).

12.3.2.1 Benthic Subtidal Ecology: Sediments

Irish Sea sediments are typically reworked glacial deposits characterised by poorly sorted sands and sandy gravels (Coughlan et al., 2021). However, to the west of the Isle of Man – where seasonal stratification and low tidal current speeds occur – muddier sediments are found in an area referred to as the Western Irish Sea Mud Belt (Coughlan et al., 2021; Mellet et al., 2015).

Study area

Ireland's Marine Atlas maps broadscale regional habitats to EUNIS Level 3 (i.e., biological zone and substrate (EUSeaMap, 2022)) and indicates that the dominant habitats across the study area are 'Atlantic offshore circalittoral sand' (MD52), and 'Atlantic circalittoral mud' (MC62). Other habitats present across the study area include 'Atlantic infralittoral rock' (MB12), 'Atlantic circalittoral sand' (MC52), 'Atlantic infralittoral sand' (MB52), 'Atlantic circalittoral mud' (MC62), and 'Atlantic offshore circalittoral mud' (MD62) (Figure 12.3).

Array area

Site-specific surveys indicate that the seabed across the array area is generally homogenous and dominated by soft sediments. Granulometric data from the 11 stations sampled within the array area classified according to the Folk 7 system identifies the sediment at the majority of sites (8) as being 'muddy sand'. This sediment type was recorded at a further eight sites to the east and north of the array area. 'Sandy mud' was recorded at the other three sites in the array area, all of which were located in the southern half of the array area; sediments at sites to the south of the array area were also classified as 'sandy mud' (Figure 12.3).

Historical data supports the findings of the site-specific surveys. According to the broadscale habitat modelling, using the EUNIS geological classification system, the primary sediment type across the array area is described as sandy mud to muddy sand or deep circalittoral mud, with a patch of sand in the southern sector (EMODnet, 2022). Cefas data indicates that sediments are predominantly sand and sandy mud, with mud and sandy mud present in the north of the array area (Cefas, 2017). The site-specific surveys validate the INFOMAR predictive substrate modelling which predicted sediments within the array area to be predominantly characterised by sandy mud (INFOMAR, 2021).

Overall, as indicated in the Physical Processes Chapter, the array area can be considered as a region of net deposition fine sediments (fine sands, silts, and muds) which is largely unresponsive to the influence of waves or tides with generally low concentrations of suspended sediment. These attributes are known to be shared with the wider area known as the Western Irish Sea Mud Belt (Coughlan, 2015).

ECC

Site-specific surveys across the ECC indicate a homogenous seabed characterised predominantly by sand with small but increasing proportions of silt and gravel evident further offshore. According to the Folk 7 classification the site-specific granulometric data would indicate that ECC sediments were predominantly 'sand' with two sites in the northeast corner classed as 'muddy sand' and one as 'mixed sediments' (Figure 12.4). The site-specific sediment data supports the predictive models available for the region and has good agreement with existing data.

According to broadscale regional habitat models, the primary sediment type across the ECC is predicted to be sandy mud to muddy sand (EMODnet, 2022) (Figure 12.3**)**. The INFOMAR model (INFOMAR, 2021) also defines the ECC as predominantly mud to muddy sand with a small proportion of gravelly sediments evident closer inshore. Cefas data from multiple years confirms that sand and muddy sand are prevalent throughout the ECC (Cefas, 2017).

As indicated in the Physical Processes Chapter sediment transport patterns are driven by increased effects of tidal current and waves associated with the relatively shallow water of the ECC. This results in lower proportion of fines in bed sediments and increased SSC compared to further offshore.

12.3.2.2 Benthic Subtidal Ecology: Organic Content of the Sediment

Terrestrially derived carbon from run-off and fluvial systems, combined with primary production from sources (including planktonic blooms) contribute to the TOC levels recorded in marine sediments. TOC represents the proportion of organic detritus present.

Organic detritus is metabolised by heterotrophic bacteria but is also consumed directly by a wide range of marine invertebrates (UK MPA, 2001), it is therefore an important source of food for benthic fauna (Snelgrove and Butman, 1994). Although unlikely in an open coastal environment such as the ECC, an over-abundance of TOC (also termed organic enrichment) may lead to community changes and a reduction in diversity by favouring detritivore groups or those tolerant of low oxygen levels (as increased oxygen demand can be brought about by elevated bacterial respiration) (see Pearson and Rosenberg, 1978).

Array area

TOC values for all sites within the array area were less than 1%. Similarly, at other sites within the study area located to the south and northeast of the array area, TOC were equal or less than 1%, with one exception (sampling station 2 – northeast of the array area) which had a value of 1.01%. Stations with a higher sand to silt ratio had lower proportions of TOC than stations dominated by silt (full details are provided in Appendix 12.1: Array Area Benthic Survey Report). It is expected that sediments with greater proportions of silt and clay would retain more organic matter than sandy fractions, due to a greater adsorption capacity of fine-grained particles as a result of a larger surface area (Keil and Hedges, 1993; Burdige, 2007). Moreover, fine-grained particles enhance the preservation of organic matter through reduced redox potential and/or remineralization rates (Hedges and Keil, 1995; Dauwe et al., 2001; Burdige, 2007).

ECC

Across the ECC, organic content (in the form of TOC) ranged between 0.66 and 1.59%. No clear relationship between TOC and proportion of silt and clay was evident (full details are provided in Appendix 12.2: Cable Route Benthic Survey Report).

12.3.2.3 Benthic Subtidal Ecology: Sediment Contaminants

For sediment quality, the physical properties of the seabed are important to provide an indication of contamination risk. For example, the potential for contamination increases with the proportion of fine sediment present since it is these smaller particles which more readily bind contaminants, due to their larger surface area to volume ratios and higher organic carbon content. Sediments consisting of coarser sand and gravel are generally accepted as carrying a much lower contamination risk. Information regarding particle sizes is an important step in assessing the contamination risk to the marine environment.

Site-specific sediment contaminant data were assessed against Irish Action Levels (Cronin et al., 2006) in order to determine the contamination levels within seabed sediments and thus the potential for releasing contaminants into the marine environment through sediment disturbance; thresholds for each contaminant are provided in the MW&SQ Chapter along with a full description of the results which have been summarised below.

Array area

Sediments within the array area are typically dominated by muddy sand and sandy mud and would therefore be expected to have higher levels of metals compared to coarser sediments owing to the larger surface area and oxyhydride and organic coatings which readily sequester metals. However, metal concentrations were considered to be generally low and were mostly lower than threshold level Irish guidelines. The only clear exceedance was for chromium where concentrations at sites in the northern part of the array area between Irish Action levels 1 and 2 indicating marginal contamination.

Metals data across the array area were normalised (to 52 parts per million (ppm) lithium) to enable comparison of results with OSPAR Background Concentrations (BC) and Background Assessment Concentrations (BAC) (OSPAR, 2008). A BC represents the concentrations of hazardous substances that would be expected in the North-East Atlantic if certain industrial developments had not happened, while BACs were developed for testing whether measured concentrations are near background levels for naturally occurring substances and close to zero for man-made substances. The mean normalised concentrations of cadmium (Cd), chromium (Cr), lead (Pb) and mercury (Hg) were all higher than the relevant BC while all other mean normalised metal concentrations were lower than the BC. No mean normalised metal concentrations were above the relevant BAC. As all metal concentrations showed a clear correlation to lithium and observed BC exceedances were no more than one fifth higher than the relevant reference concentrations sediment bound metal concentrations across the array area are at background levels.

Levels of organic chemicals were low throughout the array area with Total Hydrocarbon (THC) concentrations (comprising total n-alkanes, pristane, phytane, unresolved complex mixture (UCM) and polycyclic aromatic hydrocarbons (PAH)) being below levels at which adverse effects on benthic macrofauna have been observed (see United Kingdom Offshore Operators Association (UKOOA) 2001; Kjeilen-Eilertsen et al., 2004; UKOOA 2005). There was one concentration of the PAH Acenapthene marginally exceeding the ISQG/TEL occurring in the northern half of the array area. No organic chemical concentrations exceeded the relevant PEL.

PAH levels were compared to BCs and BACs which requires normalisation to 2.5% TOC. Concentrations of seven PAHs (Naphthalene, Benzo[a]pyrene, Phenanthrene, Anthracene, Chrysene, Fluoranthene and Pyrene) were above their respective BC values at a number of sites, while PAH level values also exceed the respective BAC at one site. The majority of these exceedances were recorded in the northern half of the array area, although the higher normalised concentrations at these sites can be explained in part by the greater proportion of fine material prevalent in the sediments in this part of the array area. Normalised PAH concentrations for chrysene, naphthalene and pyrene averaged over the array area as a whole exceeded the relevant BC.

The majority of reported concentrations of polychlorinated biphenyls (PCBs) were below the Minimum Reporting Value (MRV)[4]. Where positive results were obtained all were well below the relevant lower guideline values. All sediment bound concentrations of organotins were below the MRV.

Further details of sediment contamination are provided in the MW&SQ Chapter and Volume 9, Appendix 12.1: Array Area Benthic Survey Report.

ECC

As anticipated, due to the relatively coarse nature of sediments in the ECC, sediment-bound metal levels were generally low However, at a site 6 located in the nearshore part of the corridor (Figure 12.2) the relevant lower Irish Action Levels were exceeded for several metals with particularly high levels of cadmium and zinc reported; no metal concentrations were above upper Irish guideline.

Mean normalised concentrations of cadmium, chromium, lead, zinc and mercury all exceeded the relevant BACs, while the concentration of nickel was higher than the BC. However, observed BAC exceedances were no more than one third higher than the relevant reference figures for sediment bound metal concentrations across the array area, which are considered to be at background levels.

Concentrations of organic chemicals were generally low throughout the ECC with total loads being well below relevant lower Irish and Canadian guideline limits. However, there were exceedances of the TELs for individual PAHs benzo(a)pyrene and acenaphthylene at one site, although all reported concentration were below the upper guidance limits[5]. The BC for naphthalene was exceeded at eight out of ten sites where sediments were analysed and the overall mean concentration for the ECC was also higher than the BC. No mean normalised PAH concentrations were above the relevant BC. No organic chemical concentrations exceeded the relevant PEL.

PCB and organotin levels were below the relevant MRV at all sites where sediments were analysed.

Further details of sediment contamination are provided in Volume 9, Appendix 12.2: Cable Route Benthic Survey Report.

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[4] Minimum Reporting Value (MRV) - the lowest concentration of a substance that can be routinely determined by a particular analytical method with a known degree of confidence, and may not be equivalent to limit of detection.

[5] No Irish Als published for individual PAHs.

12.3.2.4 Benthic Subtidal Ecology: Seabed Habitat and Communities

Study area

The seabed sediments that characterise the subtidal components of the study area are typical of the northern Irish Sea where areas of subtidal mud provide habitats for sea pens and brittlestars (The Irish Sea Network, 2022), with relatively low associated species richness (Picton et al., 1997).

The area covered by BIOMÔR 2, a study which evaluated the biodiversity of benthic habitats of the south-western Irish Sea/Celtic Sea, coincides with the south of the study area. The findings revealed habitats ranging from very fine sand to muddy sand, with communities characterised by Mollusca (*Gari, Venus, Dosinia, Dentalium* and *Nucula* spp.), Echinodermata *(Echinoidea* and *Ophiuroidea),* and Annelida *(Nephthys* and *Glycera* spp. and *Spionidae)* (Wilson et al., 2001). Additionally, the honeycomb worm *Sabellaria spinulosa* was identified to the southeast of the study area including areas where aggregations of this species had formed reefs (Wilson et al., 2001).

It should be noted that no Annex I or protected species or habitats were recorded within the array area or ECC, although the biotope "Seapens and burrowing megafauna in circalittoral fine mud" (Code MC6216) which is included in the OSPAR List of Threatened and/or Declining Species & Habitats was recorded in the study area outside the array area and ECC (see Section 12.3.4).

Array area

Across the 11 sites sampled in the array area during site-specific surveys, between 5 and 24 species were identified per site with an average of 12 species per site. Abundance ranged from 8 to 47 individuals with an average of 26 per site.

The communities within the array area were characteristic of relatively fine sediments dominated by Annelids, while sites to the south of the array area (where sediments were coarser) were dominated by molluscs and echinoderms.

At the remaining 29 sites (outside the array area), between 3 and 38 species were identified per site with an average of 23 species per site. Abundance ranged from 38 to 154 individuals with an average of 70 per site.

By combining DDV data, PSA data, and macrofaunal data, two biotopes were identified within the array area (Table 12.7 and Table 12.8) (the distribution of the biotopes is presented in Figure 12.5).

The most commonly recorded biotope across the array area was 'Burrowing megafauna *Maxmuelleria lankesteri* in circalittoral mud' (MC6217), which was recorded at ten of the 11 sites sampled within the array area. Species and features typical of this biotope identified during site-specific surveys included the burrowing mud shrimp *Callianassa subterranean* and *Nephrops* burrows and mounds. This biotope was also recorded at sites to the east and northeast of the array area where fine sediments predominated.

The other site within the array area was assigned the biotope *'Amphiura filiformis*, *Kurtiella bidentata* and *Abra nitida* in circalittoral sandy mud' (MC6211). This site was located in the south of the array area where slightly coarser muddy sands were found. Species typical of this biotope recorded in site-specific surveys included the brittlestar *A. filiformis*, the bivalve *K. bidentata*, the horseshoe worm *Phoronis* sp. And the polychaete *Diplocirrus glaucus*. This biotope was also recorded at sites directly south of the array area in the transitional area where sandy mud and muddy sand sediment types were interspersed.

The sandier sediments to the south of the array area were characterised by the biotope *'Owenia fusiformis* and *Amphiura filiformis* in deep circalittoral sand or muddy sand' (MD5212). Typical species identified in the site-specific surveys included *A. filiformis*, *Phoronis* sp. and *K. bidentata*.

In the southwest corner of the subtidal component of the study area, DDV transects recorded circalittoral mixed sediment with relatively high numbers of epifaunal species. The coarse sediments and shell fragments provided suitable substrate for sessile epifauna such as hydroids, bryozoans and anemones to colonise. A single station to the south of the array area was classified as the biotope 'Seapens and burrowing megafauna in Atlantic circalittoral fine mud'(MC6216), where several individuals of the seapen *Virgula mirabilis* were present.

Further details of community structure and patterns are provided in Volume 9, Appendix 12.1 Array Area Benthic Survey Report.

Table 12.7 Biotopes found across the array area and adjacent subtidal component of the study area

EUNIS Code (2022)	Biotope Name	JNCC 04.05 Code	Location
MC6217	Burrowing megafauna Maxmuelleria lankesteri in circalittoral mud	SS.Smu.CfiMu.MegMax	Ten sites within the array area and eight sites to the east and north east of the array area
MC6211	Amphiura filiformis, Kurtiella bidentata and Abra nitida in circalittoral sandy mud	SS.Smu.CsaMu.AfilKurAnit	One site in south of array area with three directly south of the array area and five in south eastern part of survey area
MD5212	Owenia fusiformis and Amphiura filiformis in offshore circalittoral sand or muddy sand	SS.Ssa.Osa.OfusAfil	12 sites to south of array area
MC4	Circalittoral mixed sediment	SS.SMx.CMx	At DDV sites in southwest corner of the survey area
MC6216	Seapens and burrowing megafauna in circalittoral fine mud	SS.Smu.CfiMu.SpnMeg	One site in south west corner of survey area

ECC

Site-specific surveys undertaken at 30 sites located across the ECC subtidal survey area and to the area adjacent to it to the south (shown in Figure 12.2) identified a total 6,736 individuals representing 249 taxa. As detailed above, the seabed was characterised predominantly by sand with small but increasing proportions of silt and gravel evident further offshore.

Offshore communities were typified by molluscs and polychaetes, while further inshore echinoderms and molluscs dominated. At nearshore sites, molluscs and polychaetes were the dominant groups. Other groups recorded include amphipods, hydroids and bryozoans.

Epifauna was sparse throughout the ECC subtidal survey area, with the most abundant taxa observed being brittlestars which were found at the majority of stations. Other epifauna observed include fish (e.g., *Callionymidae*, Pleuronectiformes, *Gadidae*, *Triglidae*), starfish (Asteroidea), decapod crustacea (e.g., *Paguridae*, *Nephrops norvegicus*), anemones (e.g. *Adamsia palliata*, *Ceriantharia*) along with some instances of bivalves (e.g., *Pectinidae*) and tube worms (*Sabellidae*, *Terrebellidae*, *Chaetopteridae*).

By combining and considering collectively the DDV data, particle size data and macrofaunal data, two biotope complexes and five biotopes were identified within the ECC (Table 12.8; Figure 12.4).

The two most inshore sites within the ECC survey area were assigned the biotope '*Fabulina fabula* and *Magelona mirabilis* with venerid bivalves and amphipods in Atlantic infralittoral compacted fine muddy sand' (MB5236). Species typical of this biotope recorded during site-specific surveys included the polychaetes *Spiophanes bombyx*, *Magelona mirabilis*, *Nephtys* sp., *Spio* sp. and the bivalve *Nucula nitidosa*.

In the middle of the ECC subtidal survey area the biotope '*Amphiura filiformis* and *Ennucula tenuis* in circalittoral and offshore sandy mud' (MC6213) was assigned to six sites. Here site-specific surveys identified species typical of this biotope such as the brittlestar *A. filiformis*, the bivalve *K. bidentata* and the polychaete *Scalibregma inflaum*.

At a further five sites in the middle of the ECC subtidal survey area, the biotope '*Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment' (MC5214) was identified. Species typical of this biotope recorded in site-specific surveys included the polychaete *S. bombyx* and the bivalves *N. nitidosa* and *Phaxas pellucidus*. The honeycomb worm *Sabellaria spinulosa* was also recorded, although it was present as either individual or few worm tubes rather than forming a biogenic reef feature.

Closer to the array area, benthic habitats were characterised by circalittoral sandy mud with high numbers of the brittlestar *Amphiura filiformis*, bivalves and the gastropod *Turritellinella tricarinata* which were represented by the biotope '*Amphiura filiformis, Kurtiella bidentata* and *Abra nitida* in circalittoral sandy mud' (MC6211).

Stations closest to the array area contained a greater portion of gravel and mud than elsewhere in the ECC subtidal survey area. Here the communities were assigned the biotope, *'Kurtiella bidentata* and *Thyasira* spp. in circalittoral muddy mixed sediment' (MC4213). The communities here were of low diversity and characterised by high numbers of bivalves.

The biotope complex 'Atlantic circalittoral mud' (MC62) was identified at seven sites in the furthest offshore south-western corner of the ECC subtidal survey area. As no distinct community structure could be identified, the biotope could not be resolved any further. Similarly, at one station in the centre of the ECC subtidal survey area, no distinct community could be identified, and this was assigned the biotope complex 'circalittoral fine sand' (MC52). As they included species common to surrounding biotopes, it is possible that the nature of the communities assigned to these biotope complexes are transitions between identifiable community types.

Further details of community structure and patterns are provided in Volume 9, Appendix 12.2: Cable Route Benthic Survey Report.

Table 12.8 Biotopes identified across the ECC subtidal survey area and adjacent subtidal component of the study area

EUNIS Code (2022)	Biotope Name	JNCC 04.05 Code	Location
MC62	Circalittoral sandy mud	SS.Smu.CsaMu	One site in the mid section of the ECC
MB5236	Fabulina fabula and Magelona mirabilis with venerid bivalves and amphipods in Atlantic infralittoral compacted fine muddy sand	SS.Ssa.ImuSa.FfabMag	Two most inshore sites in the ECC
MC4213	Mysella bidentata and Thyasira spp. In circalittoral muddy mixed sediment	SS.SMx.CMx.KurThyMx	Two most offshore sites adjacent to array area
MC5214	Abra alba and Nucula nitidosa in circalittoral muddy sand or slightly mixed sediment	SS.Ssa.CmuSa.AalbNuc	Three nearshore sites within ECC, one site in middle of ECC and one site to the south
MC6213	Amphiura filiformis and Nuculoma tenuis in Atlantic circalittoral and offshore muddy sand	SS.Smu.CsaMu.AfilEten	Six sites within mid section area of ECC
MC52	Circalittoral fine sand	SS.Ssa.CfiSa	Five sites in offshore portion of ECC and two sites directly to south
MC6211	Amphiura filiformis, Mysella bidentata and Abra nitida in Atlantic circalittoral sandy mud	SS.Smu.CsaMu.AfilKurAnit	Four sites within the mid section of ECC and three to the south

12.3.2.5 Benthic Intertidal Ecology: Sediments

The intertidal component of the study area covers the area between HWM and LWM north of Balbriggan near Bremore Bay Beach and Coney Hill Bay Beach. This area encompasses the entire intertidal component of the ECC with additional areas directly to the north and south (see Figure 12.6). Much of the substrates here consist of boulders and rocky outcrops with shingle and sand towards the top of the shore. The shore bordering the ECC to both the north and the south are characterised by sandy substrates with rocky outcrops.

Site-specific surveys identified intertidal sediment as predominantly sands (according to the Folk classification system). However, at site 7, located in the southern third of the intertidal survey area, slightly coarser gravelly sand was recorded.

INFOMAR data for the intertidal survey area describes substrates as sand and as circalittoral fine sand or circalittoral muddy sand (according to the EUNIS classification system). Infralittoral fine sand and infralittoral muddy sands are also present in the intertidal zone in proximity to the Coney Hill landfall.

Further details of habitat types are provided in Volume 9, Appendix 12.2: Cable Route Benthic Survey Report.

12.3.2.6 Benthic Intertidal Ecology: Organic Content of the Sediment

Site-specific sediment data were analysed for organic content. Results recorded low values of TOC across the intertidal survey area ranging from 0.66% to 1.59%. These low values in TOC are expected given the low percentage of fines present in the sediment.

12.3.2.7 Benthic Intertidal Ecology: Sediment Contaminants

No site-specific sediment contaminant data were collected for intertidal sites. However, due to the relatively coarse nature of the sediments (i.e. sands and gravelly sands) and the low levels of TOC, contaminant levels are expected to be low.

12.3.2.8 Benthic Intertidal Ecology: Seabed Habitats and Communities

Site-specific surveys undertaken across the intertidal survey area identified a total of 470 individuals representing 44 infauna taxa from sediment samples, with a total of 23 species of epibiota were recorded from hard substrate. Community data in combination with substrate and physical characteristics (such as height on shore) resulted in a total of ten biotopes identified across the intertidal survey area (Table 12.9 and Figure 12.5). It should be noted that no Annex I or protected species or habitats were recorded within intertidal survey area (see Section 12.3.13).

For much of the intertidal survey area, the top of the shore was characterised by a band of coarse material which was assigned the biotope 'Barren littoral shingle' (MA3211). Typically, this habitat supported virtually no macrofauna due to the mobile and freely draining nature of the substrate with few individuals (that may be present) likely to have been stranded by the ebbing tide, such as the occasional amphipod or small polychaete. However, this biotope was absent from the upper shore at Coney Hill Beach, located at the northern end of the intertidal survey area which was characterised by a homogenous sandy habitat.

Data from the site-specific survey indicated that the community here was characterised by the bivalve *Macomangulus tenuis* with the polychaete *Nephtys cirrosa* and *Spio* sp. And was assigned the biotope 'Polychaetes and *Macomangulus tenuis* in littoral fine sand' (MA52412).

The substrate at four of the sediment stations sampled during the site-specific survey consisted predominantly of fine sand, and these were identified as either the biotope 'polychaete/amphipod-dominated fine sand shores' (MA524) or 'polychaetes in littoral fine sand' (MA5241). These sites supported communities dominated Spionid and Capitellid polychaetes with Amphipod species such as *Gammarus* spp. And *Corophium volutator* also present.

One sediment station which was dominated by the polychaete *Scolelepis (Scolelepis) squamata* was assigned the biotope '*Scolelepis spp*. In littoral mobile sand' (MA52331). This is a typically species-poor community due to the mobility of the sediment, and apart from *S. squamata* the only other species recorded were the amphipod *C. volutator* and Enchytreid worms.

In the transitional area at the top of the shore within the intertidal survey area, the biotope '*Ulva* spp. On freshwater-influenced and/or unstable upper eulittoral rock' (MA123G) occurred in two areas, which was consistent with the unstable substrate present and the opportunistic nature of the algal species.

A large proportion of the mid shore within the intertidal survey area consisted of boulders and compacted coarse sediment with some areas of bedrock. A few areas of taller barnacle dominated bedrock occurred in the mid shore which created shelter for the biotope '*Ascophyllum nodosum* on full salinity mid eulittoral mixed substrata' (MA123E2) where the macroalgae *A. nodosum* and *Fucus vesiculosus* were common; other species recorded which are typical of this biotope included the red algae *Vertebrata lanosa* and Littorinid gastropods.

Most of the low shore and some of the mid shore within the intertidal survey area was supported a mosaic of Fucoid biotopes. The most common component was the biotope '*Fucus vesiculosus* and barnacle mosaics on moderately exposed mid eulittoral rock' (MA1243). Dogwhelks, limpets, and periwinkles were common underneath the algae, although there was a lack of a well-developed understory algal community due to the lack of suitable substrate.

The biotopes *'Fucus vesiculosus* on full salinity moderately exposed to sheltered mid eulittoral rock' (MA123D1) and '*Fucus serratus* and under-boulder fauna on exposed to moderately exposed lower eulittoral boulders' (MA12442) were also present as part of the mosaic.

Table 12.9 Biotopes found across the intertidal survey area

EUNIS Code (2022)	Biotope Name	JNCC 04.05 Code	Location
MA3211	Barren littoral shingle	LS.LCS.Sh.BarSh	Area of upper shore through all but most northern section of survey area
MA524	Polychaete/amphipod-dominated Atlantic littoral fine sand	LS.Lsa.FiSa	Area of mid shore in central area of survey area and throughout mid and low shore in southern quarter of survey area
MA5241	Polychaetes in Atlantic littoral fine sand	LS Lsa.FiSa.Po.	Small area of mid to upper shore in northern area of ECC
MA52412	Polychaetes and Angulus tenuis in Atlantic littoral fine sand	LS.Lsa.FiSa.Po.Mten	Area encompassing upper to low shore in northern most part of survey area
MA52331	Scolelepis spp. In Atlantic littoral mobile sand	LS.Lsa.MoSa.AmSco .Sco	One site in upper to mid shore in central part of ECC
MA1243	Fucus vesiculosus and barnacle mosaics on moderately exposed mid eulittoral rock	LR.MLR.BF.FvesB	Three mid shore sites shore within southern half of ECC
MA123D1	Fucus vesiculosus on full salinity moderately exposed to sheltered mid eulittoral rock	LR.LLR.F.Fves.FS	One site at extreme low shore in southern half of ECC
MA12442	Fucus serratus and under-boulder fauna on exposed to moderately exposed lower eulittoral boulders	LR.MLR.BF.Fser.Bo	Two low shore sites – one each within in northern and southern halves of ECC
MA123E2	Ascophyllum nodosum on full salinity mid eulittoral mixed substrata	LR.LLR.F.Asc.X	Area of mid shore within the northern half of the ECC
MA123G	Enteromorpha spp. On freshwater-influenced and/or unstable upper eulittoral rock	LR.FLR.Eph.Ulv	Upper shore areas throughout study area directly below LS.LCS.Sh.BarSh / MA3211

12.3.3 Designated Sites

As part of this benthic regional characterisation, an assessment of relevant designated sites within proximity to the study area has been carried out. These sites have been assessed here as they have been designated for the protection of benthic subtidal or intertidal habitats and features. Sites within the benthic study area are designated under the EU Habitats Directive and Birds Directive. The sites which have been assessed here are listed in Table 12.10 which summarises the qualifying features or supporting features that relate to seabed habitats and benthic ecology and the distance from the array area and ECC. Locations of these sites in relation to the study area are presented in Figure 12.7.

As no designated sites with benthic ecology features directly overlap with the array area or ECC there will be no direct impacts on any designated sites. However, the offshore development area is wholly encompassed by the North West Irish Sea cSPA which while not being designated for any benthic features or species covers supporting habitats which are utilised by bird species for the which the site is designated.

An assessment of indirect impacts (e.g. changes in suspended sediment concentrations (SSC) and/or sediment deposition) as determined by the assessment presented in the Physical Processes Chapter has been undertaken on relevant benthic ecology features within sites that have the potential to be indirectly affected by the proposed development. Those benthic ecology and seabed habitat features of designated sites within the study area have been screened into the assessment.

Impacts on designated sites are also addressed in the Natura Impact Statement (NIS) (North Irish Sea Array Windfarm Ltd, 2024) drafted in relation to the proposed development.

Designated sites, including Natura 2000 sites, that have the potential for likely significant effects due to the proposed development are presented in Table 12.10 below.

Table 12.10 Natura 2000 sites encompassed by the study area designated for benthic features

Site code	Site name	Relative location to the proposed development	Qualifying/supporting benthic features
SAC			
003000	Rockabill to Dalkey Island	Adjacent to the array; 2.4km south of the ECC.	Reefs [1170]
001957	Boyne Coast and Estuary	16.4km west of the array; 7.9km northwest of the ECC.	Estuaries [1130] Mudflats and sandflats not covered by seawater at low tide [1140]
SPA			
004014	Rockabill	Intersects with the southern boundary of the array area – adjacent to both array area and ECC.	Designated for ornithology. Supporting habitats for these features include estuaries, mudflats, and sandflats.
004122	Skerries Island	Site is in the intertidal component of the study area, southwest of the southern boundary of the array (0.9km from array area; 0.4km from ECC).	Designated for ornithology. Supporting habitats for these features include estuaries, mudflats, and sandflats.
004158	River Nanny Estuary and Shore	Site is located in the intertidal component of the study area along the Meath coastal zone and will likely intersect with the ECC landfall (16.9km from array area; 3.1km from ECC).	Designated for ornithology. Supporting habitats for these features include estuaries, mudflats, and sandflats.
004080	Boyne Estuary	26.2km west of the array; 9.8km NW of ECC.	Designated for ornithology. Supporting habitats for these features include estuaries, mudflats, and sandflats.
004236	North West Irish Sea cSPA	Encompasses the array area and ECC.	Designated for ornithology. Supporting habitats for these features include estuaries, mudflats, and sandflats.

As of spring 2024, the Marine Protected Areas Bill is at an advanced stage and will enable Ireland to meet its national and international commitments for area-based marine protection with the aim of 30% MPA coverage of Irish waters by 2030 with work undertaken which will help inform planning decisions and establish methods and develop an evidence base which can inform future identification, designation and management of Irish MPAs (MPAAG, 2023).

12.3.4 Features of Conservation Interest

A review has been undertaken to identify benthic features of conservation interest within the benthic subtidal and intertidal ecology study area. Features of Conservation Interest are those features that are particularly threatened, rare, or declining species and habitats which are listed in the Habitats Directive Annex 1 (habitats) and Annexes II, IV and V (species). It should be noted that any likely significant effects on qualifying features within designated sites have been considered in the NIS. Any features of conservation importance that lie outside of these designated sites are identified within this section of the report.

No subtidal Annex I habitats[6] were identified during the site-specific surveys. However, the biotope "Seapens and burrowing megafauna in Atlantic circalittoral fine mud" (Code MC6216), which is listed under the OSPAR list of threatened and/or declining species and habitats, was identified at a single site in the array subtidal survey area, to the south of the array area (Figure 12.5).

Biogenic reefs comprised of dense aggregations of the tube-building polychaete *Sabellaria spinulosa* are classed as an Annex I habitat. The site-specific surveys identified individuals of *S. spinulosa* at four stations within the ECC, although abundances were relatively low, and no stations were classified as *S. spinulosa* reef according to the definition given by Gubbay (2007). Given the *S. spinulosa* were recorded as individuals and not in an aggregation form, they don't constitute and Annex I habitat. Similarly, no aggregations were identified during DDV survey undertaken south-west corner of the array area (see Appendix 12.2: Cable Route Benthic Survey Report).

Reef habitats on hard compact substrata (including rock, boulders, and cobbles) are classified as an Annex I priority habitat (European Commission, 2013). Data from the EMODnet Habitats Directive Annex I habitat maps (EUSeaMap, 2019) indicates with high confidence that there are Annex I geogenic reef habitats near to the southwest of the array area which are assigned the biotope "Moderate energy circalittoral rock". However, DDV imagery collected as part of the site-specific surveys indicated that potential reef did not in fact constitute reef according to criteria and methodology detailed by Gubbay (2007), Irving (2009) and Golding et al. (2020), therefore no Annex I geogenic reef were recorded in the ECC and array subtidal survey area during the site-specific surveys.

While no intertidal reefs were identified across the intertidal survey area during the site-specific surveys results did indicate the presence of potential reef habitats, these included:

- 'Fucus vesiculosus and barnacle mosaics on moderately exposed mid eulittoral rock' (MA1243)
- 'Fucus vesiculosus on full salinity moderately exposed to sheltered mid eulittoral rock' (MA123D1); and
- 'Fucus serratus and under-boulder fauna on exposed to moderately exposed lower eulittoral boulders' (MA12442).

12.3.5 Valued Ecological Receptors (VERs)

The value of ecological features is dependent upon their biodiversity, social, and economic value within a geographic framework of appropriate reference (CIEEM, 2018). The most straightforward context for assessing ecological value is to identify those species and habitats that have a specific biodiversity importance recognised through international or national legislation or through local, regional, or national conservation plans (e.g., Annex I habitats under the Habitats Directive, OSPAR). However, only a very small proportion of marine habitats and species are afforded protection under the existing legislative or policy framework and therefore evaluation must also assess value according to the functional role of the habitat or species. For example, some features may not have a specific conservation value in themselves but may be functionally linked to a feature of high conservation value.

The VERs, their conservation status and importance within the benthic subtidal and intertidal ecology study area and the justification and regional importance of each receptor are presented in Table 12.11. Where VERs have been recorded in the survey area, they have been assessed within this chapter for direct and indirect impacts. VERs located within the ZoI have been assessed for indirect impacts only.

[6] Natural habitat types of community interest whose conservation requires the designation of Special Areas of Conservation.

Table 12.11 VERs within the benthic subtidal and intertidal ecology study area

VER	Representative biotope (EUNIS, 2022)	Protection status	Conservation interest	Distribution within array area and ECC (offshore and intertidal)	Importance within benthic subtidal and intertidal ecology study area and justification
Subtidal					
Coarse and mixed sediments with moderate to high infaunal diversity and epibenthic communities	MC52 MB5236 MC5214 MD5212	None	Habitats of Principal importance and UK Biodiversity Action Plan (BAP) priority habitat (subtidal sands and gravels)	Identified from the nearshore to the middle area of the ECC and in the southern area of the array area.	Regional – although this habitat is representative of a nationally important marine habitat, the Irish Sea is not a single key geographic area.
Brittlestar and mollusca dominated communities in sandy mud	MC6211 MC6213	None	Habitats of Principal importance and UK BAP (subtidal sands and gravels) Sublittoral sediment included as revised Annex I of Resolution 4 habitat type of the Bern Convention	Identified from the middle area of the ECC and in the central to southern area of the array area.	Regional – although this habitat is representative of a nationally important marine habitat, the Irish Sea is not a single key geographic area.
Non-cohesive muddy sands or slightly shelly/gravelly muddy sand characterised by bivalves or polychaetes	MC4213 MC5214 MC6217 MC62	None	N/A	Identified from the middle and offshore areas of the ECC and in the northern half of the array area.	None
Seapens and burrowing megafauna in circalittoral fine mud	MC6216	None	OSPAR List of Threatened and/or Declining Species and Habitats (Region II – North Sea, Region III – Celtic Sea).	Identified from single site on eastern periphery of array area.	Regional – although this habitat is representative of a nationally important marine habitat, the Irish Sea is not a single key geographic area.
Subtidal sands and gravels	MC4	None	Habitats of Principal importance and UK BAP priority habitat (subtidal sands and gravels)	Identified from the south-western corner of the array area.	Regional – although this habitat is representative of a nationally important marine habitat, the Irish Sea is not a single key geographic area.
Intertidal					
Littoral sand dominated by polychaetes	MA524 MA5241 MA52412 MA52331	None	N/A	Identified throughout intertidal component of the study area where sedimentary habitats occurred.	None – habitat is not protected under any conservation legislation and is found widespread throughout the Irish Sea geographic area.

VER	Representative biotope (EUNIS, 2022)	Protection status	Conservation interest	Distribution within array area and ECC (offshore and intertidal)	Importance within benthic subtidal and intertidal ecology study area and justification
Phaeophyceae on moderately exposed mid eulittoral rock to full salinity mid eulittoral mixed substrata	MA1243 MA123E2 MA123D1 MA12442	None	N/A	Identified throughout the mid and lower shore of the intertidal survey area where rocky substrate predominated.	None – habitat is not protected under any conservation legislation and is found widespread throughout the Irish Sea geographic area.
Ulvophyceae on freshwater-influenced and/or unstable upper eulittoral rock	MA123G	None	N/A	Identified from the upper shore in the southern half of the intertidal survey area.	None – habitat is not protected under any conservation legislation and is found widespread throughout the Irish Sea geographic area.
Barren littoral shingle	MA3211	None	N/A	Identified in much of the upper shore of the intertidal survey area just below MHW.	None – habitat is not protected under any conservation legislation and is found widespread throughout the Irish Sea geographic area.
Annex I habitat features of SACs					
Reefs [1170]	None	Annex I habitat	Annex I within a SAC	The SAC does not overlap with the proposed development boundary. However, indirect impacts using a 12km tidal excursion have been screened into the assessment on a precautionary basis. The 12km tidal excursion from both the array area and ECC overlaps with the SAC.	International – part of European designated sites (Rockabill to Dalkey Island SAC).
Estuaries	None	Annex I habitat	Annex I within a SAC	The 12km tidal excursion from both the array area and ECC overlaps with the SACs.	International – part of European designated sites (Boyne Coast and Estuary SAC and Rogerstown Estuary SAC).
Mudflats and sandflats not covered by seawater at low tide	None	Annex I habitat	Annex I within an SAC	The SACs do not overlap with the proposed development boundary. Indirect impacts using a 12km tidal excursion have been screened into the assessment on a precautionary basis. The 12km tidal excursion from both the array area and ECC overlaps with the SACs.	International – part of European designated sites (Boyne Coast and Estuary SAC, Rogerstown Estuary SAC, and Malahide Estuary SAC). These features represent a potential resource for bird species for which SPAs listed in Table 12.10.

12.4 Characteristics of the Proposed Development

This section outlines the characteristics of the proposed development that are relevant to the identification and assessment of effects on benthic subtidal and intertidal ecology during each phase of the proposed development. In this chapter this is limited to activities and infrastructure occurring in the offshore development area and it considers both Project Option 1 and Project Option 2, the key characteristics of which are provided in Table 12.12 and are detailed in full in the Offshore Description Chapter.

Table 12.12 Key Characteristics of Project Option 1 and Project Option 2

Key Offshore Characteristics	Project Option 1	Project Option 2
Array area	88.5km^2	88.5km^2
ECC	36.45km^2	36.45km^2
Landfall	One landfall site, immediately south of Bremore Point, which includes two subtidal exit pits within the ECC	One landfall site, immediately south of Bremore Point, which includes two subtidal exit pits within the ECC
Wind Turbine Generator (WTG)	49 WTGs with 250m rotor diameter	35 WTGs with 276m rotor diameter
WTG Foundations	49 monopiles of 12.5m diameter requiring seabed preparation	35 monopiles of 12.5m diameter or jacket foundations (three or four leg configurations, with 6m diameter pin piles) requiring seabed preparation
Offshore Substation Platform (OSP) Foundations (array area)	One OSP, with either a four-legged jacket foundation with pin piles, or one monopile; or two monopiles	One OSP, with either a four-legged jacket foundation with pin piles, or one monopile; or two monopiles
Cables	Installation of 111km of array cables within the array area and installation of two 18km export cables within the ECC	Installation of 91km of array cables within the array area and installation of two 18kmexport cables within the ECC

A presentation of the potential impacts in relation to Project Option 1 and Project Option 2 is provided, and the magnitude of those impacts in relation to the size and scale of the proposed development parameters is presented in Table 12.14. This enables the identification of the project option that will result in the greatest magnitude of impact on receptors and will therefore present the greatest potential for a likely significant effect (Table 12.14).

To determine the magnitude of the impact level, modelling, calculations, and mapping have been undertaken for the project option with the greatest magnitude of impact, for all impacts for the relevant receptor/s.

The significance of effect assessment is then undertaken for both project options, which considers both receptor sensitivity and the magnitude of the impact and is detailed in Section 12.5. Given the similarity of the project options, in most instances the conclusions are the same. In some instances, the difference in magnitude of impact between project options results in a different categorisation of significance.

12.4.1 Parameters for Assessment

The below activities, infrastructure and key design parameters have been considered within this chapter when determining the potential impacts. Further detail on the offshore elements of the proposed development is provided in the Offshore Description Chapter and Offshore Construction Chapter. These parameters apply to both project options and any differences in values that may require consideration have been identified in Table 12.14.

12.4.2 Construction

During construction, the following activities and infrastructure have the potential to impact on benthic subtidal and intertidal ecology:

- Pre-construction surveys
- Preparatory dredging for foundations
- Installation of foundations
- Cable trenching
- Subtidal HDD works
- Jack up and anchoring operations; and
- Cable seabed preparation and installation activities.

12.4.3 Operational Phase

During operation, the following activities and the presence of infrastructure have the potential to impact on benthic subtidal and intertidal ecology:

- Presence of WTG foundations
- Presence of OSP foundations
- Presence of scour protection
- Presence of pre- and post-lay rock berm/mattressing
- Presence of cable protection
- Operational vessels; and
- Operation and maintenance activities in relation to the infrastructure.

12.4.4 Decommissioning

During decommissioning, the following activities and activities and infrastructure have the potential to impact on benthic subtidal and intertidal ecology:

- Removal of infrastructure; and
- Jack up and anchoring operations.

12.4.5 Embedded Mitigation Measures

The following embedded mitigation measures in Table 12.13 have been identified through the design and consultation process and are assumed to be incorporated as part of the proposed development. The embedded mitigation measures will not be considered again at the residual impact stage.

Table 12.13 Embedded mitigation measures relating to benthic subtidal and intertidal ecology

Type of mitigation measure	Description of Mitigation measure
Construction	
Cable installation measures/Cable Burial Risk Assessment	Cable installation measures will minimise adverse impacts to potentially sensitive receptors. It will also set out appropriate cable burial depth in accordance with industry good practice, reducing the risk of cable exposure and based on a cable burial risk assessment. Cables will be buried to a sufficient depth to ensure that they are not exposed by sandwave movements.

Type of mitigation measure	Description of Mitigation measure
	Where target cable burial depth cannot be achieved during the cable installation process (for any of inter-array, interconnector, or export cables), cable armouring will be implemented (e.g. mattressing, or rock placement etc). The suitability of installing rock or mattresses for cable protection will be investigated, based on (inter alia) the seabed current data at the location of interest and a risk assessment of the potential for cable damage to occur. Cable installation measures are captured in the Offshore Environmental Management Plan (EMP)
Cable burial	Cable installation will follow the burial hierarchy, where practicable two attempts will be made to bury cables before cable protection is used.
Landfall	The installation of the offshore export cables at landfall will be undertaken by HDD beneath the intertidal zone which will prevent any direct disturbance to intertidal receptors. The HDD exit pits will be located within the ECC seaward of the LWM at a point where cable installation vessels can operate.
Project Design	Presence of sensitive habitats will be identified through a review of the latest available benthic datasets and pre-construction surveys. Proposed development infrastructure will avoid protected habitats wherever reasonably practicable to an extent not resulting in a hazard for marine traffic and Search & Rescue capability.
Offshore Environmental Management Plan (EMP)	An Offshore EMP will be developed and will include details of: Marine pollution contingency measures to address the risks, methods and procedures to deal with any spills and collision incidents of the authorised project in relation to all activities carried out below the HWM; • A chemical risk review to include information regarding how and when chemicals are to be used, stored and transported in accordance with recognised best practice guidance; • Marine biosecurity measures detailing how the risk of introduction and spread of invasive non-native species will be minimised; • Waste management and disposal arrangements; • A vessel management plan, to determine vessel routing to and from construction sites and ports, to include a code of conduct for vessel operators; and • The appointment and responsibilities of a company fisheries liaison officer.
Pre-construction profile survey	Where necessary, before works commence and following reinstatement, a topographical survey of the nearshore subtidal area will be carried out to identify and map the contours of the subtidal HDD exit pit to ensure a profile similar in nature to the profile recorded during the pre-construction survey is reinstated, as far as practicable.
Operation	
EMF and cable protection	Where practicable cables will be buried to reduce the impacts of EMF on sensitive receptors and minimise the requirement for additional cable protection.
Decommissioning	
Assessment of impacts and best practice environmental management	Prior to decommissioning a study of the potential environmental impacts to benthic ecology receptors from the proposed decommissioning activities will be undertaken, considering the baseline environment at the pre-decommissioning stage. All mitigation measures to be captured will be captured within Appendix 6.2 of Volume 8 Rehabilitation Schedule and the decommissioning strategy within the Offshore EMP. Any licences or authorisations that might be required will be identified and obtained prior to decommissioning, including any validation, updating or new submission of an EIAR, as required.

12.4.6 Potential Impacts

The identification of potential impacts has been undertaken by considering the relevant characteristics from both project options (refer to Section 12.4.1) and the potential for a pathway for direct and indirect impacts on known receptors (as identified in Section 12.3). Each identified impact relevant to benthic subtidal and intertidal ecology is presented in Table 12.14.

For each impact, the relevant characteristics of Project Option 1 and Project Option 2 are presented to determine the magnitude (size or extent) of the potential impact, defined by the proposed development parameters in the Offshore Description Chapter and in consideration of the WTG Limits of Deviation (LoD[7]), in line with the approach detailed in the EIAR Methodology Chapter. A comparison of the project options has then been undertaken to determine which project option has the greatest magnitude of impact.

[7] Both Project Option 1 and Project Option 2 layouts have a 500m Limit of Deviation (LoD)

Table 12.14 Potential impacts and magnitude of impact per project option. The project option that has the greatest magnitude of impact is identified in blue

Potential Impact	Project Option 1 (49 WTG)	Project Option 2 (35 WTG)	Rationale for the project option with the greatest magnitude of impact
Construction			
Temporary increase in SSC and sediment deposition in subtidal habitats	Total volume of suspended sediment and sediment deposition 805,292m^3. **WTG foundation drill cuttings:** 49 turbines foundations with 75% requiring drilling = 338,243m^3 **OSP foundations (array):** One OSP foundation requiring seabed preparation and drilling = 22,089m^3 **Cable trenching:** Installation of 111km of array cables = 333,000m^3 Installation of two export cables = 108,000m^3 (excluding the part of the export cable within the array area) **Subtidal HDD:** Exit pits total volume = 3,960m^3. Release of drilling muds (i.e. bentonite) during exit pit punch-out = 30 tonnes	Total volume of suspended sediment and sediment deposition 897,061m^3. **WTG foundation preparatory dredging:** Dredging at the seabed in preparation for foundation placement (jacket foundations only) at 50% of locations = 133,755m^3 **WTG foundation drill cuttings:** 35 turbines foundations with 100% requiring drilling = 356,257m^3 **OSP Foundations (array):** One OSP foundation requiring seabed preparation and drilling = 22,089m^3 of sediment. **Cable trenching:** Installation of 91km of array cables = 273,000m^3 Installation of two export cables = 108,000m^3 (excluding the part of the export cable within the array) **Subtidal HDD:** Exit pits total volume = 3,960m^3. Release of drilling muds (i.e. bentonite) during exit pit punch-out = 30 tonnes	Project Option 2 represents the greatest magnitude of impact in relation to these impacts. The greatest magnitude of impact for foundation installation results from the largest volume suspended relating to jacket foundation seabed preparation and installation. For cable installation, the greatest magnitude of impact results from the greatest volume installation using energetic means. This also assumes the largest number of cables and the greatest burial depth. One OSP will be constructed within the order limits. Project Option 2 has a higher total volume than Project Option 1 (91,769m^3 more volume of materials) and presents the greatest magnitude of impact.
Temporary increase in SSC and sediment deposition in intertidal habitats	Total volume of suspended sediment and sediment deposition 111,960m^3. Export cable trenching and subtidal HDD (same as Impact 1)	Total volume of suspended sediment and sediment deposition 111,960m^3. Export cable trenching and subtidal HDD (same as Impact 1)	Project Option 1 and Project Option 2 represent the same magnitude of impact. The export cable and HDD exit pits are the same across both project options.
Temporary habitat disturbance in array area and ECC	Temporary habitat disturbance of 6,269,549m^2. Array area Seabed preparation at one OSP = 1,304m^2. Jack up vessel spud can footprint, anchoring operations, construction buoys (assumed 12) = 374,271m^2.	Temporary habitat disturbance of 5,391,017m^2. Array area Seabed preparation (dredging) at WTG foundation (jacket only) = 23,185m^2. Seabed preparation (dredging) at one OSP foundation (jacket only) = 1,304m^2.	Project Option 1 represents the greatest magnitude of impact in relation to this impact. The greatest magnitude of impact for temporary disturbance relates to seabed preparation for foundations and cables, jack up and anchoring operations, and cable installation.

Potential Impact	Project Option 1 (49 WTG)	Project Option 2 (35 WTG)	Rationale for the project option with the greatest magnitude of impact
	Cable seabed preparation and installation in the array trench area affected: 111km length, 40m width (including preparatory seabed measures) = 4,440,000m^2. **ECC** Cable seabed preparation and installation in the ECC trench area affected: 18km length, 40m width (including preparatory seabed measures) = 1,440,000m^2. **Subtidal HDD:** Total footprint of disturbance (exit pits, transition zone, temporary sidecast/ deposited material & JUV footprint) = 4,156m^2. Boulders required to be cleared across array area (IAC routes, WTG & OSP locations) & ECC = 9,817m^2	Jack up vessel spud can footprint, anchoring operations, construction buoys (assumed 12) = 275,303m^2. Cable seabed preparation and installation in the array trench width affected: 91km length, 40m width (including preparatory seabed measures) = 3,640,000m^2. **ECC** Cable seabed preparation and installation in the ECC trench area affected: 18km length, 40m width (including preparatory seabed measures) = 1,440,000m^2. **Subtidal HDD:** Total footprint of disturbance (exit pits, transition zone, temporary sidecast/ deposited material & JUV footprint) = 4,156m^2. Boulders required to be cleared across array area (IAC routes, WTG & OSP locations) & ECC = 7,069m^2.	Project Option 1 has a higher total area of temporary habitat disturbance than Project Option 2 (878,532m^2 more volume of materials) and presents the greatest magnitude of impact. (Note that habitat covered with infrastructure (e.g. WTG foundations) is considered long term or permanent habitat loss and therefore this has been assessed as an operational impact (Impact 6)) The footprint of seabed disturbance at the foundations in these impacts just relates to jacket foundations and is just the area dredged that goes beyond the footprint of the infrastructure.
Reduction in water and sediment quality through release of contaminated sediments and/or accidental contamination (see impact 1 above)	Total volume of suspended sediment and sediment deposition 805,292m^3.	Total volume of suspended sediment and sediment deposition 897,061m^3.	Project Option 2 represents the greatest magnitude of impact in relation to this impact Project Option 2 represents the greatest total seabed disturbance and therefore the greatest amount of contaminated sediment that may be released into the water column during construction activities.
Introduction of marine invasive non-native species (MINNS)	3,008 round trips to port by construction vessels.	2,530 round trips to port by construction vessels.	Project Option 1 represents the greatest magnitude of impact in relation to this impact. This scenario represents a larger magnitude of impact with regard to maximum number of vessel movements during construction activities.
Operation			
Long-term or permanent subtidal habitat loss/ change from the presence of foundations, scour protection and cable protection	Habitat change of 276,296m^2. **Array area:** WTG footprint with scour protection, based on 49 WTG =121,767m^2.	Habitat change of 297,510m^2. **Array area:** Turbine footprint with scour protection, based on 35 WTG = 162,982m^2.	Project Option 2 represents the greatest magnitude of impact in relation to this impact. The greatest magnitude of impact for long-term or permanent habitat loss relates to cable protection.

Potential Impact	Project Option 1 (49 WTG)	Project Option 2 (35 WTG)	Rationale for the project option with the greatest magnitude of impact
	One Offshore Substation Platform (OSP) foundations footprint = 4,788m^2. Pre- and post-lay rock berm area within array area (5 cable crossings) = 2750 m^2. Inter array cable protection assuming (20% cable will require additional cable protection) = 111,000m^2. **ECC:** Cable protection assuming (20% cable will require additional cable protection) = 36,000m^2.	One Offshore Substation Platform (OSP) foundations footprint = 4,778m^2. Pre- and post-lay rock berm area within array area (5 cable crossings) = 2,750m^2. Inter array cable protection assuming (20% cable will require additional cable protection) = 91,000m^2. **ECC:** Cable protection assuming (20% cable will require additional cable protection) = 36,000m^2.	Project Option 2 has a higher total area of long-term or permanent habitat loss than Project Option 1 (21,214m^2 more seabed area) and presents the greatest magnitude of impact.
Temporary habitat disturbance in array area and ECC	Total temporary habitat disturbance: 675,134m^2. **Array area:** JUV operations - Major WTG component repair/replacement = 646,540m^2. JUV - Major OSP component replacement = 13,195m^2. Inter array cable repair and/or replacement of cabling = 7,000m^2. Inter array cable reburial of any section of the offshore export cable which has become exposed = 700m^2. **ECC** Export Cable - Repair and/or replacement of cabling = 7,000m^2. Export Cable - Reburial of any section of the offshore export cable which has become exposed = 700m^2.	Total temporary habitat disturbance: 490,409m^2. **Array area:** JUV operations - Major WTG component repair/replacement = 461,814m^2. JUV - Major OSP component replacement = 13,195m^2. Inter array cable repair and/or replacement of cabling = 7,000m^2. Inter array cable reburial of any section of the offshore export cable which has become exposed = 700m^2. **ECC** Export Cable - Repair and/or replacement of cabling = 7,000m^2. Export Cable - Reburial of any section of the offshore export cable which has become exposed = 700m^2.	Project Option 1 represents the greatest magnitude of impact in relation to this impact. The greatest magnitude of impact for long-term or permanent habitat loss relates to cable protection. Project Option 1 has a higher total area of long-term or permanent habitat loss than Project Option 2 (184,725m^2 more seabed area) and presents the greatest magnitude of impact. Note that habitat disturbance would also result in increased SSC. However, the volume of sediment that could be suspended has not been calculated but will be a much smaller quantity compared with that generated by construction and decommissioning activities.
Changes in physical processes	See impact presented in the Physical Processes Chapter.	See impact presented in the Physical Processes Chapter.	Project Option 1 represents the greatest magnitude of impact in relation to this impact. This impact is defined by any anticipated changes to physical processes as defined in the Physical Processes Chapter.

Potential Impact	Project Option 1 (49 WTG)	Project Option 2 (35 WTG)	Rationale for the project option with the greatest magnitude of impact
Impacts of colonisation of introduced hard substrate on benthic ecology and biodiversity	Total surface area of introduced hard substrate in the water column: 414,766m^2. Scour protection 49 WTGs, 1 OSP = 120,533m^2. Cable protection = 196,980m^2. Post-lay rock berm = 4,125m^2. Total surface area of subsea portions of WTG foundation piles in contact with the water column = 89,476m^2. Total surface area of subsea portions of OSP foundation piles in contact with the water column = 3,652m^2.	Total surface area of introduced hard substrate in the water column: 388,128m^2. Scour protection 49 WTGs, 1 OSP = 87,460m^2. Cable protection = 170,180m^2. Post-lay rock berm (cable crossings) = 4,125m^2. Total surface area of subsea portions of WTG foundation piles in contact with the water column = 122,711m^2. Total surface area of subsea portions of OSP foundation piles in contact with the water column = 3,652m^2.	Project Option 1 represents the greatest magnitude of impact in relation to this impact. The project option with the greatest magnitude of impact is defined by the greatest area of structures, scour protection, cable protection and cable crossings introduced to the water column, including surface area of vertical structures. The greatest magnitude of impact in relation to introduction of hard substrate for colonisation is the surface of the WTG piles within the water column. Project Option 1 has a higher total area of introduced surface than Project Option 2 (26,638m^2 more available area) and presents the greatest magnitude of impact.
Introduction of MINNS (see impact 9)	Total surface area of introduced hard substrate in the water column = 414,766m^2. 1,261 vessel round trips annually.	Total surface area of introduced hard substrate in the water column = 388,128m^2. 1055 vessel round trips annually.	Project Option 1 represents the greatest magnitude of impact in relation to this impact. This scenario has the greatest magnitude of impact with regards to maximum number of vessel movements during operational activities.
Reduction in water and sediment quality through release of contaminated sediments and/or accidental contamination	The magnitude of the impact represents the greatest volume of sediments released during the operational phase, Temporary increases in SSC will result from periodic jack-up vessel deployment, and cable repair, replacement and reburial activities (activities listed under Impact 7).	The magnitude of the impact represents the greatest volume of sediments released during the operational phase. Temporary increases in SSC will result from periodic jack-up vessel deployment, and cable repair, replacement and reburial activities (Activities listed under Impact 7).	Project Option 1 represents the greatest magnitude of impact in relation to this impact. The magnitude of the impact is defined by the greatest volume of sediment that are predicted to be released into the water column during the operational phase. There is more infrastructure to maintain in Project Option 1 therefore the increase of SSC from operational activities will be greater from Project Option 1. Note the risk of accidental contamination as a result of spillages or collisions will be managed through the implementation of an Offshore EMP, and therefore no design scenarios are presented for accidental contamination.

Potential Impact	Project Option 1 (49 WTG)	Project Option 2 (35 WTG)	Rationale for the project option with the greatest magnitude of impact
Decommissioning			
Temporary increase in SSC and sediment deposition	The impacts are expected to be equivalent to Potential Impact 1 above apart from the structures that may remain (e.g. cables and cable protection measures). See the Physical Processes Chapter.	The impacts are expected to be equivalent to 1 above apart from the structures that may remain (e.g. cables and cable protection measures). See the Physical Processes Chapter.	Project Option 2 represents the greatest magnitude of impact in relation to this impact. The project option with the greatest magnitude of impact is assumed to be as per the construction phase, with all infrastructure removed in reverse-construction order. The removal of cables is considered, however the necessity to remove cables will be reviewed at the time of decommissioning.
Temporary habitat disturbance in the array area and ECC	Removal of all foundations, cables and rock protection leading to temporary habitat disturbance is equivalent to impact 3 and 6.	Removal of all foundations, cables and rock protection leading to a temporary habitat disturbance to impact 3 and 6.	Project Option 1 represents the greatest magnitude of impact in relation to this impact. The project option with the greatest magnitude of impact is assumed to be similar to the construction phase, with all infrastructure removed in reverse-construction order. The removal of cables and rock protection is considered the assessment, however the necessity to remove cables and rock protection will be reviewed at the time of decommissioning.
Reduction in water and sediment quality through release of contaminated sediments and/or accidental contamination	The assessment of reduction in water and sediment quality through release of contaminated sediments and/or accidental contamination during the decommissioning phase is presented in Impact 1 above.	The assessment of reduction in water and sediment quality through release of contaminated sediments and/or accidental contamination during the decommissioning phase is presented in Impact 1 above.	Project Option 2 represents the greatest magnitude of impact in relation to this impact. This scenario represents the greatest total seabed disturbance and therefore the greatest amount of contaminated sediment that may be released into the water column during decommissioning activities.

12.5 Potential Effects

The likely significant effects, both beneficial and adverse, on benthic subtidal and intertidal ecology receptors for each stage of proposed development are considered, specifically, the likely significant effects of the proposed development during its construction, operational, and decommissioning phases associated with the offshore development area. The environment in the vicinity of the proposed development is naturally dynamic, and as such will exhibit some level of natural variation and change over time whether the proposed development proceeds or not. Consequently, the identification and assessment of likely significant effects must be done in the context of natural change, both spatial and temporal.

The assessment of likely significant effects on the designated sites listed in Table 12.10 is an intrinsic part of the assessment of the habitat of benthic subtidal and intertidal ecology assessed in this section, of which the habitat forms part of. An assessment of the in-direct impacts on the benthic subtidal and intertidal ecology receptors designated within these sites including impacts to supporting habitats and water quality is also included in this assessment.

A NIS has been prepared, which is a standalone document independent of the findings of this EIAR, in compliance with the EU's Habitats Directive and Birds Directive. The NIS assesses how the proposed development might affect the Natura 2000 conservation objectives, and the mitigation measures that will be implemented to ensure that adverse effects on site integrity do not arise, are considered. The conclusion of the NIS assessment was that the proposed development will not adversely affect the integrity of any European site, either alone or in-combination with other plans or projects.

12.5.1 Do-Nothing Scenario

Should the proposed development not be constructed, the baseline environment is unlikely to show future natural variations outside of that presented by the future receiving environment as follows.

An assessment of the future receiving environment (without the proposed development) has been carried out and is described within this section. The receiving environment is not static and will exhibit some degree of natural change over time related to naturally occurring cycles and processes. Therefore, when undertaking impact assessments, it will be necessary to place any potential impacts in the context of the envelope of change that might occur naturally over the timescale of the proposed development.

Further to potential change associated with existing cycles and processes, it is necessary to take account of the likely significant effects of climate change on the marine environment. The quality of the marine environment, in particular, the integrity of marine ecosystems, is still at risk from the impact of global climate change, especially rising sea temperatures with an increase in sea surface temperature of 0.6°C per decade observed in Irish waters since 1994 (Department of Housing, Local Government and Heritage, 2021 (OREDP, 2010). Marine ecosystems are impacted by warming temperatures, changing wind patterns, shifting oceanic circulation patterns, increasing acidification and altering precipitation rates and hence salinity. These changes have the potential to change the distribution, abundance, size and behaviour of aquatic organisms (NPWS, 2019). Climate change impacts will change species distribution, reproduction, growth, migration and interactions. (EPA, 2014). Studies of the benthic ecology over the last three decades have shown that biomass has increased by at least 250 to 400%; opportunistic and short-lived species have increased; and the abundance of long-living sessile animals has decreased (Krönke, 1995; Krönke, 2011).

Sea surface temperatures in Irish waters have shown a progressive warming from the mid-1990s (Cámaro García and Dwyer, 2020). The warming observed in the last three decades has been particularly strong in parts of the north-east Atlantic, with the sea surface around Ireland warming at rates six times greater than the global average (Dye et al., 2013).

Furthermore, most literature to date focuses specifically on temperature, with regards to the effects of climate change on marine habitats. Climatic warming also causes deoxygenation within the water column. Over decadal timescales, there has been a measurable decline in dissolved oxygen content in the global ocean in response to ocean warming (Mahaffey et al., 2020), with a further 7% decrease predicted for the year 2100 (IPCC,2013). It was concluded from 26 years of monitoring a benthic community within the Firth of Clyde that benthic communities had been affected by the decreasing levels of oxygen.

This finding agreed with other short-term studies (Breitburg et al., 2018, Levin et al., 2009). Specific changes included changes in morphology, burrow depth, bioturbation and feeding mode (Caswell et al., 2018).

As such, the baseline in the benthic subtidal and intertidal ecology study area study area described in Section 12.3 is a 'snapshot' of the present benthic ecosystem within a gradually yet continuously changing environment. Any changes that may occur during the design life span of the proposed development should be considered in the context of both greater variability and sustained trends occurring on national and international scales in the marine environment.

12.5.2 Construction Phase

This section presents the assessment of impacts arising from the construction phase of the proposed development. The potential impacts arising from construction of the proposed development are listed in Table 12.14 along with the project option with the greatest magnitude of impact against which each construction phase impact has been assessed. A description of the likely significant effect on benthic subtidal and intertidal ecology receptors caused by each identified impact is given below.

Potential impacts of the construction phase include:

- Temporary increase in SSC and sediment deposition in subtidal habitats
- Temporary increase in SSC and sediment deposition in intertidal habitats
- Temporary habitat disturbance in the array area and ECC
- Reduction in water and sediment quality through release of contaminated sediments and/or accidental contamination; and
- Introduction of MINNS.

12.5.2.1 Impact 1 - Temporary increase in SSC and sediment deposition in subtidal habitats

Sensitivity of the receptor

The communities and habitats identified across the study area are typical of the Irish Sea. All biotopes identified within the array area, the ECC and across the wider benthic ecology survey area are tolerant of variations in SSC and some degree of sediment deposition.

The contemporary MarESA sensitivity assessment uses annual mean values to determine the sensitivity of habitats to SSCs. Specific benchmarks (duration and intensity) are defined for the different impacts for which sensitivity has been assessed (e.g., smothering, abrasion, habitat alteration etc.). Detailed information on the benchmarks used and further information on the definition of resistance and resilience can be found on the MarLIN website[8]. As a result of the short-term nature of the construction phase of the proposed development, the benchmarks will not be breached, as elevations in SSC created by the construction works will not reach a sufficient scale or magnitude to significantly alter the annual mean values. Consequently, for the purposes of this assessment, reference has been made to the previous MarLIN sensitivity benchmark for short-term acute increases in SSC (i.e. an arbitrary change of 100mg/l for 1 month) together with that for short-term acute changes in turbidity (i.e. a change in two categories of the water clarity scale for a period of one month – the water clarity scale refers to the effect of changes in light penetration because of changes in turbidity).

The sensitivity of the biotopes with reference to benchmarks for deposition SSC and turbidity is summarised in Table 12.15.

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[8] https://www.marlin.ac.uk/evidence

Table 12.15 Sensitivity assessment for the benthic subtidal habitats for temporary increase in SSC and sediment deposition

Biotope name	Biotope code (EUNIS, 2022)	Sensitivity to longer term changes in suspended sediment and turbidity	Sensitivity to light smothering (<5cm)	Sensitivity to heavy smothering (5-30cm)
Burrowing megafauna Maxmuelleria lankesteri in circalittoral mud	MC6217	Not sensitive	Not sensitive	Not sensitive
Amphiura filiformis, Kurtiella bidentata and Abra nitida in circalittoral sandy mud	MC6211	Not sensitive	Not sensitive	Medium
Owenia fusiformis and Amphiura filiformis in offshore circalittoral sand or muddy sand	MD5212	Not sensitive	Low	Medium
Seapens and burrowing megafauna in circalittoral fine mud	MC6216	Not sensitive	Not sensitive	Not sensitive
Burrowing megafauna Maxmuelleria lankesteri in circalittoral mud	MC6217	Not sensitive	Not sensitive	Not sensitive
Abra alba and Nucula nitidosa in circalittoral muddy sand or slightly mixed sediment	MC5214	Low	Low	Medium
Fabulina fabula and Magelona mirabilis with venerid bivalves and amphipods in Atlantic infralittoral compacted fine muddy sand	MB5236	Low	Low	Medium
Kurtiella bidentata and Thyasira spp. in circalittoral muddy mixed sediment	MC4213	Not sensitive	Not sensitive	Low
Amphiura filiformis and Ennucula tenuis in circalittoral and offshore sandy mud	MD5212 closest	Not sensitive	Not sensitive	Medium
Amphiura filiformis, Kurtiella bidentata and Abra nitida in circalittoral sandy mud	MC6211	Not sensitive	Not sensitive	Medium

The benthic habitats that characterise the subtidal survey area are deemed to have at greatest, medium vulnerability to heavy smothering and, at worst, medium recoverability (recovery is likely to take 2-10 years depending on the scale of the impact). The sensitivity of the receptors is therefore considered to be in the range from low to medium according to the EIA assessment values, although Table 12.15 demonstrates that lower levels of sensitivity are recorded for light smothering (which will be the spatially larger impact) and longer-term changes in SSC.

Features of Conservation Importance

The biotope “seapens and burrowing megafauna in circalittoral fine mud” is included in the OSPAR List of Threatened and/or declining species and habitats. The MarESA sensitivity assessment defines this biotope as being ‘not sensitive’ to increases in SSC and light deposition. Seapens have been found to recover rapidly from the effects of dragging, uprooting, and smothering (Eno et al., 2001). Seapens *Pennatula phosphorea* and *Funiculina quadrangularis* recovered with 72-96 hours after experimental smothering for 24 hours by pot or creel and after 96-144 hours of smothering for 48 hours (Kinnear et al. 1996; Eno et al., 2001). The species characteristic of this biotope occur in deep, sheltered muddy habitats where the deposition rates are potentially high. Both *Pennatula phosphorea* and *Virgularia mirabilis* can burrow and move into and out of their own burrows.

It is probable therefore that deposition of 30cm of fine sediment will have little effect other than to temporarily suspend feeding and the energetic cost of burrowing. Thus, the MC6216 biotope has a high resistance, and recovery is rapid and is assessed as high. Where a proportion of the population is removed, then the species have a high dispersal potential and long-lived benthic larvae however recovery will take many years.

Despite the importance of the biotope 'seapens and burrowing megafauna in circalittoral fine mud', the overall sensitivity value is assessed as negligible due to the high recoverability and resilience of this biotope to increases in SSC and deposition.

Annex I reef is a primary feature of the Rockabill to Dalkey Island SAC. The SAC supports both intertidal and subtidal reef community complexes up to a total of 181.835 ha (European Environment Agency, 2019). The subtidal reef ranges from moderately exposed to exposed reef including flat and sloping bedrock, to bedrock with boulders and also a mosaic of cobbles and boulders. At Rockabill and Ireland's Eye, areas of both sediment scouring and a thin veneer of silt were observed on the reefs; the veneer of silt was also recorded at Lambay Island. In the shallow reaches of this community complex, the anemone *Alcyonium digitatum* occurs in moderate abundances as well as *Metridium senile*. In the deeper waters, bryozoans such as *Flustra foliacea* and *Chartella papyracea* and hydroids including *Nemertesia antennina* are recorded along with the ascidian *Aplidium punctum*. The starfish *Asterias rubens* is recorded throughout the site while the barnacle *Balanus crenatus* and the echinoderms *Echinus esculentus* and *Antedon bifida* also occur (NPWS, 2013). In general, it was noted that where the reef was subjected to the effects of sediment, either through scouring or settlement of silt, low numbers of species and individuals occurred (NPWS, 2013a). The sensitivity of these communities is considered to be in the range from low to medium in relation to the effects of raised SSC and deposition.

The subtidal reef habitats of Rockabill to Dalkey Island and Lambay Island SACs are deemed to be of medium vulnerability, medium to high recoverability and international importance. The sensitivity of these receptors is therefore considered to be medium at most.

The Annex 1 habitat "Estuaries" are habitat complexes comprised of a mosaic of subtidal and intertidal habitats and support diverse invertebrate and fish communities and provide feeding and roosting resources for many bird species. Inputs of riverine sediments allied to the sheltered nature of estuaries and typically low current regimes lead to the presence sediment-filled subtidal channels and extensive intertidal sediment flats (see "Mudflats and sandflats not covered by seawater at low tide" below). Subtidal benthic communities are influenced by the primarily muddy bed characteristics with communities being dominated by polychaetes and oligochaetes with bivalve molluscs and amphipod crustacea also present.

Subtidal communities are strongly influenced by salinity regimes with clear longitudinal patterns. Estuaries are listed as qualifying features in the Boyne Coast and Estuary SAC and Rogerstown Estuary SAC. These habitats are tolerant of increased SSC and deposition and the sensitivity of these receptors is considered to be negligible. Considering the VERs and features of conservation importance the greatest sensitivity of benthic receptors is medium for this impact.

Magnitude of impact

When finer sediments are mobilised, they are typically carried in suspension, contributing to a period of higher SSC and increased turbidity of water. Temporary localised increases in SSC and associated sediment deposition and smothering (which can result in the blocking of feeding and respiratory structures of benthic species) are expected from foundation works, cable installation and seabed preparation works. This assessment should be read in conjunction with the Physical Processes Chapter which provides the detailed offshore physical environment assessment (including proposed development specific spreadsheet modelling of sediment plumes).

The project option with the greatest magnitude of impact for activities resulting in disturbance of the seabed is provided in Table 12.12 and has been considered using numerical modelling both within the array area and along the ECC, for both spring and neap tides. The release events that have been simulated within the numerical model, as described in the Physical Processes Chapter, have been specifically designed to capture the full range of realistic outcomes:

- Sediment plume concentrations
- Sediment plume extent
- Vertical deposition depth (bed level change); and
- Horizontal extent of deposition (bed level change).

A full assessment of the above, including the methodological approach used to assess the characteristics of sediment plumes and associated changes in bed level arising from settling of material is set out in the Physical Processes Chapter. To provide a robust assessment, a range of realistic combinations have been considered, based on conservatively representative location (environmental) and proposed development specific information, including a range of water depths and sediment types. Table 12.16 details the peak increases in SSC and deposition that could occur as a result of construction activities.

Table 12.16 Temporary increases in SSC and sediment deposition as a result of construction activities

Construction Impact	Location	Details of increase in SSC and deposition
Seabed levelling	Array area	SSCs within sediment plumes associated with overspill can be in the order of hundreds of mg/l in the vicinity of the dredger, reducing to tens of mg/l with distance, but also quickly dissipating in time after release; After a period of around 18 hours from the initial release the plume covers an area of between 0.2 to 0.4km^2 on neap releases (peak concentration around 240 to 270mg/l) and 0.8 to 0.9km^2 on spring releases (peak concentration of 100 to 110mg/l); and Area of near-field covered by spoil depths above 50mm (0.05m) is estimated to be around 0.15km^2, and 0.08km^2 for depths above 0.30m. All far-field deposition depths are estimated as less than 50mm (0.05m).
Drilling for foundation installation	Array area	On a neap tide release at 20 hours the sediment plume extends to an area of up to 8km^2 with greatest SSC of around 33mg/l. The spring tide release at this time extends over an area of around 10km^2 with a greatest SSC of around 43mg/l; and All deposition depths of settled sediment remain less than 50mm (0.05m) close to the drilling location which reduces to between 2 to 10mm over a distance of up to 8km. Only trace levels (<1mm) exceed the tidal excursion buffer.
Cable installation	Array area	After a period of around 20 hours from the initial release the plume covers an area of between 1.7 to 2.1km^2 on neap release (peak concentration around 20 to 10mg/l, respectively) and 4.7 to 5.5km^2 on spring releases (peak concentration of 11 to 8mg/l, respectively); and Highest levels of deposition between 52 to 65mm occur along the trenching line (i.e., material falling back into the trench). Levels above 1mm remain within 3.5km of the trenching line on both flood and ebb tides. Trace levels (<1mm) spread further afield.
	ECC	Highest SSC concentrations in the range 600 to 800mg/l limited along the trenching line and for the period of trenching. Over six-hour release period and after a period of around ten hours from the initial release the plume covers an area of between 1.2 to 1.7km^2 on neap releases (peak concentration around 5 to 2mg/l, respectively) and 3.6 to 3.9km^2 on spring releases (peak concentration of 2mg/l); and Highest levels of deposition between 17 to 32mm occur along the trenching line (i.e., material falling back into the trench). Levels above 1mm remain within 1km of the trenching line on both flood and ebb tidal axis. Trace levels (<1mm) spread further afield with a distribution mainly to the north of the trench due to the flood dominant tide.
Excavation of HDD exit pits	Subtidal HDD exit pit	The plume covers a greatest distance of around 2.2km to the north-west (flood) and to the south-east (ebb) for concentrations >1mg/l on spring releases, and around 1.3km on neap releases. The highest elevated concentrations remain close to the exit pits within the ECC boundary with levels up to 1,120mg/l. The greatest spread of deposition is around 2.5km to the north-north-west and south-south-east of the exit pit trench. The greatest depth of deposition remains close to the pits with highest levels of between 68 to 193mm predicted within the ECC boundary, spreading parallel to the coast over about 300 m in a north-west to south-east direction.

Construction Impact	Location	Details of increase in SSC and deposition
Bentonite release	Subtidal HDD exit pit	The plume covers a greatest distance of around 1.1km to the north-west (flood) and 0.8km to the south-east (ebb) along the coast for concentrations >1mg/l on spring releases, and shorter distances on neap releases. The highest elevated concentrations remain close to the HDD exit pits with levels 29mg/l. The greatest spread of bentonite deposition is around 1.7km to the north-north-west and 1.4km to the south-south-east of the exit pit trench with greatest depths of deposition remaining closest to the pits with levels between 0.3 to 0.7mm (trace levels).

Seabed disturbance during the construction phase is expected to produce discrete sediment plumes, with the spread of these plumes determined by the prevailing tidal conditions. Since the sediments involved are likely to be mainly fine, these plumes will spread over several tides prior to completely settling outside of the flood-dominant phase favouring a net drift of the plume to the north on most tides. The greatest distance and the overall spatial extent that any resultant plume might be reasonably experienced can be estimated as the spring tidal excursion distance. Modelling indicates that the highest SSC concentrations (>1,000mg/l) associated with sediment plumes produced by drill cuttings are confined to the point of discharge while overall the plume of SSC above background levels extends to a greatest distance of 10.2km on the flood tide and 6.6km on the ebb. The highest SSC associated with trenching activity was modelled as an illustration of plume development, at 20 hours the sediment plume resulting from drilling in the array area on a neap tide will cover an area of up to 8km^2, while on a spring tide the extent is around 10km^2. Any location beyond the tidal excursion distance is unlikely to experience any measurable change in SSC from a sediment plume. Given the nature of the sediment disturbance (temporary), any impacts are also anticipated to be relatively short-lived, with any deposited material re-worked by biological activity (Newell et al., 1998) and, to a lesser extent, hydrodynamic factors (van der Veer et al., 1985).

The modelling further indicates that all deposition depths of settled material associated with drilling remain less than 50mm (0.05m) close to the drilling location which reduces to between 2 to 10mm over a distance of up to 8km, while in relation to trenching deposition of between 52 to 65mm may occur along the trenching line (i.e., material falling back into the trench) with levels above 1mm occurring within 3.5km of the trenching line. However, these levels of short-term deposition are considered to be light levels of smothering for any benthic receptors as most species common in soft-bottom communities are able to avoid burial with 5–10cm of sediment (Nichols et al., 1978).

For the ebb spring tide release from trenching, tidal advection has the potential to carry the plume into the Rockabill to Dalkey Island SAC but only with very low concentrations (1 to 2mg/l) and for a short period. The sensitive receptor of interest within the SAC are “Reefs” which surround rocky features such as Rockabill. The temporary period of raised suspended sediment (which increases turbidity and lowers light penetration) reaching the SAC are considered to be lower than the monthly variation of average suspended sediments and therefore insignificant.

HDD operations releases a viscous drilling fluid which consists of a mixture of water and bentonite, a non-toxic, naturally occurring clay mineral. It is estimated that when HDD emerges in subtidal exit pits in the ECC bentonite will be released under pressure for a short period (10 tonnes of drilling muds over a period of around 200 seconds). This will be followed by a longer reaming period (20 tonnes over around 24 hours) when there will be a further volume of bentonite emerging under lower pressure.

The release of drilling fluid and drill cuttings from HDD operations will result in a localised and temporary plume of elevated SSC. The drilling fluid has an overall density and viscosity similar to seawater and so is expected to behave in a similar manner. The majority of the plume will be advected in the direction of the ambient tidal currents, which are broadly aligned to the coast. Modelling indicates that on a spring tide release a greatest excursion distance for the bentonite (at concentrations >1mg/l) will be around 1.1km to the north-west (on the flood) and 0.8km to the south-east (on the ebb); on a neap tide the plume will extend a shorter distance. The highest elevated concentrations of bentonite will remain close to the exit pits with levels up to 29mg/l estimated with greatest depths of deposition of between 0.3 to 0.7mm.

In summary, sediment plumes caused by seabed preparation and construction activities are expected to be restricted to within a single tidal excursion from the point of release, which is captured by the benthic subtidal and intertidal ecology study area (Figure 12.1). Sediment plumes are expected to quickly dissipate after cessation of the construction activities, due to settling and wider dispersion with the concentrations reducing quickly over time to background levels (i.e., within a couple of tidal cycles). Sediment deposition will consist primarily of coarser sediments deposited close to the source (a few hundred meters), with a small proportion of silt deposition (reducing exponentially from source). Further information on sediment plume distances and modelling are provided in the Physical Processes Chapter.

Taking the above into consideration, the impact of increased SSC and smothering from sediment deposition from construction activities is expected to be temporary, infrequent, of localised extent and reversible. The overall magnitude of impact of increased SSC and deposition across the receiving environment is considered to be low adverse.

Consequently, the magnitude of impact from Project Option 1 and Project Option 2 resulting from Temporary increase in SSC and sediment deposition in array area and ECC is assessed as low adverse.

Significance of effect

Increases in SSC and associated sediment deposition will represent a temporary and short-term intermittent impact, affecting a relatively small portion of the benthic subtidal habitats in the subtidal component of the study area. Most receptors are known to have a medium to high degree of tolerance to this impact.

The MarESA sensitivity assessment confidence scores were variable (Table 12.15) with low confidence scores due predominately to low confidence for the resistance and also to the applicability for the resilience assessment. The significance of effect has been assessed based on the low resistance and low resilience as part of the assessments. Therefore, while the confidence score is low, the assessment is using the most conservative sensitivity. As such, the sensitivity assessment conclusion of an overall level of medium remains valid and robust.

Overall, it is predicted that in relation to Project Option 1 and Project Option 2 the sensitivity of receptors to is medium and the magnitude of the impact is low adverse. The medium sensitivity and low adverse magnitude of the impact on subtidal benthic receptors would result in a slight impact, which is not significant in EIA terms.

12.5.2.2 Impact 2 – Temporary increase in SSC and sediment deposition in intertidal habitats

Sensitivity of the receptor

Increases in SSC and associated sediment deposition will represent a temporary and short-term intermittent impact, affecting a relatively small portion of the benthic intertidal habitats in the intertidal component of the study area. The biotopes that characterise the intertidal component of the study area have been assessed as having low sensitivity at most to increases in SSC and turbidity (according to both the MarESA and MarLIN benchmarks), except for the *Fucus vesiculosus* biotopes that have a medium sensitivity (Table 12.17). Most biotopes had a low sensitivity at most to light deposition (0-5cm) with the exception of the *Ascophyllum nodosum* and *F. vesiculosus* biotopes that had a medium sensitivity. Sensitivity of heavy deposition (5-30cm) ranged from not sensitive to high sensitivity with most biotopes having a low to medium sensitivity to heavy deposition. Most receptors are known to have a low to medium to high degree of tolerance to this impact (Table 12.17). The resilience of all biotopes was assessed as high, with most biotopes subject to natural and anthropogenic disturbance with recovery anticipated within 2-4 years.

The Annex I habitat "Mudflats and sandflats not covered by seawater at low tide" support diverse communities of invertebrates, algae and eel grass. Mudflats are usually located in the most sheltered areas of the coast where large quantities of silt from rivers are deposited in estuaries. In sheltered areas communities are typically dominated by polychaete worms, e.g., *Arenicola* and bivalve molluscs and may support very high densities of the mud-snail *Peringia ulvae*. Sand flats occur on open coast beaches and bays where wave action or strong tidal currents prevent the deposition of finer silt. On more exposed coasts the biodiversity may be lower, and the communities dominated by crustaceans such as *Bathyporeia*. The strand line on most shores is characterised by Talitrid amphipods.

These intertidal flats represent a considerable feeding resource for a wide range of waders and other bird species. Where *Zostera* occurs, faunal diversity is higher. Mudflats and sandflats are listed as qualifying features in Boyne Coast and Estuary SAC, Rogerstown Estuary SAC and Malahide Estuary SAC. These habitats are tolerant of increased SSC and deposition and the sensitivity of these receptors is considered to be negligible.

Table 12.17 Sensitivity assessment for the benthic intertidal habitats for increase in suspended sediment and turbidity

Biotope name	Biotope code (EUNIS, 2022)	Sensitivity to longer term changes in suspended sediment and turbidity	Sensitivity to light smothering (<5cm)	Sensitivity to heavy smothering (5-30cm)
Barren littoral shingle	MA3211	Not sensitive	Not sensitive	Not sensitive
Polychaete/amphipod-dominated in Atlantic littoral fine sand	MA5241	Not sensitive	Not sensitive	Low
Polychaetes and Macomangulus tenuis in littoral fine sand	MA52412	Not sensitive	Low	Low
Scolelepis spp. In Atlantic littoral mobile sand	MA52331	Low	Not sensitive	Low
Fucus vesiculosus and barnacle mosaics on moderately exposed mid eulittoral rock	MA1243	Medium	Medium	Medium
Fucus vesiculosus on full salinity moderately exposed to sheltered mid eulittoral rock	MA123D1	Medium	Medium	Medium
Fucus serratus and under-boulder fauna on exposed to moderately exposed lower eulittoral boulders	MA12442	Low	Low	Medium
Ascophyllum nodosum on full salinity mid eulittoral mixed substrata	MA123E2	Not sensitive	Medium	High
Enteromorpha spp. On freshwater-influenced and/or unstable upper eulittoral rock	MD5212 closest	Not sensitive	Low	Low

The intertidal reef feature of Rockabill to Dalkey Island SAC ranges from exposed to moderately exposed cobbles and boulders on bedrock. The species associated with this community complex include the fucoids *Fucus serratus*, *F. vesiculosus*, *F. spiralis*, *Ascophyllum nodosum* and *Pelvetia canaliculata*, the barnacle *Semibalanus balanoides* and the blue mussel *Mytilus edulis* (National Parks and Wildlife Service (NPWS, 2013a). Most of these species have been included in the assessments detailed in Table 12.17. Of those species not included in Table 12.17 *M. edulis* is not expected to be impacted by increased SSC, according to the sensitivity of the biotopes ‘Mussel beds on Atlantic infralittoral sediment’ (MB2223) and ‘Bivalve reefs in the Atlantic circalittoral zone’ (MC223) which are characterised as not being sensitive to changes in SSC and turbidity (according to the MarESA and MarLIN benchmarks).

From Table 12.17 it is evident that that the greatest sensitivity of the receptors located across the intertidal component of the study area is medium.

However, the MarESA assessments do not take into account the site-specific environmental conditions, and in considering these it is concluded unlikely that the effects would be detectable above natural background variability. Consequently, the overall sensitivity of intertidal benthic receptors is regarded as negligible.

Magnitude of impact

Sediment plumes caused by seabed preparation and construction activities in the nearshore ECC and subtidal exit pit are expected to be restricted to within a single tidal excursion from the point of release. Sediment plumes are expected to quickly dissipate after cessation of the construction activities, due to settling and wider dispersion with the concentrations reducing quickly over time to background levels (i.e., within a couple of tidal cycles). While this work is subtidal, dispersed of material from nearshore works will enter the intertidal where deposition may occur. While coarser sediments will deposit close to the source (a few hundred meters), finer material will be dispersed further with such material entering the intertidal. However, as modelling indicates that the predominant tidal flow will disperse material parallel to the and SSC will reduce exponentially from source the levels of material reaching the intertidal and depositing will be low.

There is a requirement to use drilling mud, such as bentonite (or another inert mud), in order to undertake HDD techniques and make landfall. Although the punch out for the HDD exit pit will be located subtidally there is a likelihood that the plume may extend into the intertidal depending on the state of the tide on release. Bentonite is a non-toxic, natural clay mineral (<63µm particle diameter) and is included in the 'List of Notified Chemicals' approved for use and discharge into the marine environment and is classified as a Group E substance under the 'Offshore Chemical Notification Scheme'. Substances in Group E are defined as the group least likely to cause environmental harm and are "readily biodegradable and non-bioaccumulative". This is further supported by bentonite being included on the OSPAR List of Substances Used and Discharged Offshore which are considered to Pose Little or No Risk to the Environment (PLONOR)[9].

As bentonite is a clay-based substance, it may persist in suspension for hours to days or longer, becoming diluted to very low concentrations (indistinguishable from natural background levels and variability) within timescales of around one day. The SSC at the point of the HDD exit pits, would decrease notably within one tidal cycle. Any fine material being dispersed from the exit pits during excavation is likely to be widely dispersed and quickly form part of the background concentration of SSC along the nearshore.

The impact of SSC in the intertidal is of temporary duration, reversible, and localised while the intertidal biotopes are not rare or geologically restricted. Consequently, the magnitude of impact resulting from temporarily increased levels of SSC and sediment deposition in intertidal habitats would be negligible.

Significance of the effect

Temporary increases in SSC will represent a local spatial extent, be short term and intermittent and affect a relatively small proportion of intertidal benthic habitats across the study area, while most intertidal receptors are known to have a high degree of tolerance to this impact. Consequently, it is predicted that the sensitivity of the benthic intertidal biotopes and receptors is negligible, and the magnitude of the impact is negligible. The negligible sensitivity and negligible magnitude of the impact on benthic receptors would result in an imperceptible impact.

As the sensitivity of the intertidal qualifying features within the designated sites to increased SSC and deposition are characterised as negligible the significance of any effect is therefore concluded to be imperceptible, which is not significant in EIA terms.

Overall, it is predicted that in relation to Project Option 1 and Project Option 2 the sensitivity of receptors is negligible, and the magnitude of the impact is also negligible. The negligible sensitivity and magnitude of the impact on intertidal benthic receptors would result in an imperceptible impact, which is not significant in EIA terms.

[9] https://www.cefas.co.uk/data-and-publications/ocns/downloads-and-useful-links/

12.5.2.3 Impact 3 - Temporary habitat disturbance in array area and ECC

Sensitivity of the receptor

The sensitivity of all biotopes to disturbance that are known to characterise the array area and the subtidal component of the ECC have been assessed according to the detailed MarESA sensitivity assessment (Table 12.18). Temporary disturbance in intertidal areas has been screened out as no direct impacts have been identified due to the use of HDD under the intertidal zone and the exit pits being in the subtidal.

Table 12.18 Sensitivity assessment for the benthic subtidal habitats for disturbance

Biotope name	Biotope code (EUNIS, 2022)	Sensitivity assessment
Array area		
Burrowing megafauna Maxmuelleria lankesteri in circalittoral mud	MC6217	Medium (based on medium resistance and medium resilience)
Amphiura filiformis, Kurtiella bidentata and Abra nitida in circalittoral sandy mud	MC6211	Medium (based on medium resistance and medium resilience)
ECC		
Abra alba and Nucula nitidosa in circalittoral muddy sand or slightly mixed sediment	MC5214	Low (based on medium resistance and high resilience)
Fabulina fabula and Magelona mirabilis with venerid bivalves and amphipods in Atlantic infralittoral compacted fine muddy sand	MB5236	Low (based on medium resistance and high resilience)
Kurtiella bidentata and Thyasira spp. in circalittoral muddy mixed sediment	MC4213	Low (based on medium resistance and high resilience)
Amphiura filiformis and Ennucula tenuis in circalittoral and offshore sandy mud	MD5212	Medium (based on low resistance and medium resilience)
Amphiura filiformis, Kurtiella bidentata and Abra nitida in circalittoral sandy mud	MC6211	Medium (based on low resistance and medium resilience)

The biotopes in the offshore development area are characterised by generally muddy substrates and have been assessed as having medium sensitivity to disturbance. For instance, the biotope ‘Burrowing megafauna *Maxmuelleria lankesteri* in circalittoral mud’ (MC6217) is described as having a medium sensitivity to disturbance. Studies of fishing grounds indicates that key species of this biotope can withstand and recover from repeated disturbances, although where the community suffers significant mortality then recovery is likely to be prolonged (Vergnon & Blanchard, 2006; OSPAR, 2010; Ungfors et al., 2013). However, as the area of disturbance is considered to limited and not prolonged sensitivity is deemed to be medium.

As demonstrated in Table 12.18, this assessment has determined that all biotopes recorded at sites in the vicinity of the array area have a medium sensitivity to a disturbance of this nature. These biotopes are typical of high energy environments and are therefore naturally subject to, and tolerant of, high levels of physical disturbance with communities characterised by infaunal species such as polychaetes and bivalves that can re-enter the substratum following a temporary habitat disturbance of this nature. The recoverability of such communities is likely to occur as a result of a combination of recruitment from surrounding unaffected areas and larval dispersal, and recovery is likely to occur within one to ten years (based on the MarESA assessments).

Although MarESA does not provide an assessment for the sensitivity of communities classified at the biotope complex level, the circalittoral sandy mud (MC621), circalittoral fine sand (MC521) and circalittoral mixed sediment (MC42) are expected to demonstrate low sensitivity to the temporary disturbance predicted for the same reasons as the sandy biotopes.

These sandy biotopes are prevalent in deep subtidal mud habitats and are considered to be more sensitive to habitat disturbance as they are adapted to stable conditions (Pommer et al., 2016). Muddy sands have been shown to be sensitive to the consequences of fishing activities on the benthic biota of different habitats, with recovery timeframes anticipated to take years (Kaiser et al., 2006). Muddy sand habitats have a longer recovery time as they are mediated by a combination of physical, chemical and biological processes (compared to sand habitats which are dominated by physical processes and recovery time takes days-months).

While the biotope 'Seapens and burrowing megafauna in circalittoral fine mud' (MC6216) is noted as having a low resilience to an impact of this type, sea pens have been shown to recover rapidly from displacement and removal from the seabed with individuals re-establishing themselves after 72 hours after the disturbance occurred (Eno et al., 2001).

The biotopes *'Amphiura filiformis*, *Kurtiella bidentata* and *Abra nitida* in circalittoral sandy mud' (MC6211), *'Owenia fusiformis* and *Amphiura filiformis* in offshore circalittoral sand or muddy sand' (MD5212) characterising species include infaunal mobile species such as polychaetes, bivalves and brittlestars. Such species can re-enter the substratum following temporary habitat disturbance. However, *Abra* spp. are shallow burrowers and have been considered amongst the list of bivalve species most vulnerable to trawling (Bergmann & Van Santbrink, 2000). Brittlestars can resist considerable damage (Sköld, 1998, Makra & Keegan, 1999) and may migrate to recover from impacts with a small spatial footprint. However, sensitivity is described as having a medium sensitivity when a considerable proportion of the population is lost.

The subtidal benthic habitats that characterise the array area and ECC are deemed to be a highest of medium vulnerability, a lowest of low recoverability and of regional to national value. The greatest sensitivity of the receptors is therefore, considered to be medium according to the MarLIN MarESA sensitivity category, which can be directly related to the same values in the sensitivity matrix (Table 12.4).

Magnitude of impact

The total greatest area of disturbance of subtidal habitat due to pre-construction and construction activities is described in Table 12.14, which, for Project Option 1, equates to approximately 6.3km^2 of the seabed area within the array area and ECC and 5.4km^2 for Project Option 2. It should be noted that the assessment presents a precautionary approach to temporary habitat disturbance because it counts both the total footprint of seabed preparatory works as well as cable burial across both the array area and ECC. This approach effectively counts the footprint of seabed habitat to be impacted by construction in the same area twice. This precautionary approach has been taken because there is some potential for recovery of habitats between the different activities due to project timescales.

Of the total area of temporary habitat loss described in Table 12.14, a greatest area of approximately 4.8km^2 (Project Option 1) is predicted to be temporarily lost/ disturbed within the array area as a result of seabed preparations for foundations, jack-up barge operations and the installation and burial of inter-array and interconnector cables (including associated anchor placements). This equates to approximately 5.5% of the total seabed area within the array area.

Of the total area of temporary habitat loss described in Table 12.14, a greatest area of approximately 1.4km^2 will be temporarily disturbed for both options within the subtidal areas of the ECC as a result of seabed preparation, export cable installation, burial and jointing. This equates to approximately 4% of the total seabed area within the ECC.

The benthic communities are typical of the sand and mud sediments characterising the array area and ECC. The temporary habitat disturbance during construction activities would therefore have an impact on a very limited footprint, particularly when compared to the overall extent of such habitats and this loss is not expected to undermine regional ecosystem functions or diminish biodiversity.

Furthermore, any impacts will be intermittent and with high reversibility. Consequently, the magnitude is therefore, considered to be negligible.

No Annex I reef features were recorded during the site-specific surveys Consequently no pathway for direct impact to this receptor is evident and thus no disturbance is anticipated. The magnitude of impact to potential Annex I reef is therefore regarded as negligible. No impacts on the Rockabill and Dalkey Island SAC are expected from direct habitat disturbance as it is outside of the offshore development area.

Consequently, the overall magnitude of impact resulting from temporary habitat disturbance in subtidal habitats would be negligible.

Significance of the effect

Temporary habitat disturbance will represent a local spatial extent, short term intermittent impact, affecting a relatively small portion of the benthic subtidal habitats in the offshore development area. Most benthic receptors are known to have a high degree of tolerance to this impact, based on MarESA assessments and are common and widespread throughout the wider region and Irish sea (as previously detailed).

Overall, it is predicted that the sensitivity of the benthic subtidal biotopes and receptors is medium, and the magnitude of the impact is negligible. The medium sensitivity and negligible magnitude of the impact on benthic receptors would result in a not significant impact, which is not significant in EIA terms (as per the matrix in Table 12.6).

Overall, it is predicted that in relation to Project Option 1 and Project Option 2 the sensitivity of receptors to is medium and the magnitude of the impact is negligible. The medium sensitivity and negligible magnitude of the impact on benthic receptors would result in a not significant effect, which is not significant in EIA terms.

12.5.2.4 Impact 4 - Reduction in water and sediment quality through release of contaminated sediments and/or accidental contamination

Sensitivity of the receptor

Sensitivity of the receptor is not assessed on a biotope basis due to the lack of research and the pressures are not assessed within the Marlin MarESA sensitivity assessment. The sensitivity of benthic species to toxic pollutants that may be released because of construction activities is therefore deemed to be high which is considered precautionary and reflects the lack of evidence on individual receptors and biotopes. A sensitivity of high describes the habitat or species as exhibiting ‘none’ or ‘low’ resistance (tolerance) to an external factor and is expected to recover only over very extended timescales, e.g. greater than 25 years or not at all.

Magnitude of impact

There is the potential for sediment-bound contaminants, such as metals, hydrocarbons, and organic pollutants, to be released into the water column and lead to an effect on benthic ecology receptors, as a result of construction activities and associated sediment mobilisation.

The assessment of contaminants undertaken across the array and ECC subtidal survey area (Section 12.3.5) indicated that sediment bound metal concentrations were close to background concentrations. Similarly, levels of organic chemicals were low throughout the array area and ECC with THC being below levels at which adverse effects on benthic macrofauna have been observed. Higher THC levels observed at some of these stations are consistent with the elevated TOC.

Following disturbance as a result of construction activities, the majority of re-suspended sediments are expected to be deposited in the immediate vicinity of the works. The release of contaminants from the small proportion of fine sediments is likely to be rapidly dispersed with the tide and/ or currents and therefore increased bioavailability resulting in adverse eco-toxicological effects are not expected.

The magnitude of an accidental spill incident will be limited by the size of the chemical or oil inventory on construction vessels. In addition, released hydrocarbons would be subject to rapid dilution, weathering and dispersion and would be unlikely to persist in the marine environment. The likelihood of an incident will be reduced by implementation of an Offshore Environmental Management Plan (EMP) – see Table 12.13.

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. Overall, the magnitude is considered to be negligible.

Significance of the effect

Overall, it is predicted that in relation to Project Option 1 and Project Option 2 the sensitivity of receptors is high, and the magnitude of the impact is negligible. The high sensitivity and negligible magnitude of the impact on benthic receptors would result in a not significant effect, which is not significant in EIA terms.

12.5.2.5 Impact 5 - Introduction of MINNS

Sensitivity of the receptor

Where data is available the sensitivity of benthic biotopes within the array area and ECC to the introduction or spread of MINNS ranges between 'low' and 'high' according to the MarESA criteria (Table 12.19). Therefore, the sensitivity is considered to be high, reflecting that in the most impactful scenario, benthic receptors have 'none' or 'low' resistance (tolerance) to an impact of this nature.

Table 12.19 MarESA assessment for the benthic subtidal habitats for introduction of MINNS

Biotope name	Biotope code (EUNIS, 2022)	Sensitivity assessment
Array area		
Burrowing megafauna Maxmuelleria lankesteri in circalittoral mud	MC6217	No evidence on Marlin MarESA assessment, so a high sensitivity has been adopted.
Amphiura filiformis, Kurtiella bidentata and Abra nitida in circalittoral sandy mud	MC6211	No evidence on Marlin MarESA assessment, so a high sensitivity has been adopted.
Survey area		
Owenia fusiformis and Amphiura filiformis in offshore circalittoral sand or muddy sand	MD5212	No evidence on Marlin MarESA assessment, so a high sensitivity has been adopted
Seapens and burrowing megafauna in circalittoral fine mud	MC6216	No evidence on Marlin MarESA assessment, so a high sensitivity has been adopted
ECC		
Abra alba and Nucula nitidosa in circalittoral muddy sand or slightly mixed sediment	MC5214	High (based on no resistance and very low resilience)
Fabulina fabula and Magelona mirabilis with venerid bivalves and amphipods in Atlantic infralittoral compacted fine muddy sand	MB5236	High (based on no resistance and very low resilience)
Kurtiella bidentata and Thyasira spp. in circalittoral muddy mixed sediment	MC4213	High (based on no resistance and very low resilience)
Amphiura filiformis and Ennucula tenuis in circalittoral and offshore sandy mud	MD5212	Low (based on low resistance and low resilience)
Amphiura filiformis, Kurtiella bidentata and Abra nitida in circalittoral sandy mud	MC6211	No evidence on Marlin MarESA assessment, so a high sensitivity has been adopted.

Magnitude of impact

The main pathways for the transport and introduction of MINNS have been identified as recreational boating, aquaculture, fisheries, shipping, and offshore energy (Marine Pathways Project, 2014). Pathways of introduction involving vessel movements represent the single highest potential risk route for the introduction of MINNS; this could either be from discharge of ballast water at a site or via transportation on vessel hulls (Carlton, 1992; Pearce et al., 2012).

Once MINNS species become established and disperse within a new habitat they can out-compete local species for space and resources, prey directly on local species, or introduce pathogens (Roy et al., 2014). Consequently, the introduction of MINNS during construction could potentially affect the ecological functioning of the communities occupying intertidal and subtidal habitats within the study area.

There is a risk that the introduction of hard substrate into a sedimentary habitat will enable the colonisation of the introduced substrate by invasive/ non-indigenous species that might otherwise not have had a suitable habitat for colonisation, thereby enabling their spread. This along with the movement of vessels in and out of the proposed development area has the potential to impact upon benthic ecology and biodiversity locally and in the broader region.

While no MINNS were identified during the site-specific surveys, records for a number of non-native species exist from the study area such as slipper limpet, *Crepidula fornicata*, wireweed *Sargassum multicum*, carpet sea squirt *Didenmum vexillum*, Japanese skeleton shrimp *Caprella mutica*, leathery sea squirt *Styela clava* and the Pacific oyster *Magallana gigas*.

In addition to this, there will be 3008 round trips (Project Option 1) or 2530 trips (Project Option 2) to port during the construction phase, which will contribute to the risk of introduction or spread of MINNS through ballast water discharge.

The Offshore EMP includes measures aimed at ensuring that the risk of potential introduction and spread of MINNS will be reduced.

Any impacts are predicted to be of low spatial extent, long term/permanent duration, continuous and irreversible. While any impacts may be of limited spatial extent it should be considered that the introduction of structures such as foundations, scour protection and cable protection could serve as ‘stepping stones’ allowing any initial localised colonisation to spread and impact beyond a local scale. However, based on current scientific knowledge it is not possible to predict whether such a spread will occur and to what extent and it is predicted that the impact will affect receptors indirectly. The magnitude of this impact is therefore considered to be negligible.

Significance of the effect

Overall, it is predicted that in relation to Project Option 1 and Project Option 2 the sensitivity of receptors is high, and the magnitude of the impact is negligible. The high sensitivity and negligible magnitude of the impact benthic subtidal receptors would result in a not significant effect, which is not significant in EIA terms.

12.5.3 Operational Phase

The potential impacts of the offshore operation and maintenance of the proposed development have been assessed on benthic subtidal and intertidal ecology. The potential environmental impacts arising from the operation and maintenance of the proposed development are listed in Table 12.14 against which each operational phase likely significance effects has been assessed.

Potential impacts of the operational phase activities include:

- Long-term or permanent subtidal habitat loss/ change from the presence of foundations, scour protection and cable protection.
- Temporary habitat disturbance in array area and ECC
- Changes in physical processes

- Impacts of colonisation of introduced hard substrate on benthic ecology and biodiversity.
- Introduction of MINNS; and
- Reduction in water and sediment quality through release of contaminated sediments and/or accidental contamination.

12.5.3.1 Impact 6 – Long-term or permanent subtidal habitat loss/ change from the presence of foundations, scour protection and cable protection.

Sensitivity of the receptor

The species and habitats identified during the site-specific surveys are typical of the wider region and Irish Sea (as previously discussed in Section 12.3). All biotopes identified within the array area and ECC have been assessed according to the MarESA criteria as having no resistance to permanent habitat loss / change, with recovery assessed as very low as the change at the pressure benchmark is at worst case permanent (Table 12.20). The sensitivity of subtidal receptors is therefore considered to be at greatest high according to the EIA assessment values. No habitat loss will occur in intertidal habitats during the operational phase.

Table 12.20 MarESA assessment for the benthic subtidal habitats for long term habitat loss

Biotope name	Biotope code (EUNIS, 2022)	Sensitivity assessment
Array area		
Burrowing megafauna Maxmuelleria lankesteri in circalittoral mud	MC6217	High (based on no resistance and very low resilience)
Amphiura filiformis, Kurtiella bidentata and Abra nitida in circalittoral sandy mud	MC6211	High (based on no resistance and very low resilience)
Survey area		
Owenia fusiformis and Amphiura filiformis in offshore circalittoral sand or muddy sand	MD5212	High (based on no resistance and very low resilience)
Seapens and burrowing megafauna in circalittoral fine mud	MC6216	High (based on no resistance and very low resilience)
Burrowing megafauna Maxmuelleria lankesteri in circalittoral mud	MC6217	High (based on no resistance and very low resilience)
ECC		
Abra alba and Nucula nitidosa in circalittoral muddy sand or slightly mixed sediment	MC5214	High (based on no resistance and very low resilience)
Fabulina fabula and Magelona mirabilis with venerid bivalves and amphipods in Atlantic infralittoral compacted fine muddy sand	MB5236	High (based on no resistance and very low resilience)
Kurtiella bidentata and Thyasira spp. In circalittoral muddy mixed sediment	MC4213	High (based on no resistance and very low resilience)
Amphiura filiformis and Ennucula tenuis in circalittoral and offshore sandy mud	MD5212 closest	High (based on no resistance and very low resilience)
Amphiura filiformis, Kurtiella bidentata and Abra nitida in circalittoral sandy mud	MC6211	High (based on no resistance and very low resilience)

Magnitude of impact

The presence of the WTG and OSP foundations and the associated scour protection, along with the cable protection measures used at cable crossings and areas where cable burial is not possible, will lead to a change from a sedimentary habitat to one characterised by hard substrate.

This will be either a long-term (for the 35-year design life duration of the proposed development where at the point of decommissioning foundations are clipped at between 1-2 m below seabed level), or permanent for structures that are left in-situ (such as scour protection and cable protection) at the point of decommissioning. This is therefore considered an impact of the operational phase of the development and potentially beyond. It is assessed here as habitat loss and a potential adverse effect (due to the potential shift in the baseline condition), although it is noted that this also comprises potential beneficial effects (e.g. providing new habitats for different faunal assemblages to colonise, resulting in potential increases in biodiversity and biomass).

Table 12.14 identifies the project option that has the greatest magnitude of impact for foundation, scour and cable protection footprint. For Project Option 1 the total habitat loss from these components equates to approximately 276,296m^2 of the array area and ECC representing approximately 0.22% of the combined areas, while for Project Option 2 the figures are 297,510m^2 and 0.24%.

While the impact will be locally significant and comprise a permanent change in seabed habitat within the footprint of the structures and scour and cable protection, the footprint of the area affected is highly localised. A change of subtidal sediment biotopes to rock or artificial hard substratum would alter the loss of the sedimentary community and a change in the character of the biotope leading to reclassification. However, as the habitats and characterising biotopes are common and widespread throughout the wider region (Table 12.11) the magnitude of the loss of these habitats would be negligible. Consequently, the overall magnitude is therefore assessed as negligible.

Significance of the effect

Overall, it is predicted that in relation to Project Option 1 and Project Option 2 the sensitivity of receptors is high, and the magnitude of the impact is negligible. The high sensitivity and negligible magnitude of the impact on benthic receptors would result in a not significant effect, which is not significant in EIA terms.

12.5.3.2 Impact 7 – Temporary habitat disturbance in array area and ECC

Sensitivity of the receptor

As detailed in the assessment of construction impacts the subtidal benthic habitats that characterise the array area and ECC are deemed to be a greatest of medium vulnerability, a lowest of low recoverability and of regional to national value (Table 12.18). The greatest sensitivity of the receptors is therefore, considered to be medium. There will be no habitat disturbance to intertidal habitats during the operational phase.

Magnitude of impact

Subtidal habitat disturbance will arise from the use of jack-up vessels for operational activities as well as from cable maintenance and cable replacement. As indicated in Table 12.14, the total area likely to be affected over the design life of the proposed development is 0.68km^2 for Project Option 1 and 0.49km^2 for Project Option 2. However, given that the habitats are common and widespread throughout the region impacts from the individual operational activities will represent a very small footprint compared to their overall extent.

The impacts are predicted to be temporary and of short-term duration and only a single event in each location, intermittent and reversable. It is predicted that the impact will affect the receptors directly. The magnitude of this impact is therefore considered to be negligible.

Significance of the effect

Temporary habitat disturbance will represent a local spatial extent, short term intermittent impact, affecting a relatively small portion of the subtidal habitats in the proposed development boundary. Most subtidal receptors are known to have a high degree of tolerance to this impact, based on MarESA assessments.

Overall, it is predicted that in relation to Project Option 1 and Project Option 2 the sensitivity of receptors is medium, and the magnitude of the impact is also negligible. The medium sensitivity and negligible magnitude of the impact on benthic subtidal biotopes and receptors would result in a not significant effect, which is not significant in EIA terms.

12.5.3.3 Impact 8 – Changes in physical processes

Sensitivity of the receptor

As detailed above in relation to disturbance (Table 12.18) the subtidal benthic habitats that characterise the array area and ECC are deemed to be a greatest of medium vulnerability, a lowest of low recoverability and are of regional to national value. The greatest sensitivity of the receptors is therefore, considered to be medium according to the MarLIN MarESA sensitivity category.

Magnitude of impact

The presence of foundations may introduce changes to the local hydrodynamic and wave regime, resulting in changes to the sediment transport pathways with associated effects associated with scouring and changes in sediment transport potentially making benthic habitats less suitable for some species. However, as detailed in the Physical Processes Chapter local scouring around foundations is not anticipated to be prevalent and that overall, the impacts on hydrodynamic and wave regimes will not be significant and will not result in any significant changes to sediment transport. Consequently, no significant impacts on benthic ecology are anticipated and the magnitude of this impact is therefore considered to be negligible.

Significance of the effect

Overall, it is predicted that in relation to Project Option 1 and Project Option 2 the sensitivity of receptors is medium, and the magnitude of the impact is negligible. The medium sensitivity and negligible magnitude of the impact on benthic intertidal biotopes and receptors would result in a not significant impact, which is not significant in EIA terms.

12.5.3.4 Impact 9 – Impacts of colonisation of introduced hard substrate on benthic ecology and biodiversity

Sensitivity of the receptor

The introduction of new hard substrate will represent a potential shift in the baseline condition within a small proportion of the array area and subtidal component of the ECC.

The sediment biotopes likely to be affected are deemed to be of low vulnerability and of local to regional value (Table 12.11). Recoverability following removal of the infrastructure is expected to be high although not all introduced hard substrate is likely to be removed, with protection assumed to be remaining in-situ. The sensitivity of these receptors is therefore, considered to be at worst case high, in areas where infrastructure is not removed.

Magnitude of impact

The introduction of hard substrate will change the type of available habitats within the array area and subtidal components of the ECC. However, the amount of introduced substrate is relatively small at approximately 0.41km^2 for Project Option 1 and 0.39km^2 for Project Option 2 (Table 12.14).

Hard substrate habitats are rare within the study area which is dominated by sedimentary habitats. The introduction of hard substrate, and associated increases in biodiversity, will alter the biotopes that characterise the area at the location of the introduction of infrastructure and will be long-term, lasting for the duration of the proposed development.

Potential beneficial effects that may occur are associated with the likely increase in biodiversity and biomass, as has been observed at the Egmond aan Zee Offshore Windfarm (Lindeboom et al., 2011). Individual species with the potential to benefit from the introduction of hard substrate due to increased substrate for attachment are those which are typical of rocky habitats and intertidal environments.

The species potentially introduced may also have indirect and adverse effects through increased predation on, or competition with, neighbouring soft sediment species.

However, such effects are difficult to predict. The increased biodiversity associated with the structures could provide benefits at higher trophic levels as the benthic organisms colonising the structures provide an additional food source. Studies have shown that offshore wind farms (OWF) structures provide a suitable habitat for lobsters (Thatcher et al., 2023) and are used as successful nursery habitats for the edible crab Cancer pagurus (BioConsult 2006; Krone et al., 2017). However, any direct benefits are only likely to occur on a very localised basis (i.e. near the infrastructure).

Given the presence of epifaunal species and colonising fauna within discrete parts of the subtidal components of study area already (i.e. associated with coarser sediment habitats), it is predicted that colonisation of hard substrates by common species such as bryozoans and ascidians will occur.

The impact is therefore predicted to be of local spatial extent, long-term or permanent duration but reversable where infrastructure is removed. It is predicted that the impact will affect the receptor directly. As the habitats and characterising biotopes are common and widespread throughout the wider region (see Table 12.11) the magnitude of impact in relation to the loss of these habitats is therefore considered to be low adverse.

Significance of the effect

Any beneficial effects associated with an increase in biodiversity will be highly localised in nature and are not regarded as mitigation for the loss of sedimentary habitat associated with the installation of these structures. The introduction of hard structures such as scour protection can lead to an increase in biomass and biodiversity which may be considered beneficial, but it also represents a change from the baseline environment which may be considered adverse.

Overall, it is predicted that in relation to Project Option 1 and Project Option 2 the sensitivity of receptors is high and the magnitude of the impact is low. The high sensitivity and low magnitude of the impact on benthic receptors would result in a moderate impact, which is not significant in EIA terms.

12.5.3.5 Impact 10 – Introduction of MINNS

Sensitivity of the receptor

The sensitivity of benthic biotopes within the array area and ECC to the introduction or spread of MINNS ranges between low and high according to the MarESA criteria (Table 12.19). Therefore, the sensitivity is considered to be high, reflecting that in the most impactful scenario, benthic receptors have ‘none’ or ‘low’ resistance (tolerance) to an impact of this nature.

Magnitude of impact

There is a risk that the introduction of hard substrate into a sedimentary habitat will enable the colonisation of the introduced substrate by MINNS that might otherwise not have had a suitable habitat for colonisation, thereby enabling their spread. This along with the movement of vessels in and out of the offshore development area has the potential to impact upon benthic ecology and biodiversity locally and in the broader region.

As indicated in Table 12.14 approximately 0.41km^2 for Project Option 1 and 0.39km^2 for Project Option 2 of new hard substrate habitat will be introduced into the array area and subtidal component of the ECC, which has the potential to provide new habitat for colonisation by MINNS. In addition to this, there will be 1,261 round trips to port by operation and maintenance vessels, which will contribute to the risk of introduction or spread of MINNS through ballast water discharge.

The Offshore EMP contains measures aimed at ensuring that the risk of potential introduction and spread of MINNS will be reduced.

The impacts on biotopes within the study area is predicted to be of low spatial extent (though the introduction of structures may serve as 'stepping stones' and extend the impact beyond a local scale, however based on current scientific knowledge it is not possible to predict whether such a spread will occur and to what extent and which species, if any, this may involve), permanent duration, continuous and irreversible.

It is predicted that the impact will affect the receptors indirectly. The magnitude of this impact is therefore considered to be negligible.

Significance of the effect

Overall, it is predicted that in relation to Project Option 1 and Project Option 2 the sensitivity of receptors is high, and the magnitude of the impact is negligible. The high sensitivity and negligible magnitude of the impact on benthic subtidal and intertidal receptors would result in a not significant effect, which is not significant in EIA terms.

12.5.3.6 Impact 11 - Reduction in water and sediment quality through release of contaminated sediments and/or accidental contamination

Sensitivity of the receptor

As discussed in Section 12.5.2.4 the sensitivity of benthic receptors to contamination is deemed to be high (see Section 12.5.2.4).

Magnitude of impact

The assessment of contaminants undertaken across the array ad ECC subtidal survey area indicated that sediment bound metal concentrations were close to background concentrations. Similarly, levels of organic chemicals were low throughout the array area and ECC with THC being below levels at which adverse effects on benthic macrofauna have been observed. Higher THC levels observed at some of these stations are consistent with the elevated TOC.

There is a risk that indirect disturbance arising from the accidental release of pollutants such as synthetic compounds, heavy metal and hydrocarbon contamination resulting from 49 WTGs. Accidental pollution may also result from 1,261 operational vessel return trips over the design lifetime, which could lead to an adverse effect on benthic subtidal and intertidal ecology receptors.

However, the release of contaminants from the small proportion of fine sediments is likely to be rapidly dispersed with the tide and/ or currents and therefore increased bioavailability resulting in adverse eco-toxicological effects are not expected.

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 negligible.

Significance of the effect

Overall, it is predicted that in relation to Project Option 1 and Project Option 2 the sensitivity of receptors is high and the magnitude of the impact is negligible. The high sensitivity and negligible magnitude of the impact benthic receptors would result in a not significant effect, which is not significant in EIA terms.

12.5.4 Decommissioning

The impacts of the offshore decommissioning of the proposed development have been assessed on benthic subtidal and intertidal ecology. The environmental impacts arising from the decommissioning of the proposed development listed in Table 12.14 have been assessed to determine the magnitude of impact of both project options. A description of the significance of effect upon benthic subtidal and intertidal receptors caused by each identified impact is provided below.

Potential impacts of the decommissioning phase include:

- Temporary increase in SSC and sediment deposition

- Temporary habitat disturbance in the array area and ECC; and
- Reduction in water and sediment quality through release of contaminated sediments and/or accidental contamination.

12.5.4.1 Impact 12 - Temporary increase in SSC and sediment deposition

Increases in SSC and sediment deposition from the decommissioning works are expected to be less than that for construction and are therefore of a reduced magnitude. The magnitude of the impact and the sensitivities of the benthic habitats to SSC and sediment deposition are as described for the construction phase (see 12.5.2.1 above).

Sensitivity of the receptor

Based on the assessment undertaken for construction, which would be considered to be a very precautionary assessment for the decommissioning process, it is predicted that the greatest sensitivity of the receptors is medium.

Magnitude of impact

Based on the assessment undertaken for construction, which would be considered to be a very precautionary assessment for the decommissioning process, it is predicted that the magnitude of impact is low.

Significance of the effect

Overall, it is predicted that in relation to Project Option 1 and Project Option 2 the sensitivity of receptors is medium, and the magnitude of the impact is low adverse. The medium sensitivity and low adverse magnitude of the impact on benthic subtidal and intertidal receptors would result in a slight impact, which is not significant in EIA terms.

12.5.4.2 Impact 13 - Temporary habitat disturbance in the array area and ECC

Sensitivity of the receptor

The sensitivities of the benthic habitats to temporary habitat disturbance are as described for the construction phase and detailed in Table 12.18 which indicates that the greatest sensitivity of the receptors is medium.

Magnitude of impact

Decommissioning has the potential to cause temporary loss of, or disturbance to, benthic habitats within the offshore development area, similar to those described during the construction phase (Section 12.5.2.3). However, as seabed preparation works will not be required as part of decommissioning, the primary causes of disturbance will be associated with the use of JUVs, anchoring and the removal of infrastructure. Consequently, the magnitude of this impact will be lower than during the construction phase. The magnitude of this pressure is considered to be negligible.

The details of the proposed decommissioning process will be included within the Offshore EMP which will be developed and updated throughout the lifetime of the proposed development to account for changing best practice.

Significance of the effect

Overall, it is predicted that in relation to Project Option 1 and Project Option 2 the sensitivity of receptors is medium, and the magnitude of the impact is negligible. The medium sensitivity and negligible magnitude of the impact benthic receptors would result in a not significant impact, which is not significant in EIA terms.

12.5.4.3 Impact 14 - Reduction in water and sediment quality through release of contaminated sediments and/or accidental contamination

Sensitivity of receptor
The sensitivity of benthic receptors to contamination related to decommissioning activities is deemed to be low (see section 12.5.2.4). Receptors with low sensitivity are those with high resistance, or where recovery from any impacts caused by pressure is rapid, so that the feature recovers within two years from cessation of the activity causing the pressure.

Magnitude of impact
As a result of decommissioning processes there is the potential for sediment bound contaminants, such as metals, hydrocarbons and organic pollutants, to be released into the water column and lead to an effect on benthic subtidal ecology receptors.

As no seabed preparation is required there is likely to be less mobilisation of sediments during the decommissioning phase than that for construction, with sources primarily being associated with JUV, anchoring and removal of infrastructure and therefore, a reduced magnitude is expected. However, as a precautionary approach, the magnitude of the impact and the sensitivities of the benthic habitats to SSC and sediment deposition described for the construction phase in Section 12.5.2 are followed here.

The magnitude of an accidental spill incident will be limited by the size of the chemical or oil inventory on decommissioning vessels. In addition, released hydrocarbons would be subject to rapid dilution, weathering and dispersion and would be unlikely to persist in the marine environment. The likelihood of an incident will be reduced by implementation of the Offshore EMP.

Consequently, the overall magnitude of the reduction in water and sediment quality through release of contaminated sediments and/or accidental contamination is deemed to be negligible.

Significance of the effect
Overall, it is predicted that in relation to Project Option 1 and Project Option 2 the sensitivity of receptors is low, and the magnitude of the impact is negligible. The low sensitivity and negligible magnitude of the impact on subtidal and intertidal benthic receptors would result in a not significant effect, which is not significant in EIA terms.

12.6 Mitigation and Monitoring Measures

Mitigation measures that were identified and adopted as part of the evolution of the proposed development design (embedded into the proposed development design) and that are relevant to benthic subtidal and intertidal ecology are listed in Table 12.13 and not considered again here. No additional mitigation or monitoring measures are considered necessary for the construction, operation and decommissioning phases specific to the potential impacts on subtidal and intertidal benthic ecology.

12.7 Residual Effects

This section presents the residual effects of the proposed development once the mitigation outlined in Section 12.6 has been applied. No additional measures are considered necessary to mitigate against potential significant effects on benthic subtidal and intertidal receptors, and therefore there is no difference between the pre-mitigation effects outlined in Section 13.5 and the residual effects. Table 12.21 provides a summary of the impact assessment outcomes.

Table 12.21 Residual effects relating to benthic subtidal and intertidal ecology

Potential Impact	Likely Significant Effect– Project Option 1	Likely Significant Effect Project Option 2	Residual Effect – Project Option 1	Residual Effect – Project Option 2
Construction				
1. Temporary increase in SSC and sediment deposition in subtidal habitats	Subtidal benthic receptors: slight	Subtidal benthic receptors: slight	Subtidal benthic receptors: slight	Subtidal benthic receptors: slight
2. Temporary increase in SSC and sediment deposition in intertidal habitats	Intertidal benthic receptors: imperceptible	Intertidal benthic receptors: imperceptible	Intertidal benthic receptors: imperceptible	Intertidal benthic receptors: imperceptible
3. Temporary habitat disturbance in array area and ECC	Benthic receptors: not significant	Benthic receptors: not significant	Benthic receptors: not significant	Benthic receptors: not significant
4. Reduction in water and sediment quality through release of contaminated sediments and/or accidental contamination	Benthic receptors: not significant	Benthic receptors: not significant	Benthic receptors: not significant	Benthic receptors: not significant
5. Introduction of MINNS	Benthic subtidal receptors: not significant	Benthic subtidal receptors: not significant	Benthic subtidal receptors: not significant	Benthic subtidal receptors: not significant
Operation				
6. Long-term or permanent subtidal habitat loss/change from the presence of foundations, scour protection and cable protection	Benthic receptors: not significant	Benthic receptors: not significant	Benthic receptors: not significant	Benthic receptors: not significant
7. Temporary habitat disturbance in array area and ECC	Benthic intertidal biotopes and receptors: not significant	Benthic intertidal biotopes and receptors: not significant	Benthic intertidal biotopes and receptors: not significant	Benthic intertidal biotopes and receptors: not significant
8. Changes in physical processes	Benthic intertidal biotopes and receptors: not significant	Benthic intertidal biotopes and receptors: not significant	Benthic intertidal biotopes and receptors: not significant	Benthic intertidal biotopes and receptors: not significant
9. Impacts of colonisation of introduced hard substrate on benthic ecology and biodiversity	Benthic receptors: moderate	Benthic receptors: moderate	Benthic receptors: moderate	Benthic receptors: moderate
10. Introduction of MINNS	Benthic subtidal receptors: not significant	Benthic subtidal receptors: not significant	Benthic subtidal receptors: not significant	Benthic subtidal receptors: not significant
11.Reduction in water and sediment quality through release of contaminated sediments and/or accidental contamination	Benthic receptors: not significant	Benthic receptors: not significant	Benthic receptors: not significant	Benthic receptors: not significant
Decommissioning				
12. Temporary increase in SSC and sediment deposition	Subtidal benthic receptors: slight	Subtidal benthic receptors: slight	Subtidal benthic receptors: slight	Subtidal benthic receptors: slight

Potential Impact	Likely Significant Effect– Project Option 1	Likely Significant Effect Project Option 2	Residual Effect – Project Option 1	Residual Effect – Project Option 2
13. Temporary habitat disturbance in the array area and ECC	Benthic receptors: not significant	Benthic receptors: not significant	Benthic receptors: not significant	Benthic receptors: not significant
14. Reduction in water and sediment quality through release of contaminated sediments and/or accidental contamination	Benthic receptors: not significant	Benthic receptors: not significant	Benthic receptors: not significant	Benthic receptors: not significant

12.8 Transboundary Effects

Transboundary effects are defined as those effects upon the receiving environment of other states, whether occurring from the proposed development alone, or cumulatively with other projects in the wider area. No transboundary effects have been identified as the predicted changes to the key physical process pathways (i.e. tides, waves, and sediment transport) are not anticipated to be sufficient to influence identified benthic receptors beyond the Ireland-UK border which lies 13.6km north and 36.5km east of the array area which is beyond the ZoI in relation to benthic subtidal and intertidal ecology.

12.9 Cumulative Effects

Likely significant cumulative effects of the proposed development with existing and / or approved projects for benthic subtidal and intertidal ecology have been identified, considered and assessed. The methodology for this cumulative assessment is a three-stage approach which is presented in the Cumulative and Inter-Related Effects Chapter.

The Cumulative and Inter-Related Effects Chapter contains the outcome of Stage 1 Establishing the list of 'Other Existing and/or Approved Projects'; and Stage 2 'Screening of 'Other Existing and/or Approved Projects'. This section presents Stage 3, an assessment of whether the proposed development, when considered cumulatively with other projects grouped in tiers, would be likely to result in significant cumulative effects.

The assessment specifically considers whether any existing or approved developments in the local or wider area have the potential to alter the significance of effects associated with the proposed development. Developments which are already built and operating, and which are not identified in this chapter, are included in the baseline environment or have been screened out as there is no potential to alter the significance of effects.

The assessment of cumulative effects has considered likely significant effects that may arise during construction, operation and decommissioning of the proposed development. Cumulative effects were assessed to a level of detail commensurate with the information that has either been directly shared with the proposed development or was publicly available at the time of assessment.

Given the location and nature of the proposed development, a tiered approach to establishing the list of other existing and/or approved projects has been undertaken in Stage 1 of the cumulative effects assessment. The tiering of projects is based on project relevance to the proposed development, and it is not a hierarchal approach based on weighting. Further information on the tiers is provided in Section 12.9.2 and in the Cumulative and Inter-Related Effects Chapter.

12.9.1 Benthic and intertidal cumulative screening exercise

The existing and/or approved projects selected as relevant to the cumulative effects assessment of impacts to benthic subtidal and intertidal ecology are based on an initial screening exercise undertaken on a long list (see Cumulative and Inter-Related Effects Chapter) based on spatial distance to the proposed development. Consideration of effect-receptor pathways, data confidence and temporal and spatial scales has then allowed the selection of the relevant projects within the benthic and intertidal cumulative short-list.

When assessing the likely significant effects for benthic and intertidal ecology, projects were screened into the assessment based on their ability to impact receptors within a 24km screening range surrounding the array area, and a 24km range around the ECC representing twice the tidal ellipse distance for a single tidal cycle and therefore encompasses the combined extent of potential impacts to benthic and intertidal ecology from the proposed development and also any regional projects likely to contribute to cumulative effects under a precautionary assumption that other projects may have a similar ZoI to the proposed development.

For the full list of projects considered, including those screened out, please see the Cumulative and Inter-Related Effects Chapter and Appendix 38.1.

12.9.2 Projects considered within the benthic and intertidal cumulative effects assessment

The planned, existing and/or approved projects selected through the screening exercise as potentially relevant to the assessment of impacts to benthic subtidal and intertidal ecology are presented in Table 12.22.

The tiers for the assessment are:

- Tier 1 is limited to the Operation and Maintenance Facility (OMF) for the proposed development. The OMF option being considered involves the adaption and leasing part of an existing port facility at Greenore. Further detail is provided in the Offshore Description Chapter.
- Tier 2 is the east coast Phase One Offshore Wind Farms (OWF).
- Tier 3 is all other projects that have been screened in for this topic.

The tiering structure is intended to provide an understanding of the potential for likely significant effects of the proposed development with the construction of its OMF (tier one); followed by a cumulative assessment of the likely significant effect of that scenario combined with the east coast Phase One OWFs (tier two); and lastly the combination of tier one and tier two with all other existing and/or approved projects that have been screened in (tier three).

Table 12.22 Projects and plans considered within the cumulative impact assessment

Development Type	Project	Status	Data Confidence	Distance to NISA		Justification for screening into the cumulative effects assessment
				Array area	ECC	
Tier 1						
Proposed development OMF at Greenore	Greenore Operation and Maintenance Facility (OMF)	Pre-consent	Low – No published documentation available at time of writing.	33.9km	38.8km	Owing to the early stage of the project within the planning process, exact information related to the proposed works is not available. However, it is anticipated that some piling may be required for the pontoon, for which there may be an impact on benthic ecology receptors.
Tier 2						
Phase One Offshore wind farm	Oriel Wind Park	Pre-consent	Medium – scoping report available at time of writing. A foreshore licence has been granted for site investigations (2022-2027). Reference FS007383	16.9km	21.6km	Overlap in construction period, Oriel Wind Park due to construct during 2026-2028.
Tier 3						
Dredging	Sea disposal of dredging material from Warrenpoint Harbour (Warrenpoint B)	Consented	High – consented. Licence ML2023040	23.7km	28.9km	Overlap in operation and maintenance periods: 2024 - 2027
Dredging	Drogheda Port Company	Consented	High - Consented Licence: S0015-03	11.7km	10.2km	Overlap in operation and maintenance periods: 2021 - 2029

12.9.3 Project impacts included in the cumulative assessment

The identification of potential impacts has been undertaken by considering the relevant characteristics from both project options (refer to Section 12.4.1) and the potential for a pathway for them to have direct and indirect effects on known receptors (as identified in Section 12.3) when combined with other projects. Each identified impact relevant to benthic subtidal and intertidal ecology is presented in Table 12.23.

For each impact, the project option with the greatest potential for a likely significant effect has been determined based on the comparison and justification provided in Table 12.6. The impacts considered in the cumulative assessment are presented in Table 12.14.

The identification of potential impacts has been undertaken by considering the outcome of the residual effects assessment (Section 12.7) and the potential for a pathway for those impacts to have direct and/or indirect effects on known receptors (as identified in Section 12.3) when combined with the impacts from other projects. Each identified impact relevant to the cumulative assessment of benthic subtidal and intertidal ecology is presented in Table 12.23. As the residual effects for Project Option 1 and Project Option 2 are the same (as identified in Section 12.7), the cumulative effects assessment presented in this section applies to both options.

Table 12.23 Identified impacts considered for the assessment of cumulative impacts

Potential cumulative impact	Phase	Tiers and Projects	Justification for inclusion in cumulative effects assessment
1. Cumulative temporary habitat loss as a result of construction activities	Construction, Decommissioning	Tier 2 – Phase One Offshore Wind Farm (OWF) projects	Seabed preparation works, foundation and cable installation works from other projects can put temporary habitat disturbance/loss pressures on benthic subtidal ecology species and their supporting habitats
2. Cumulative increases in SSC and associated sediment deposition	Construction, Decommissioning	Tier 2 – Phase One OWF projects Tier 3 – Dredging projects	Capital dredging and disposal, seabed preparation works, foundation and cable installation works from other projects can cause temporary increases in SSC and associated sediment deposition and smothering of the benthos.
3. Cumulative long-term or permanent habitat loss / change from the presence of foundations, scour protection and cable protection (operational phase).	Operation and Maintenance	Tier 2 – Phase One OWF projects	The presence of OWF infrastructure in the marine environment, including foundations, scour protection and cable protection has the potential to cause long term changes in habitat through the presence of infrastructure in the marine environment.
4. Changes to seabed habitats arising from effects on physical processes, including scour effects and changes in the sediment transport and wave regimes resulting in likely significant effects on benthic communities (operational phase)	Operation and Maintenance	Tier 2 – Phase One OWF projects	Changes in the tidal and wave regimes through the presence of structures in the marine environment from other projects could potentially affect subtidal benthic receptors through scour effects and changes in the sediment transport and wave regimes

12.9.4 Cumulative Impact 1 – Cumulative temporary habitat loss as a result of construction and decommissioning activities

Seabed preparation works and foundation and cable installation works from other projects can put temporary habitat disturbance/loss pressures on benthic subtidal ecology species and their supporting habitats. This impact is associated primarily with construction and decommissioning phases. The likely significant cumulative effects, as a result of cumulative temporary habitat loss is presented in the following section.

12.9.4.1 Tier 1

The proposed construction of the OMF is limited to the onshore expansion of facilities and is therefore not considered to have the potential to contribute to cumulative loss of benthic habitats.

12.9.4.2 Tier 1 and 2

Plans for Oriel OWF indicate that the proposed development will comprise 25 WTGs. Owing to the early stage of the Oriel OWF project within the planning process, site-specific information relating to temporary habitat loss is very limited.

The nature of the impacts associated with construction and decommissioning of Oriel OWF are assumed to be of similar to that for the proposed development as it is a OWF of a similar size and scale to the proposed development. Consequently, cumulative impacts of temporary habitat disturbance are expected to be of local spatial extent, short-term duration, intermittent and reversible.

The sensitivity of subtidal benthic habitats to temporary habitat disturbance have been documented in Table 12.18 (Impact 2). The greatest sensitivity for benthic subtidal ecology receptors is rated as high.

The magnitude of the potential cumulative temporary habitat loss from concurrent construction and decommissioning is concluded to be low. The greatest sensitivity of receptors in the area is assessed as high; this would result in a moderate effect, which is not significant in EIA terms.

12.9.4.3 Tier 1, 2 and 3 (All tiers)

No Tier 1 projects are considered relevant to Cumulative Impact 1 and Oriel OWF is screened into Tier 2 which is considered within this assessment.

The dredging and disposal works at Drogheda and Warren Point have not been screened in to Tier 3 as they are not considered to have the potential to contribute to cumulative loss of benthic habitats.

Therefore, the cumulative effect of Impact 1 remains the same as assessed for Tier 1 and 2; the sensitivity of the receptors is high and the magnitude of the impact is low, resulting in the significance of effect through the construction and decommissioning phases being moderate, which is not significant in EIA terms.

12.9.5 Cumulative Impact 2 – Cumulative increases in SSC and associated sediment deposition

Capital dredging and disposal, seabed preparation works, foundation and cable installation works from other projects can cause temporary increases in SSC and associated sediment deposition and smothering of the benthos. This impact is associated primarily with construction and decommissioning phases. The likely significant cumulative effects, as a result of concurrent sediment disturbance, are presented in the following sections.

12.9.5.1 Tier 1

The proposed construction of the OMF is limited to the onshore expansion of facilities and is therefore not considered to have the potential to contribute to cumulative impacts associated with increases in SSC and associated deposition.

12.9.5.2 Tier 1 and 2

Except for within the immediate vicinity of some of the activities (refer to the Physical Processes Chapter), the SSC levels predicted within the SSC plumes from Oriel OWF will be below background levels recorded during storm events.

Therefore, benthic subtidal ecology receptors within the baseline are expected to easily adapt to and/or tolerate the SSC plumes that are predicted both alone and cumulatively, particularly as SSC plumes are expected to quickly dissipate following cessation of activities.

The magnitude of the potential cumulative increases in SSC and deposition from concurrent operations is concluded to be low, i.e. the same as the project alone. The greatest sensitivity of receptors in the area is assessed as high; this would result in a moderate cumulative significance of effect, which is not significant in EIA terms.

No additional mitigation to that already identified in Table 12.13 are considered necessary to prevent significant effects.

12.9.5.3 Tier 1, 2 and 3 (All tiers)

No Tier 1 projects are considered relevant to Cumulative Impact 2 and Oriel OWF is screened into Tier 2 which is considered within this assessment.

Within Tier 3 a small number of operational dredge disposal sites are located within the cumulative assessment area and therefore there is the potential for a cumulative sediment plume effect. It is not known what volumes of sediment will be released from these disposal sites at any one time, and as the dredging activities is intermittent, it is not possible to determine if the use of these sites will overlap with sediment deposition from activities at the proposed development likely to produce a sediment plume. If construction activities at the proposed development re undertaken concurrently with dredge disposal and construction at Oriel OWF then a larger combined sediment plume may form. However, it is anticipated that except for the immediate vicinity of dredge disposal activities and the Oriel OWF construction site SSC levels within the associated plumes will be close to background levels and will quickly disperse. This, allied to the distances from the proposed development site (Drogheda site is 14.3km and Oriel OWF 16.9km from the proposed development), and given the dynamic nature of the environment, only a minimal potential for of any interaction between suspended sediment from the proposed development and dredge spoil disposal is likely. Therefore, no significant cumulative effects are predicted.

The magnitude of the potential cumulative increases in SSC and deposition from concurrent operations is concluded to be low, i.e. the same as the project alone. The greatest sensitivity of receptors in the area is assessed as high; this would result in a moderate cumulative significance of effect, which is not significant in EIA terms.

No additional mitigation to that already identified in Table 12.13 are considered necessary to prevent significant effects.

12.9.6 Cumulative Impact 3 – Cumulative long-term or permanent habitat loss / change from the presence of foundations, scour protection and cable protection

The presence of OWF infrastructure in the marine environment, including foundations, scour protection and cable protection has the potential to cause long term changes in habitat through the presence of infrastructure in the marine environment and is considered as being associated primarily with the operational phase. Also, any infrastructure left in situ following decommissioning will represent a permanent loss of habitat. The likely significant cumulative effects, as a result of concurrent long-term or permanent habitat loss, is presented in the following section.

12.9.6.1 Tier 1

The proposed construction of the OMF is limited to the onshore expansion of facilities and is therefore not considered to have the potential to contribute to cumulative impacts associated with long-term or permanent habitat loss / change from the presence of foundations, scour protection and cable protection.

12.9.6.2 Tier 1 and 2

Owing to the early stage of the Oriel OWF project within the planning process, no site-specific information relating to long-term or permanent habitat loss is available. However, it is understood that there will be a 25 WTGs at most.

It should be noted that in relation to Oriel OWF comparable habitats likely to be impacted are widely distributed in the Irish Sea, so long-term or permanent habitat loss at the scale predicted for the proposed development is not predicted to diminish regional ecosystem functions.

The sensitivity of benthic habitats to long-term or permanent habitat loss is considered high, as there will be a complete loss of that habitat type.

While the impact will be locally significant for both the proposed development and Oriel OWF and comprise a permanent change in seabed habitat within the footprint of the structures and scour and cable protection of each development, the footprint of the areas affected is highly localised and relatively remote from each other (16.9km). Consequently, the magnitude of the potential cumulative long-term or permanent habitat loss from concurrent operational phases is concluded to be low. The greatest sensitivity of receptors in the area is assessed as high; this would result in a moderate effect, which is not significant in EIA terms.

No additional mitigation to that already identified in Table 12.13 are considered necessary to prevent significant effects.

12.9.6.3 Tier 1, 2 and 3 (All tiers)

No Tier 1 projects are considered relevant to Cumulative Impact 3 and Oriel OWF is screened into Tier 2 which is considered within this assessment.

The dredging and disposal works at Drogheda and Warren Point have not been screened in to Tier 3 as they are not considered to have the potential to contribute to cumulative long-term or permanent habitat loss / change from the presence of foundations, scour protection and cable protection.

Therefore, the cumulative effect of Impact 3 remains the same as assessed for Tier 1 and 2; the sensitivity of the receptors is high and the magnitude of the impact is low, resulting in the significance of effect through the operational phase being moderate, which is not significant in EIA terms.

12.9.7 Cumulative Impact 4 – Changes to seabed habitats arising from effects on physical processes, including scour effects and changes in the sediment transport and wave regimes resulting in likely significant effects on benthic communities

Changes in the tidal and wave regimes through the presence of structures in the marine environment could potentially affect those subtidal benthic receptors detailed in Table 12.18 through scour effects and changes in the sediment transport and wave regimes during the operational phase. The likely significant cumulative effects, as a result of concurrent changes to seabed habitats arising from effects on physical processes, on benthic communities is presented in the following section.

12.9.7.1 Tier 1

The proposed construction of the OMF is limited to the onshore expansion of facilities and is therefore not considered to have the potential to contribute to cumulative impacts associated with changes to seabed habitats arising from effects on physical processes, including scour effects and changes in the sediment transport and wave regimes resulting in likely significant effects on benthic communities.

12.9.7.2 Tier 1 and 2

The effects on the tidal and wave regimes from the proposed development alone on benthic receptors (see Table 12.18) were deemed to be of negligible magnitude for the proposed development (Physical Processes Chapter) and that the influence on the regimes was highly localised. Given the similar technologies, scales of development and analogous location Oriel OWF project, it is anticipated that similar magnitudes of effects would occur for this project alone, i.e. localised and not significant in EIA terms

The sensitivity of benthic habitats to the wave and tidal regimes have been documented in Impact 8 (Section 12.5.3.3). As indicated in the discussion the greatest sensitivity of the receptors is considered to be medium according to the MarLIN MarESA sensitivity category.

No additional mitigation to that already identified in Table 12.13 are considered necessary to prevent significant effects.

Despite being potentially additive, it is not anticipated that the cumulative changes arising from the developments would be measurable and therefore the magnitude is concluded to be negligible. The greatest sensitivity of receptors in the area is assessed as medium; this would result in a not significant effect, which is not significant in EIA terms.

No additional mitigation to that already identified in Table 12.13 are considered necessary to prevent significant effects.

12.9.7.3 Tier 1, 2 and 3 (All tiers)

No Tier 1 projects are considered relevant to Cumulative Impact 4 and Oriel OWF is screened into Tier 2 which is considered within this assessment.

The dredging and disposal works at Drogheda and Warren Point have not been screened into Tier 3 as they are not considered to have the potential to contribute to cumulative changes to seabed habitats arising from effects on physical processes, including scour effects and changes in the sediment transport and wave regimes resulting in likely significant effects on benthic communities.

Therefore, the cumulative effect of Impact 4 remains the same as assessed for Tier 1 and 2; the sensitivity of the receptors is medium and the magnitude of the impact is negligible, resulting in the significance of effect through the operational phase being not significant, which is not significant in EIA terms.

12.10 References

[1] Aquafact International Services Ltd. (2017). JN1445 Marine ecology Baseline Chapter 1.

Aquatic Services Unit (2019). Dublin Port Maintenance Dredging 2022 – 2029 Benthic and Fisheries Assessment. Available at: https://assets.gov.ie/136524/43d59590-a5eb-42cc-9c08-a91482e5a8dc.pdf

Araújo, R., Isabel, S.-P., Serrao, E.A. & Per, Å., 2012. Recovery after trampling disturbance in a canopy-forming seaweed population. Marine Biology, 159 (3), 697-707. DOI https://doi.org/10.1007/s00227-011-1847-8

Araújo, R., Vaselli, S., Almeida, M., Serrão, E. & Sousa-Pinto, I., 2009. Effects of disturbance on marginal populations: human trampling on Ascophyllum nodosum assemblages at its southern distribution limit. Marine Ecology Progress Series, 378, 81-92. DOI https://doi.org/10.3354/meps07814

Ball, B, J, Fox, G, Munday, B, W. (2000) Long- and short-term consequences of a Nephrops trawl fishery on the benthos and environment of the Irish Sea, ICES Journal of Marine Science, 57: 1315-1320

Barnes M.D. (2017) Guidance on EIS and NIS Preparation for Offshore Renewable Energy Projects, Report for the Environmental Working Group of the Offshore Renewable Energy Steering Group and the Department of Communications, Climate Action and Environment, Dublin: Department of Communications, Climate Action and Environment, Available at: https://cieem.net/resource/guidance-on-eis-and-nis-preparation-for-offshore-renewable-energy-projects/ [Accessed: February 2022]

Bergman, M.J.N. & Van Santbrink, J.W., 2000. Fishing mortality of populations of megafauna in sandy sediments. In The effects of fishing on non-target species and habitats (ed. M.J. Kaiser & S.J de Groot), 49-68. Oxford: Blackwell Science.

BGS (2022), BGS Rock Classification Scheme, Available at: https://webapps.bgs.ac.uk/bgsrcs/rcs_details.cfm?code=MARSDU [Accessed: February 2022]

Bioconsult (2006) Benthic communities at Horns Rev, before, during and after construction of Horns Rev offshore wind farm. Final annual report 2005.

Blott, S, J, Pye, K. (2012), Particle size scales and classification of sediment types based on particle size distributions: Review and recommended procedures, The Journal of the International Association of Sedimentologists, 59 (7)

Breitburg, D., Levin, L. A., Oschlies, A., Grégoire, M., Chavez, F. P., Conley, D. J., et al. (2018). Declining oxygen in the global ocean and coastal waters. Science, 359(6371). Available at: https://doi.org/10.1126/science.aam7240

Brosnan, D.M., 1993. The effect of human trampling on biodiversity of rocky shores: monitoring and management strategies. Recent Advances in Marine Science and Technology, 1992, 333-341.

Burdige, D.J. (2007). Preservation of Organic Matter in Marine Sediments: Controls, Mechanisms, and an Imbalance in Sediment Organic Carbon Budgets? Chemistry Review, 107(2), 467-485.

Cámaro García, W.C.A. and Dwyer, N. (2020). The Status of Ireland's Climate, 2020. Government of Ireland. Available at: https://www.epa.ie/publications/research/climate-change/research-386-the-status-of-irelands-climate-2020

Carlton J. T. (1992). Marine species introductions by ships' ballast water: an overview. In: Proceedings of the conference and workshop on introductions and transfers of marine species: achieving a balance between economic development and resource protection, Hilton Head Island, South Carolina October 30 - November 2, 1991, ed. by M.R. De Voe. pp. 23-25. South Carolina Sea Grant Consortium.

Caswell BA, Paine M, Frid CLJ (2018) Seafloor ecological functioning over two decades of organic enrichment. Mar Poll Bull 136: 212–229. Available at: https://www.sciencedirect.com/science/article/abs/pii/S0025326X18306052?via%3Dihub

CCME. Canadien Environmental Quality Guidelines. Available at: https://ccme.ca/en/resources/sediment

Cefas (2002). Guidelines for the Conduct of Benthic Studies at Marine Aggregate Extraction Sites (2nd edition). Marine Aggregate Levy Sustainability Fund, 80 pp. Available at: http://www.marbef.org/qa/documents/ConductofsurveysatMAEsites.pdf

Cefas (2004), Guidance note for Environmental Impact Assessment In respect of FEPA and CPA requirements – Version 2, Available at: https://www.ctc-n.org/sites/www.ctc-n.org/files/resources/windfarm-guidance.pdf [Accessed: February 2022]

Cefas (2012), Guidelines for data acquisition to support marine environmental assessments of offshore renewable energy projects, Available at: https://tethys.pnnl.gov/sites/default/files/publications/CEFAS_2012_Eenvironmental_Assessment_Guidance.pdf [Accessed: February 2022]

CEFAS (2017). Sediment Organic Carbon in Marine Sediments around England and Wales 1996 – 2015. Available at: https://www.cefas.co.uk/data-and-publications/dois/sediment-organic-carbon-in-marine-sediments-around-england-and-wales-1996-2015/

Cervin, G., Åberg, P. & Jenkins, S.R., 2005. Small-scale disturbance in a stable canopy dominated community: implications for macroalgal recruitment and growth. Marine Ecology Progress Series, 305, 31-40. DOI https://doi.org/10.3354/meps305031

CIEEM (2018), Guidelines for Ecological Impact Assessment in the UK and Ireland, Available at: https://cieem.net/wp-content/uploads/2019/02/Combined-EclA-guidelines-2018-compressed.pdf [Accessed: February 2022]

Cook, E.J., Macleod, A. Payne, R.D. and Brown, S. 2014. edited by Natural England and Natural Resources Wales (2015). Marine Biosecurity Planning – Guidance for producing site and operation-based plans for preventing the introduction and spread of non-native species. [Online]. [Accessed 03 January 2019]. Available from: https://www.nature.com/articles/srep02831#supplementary-information

Coughlan. M. (2015). Quaternary Geology Of The German North Sea And Western Irish Sea Mud Belt: Revised Stratigraphies, Geotechnical Properties, Sedimentology And Anthropogenic Impacts. PhD Thesis National University Cork. Available at: https://www.researchgate.net/publication/299489863_Quaternary_Geology_of_the_German_North_Sea_and_Western_Irish_Sea_Mud_Belt_revised_stratigraphies_geotechnical_properties_sedimentology_and_anthropogenic_impacts

Coughlan, M, Guerrini, M, Creane, S, O'Shea, M, Ward, S.L,Van Landeghem, K.J.J, Murphy, J, Doherty, P. (2021), A New Seabed Mobility Index for the Irish Sea: Modelling Seabed Shear Stress and Classifying Sediment Mobilisation to Help Predict Erosion, Deposition, and Sediment Distribution'. Continental Shelf Research 229

Cronin, M., McGovern, E., McMahon, T. & Boelins, R. (2006). Guidelines for the assessment of dredge material for disposal in Irish water. Marine Environment and Health Series, No. 24, 2006. Available at: https://oar.marine.ie/handle/10793/251

Dalkin, M. (2008). JNCC. Mid Irish Sea Reefs habitat mapping report. Available at: https://data.jncc.gov.uk/data/c74e7820-b959-4d2a-b235-a2a187a5fbae/JNCC-Report-411-FINAL-WEB.pdf

Davies, J., Baxter, J., Bradley, M., Connor, D., Khan, J., Murray, E., Sanderson, W., Turnbull, C. and Vincent, M., (eds) 2001. Marine Monitoring Handbook. Joint Nature Conservation Committee, Peterborough. 405pp. https://data.jncc.gov.uk/data/ed51e7cc-3ef2-4d4f-bd3c-3d82ba87ad95/marine-monitoring-handbook.pdf

Dauwe, B., Middelburg, J.J. & Herman, P.M.J. (2001). Effect of oxygen on the degradability of organic matter in subtidal and intertidal sediments of the North Sea area. Marine Ecology Progress Series, 215, 13-22. Available at: https://www.jstor.org/stable/24864252

DCCAE, 2017. 'Guidance on Environmental Impact Statement (EIS) and Natura Impact Statement (NIS) Preparation for Offshore Renewable Energy Projects. Available at: https://www.gov.ie/en/publication/3d6efb-guidance-documents-for-offshore-renewable-energy-developers/

DCCAE, 2018. Guidance on Marine Baseline Ecological Assessments & Monitoring Activities for Offshore Renewable Energy Projects Parts 1 and 2. Available at: https://www.gov.ie/en/publication/3d6efb-guidance-documents-for-offshore-renewable-energy-developers/Department of Housing, Planning and Local Government (2018). Guidelines for Planning Authorities and An Bord Pleanála on carrying out Environmental Impact Assessment.

Dye, S., Hughes, S., Tinker, J. & Berry, D.I. (2013). Impacts of climate change on temperature (air and sea). Marine Climate Change Impacts Partnership: Science Review, 2013: 1-12. Available at: https://www.researchgate.net/publication/304351301_Impacts_of_climate_change_on_temperature_air_and_sea

EMODnet Map Viewer. Habitats Directive Annex I habitat maps. Available at: https://www.emodnet-seabedhabitats.eu/access-data/launch-map-viewer/

Eno, N.C., MacDonald, D.S., Kinnear, J.A.M., Amos, C.S., Chapman, C.J., Clark, R.A., Bunker, F.S.P.D. & Munro, C., 2001. Effects of crustacean traps on benthic fauna ICES Journal of Marine Science, 58, 11-20. DOI https://doi.org/10.1006/jmsc.2000.0984

Environmental Protection Agency (2014). Biodiversity Action Plan 2014-2018. Available at: https://www.epa.ie/publications/circular-economy/resources/epa-biodiversity-action-plan-2014-2018.php

Environmental Protection Agency (2022). Guidelines on the information to be contained in Environmental Impact Assessment Reports. Available at: https://www.epa.ie/publications/monitoring--assessment/assessment/guidelines-on-the-information-to-be-contained-in-environmental-impact-assessment.php

EPA (2022). Guidelines on the information to be contained in Environmental Impact Assessment Reports. Available at: https://www.epa.ie/publications/monitoring--assessment/assessment/EIAR_Guidelines_2022_Web.pdf

EUSeaMap (2021). EMODnet broad-scale seabed habitat map of Europe. Available at: https://www.emodnet-seabedhabitats.eu/European Environment Agency (EEA) (2013), Interpretation Manual of European Union Habitats, version EUR 28, Available at: https://ec.europa.eu/environment/nature/legislation/habitatsdirective/docs/Int_Manual_EU28.pdf [Accessed: February 2022]

European Environment Agency, 2019 'EUNIS -Site Factsheet for Rockabill to Dalkey Island SAC'. https://eunis.eea.europa.eu/sites/IE0003000

European Environment Agency, 2022 'EUNIS marine habitats classification 2022 with crosswalks to Annex I in separate rows'. https://www.eea.europa.eu/ds_resolveuid/Q13MWPBFSG

Fair Seas (2022), Revitalising Our Seas: Identifying Areas of Interest for Marine Protected Area Designation in Irish Waters, https://fairseas.ie/wp-content/uploads/2022/06/Revitalising_Our_Seas_Report_Marine_Protected_Areas_Fair_Seas.pdf

Fletcher, H. & Frid, C.L.J., 1996a. Impact and management of visitor pressure on rocky intertidal algal communities. Aquatic Conservation: Marine and Freshwater Ecosystems, 6, 287-297.

Foden J., Rogers S.I. and Jones A.P. (2011) Human pressures on UK seabed habitats a cumulative impact assessment. Marine Ecology Progress Series, 428, p.33–47.

Folk, R, L. (1954), The Distinction between Grain Size and Mineral Composition in Sedimentary-Rock Nomenclature, The Journal of Geology, 62 (4), 344-359

Food and Agriculture Organisation (FAO) (2011), European Communities (Marine Strategy Framework) Regulations 2011 (S. I. No. 249 of 2011).

Fugro (2022). Geophysical Survey Results Report | Ireland, Irish Sea. Results Report - Fugro Mercator. F202831-REP-003. Issue 1. For North Irish Sea Array Windfarm Limited.

Golding. N., Albrecht. J., McBreen. F. 2020. Refining criteria for defining areas with a 'low resemblance' to Annex I stony reef; Workshop Report. JNCC Report No. 656, JNCC, Peterborough, ISSN 0963-8091. Available at: https://data.jncc.gov.uk/data/4b60f435-727b-4a91-aa85-9c0f99b2c596/JNCC-Report-656-FINAL-WEB.pdf

Gubbay, S. (2007). Defining and managing *Sabellaria spinulosa* reefs: Report of an inter-agency workshop 1-2 May,2007, JNCC Report No. 405.

Hedges, J.I., Keil, R.G., 1995. Sedimentary organic matter preservation: an assessment and speculative synthesis. Mar. Chem., 49 (1995), pp. 81-115

INFOMAR (2021). Integrated Mapping for the Sustainable Development of Ireland's Marine Resources. Available at: https://www.marine.ie/Home/site-area/areas-activity/seabed-mapping/infomar

IPCC (2013). Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Available at: https://www.ipcc.ch/report/ar5/wg1/

Irving, R. 2009. The identification of the main characteristics of stony reef habitats under the Habitats Directive. Summary report of an inter-agency workshop 26-27 March 2008. JNCC Report No. 432, JNCC, Peterborough, ISSN 0963-8091. https://hub.jncc.gov.uk/assets/4b60f435-727b-4a91-aa85-9c0f99b2c596

Jenkins, S.R., Hawkins, S.J. & Norton, T.A., 1999. Direct and indirect effects of a macroalgal canopy and limpet grazing in structuring a sheltered inter-tidal community. Marine Ecology Progress Series, 188, 81-92.

Jenkins, S.R., Norton, T.A. & Hawkins, S.J., 2004. Long term effects of Ascophyllum nodosum canopy removal on mid shore community structure. Journal of the Marine Biological Association of the United Kingdom, 84, 327-329. DOI https://doi.org/10.1017/S0025315404009221h

JNCC (2019), Guidance on Assigning Benthic Biotopes using EUNIS or the Marine Habitat Classification of Britain and Ireland (Revised 2019), Available at: https://data.jncc.gov.uk/data/f23a26d7-07ad-4291-a42d-b422dad82351/JNCC-Report-546-REVISED-WEB.pdf [Accessed: February 2022]

Kaiser, M., Clarke, K., Hinz, H., Austen, M., Somerfield, P. & Karakassis, I., 2006. Global analysis of response and recovery of benthic biota to fishing. Marine Ecology Progress Series, 311, 1-14.

Kenny, A. J., Cato, I., Desprez, M., Fader, G., Schuttenhelm, R. T. E., and Side, J. 2003. An overview of seabed-mapping technologies in the context of marine habitat classification. – ICES Journal of Marine Science, 60: 411–418.

Kinnear, J.A.M., Barkel, P.J., Mojseiwicz, W.R., Chapman, C.J., Holbrow, A.J., Barnes, C. & Greathead, C.F.F., 1996. Effects of Nephrops creels on the environment. Fisheries Research Services Report No. 2/96, 24 pp. Available from https://www2.gov.scot/Uploads/Documents/frsr296.pdf

Krone, R., Dederer, G., Kanstinger, P., Krämer, P., Schneider, C., & Schmalenbach, I. (2017). Mobile demersal megafauna at common offshore wind turbine foundations in the German Bight (North Sea) two years after deployment - increased production rate of Cancer pagurus. Marine Environmental Research, 123, 53–61. Available at: https://www.sciencedirect.com/science/article/abs/pii/S0141113616303014

Kröncke, I., (1995). Long-term changes in North Sea benthos. Senckenberg Marit, 26, p.73-80.

Krönke, I. (2011) Changes in Dogger Bank macrofauna communities in the 20th century caused by fishing and climate. Estuarine and Coastal Shelf Science, 94(3), 234-245.

Levin, L.A., et al. (2009). Effects of natural and human-induced hypoxia on coastal benthos. Biogeosciences, 6, 2063–2098. Available at: https://bg.copernicus.org/articles/6/2063/2009/bg-6-2063-2009.pdf

Lindeboom, H.J., Kouwenhoven, H.J., Bergman, M.J.N., Bouma, S., Brasseur, S., Daan, R., Fijn, R.C., Haan, De d.,Dirksen, S., Hal, R. van., Hille Ris Lambers, R., Hofsted, R ter., Krijgsveld, K.L., Leopold, M. and Scheidat, M.(2011) Short-term ecological effects of an offshore wind farm in the Dutch coastal zone; a compilation. Environmental Research Letters, 6 (3).

Long, D. (2006), BGS detailed explanation of seabed sediment modified folk classification, Available at: https://www.researchgate.net/profile/David-Long-5/publication/284511408_BGS_detailed_explanation_of_seabed_sediment_modified_folk_classification/links/56545ab308aeafc2aabbc3c9/BGS-detailed-explanation-of-seabed-sediment-modified-folk-classification.pdf [Accessed: February 2022]

Mackie, A.S.Y. (1990). Offshore Benthic Communities of the Irish Sea. In: The Irish Sea: An Environmental Review, Part 1, 169-218. Available at: https://gis.ices.dk/geonetwork/srv/api/records/4908b026-1ee4-4921-9a9c-ce53f802864e

Mahaffey, C., Palmer, M., Greenwood, N. & Sharples, J. (2020). Impacts of climate change on dissolved oxygen concentration relevant to the coastal and marine environment around the UK. MCCIP Science Review, 2002. 31-53. Available at: https://nora.nerc.ac.uk/id/eprint/527795/

Makra, A. & Keegan, B. F., 1999. Arm regeneration in *Acrocnida brachiata* (Ophiuroidea) at Little Killary, west coast of Ireland. Biology and Environment: Proceedings of the Royal Irish Academy, 99 (2) 95-102.

Marine Institute (2019). Distribution of Coastal Habitats in Ireland 2013-2018. Available at: https://data.marine.ie/geonetwork/srv/eng/catalog.search#/metadata/ie.marine.data:dataset.3993

Marine Pathways Project. 2014. Project information. [Online]. [Accessed 03 June 2018]. Available from: http://www.nonnativespecies.org/index.cfm?pageid=590

MarLIN, The Marine Biological Association of the UK (2022), Available at: https://www.marlin.ac.uk/sensitivity/sensitivity_rationale [Accessed: February 2022]

McCook, L. & Chapman, A., 1992. Vegetative regeneration of Fucus rockweed canopy as a mechanism of secondary succession on an exposed rocky shore. Botanica Marina, 35 (1), 35-46.

Mellet, C, Long, D, Carter, G, Chiverell, R, Van Landeghem, K. (2015). Geology of the seabed and shallow subsurface: The Irish Sea. British Geological Survey Commissioned Report, CR/15/057, 52

MPAAG (2023). Ecological sensitivity analysis of the western Irish Sea to inform future designation of Marine Protected Areas (MPAs). Report by the Marine Protected Area Advisory Group for the Department of Housing, Local Government and Heritage, Ireland.

Newell, R.C., Seiderer, L.J. & Hitchcock, D.R. 1998. The impact of dredging works in coastal waters: a review of the sensitivity to disturbance and subsequent recovery of biological resources on the sea bed. Oceanography and Marine Biology: an Annual Review, 36: 127-178.

Newell R.C., Siederer L.J., Simpson N.M. and Robinson J.E. (2004) Impacts of marine aggregate dredging on benthic macrofauna off the South Coast of the United Kingdom. Journal of Coastal Research, 20, p.115-125.

Nichols, J. A., Powe, G.T, Clifford, C.H. & Young, R.A. (1978). In situ experiments on the burial of marine invertebrates. Journal of Sediment Petrology 48: 419–425.

North Irish Sea Array Windfarm Ltd, 2024. Natura Impact Statement.

NPWS (2011) Conservation Objectives: Dundalk Bay SAC 000455, Dundalk Bay SPA 004026. Version 1. National Parks and Wildlife Service, Department of Arts, Heritage and the Gaeltacht. Available at: https://www.npws.ie/sites/default/files/protected-sites/conservation_objectives/CO004026.pdf [Accessed: February 2022]

NPWS (2012) Conservation Objectives: Boyne Coast and Estuary SAC 001957. Version 1.0. National Parks and Wildlife Service, Department of Arts, Heritage and the Gaeltacht. Available at: https://www.npws.ie/sites/default/files/protected-sites/conservation_objectives/CO001957.pdf [Accessed: February 2022]

NPWS (2012) Conservation Objectives: River Nanny Estuary and Shore SPA 004158. Version 1.0. National Parks and Wildlife Service, Department of Arts, Heritage and the Gaeltacht. Available at: https://www.npws.ie/sites/default/files/protected-sites/conservation_objectives/CO004158.pdf [Accessed: February 2022]

NPWS (2013) Conservation Objectives: Boyne Estuary SPA 004080. Version 1. National Parks and Wildlife Service, Department of Arts, Heritage and the Gaeltacht. Available at: https://www.npws.ie/sites/default/files/protected-sites/conservation_objectives/CO004080.pdf [Accessed: February 2022]

NPWS (2013) Conservation Objectives: Carlingford Shore SAC 002306. Version 1. National Parks and Wildlife Service, Department of Arts, Heritage and the Gaeltacht. Available at: https://www.npws.ie/sites/default/files/protected-sites/conservation_objectives/CO002306.pdf [Accessed: February 2022]

NPWS (2013) Conservation Objectives: Carlingford Lough SPA 004078. Version 1. National Parks and Wildlife Service, Department of Arts, Heritage and the Gaeltacht. Available at: https://www.npws.ie/sites/default/files/protected-sites/conservation_objectives/CO004078.pdf [Accessed: February 2022]

NPWS (2013) Conservation Objectives: Lambay Island SAC 000204. Version 1. National Parks and Wildlife Service, Department of Arts, Heritage and the Gaeltacht. Available at: https://www.npws.ie/sites/default/files/protected-sites/conservation_objectives/CO000204.pdf [Accessed: February 2022]

NPWS (2013) Conservation Objectives: Rockabill SPA 004014. Version 1. National Parks and Wildlife Service, Department of Arts, Heritage and the Gaeltacht. Available at: https://www.npws.ie/sites/default/files/protected-sites/conservation_objectives/CO004014.pdf [Accessed: February 2022]

NPWS (2013) Conservation Objectives: Rockabill to Dalkey Island SAC 003000. Version 1. National Parks and Wildlife Service, Department of Arts, Heritage and the Gaeltacht. Available at: https://www.npws.ie/sites/default/files/protected-sites/conservation_objectives/CO003000.pdf [Accessed: February 2022]

NPWS (2013a). Rockabill to Dalkey Island SAC (site code: 3000). Conservation objectives supporting document - Marine Habitats and Species. National Parks and Wildlife Service, Department of Arts, Heritage and the Gaeltacht. Available at: https://www.npws.ie/sites/default/files/publications/pdf/003000_Rockabill%20to%20Dalkey%20Island%20SAC%20Marine%20Supporting%20Doc_V1.pdf

NPWS, (2019). Ireland's Biodiversity Sectoral Climate Change Adaptation Plan. Consultation Draft. Available at: https://www.npws.ie/news/public-consultation-irelands-biodiversity-sectoral-climate-change-adaptation-plan

OREDP, 2010, Strategic Environmental Assessment (SEA) of the Offshore Renewable

Energy Development Plan (OREDP) in the Republic of Ireland. OSPAR (2008), Assessment of the Environmental Impact of Offshore Windfarms, Available at: [Accessed: February 2022]

OSPAR Commission, 2010. Background document for Seapen and Burrowing Megafauna communities. OSPAR Commission Biodiversity Series. OSPAR Commission: London. Available at: https://qsr2010.ospar.org/media/assessments/Species/P00481_Seapen_and_burrowing_megafauna.pdf

OSPAR (2008). CEMP Assessment Manual Co-ordinated Environmental Monitoring Programme Assessment Manual for contaminants in sediment and biota: Available at: https://www.ospar.org/documents?v=7115

Pearce, F., Peeler E. and Stebbing, P. (2012). Modelling the risk of the introduction and spread of non-indigenous species in the UK and Ireland. Project report for E5405W.

Pearson, T.H. and Rosenberg, R. (1978). Macrobenthic Succession in Relation to Organic Enrichment and Pollution of the Marine Environment. Oceanography and Marine Biology—An Annual Review, 16, 229-311.

Picton B.E., Emblow, C.S., Morrow, C.C., Sides, E.M., Tierney, P., McGrath, D., McGeough, G., McCrea, M., Dinneen, P., Falvey, J., Dempsey, S., Dowse, J. & Costello, M. J., 1997. Marine sites, habitats and species data collected during the BioMar survey of Ireland.

Pommer, C.D., Olesen, M. & Hansen, J.L.S., 2016. Impact and distribution of bottom trawl fishing on mud-bottom communities in the Kattegat. Marine Ecology Progress Series, 548, 47-60

Rees, E, I, S. (1995), Drilling and pipelines: the effect on the benthic environment, Available at: https://www.osti.gov/etdeweb/biblio/505514 [Accessed: February 2022]

Roy, H. E., Peyton, J., Aldridge, D. C., Bantock, T., Blackburn, T. M., Britton, R., Clark, P., Cook, E., Dehnen‐Schmutz, K., Dines, T., Dobson, M., Edwards, F., Harrower, C., Harvey, M. C., Minchin, D., Noble, D. G., Parrott, D., Pocock, M. J., Preston, C. D., Roy, S., Salisbury, A., Schönrogge, K., Sewell, J., Shaw, R. H., Stebbing, P., Stewart, A. J. and Walker, K. J. 2014. Horizon scanning for invasive alien species with the potential to threaten biodiversity in Great Britain. Glob Change Biol, 20: 3859-3871. doi:10.1111/gcb.12603

Saunders, G., Bedford, G.S., Trendall, J.R., and Sotheran, I. (2011). Guidance on survey and monitoring in relation to marine renewables deployments in Scotland. Volume 5. Benthic Habitats. Unpublished draft report to Scottish Natural Heritage and Marine Scotland.

Sköld, M., 1998. Escape responses in four epibenthic brittle stars (Ophiuroidea: Echinodermata). Ophelia, 49, 163-179.

Snelgrove, P. V. R., and Butman, C. A., 1994. Animal–sediment relationships revisited: cause versus effect. Oceanography and Marine Biology Annual Review 32: 111–177.

Tech Works Marine (2013). Greater Dublin Drainage Scheme: Hydrographic Survey Report GEO13_GDD. Available at: https://assets.gov.ie/109918/2501a74e-c4af-48a9-a598-44d9026d7355.pdf

Thatcher, H, Stamp, T., Wilcockson, D. & Moore, P.J. (2023). Residency and habitat use of European lobster (*Homarus gammarus*) within an offshore wind farm. ICES Journal of Marine Science, 80(5), 1410–1421.

The Irish Sea Network (2022). Review of the Irish Sea 2022. Irish Sea Network.

Tillin, H, Tyler-Walters, H. 2013. Assessing the sensitivity of subtidal sedimentary habitats to pressures associated with marine activities.

Tyler-Walters, H., Tillin, H.M., d'Avack, E.A.S., Perry, F., Stamp, T., 2018. Marine Evidence-based Sensitivity Assessment (MarESA) – A Guide. Marine Life Information Network (MarLIN). Marine Biological Association of the UK, Plymouth, pp. 91. Available from https://www.marlin.ac.uk/publications

Phase 1 Report: Rationale and proposed ecological groupings for Level 5 biotopes against which sensitivity assessments would be best undertaken JNCC Report No. 512A. Available at: https://data.jncc.gov.uk/data/4204b127-cda2-418c-abd1-ba3589341535/JNCC-Report-512A-FINAL-WEB.pdf

Ungfors, A., Bell, E., Johnson, M.L., Cowing, D., Dobson, N.C., Bublitz, R. & Sandell, J., 2013. Nephrops Fisheries in European Waters. In Johnson, M.L. and Johnson, M.P. (eds.). The Ecology and Biology of *Nephrops norvegicus*. Advances in Marine Biology, vol. 64, Academic Press, pp. 247-314. Available at: https://gup-server.ub.gu.se/v1/asset_data/187177.pdf

van der Veer, H. W., Bergman, M. J. N & Beukema, J. J. 1985. Dredging activities in the Dutch Waddensea: effects on macrobenthic infauna. Netherlands Journal of Sea Research 19, 183-90. Available at:

Vergnon, R. & Blanchard, F., 2006. Evaluation of trawling disturbance on macrobenthic invertebrate communities in the Bay of Biscay, France: Abundance Biomass Comparison (ABC method). Aquatic Living Resources, 19 (3), 219-228. Available at: https://www.alr-journal.org/articles/alr/pdf/2006/03/alr015-06.pdf

Ware, S.J. & Kenny, A.J. 2011. Guidelines for the Conduct of Benthic Studies at Marine Aggregate Extraction Sites (2nd Edition). Marine Aggregate Levy Sustainability Fund, 80pp. Available at: Guidelines for the Conduct of Benthic Studies at Marine Aggregate https://www.yumpu.com/en/document/view/15696156/guidelines-for-the-conduct-of-benthic-studies-at-marine-aggregate-

Wilson, J. G., Mackie, A. S. Y., O'Connor, B. D. S., Rees, E. I. S. & Darbyshire, T. 2001. Benthic Biodiversity in the Southern Irish Sea 2: The South-West Irish Sea Survey. —Studies in Marine Biodiversity and Systematics from the National Museum of Wales. BIOMÔR Reports 2 (1): 1-143.

Xu, X, Zhu, Q, Zhou, Q, Liu, J, Yuan, J, Wang, J. (2018), An improved method for quantitatively measuring the sequences of total organic carbon and black carbon in marine sediment cores, Journal of Oceanology and Limnology, 36, 105-113

Yao, Q, Wang, X, Jian, H, Chen, H, Yu, Z. (2015), Characterisation of the Particle Size Fraction associated with Heavy Metas in Suspended Sediments of the Yellow River, Int. J. Environ. Res. Public Health 2015, 12(6), 6725-6744