Environmental Impact Assessment Report

Volume 3

Chapter 6 Marine Geology, Sediments and Coastal Processes

codling wind park

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Abbreviations

Abbreviation	Term in Full
ABP	An Bord Pleanála
ABPmer	Associated British Ports Marine Environmental Research
ABR	Alexandra Basin Redevelopment
ADCP	Acoustic Doppler Current Profiler
AEZ	Archaeological Exclusion Zone
BGS	British Geological Survey
BP	Before Present
BPZ	Bedload Parting Zone
CD	Chart Datum
CEA	Cumulative Effects Assessment
CEFAS	Centre for Environment, Fisheries and Aquaculture Science
CLV	Cable Laying Vessel
COWRIE	Collaborative Offshore Windfarm Research into the Environment
CPA	Coast Protection Act
CR	Cable Route
CTD	Conductivity, Temperature and Depth
CVI	Coastal Vulnerability Index
CWP	Codling Wind Park
CWPL	Codling Wind Park Limited
d_{50}	Grain size representing the 50th percentile grain size in the distribution from a sample
DPC	Dublin Port Company
EC	European Commission
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
EIAR	Environmental Impact Assessment Report
EMODnet	The European Marine Observation and Data Network
EPA	Environmental Protection Agency
ES	Environmental Statement
EU	European Union
FEPA	Food and Environment Protection Act

Abbreviation	Term in Full
GEBCO	General Bathymetric Chart of the Oceans
HABMAP	Habitat Map
HAT	Highest Astronomical Tide
H_{max}	Maximum Wave Height
H_s	Significant Wave Height
HWM	High Water Mark
IAC	Inter-Array Cable
IAM	Impact Assessment Matrix
JUV	Jack-Up Vessel
LAT	Lowest Astronomical Tide
LoD	Limit of Deviation
MAC	Maritime Area Consent
MAP	Maritime Area Planning
MHW	Mean High Water
MHWN	Mean High Water Neaps
MHWS	Mean High Water Springs
MLW	Mean Low Water
MLWN	Mean Low Water Neaps
MLWS	Mean Low Water Springs
MNR	Mean Neap Range
MSFD	Marine Strategy Framework Directive
MSL	Mean Sea Level
MSP	Maritime Spatial Planning
MSR	Mean Spring Range
NPWS	National Parks and Wildlife Services
NTU	Nephelometric Turbidity Unit
OECC	Offshore Export Cable Corridor
OSPAR	The Convention for the Protection of the Marine Environment of the Northeast Atlantic
OSS	Offshore Substation
OTI	Onshore Transmission Infrastructure
OWF	Offshore Wind Farm
PLGR	Pre-Lay Grapnel Run
PSA	Particle Size Analysis

Abbreviation	Term in Full
RCP	Representative Concentration Pathway
SAC	Special Area of Conservation
SAR	Search and Rescue
SD	Standard Deviation
SEA	Strategic Environmental Assessment
SPA	Special Protection Area
SPM	Suspended Particulate Material
SSC	Suspended Sediment Concentration
SSSI	Site of Scientific Interest
SWISS	Southwest Irish Sea Survey
T_0	Bed Shear Stress
T_{crit}	Critical Bed Shear Stress
T_p	The spectral peak period
TJB	Transition joint bay
TSS	Total Suspended Solids
TSHD	Trailer Suction Hopper Dredger
T_z	The mean zero-crossing wave period
U_{cr}	Critical current speed
UHRS	Ultra-High Resolution Seismic
WFD	Water Framework Directive
WTG	Wind Turbine Generator

Definitions

Glossary	Meaning
the Applicant	The developer, Codling Wind Park Limited (CWPL).
array site	The area within which the wind turbine generators (WTGs), inter-array cables (IACs) and the offshore substation structures (OSSs) are proposed.
amphidromic point	A location where the tidal range is effectively nil but increases with distance from this point in a rotary manner due to the Coriolis effect.
bedload parting zone	The region where the sediment transport pathways (most likely under bedload transport) diverge.
bedload transport	Transport of sediment grains by means of rolling, sliding and / or saltating (hopping).
current speed	Magnitude of local current flow.
Codling Wind Park (CWP) Project	The proposed development as a whole is referred to as the Codling Wind Park (CWP) Project, comprising of the offshore infrastructure, the onshore infrastructure and any associated temporary works.
Codling Wind Park Limited (CWPL)	A joint venture between Fred. Olsen Seawind (FOS) and Électricité de France (EDF) Renewables, established to develop the CWP Project.
combi-wall	A piling wall that is comprised of high modulus structural components interspaced by lighter sheet piles. The high modulus components – known as king piles – can be tubular, box, bearing or other types of fabricated piles.
Dun Laoghaire Harbour	The historic harbour of Dun Laoghaire on the southern shore of Dublin Bay, with limits defined as the areas contained within and including the East and West piers of Dún Laoghaire Harbour and within 600 m of the entrance to that harbour, together with any adjoining land, banks, inlets and havens vested in Dún Laoghaire Harbour Company and the docks, piers, jetties, quays and other works vested in that company.
Environmental Impact Assessment (EIA)	A systematic means of assessing the likely significant effects of a proposed project, undertaken in accordance with the EIA Directive and the relevant Irish legislation.
Environmental Impact Assessment Report (EIAR)	The report prepared by the Applicant to describe the findings of the EIA for the CWP Project.
export cables	The cables, both onshore and offshore, that connect the offshore substations with the onshore substation.
fetch	The uninterrupted distance of open water over which the wind blows without significant change in direction.
highest Astronomical Tide	The maximum level of sea surface due to tidal forcing alone.
Holocene	The most recent geological epoch, from around 11,700 BP (Before Present) to the present day, which is defined by the time since the end of the last glacial period (Pleistocene).

Glossary	Meaning
inter-array cables (IACs)	The subsea electricity cables between each WTG and the OSSs.
interconnector cables	The subsea electricity cables between OSSs.
landfall	The point at which the offshore export cables are brought onshore and connected to the onshore export cables via the transition joint bays (TJB). For the CWP Project, the landfall works include the installation of the offshore export cables within Dublin Bay, out to approximately 4 km offshore, where there are water depths that are too shallow for conventional cable lay vessels to operate within.
limit of deviation (LoD)	Locational flexibility of permanent and temporary infrastructure is described as a LoD from a specific point or alignment.
local scale	Near-field spatial scale considers sandwave features, individual foundations and cable routes.
long-term	Temporal scale considered over years and decades (compatible with project lifetime) and climate change influences.
lowest Astronomical Tide	The minimum level of sea surface due to tidal forcing alone.
Maritime Area Consent (MAC)	A Maritime Area Consent (MAC) provides State authorisation for a prospective developer to undertake a maritime usage and occupy a specified part of the maritime area. A MAC is required to be in place before planning consent can be sought.
Maritime Area Planning (MAP) Act 2021	An Act to regulate the maritime area, to achieve such regulation by means of a National Marine Planning Framework, maritime area consents for the occupation of the maritime area for the purposes of maritime usages that will be undertaken for undefined or relatively long periods of time (including any such usages which also require development permission under the Planning and Development Act 2000) and licences for the occupation of the maritime area for maritime usages that are minor or that will be undertaken for relatively short periods of time.
metocean	Meteorological and oceanographic data (for example metocean data or metocean conditions).
mean high water neaps	The height of mean high water neaps is the average throughout the year (when the average maximum declination of the moon is 23.5°) of two successive high waters during those periods of 24 hours when the range of the tide is at its least.
mean high water springs	The height of mean high water springs is the average throughout the year (when the average maximum declination of the moon is 23.5°) of two successive high waters during those periods of 24 hours when the range of the tide is at its greatest.
high water mark	High water (referred to as the ‘high water mark’) of ordinary or medium tides of the sea, as defined within the MAP Act, 2021.
mean high water	Mean of all high water levels.
mean low water	Mean of all low water levels.

Glossary	Meaning
mean low water neaps	The height of the mean low water neaps is the average height obtained by the two successive low waters during the same period as those described for mean high water neaps.
mean low water springs	The height of the mean low water springs is the average height obtained by the two successive low waters during the same period as those described for mean high water springs.
mean sea level	Mean sea surface elevation over a prolonged period.
mean zero-crossing wave period	The spectral mean wave period, estimated from the wave spectrum as $\sqrt{m_0/m_2}$.
medium-term	Temporal scale considered over months to years in response to the periodic lunar tidal cycles and episodic seasonal wave variations.
megaripples	Flow-transverse bed forms with a typical length of 5 to 20 m and crest heights of 0.2 to 1.5 m (e.g., Tobias, 1989; Ashley, 1990).
meso-scale	Intermediate-field spatial scale considers sandbank features, coastlines and array scale issues.
moribund	A seabed feature formed during periods of lower sea level that are no longer actively maintained by contemporary sediment transport processes (stranded in locations where currents become weaker) and thus have become relict features. Moribund is a term first introduced by Kenyon et al. (1981).
morphodynamics	The interaction and adjustment of the seafloor topography and fluid hydrodynamic processes, seafloor geomorphologies and sequences of change dynamics involving the motion of sediment.
offshore development area	The total footprint of the offshore infrastructure and associated temporary works including the array site and the OECC.
offshore export cables	The cables which transport electricity generated by the wind turbine generators (WTGs) from the offshore substation structures (OSSs) to the TJBs at the landfall.
offshore export cable corridor (OECC)	The area between the array site and the landfall, within which the offshore export cables will be installed along with any cable protection and other temporary infrastructure required for construction.
offshore infrastructure	The permanent offshore infrastructure, comprising of the WTGs, IACs, OSSs, interconnector cables, offshore export cables and other associated infrastructure, such as cable and scour protection.
offshore substation structure (OSS)	A fixed structure located within the array site, containing electrical equipment to aggregate the power from the wind turbine generators and convert it into a more suitable form for export to shore.
OSS monopile foundation	The bottom fixed structure piled in to the seabed supporting the OSS topside. It consists of a monopile and a transition piece. It can include systems such as electrical, SCADA, cathodic protection, safety and mechanical equipment.

Glossary	Meaning
onshore transmission infrastructure (OTI)	The onshore transmission assets comprising the TJBs, onshore export cables and the onshore substation. The EIAR considers both permanent and temporary works associated with the OTI.
operations and maintenance (O&M) activities	Activities (e.g., monitoring, inspections, reactive repairs, planned maintenance) undertaken during the O&M phase of the CWP Project.
O&M phase	This is the period of time during which the CWP project will be operated and maintained.
planning application boundary	The area subject to the application for development consent, including all permanent and temporary works for the CWP Project.
pleistocene	Geological epoch that lasted from about 2,580,000 to 11,700 BP, spanning the world's most recent period of repeated glaciations. The end of the Pleistocene corresponds with the end of the last glacial period.
regional scale	Far-field spatial scale considers exposure conditions or site and wider linkages between macro bedforms (e.g., sediment pathways, sources, and stores).
residual level	Difference between the tidal level estimated by harmonic analysis/prediction and the actual level. Includes any errors due to failure to adequately resolve the tidal signal. Includes meteorologically induced storm surge.
revetment	A facing of impact-resistant material applied to a bank or wall in order to absorb the energy of incoming water and protect it from erosion.
sandbanks	Large scale bedforms consisting of cohesive and / or non-cohesive sediments found in estuarine and continental shelf areas.
sandwaves	Flow-transverse subaqueous marine dunes, often with superimposed megaripples. These features have a typical length of 100 to 800 m and crest heights (i.e., amplitude, crest to trough) of several metres (e.g., van Dijk and Kleinhans, 2005).
seabed mobility	In many offshore locations the sediments on the seabed are mobile due to the action of currents and / or waves. The criteria for mobility (sediment transport) is that the shear stress imparted by the currents and / or waves exceeds the resisting forces holding the sediment in place (Draper et al., 2018). Note: a mobile seabed does not necessarily drive a vertical change in seabed level; if the sediment supply is equal to the sediment loss from the area, the net change in seabed level will be negligible.
sheet piles	Sections of sheet materials with interlocking edges that are driven into the ground to provide earth retention and excavation support. Sheet piling is used in construction to provide both temporary and permanent walls.
short-term	Temporal scale considering individual tidal cycle, individual extreme events.
significant wave height	Approximately the average height of the highest one third of the waves in a defined period, estimated from the wave spectrum as $4\sqrt{m_0}$. N.B.

Glossary	Meaning
	The method of individual contractors to determine Hs may differ between contractors.
spectral peak period	The period at which most energy is present in the wave spectrum.
still water level	Instantaneous water level in the absence of waves, but including water level variations due to tide and meteorologically induced forcing.
study Area	For the purpose of this assessment, the study area is defined herein as the area within which the marine geology, sediments and coastal processes may be impacted.
surge current	Current driven by processes excluding astronomical forcing and wave induced motions.
suspended load transport	Sediment uplifted by the fluid's flow in the process of sediment transportation. It is kept suspended by the fluid's turbulence.
temporary cofferdam	A barrier installed to prevent tidal inundation, whilst the existing stone covered foreshore is temporarily excavated and removed to install the landfall cable ducts.
tidal current	Current driven by astronomical forcing.
tidal level	Still water level relative to a defined datum due to astronomical forcing. Tidal elevations exclude all meteorologically induced forcing.
total current	Combination of tidal and surge current.
transition joint bay (TJB)	This is required as part of the OTI and is located at the landfall. It is an underground bay housing a joint which connects the offshore and onshore export cables.
transition zone	The section between the offshore end of installed intertidal cable ducts, approximately 350 m from the high water mark (HWM), and the limit of operability for the cable lay vessel (CLV), approximately 4 km offshore. This zone represents the section of the OECC where water depths would be unsuitable for the draft of a typical offshore CLV.
wind turbine generator	All the components of a wind turbine, including the tower, nacelle and rotor.

6 MARINE GEOLOGY, SEDIMENTS AND COASTAL PROCESSES

6.1 Introduction

1. Codling Wind Park Limited (hereafter 'the Applicant') is proposing to develop the Codling Wind Park (CWP) Project, which is located in the Irish sea approximately 13–22 km off the east coast of Ireland, at County Wicklow.

2. This chapter forms part of the Environmental Impact Assessment Report (EIAR) for the CWP Project. The purpose of the EIAR is to provide the decision-maker, stakeholders and all interested parties with the environmental information required to develop an informed view of any likely significant effects resulting from the CWP Project, as required by the European Union (EU) Directive 2011/92/EU (as amended by Directive 2014/52/EU) (the EIA Directive).

3. This EIAR chapter describes the potential impacts of the CWP Project's offshore infrastructure on marine geology, sediments and coastal processes during the construction, operation and maintenance, and decommissioning phases.

4. In summary, this EIAR chapter:

   - Details the EIA scoping and consultation process undertaken and sets out the scope of the impact assessment for marine geology, sediments and coastal processes;
   - Identifies the key legislation and guidance relevant to the assessment of marine geology, sediments and coastal processes with reference to the latest updates in guidance and approaches;
   - Confirms the study area for the assessment and presents the impact assessment methodology for marine geology, sediments and coastal processes;
   - Describes and characterises the baseline receiving environment for marine geology, sediments and coastal processes established from desk studies, project survey data and consultation;
   - Defines the project design parameters for the impact assessment and describes any mitigation measures relevant to the assessment of marine geology, sediments and coastal processes which are to be applied as a result of the iterative assessment process;
   - Presents the assessment of potential impacts on marine geology, sediments and coastal processes and identifies any assumptions and limitations encountered in undertaking the impact assessment; and
   - Details any additional mitigation and / or monitoring necessary to prevent, minimise or reduce potentially significant effects identified in the impact assessment.

5. The assessment should be read in conjunction with **Appendix 6.1 Cumulative Effects Assessment (CEA)**, which considers other plans, projects and activities that may act cumulatively with the CWP Project and provides an assessment of the potential cumulative impacts on marine geology, sediments and coastal processes.

6. Additional data and information to support the assessment include those data acquired from surveys conducted across the site, including:

   - **Appendix 6.2 Representative Scenario and LoD Assessment;**
   - **Appendix 6.3 Modelling Report;**
   - **Appendix 6.4 Codling Wind Park. Hydraulic Modelling Support**;
   - Hydrodynamic, wave and turbidity measurement data acquired from the site-specific Metocean Survey (Techworks 2021a, 2021b, 2021c);
   - Geophysical and 2D Ultra High Resolution Seismic (UHRS) Survey Report (Document No. 103710-CWP-MMT-SUR-REP-SURVEYRE-C) (Osiris Projects, 2014 and MMT, 2021); and
   - Seabed sediment grain size information from the benthic and intertidal ecology survey report. **Appendix 8.3 CWP Benthic Baseline Report**.

6.2 Consultation

7. Consultation with statutory and non-statutory organisations is a key part of the EIA process. Consultation with regard to marine geology, sediments and coastal processes has been undertaken to inform the approach to, and scope of, the assessment.

8. The key elements to date have included EIA scoping, consultation events and ongoing engagement and topic specific meetings with key stakeholders. The feedback received throughout this process has been considered in preparing the EIAR. EIA consultation is described further in **Chapter 5 EIA Methodology,** the **Planning Documents** and in the **Public and Stakeholder Consultation Report**, which has been submitted as part of the development consent application.

9. To date, no significant issues have been raised during the consultation process relevant to marine geology, sediments and coastal processes.

6.3 Legislation, policy and guidance

6.3.1 Legislation

10. The legislation that is applicable to the assessment of potential impacts on marine geology, sediments and coastal processes is summarised below. Further detail is provided in **Chapter 2 Policy and Legislative Context**.

- The EU Water Framework Directive ('WFD') (2000/60/EC).
- Directive 2008/56/EC (Marine Strategy Framework Directive 'MSFD').
- The European Communities (Water Policy) Regulations 2003 (S.I. No 722 of 2003).
- Habitats Directive (92/43/EEC).
- EIA Directive (2011/92/EU).
- Planning and Development Act 2000.
- The Maritime Area Planning Act 2021 (as amended).
- Bathing Water Quality Regulations 2008 (S.I. No. 79/2008).
- The European Communities (Birds and Natural Habitats) Regulations 2011 (S.I. No. 477/2011).
- The Directive 2006/7/EC regarding the management of bathing water quality and the revised Directive 76/160/EEC.
- The Quality of Shellfish Water Directive 2006/113/EC.
- Directive 91/271/EC of the European Parliament concerning urban wastewater management.
- Directive 2014/89/EU regarding the Maritime Spatial Planning (MSP).

6.3.2 Policy

11. The overarching planning policy relevant to the CWP Project is described in EIAR **Chapter 2 Policy and Legislative Context**.

12. The assessment of the CWP Project against relevant planning policy is provided in the **Planning Report**. This includes planning policy relevant to the marine geology, sediments and coastal processes.

6.3.3 Guidance

13. This baseline assessment was conducted in line with several key technical guidance documents. These guidance documents are widely used and represent a good breadth of best practices for various consenting regimes and thus are considered to form useful guidance to inform this assessment. These include:

- **Guidance on the information to be contained in Environmental Impacts Assessment (EPA, 2022):** This guidance was written in order to improve the quality of EIARs for all types of projects (including Offshore Wind Farms (OWFs)) with a view to facilitate compliance with their respective directives, it is written with a focus on obligations of developers who are preparing the EIARs. The guidelines are also intended to provide all parties in the EIA process with an authoritative reference to be regarded when considering an EIAR.
- **Assessment of Impact of Offshore Wind Energy Structures on the Marine Environment (Marine Institute, 2000):** This guidance aims to provide an insight into the 'below the water' impacts of offshore wind structures on the marine environment; the effects during installation, operation and decommissioning are discussed.
- **Coastal and marine environmental site guide (John et al., 2003):** The guidance relates to implementing good construction practices and design for coastal and marine sites. This is relevant to this assessment as it contains guiding principles on how to minimise or mitigate adverse impacts on coastal and marine processes and geomorphology.
- **The Marine Monitoring Handbook (Davies et al., 2001):** This is used as guidance by the UK government's statutory nature conservation agencies and their key partners in drawing up monitoring schemes for marine Special Area of Conservation (SACs). The Handbook provides guidance on the different options and their relative costs and benefits and describes best practice through a series of procedural guidelines for the common survey / monitoring techniques. It draws upon the information gathered from extensive trials of different techniques and their deployment undertaken during the UK Marine SACs project to ensure all advice has a sound practical basis. It includes guidance (for example) on sediment sampling that has relevance to the interpretation of surficial sediment data. Though this guidance has been developed through a specific programme to monitor marine SACs, the Marine Monitoring Handbook is widely accepted as a contributing pillar in the development of comprehensive guidance for marine monitoring strategies.
- **Offshore Wind Farms: Guidance Note for EIA in Respect to (formerly) Food and Environment Protection Act 1985 (FEPA)** and Coast Protection Act 1949 (CPA) Requirements (Centre for Environment, Fisheries, and Aquaculture and Science ('Cefas'), 2004): This guidance details EIA / licensing requirements for OWFs in the UK. The aim of this document is to provide scientific guidance to those involved with the gathering, interpretation and presentation of data within an EIA. Though not specific to Irish Waters, this document provides comprehensive guidance regarding data presentation and interpretation relevant to the CWP Project.
- **Adapting to Climate Change: Advice for Flood and Coastal Erosion Risk Management Authorities (Environment Agency (EA), 2011):** The purpose of this document is to ensure that an economically credible appraisal, taking account of the uncertainties associated with climate change, can be made to support Government investment decisions. In addition, the document provides important information on baseline evolution, which is directly relevant to this report. Though not specific to Irish Waters, this document provides comprehensive guidance regarding data presentation and interpretation relevant to the CWP Project.
- **Good practice guidelines for ports and harbours operating within or near UK European marine sites (Associated British Ports Research & Consultancy, 1999):** These guidelines aim to avoid, minimise and address potential environmental impacts arising from ports and harbours, and their operations. The potential exists for processes in dredge and disposal areas to cause alteration of erosion and sedimentation patterns in adjacent areas, potentially resulting in erosion, or the creation of an intertidal and / or subtidal habitat. There could also be changes in site hydrodynamics and geomorphology at the dredge and disposal sites. Guidance recommends that the effects of suspended sediments and turbidity are generally short term (less than one week

after activity) and near field (less than 1 km from activity). The guidance recommends ensuring that dredging is undertaken in a manner that limits, as far as practicably possible, the disturbance and dispersion of sediments from the dredger and barges during dredging operations. Though not specific to Irish Waters, this document provides comprehensive guidance regarding data presentation and interpretation relevant to the CWP Project.

- **Assessment of the environmental impacts of cables (Oslo and Paris Conventions (OSPAR), 2009):** Guidance considering the potential environmental impacts resulting from submarine cables suggests that most construction stage (cable laying / installation) activities are local and temporary, and the primary long-term impact of submarine cables can be the cable itself and any accompanying protective structures. Though not specific to Irish Waters, this document provides comprehensive guidance regarding data presentation and interpretation relevant to the CWP Project.
- **Natural England (NE) Offshore Wind Cabling: ten years' experience and recommendations (Fawcett, 2018):** This note documents the experience NE, in England, has gained from advising on the environmental impacts of power cable installation over the last ten years, to highlight where issues have arisen with both installation and maintenance that have caused concern from a nature conservation perspective. The note provides some evidence for the current advice NE provide to industry and regulators on offshore wind cabling activities and emphasises that better solutions can be found for both the environment and offshore industries. Though not specific to Irish Waters, this document provides comprehensive guidance regarding data presentation and interpretation relevant to the CWP Project.
- **Coastal Process Modelling for Offshore Wind Farm Environmental Impact Assessment: Best Practice Guide. Collaborative Offshore Windfarm Research into the Environment (COWRIE) Coast-07-08:** The purpose of this guidance is to specify more information about available methods of assessing OWFs on coastal and offshore processes, identify when qualitative analysis or detailed numerical modelling is required, the best fit-for-purpose modelling tools available, and the appropriate quantity and quality of data to use in the assessment. Though not specific to Irish Waters, this document provides comprehensive guidance regarding data presentation and interpretation relevant to the CWP Project.
- **Review of cabling techniques and environmental effects applicable to the Offshore Wind Farm industry technical report (Department for Business, Enterprise, and Regulatory Reform, 2008):** This guidance aims to provide information on the range of cable installation techniques available, their likely environmental effects and potential mitigation, drawing on wind farm and other marine industry practice and experience. Though not specific to Irish Waters, this document provides comprehensive guidance regarding data presentation and interpretation relevant to the CWP Project.

6.4 Impact assessment methodology

14. **Chapter 5 EIA Methodology** provides a summary of the general impact assessment methodology applied to the CWP Project, which includes the approach to the assessment of transboundary and inter-related effects. The approach to the assessment of cumulative impacts is provided in **Appendix 5.1 CEA Methodology**.

15. The following sections describe the methodology used to assess the potential impacts on marine geology, sediments and coastal processes.

16. The approach followed to develop the baseline understanding is in accordance with the guidance detailed by Centre for Environment, Fisheries and Aquaculture Science (CEFAS) (2004), which states that it is necessary to assess the magnitude and significance of change caused directly to the following:

- Sediments (e.g., composition, particle size).
- Hydrodynamics (e.g., tidal and currents including meteorological effects) and waves.

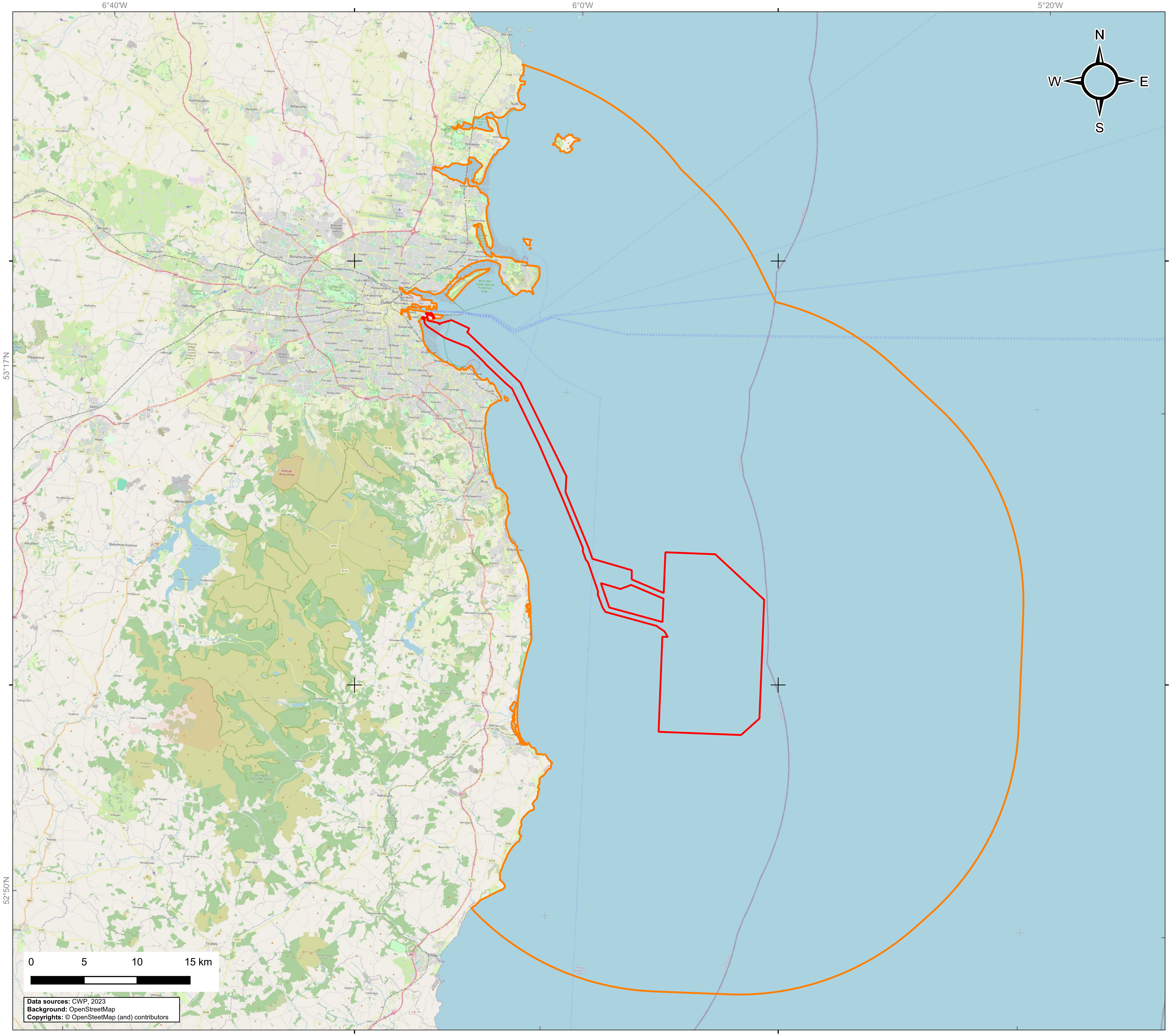
- Sedimentary environment (e.g., sediment resuspension, transport pathways, patterns and rates and sediment deposition).
- Sedimentary structures (e.g., channels, banks, large scale bedforms).
- Suspended Sediment Concentrations (‘SSC’).
- Coastal processes.

17. Whilst not specific to Ireland, this approach is considered best practice for the purposes of the assessment of potential impacts on marine geology, sediments and coastal processes.

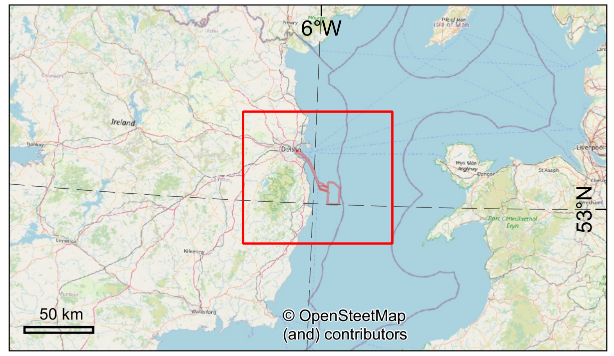
6.4.1 Study Area

18. The study area for the marine geology, sediments and coastal processes assessment has been defined on the basis of the consideration of processes occurring at both the local and regional scale (**Figure 6-1**). For the purposes of this chapter, the term ‘local scale’ reflects the boundaries of the planning application boundary for the CWP Project, including the extent of the array site, the offshore export cable corridor (OECC), landfall and the onshore substation in so far as is relevant up to Mean High Water Springs (MHWS). The study area has been defined through reference to the offshore development area, as this represents the area in which construction and operation of the development will take place, with the Marine Safety Demarcation Area being used only for short term navigation safety activities, such as deployment of buoyage. The term ‘regional scale’ reflects broader scale boundaries of marine, coastal and seabed areas outside the local scale study area, remaining inside a relevant area that the CWP Project may influence. Adopting a precautionary approach, the regional scale area extends 25 km beyond the bounds of the array site and the offshore export cable corridor. This boundary, which exceeds the estimated (maximum) tidal excursion distance, establishes linkages and connectivity across the region. The adoption of these spatial scales ensured that a robust assessment of the impacts on marine geology, sediments and coastal processes of the CWP Project was performed.

6°40'W 6°0'W 5°20'W



53°17'N
52°50'N
5,920,000
5,880,000
280,000
320,000



Legend

- Planning application boundary (local scale extent)
- Regional scale extent

Project: Codling Wind Park	Contractor: Partrac.com

Figure 6.1
Physical processes study area

CWP doc. number: CWP-PAR-ENG-08-01-MAP-0885

Internal descriptive code: OFFSH.ALL - PAB..STUDY.AREA.FOR.PHYSICAL. PROCESSES - EIAR.FIG.06.01	*Size:* A3 *Scale:* 1:350,000	*CRS:* EPSG 25830

Rev.	*Updates*	*Date*	*By*	*Chk'd*	*App'd*
00	Final for issue	2024/03/14	MG	JP	JP

6.4.2 Data and information sources

19. To develop a comprehensive understanding of the baseline scenario, a wide variety of sources were consulted including regional and site-specific data, information and data from public sources and the published scientific literature. **Table 6-1** details the data acquired from site surveys and **Table 6-2** details the data acquired from public sources used as part of this assessment. The survey data remains valid and an appropriate characterisation of the receiving environment at the point of application.

Table 6-1 Data acquired from site specific surveys consulted for this assessment

Data	Source	Date	Utilisation
Site specific Geophysical Campaign	Osiris Projects	2013	These data provide high resolution bathymetry which were used to support assessment of seabed features across the array site. These data were also implemented within the coupled hydrodynamic and wave model. The geophysical data also provided insight into the underlying surficial sediment composition within the array site.
Site specific Geophysical Campaign	G-tech	2021	These data provided further high-resolution bathymetry which was used to support assessment of water levels and seabed features along the offshore export cable corridor. These data were also implemented within the coupled hydrodynamic and wave model.
Site specific metocean measurement campaign	Techworks	2021	Metocean measurement campaign that included wave measurements, current measurements, wind measurements and Conductivity, Temperature and Depth (CTD) data. This dataset was utilized in calibrating and validating the numerical model developed for the area. The CTD data was used to assess the prevailing suspended sediment transport regime in the area and response to the wave \ tidal regime.
Site specific Geophysical Campaign	MMT	2021	These high-resolution bathymetric data were used to assess water levels across the array site and provided further evidence on seabed sediments and seabed mobility between 2013 and 2021.
Benthic and Intertidal Ecological Survey Campaign (**Appendix 8.3**)	Natural Power	2023	This site specific Particle Size Analysis (PSA) data was used to investigate and characterise the local surficial seabed sediment classification (Sand, Gravel, Fines).

Table 6-2 Publicly available data sources and scientific publications consulted for this assessment and their utilisation

Data	Source	Date	Notes
The European Marine Observation and Data Network (EMODnet) \ General Bathymetric Chart of the Oceans (GEBCO) Bathymetry	https://emodnet.ec.europa.eu/geoviewer/ https://www.gebco.net/	2020 2022	These data provide coarse resolution bathymetry which were used to support assessment of wider region bathymetry. These data were also implemented within the coupled hydrodynamic and wave model. It is noteworthy that EMODnet data reflects the data available from the INFOMAR dataset.
Pugh, 1981 \ Pingree and Griffiths, 1978 \ Howarth, 2005 \ Flather, 1987 \ Tooley, 1985 \ Carter, 1993	Various	Various	These scientific publications were used to garner robust understanding of the regional oceanographic regime (see reference titles for more details).
Dublin Port tide gauge	https://www.dublinport.ie/information-centre/tide-tables/	2022	These data were used to derive key statistics regarding local water levels at the coastline.
Ziegler, 1982 \ Belderson, 1964 \ Robinson et al., 2008 \ Wilson et al., 2001 \ Pantin and Evans, 1984.	Various	Various	These scientific publications were used to garner robust understanding of the regional geology (see reference titles for more details).
Harris et al., 1995 \ Holmes and Tappin, 2005 \ Kenyon and Cooper, 2005 \ Van Landeghem et al., 2009 \ Mellet et al., 2015 \ McCarron et al., 2019	Various	Various	These scientific publications were used to garner robust understanding of the regional sediment transport regime (see reference titles for more details).
Seabed sediments	BGS	2019	British Geological Survey (BGS) mapping of the Irish Sea was interrogated to discern the underlying and superficial geology across the region and offshore development area.
Suspended sediments climatology around the UK	Cefas	2016	This publication was used to support assessment of typical and storm induced suspended sediment concentrations within marine and coastal waters within the Irish Sea.
'Coastal vulnerability assessment of Co. Dublin and Co. Wicklow to impacts of sea level rise.'	Caloca-Casado, S.	2018	This publication was used to support assessment of the prevailing coastline processes and the vulnerability of the coastline to erosion.

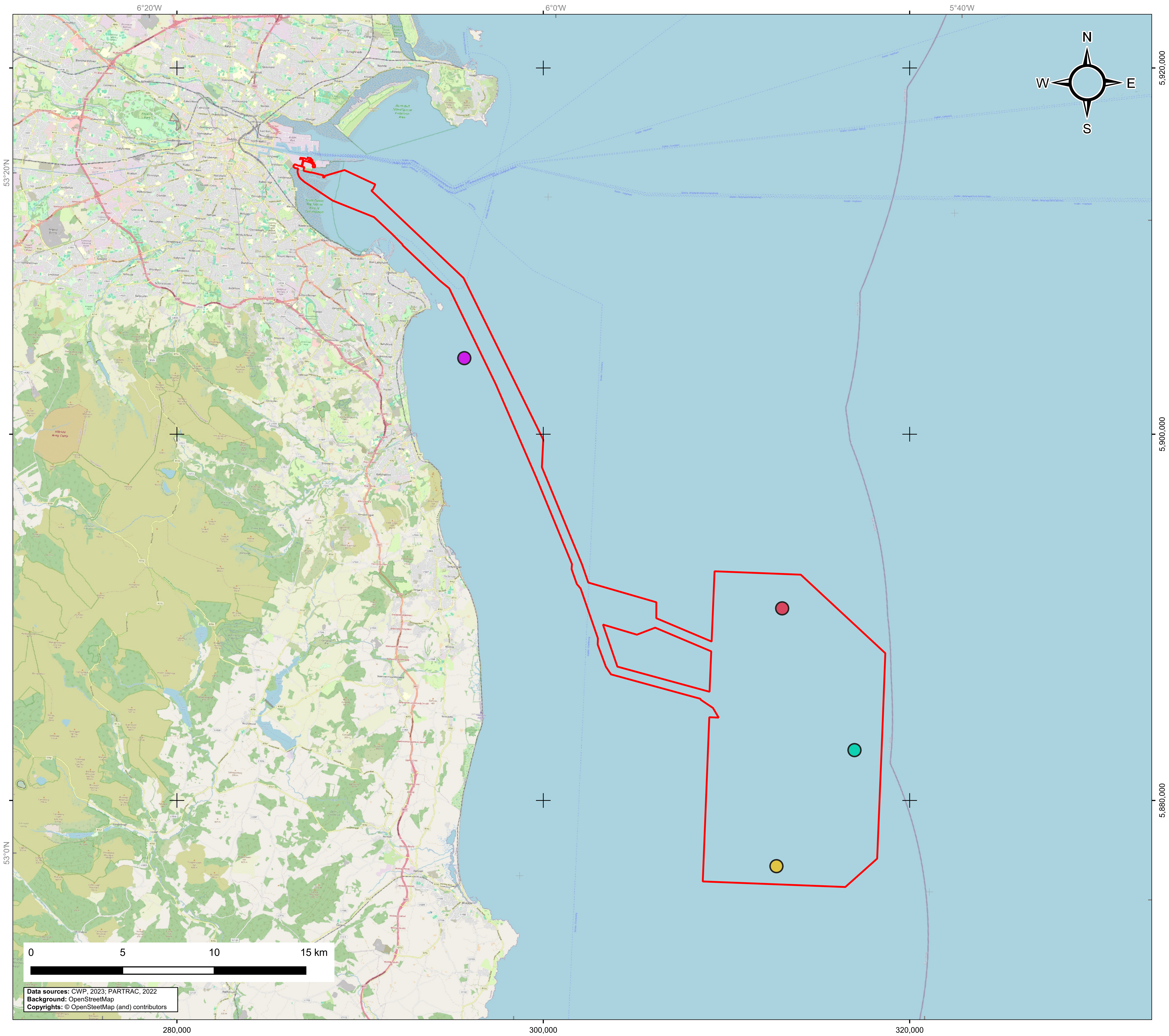
Data	Source	Date	Notes
Climate change knowledge portal. Sea level rise predictions for the Irish Sea.	World Bank	2022	These climate projections were used to support assessment of the evolving baseline.
PSA data	Marine Institute	–	PSA data acquired along the coastline adjacent to the CWP Project was used to further investigate the seabed sediment composition and surficial sedimentology nearshore.

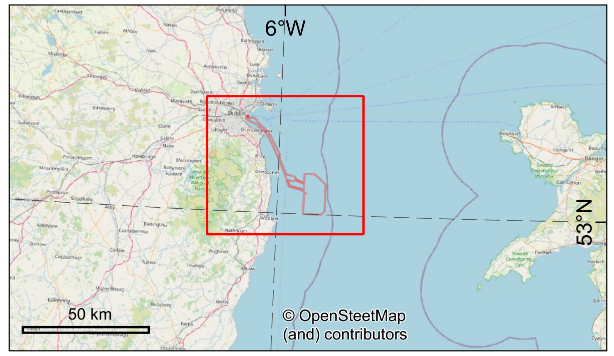
20. In addition, to facilitate a thorough and complete consideration and assessment of the prevailing wave and hydrodynamic regime across the array site, site specific coupled hydrodynamic and wave models were developed for the EIAR (**Appendix 6.3 and Appendix 6.4**). The models have been validated extensively, in accordance with industry standard guidelines, utilising water level, wave and tidal flow measurement data from several locations across the offshore development area and the wider region. The model performance during the validation exercise is described in **Appendix 6.3** and **Appendix 6.4**, respectively.

21. Following validation, a hindcast simulation was performed to generate tide and wave data (between January 2000–July 2021). These data were extracted from the model at four pertinent locations across the offshore development area and analysed to support the interpretation of baseline marine geology, sediments and coastal processes. These model inspection points are positioned in the north, south and east of the array site and at a location along the offshore export cable corridor. **Table 6-3** details the locations of the model inspection points which are illustrated in **Figure 6-2**.

Table 6-3 Model inspection points where data was extracted from the coupled hydrodynamic wave model

Point location	Longitude (EPSG: 4326)	Latitude (EPSG: 4326)
CWP Maritime Area Consent (MAC) East	-5.730	53.060
CWP MAC North	-5.790	53.130
CWP MAC South	-6.010	52.990
Cable Route (CR) North	-6.060	53.240





Legend

- Planning application boundary

Model inspection points

- CR North
- CWP MAC East
- CWP MAC North
- CWP MAC South

codling wind park	*Project:* Codling Wind Park	*Contractor:* Partrac.com

Figure 6.2
Location of model inspection points

CWP doc. number:	CWP-PAR-ENG-08-01-MAP-0886				
Internal descriptive code: WE - PAB. MODEL.INSPECTION.POINTS - EIAR.FIG.06.02	*Size:* A3 *Scale:* 1:200,000	*CRS:* EPSG 25830			
Rev.	*Updates*	*Date*	*By*	*Chk'd*	*App'd*
00	Final for issue	2024/03/14	MG	JP	JP

6.4.3 Impact Assessment

22. The significance of potential effects has been evaluated using a systematic approach, based upon identification of the importance and value of receptors and their sensitivity to the project activity, together with the predicted magnitude of the impact.

23. The terms used to define receptor sensitivity are presented in **Table 6-4**. The terms used to define magnitude of impact are presented in **Table 6-5**. These criteria have been adopted in order to implement a specific methodology for the assessment of marine geology, sediments and coastal processes.

Sensitivity of receptor

24. For each effect, the assessment identifies receptors sensitive to that effect and implements a systematic approach to understanding the impact pathways and the level of impacts on given receptors.

25. Receptor sensitivity is determined by considering a combination of value, tolerance, adaptability and recoverability. The definitions of receptor sensitivity for the purpose of the marine geology, sediments and coastal processes assessment are provided in **Table 6-4**.

Table 6-4 Criteria for determination of receptor sensitivity

Sensitivity	Criteria
Very high	Receptor has very limited or no capacity to accommodate changes or influences. The receptor possesses fundamental characteristics which contribute significantly to the distinctiveness, rarity and character of the resource, is of very high importance that is international in scale (e.g., designated sites such as SACs, Special Protection Areas (SPAs), Ramsar Sites, World Heritage Sites, Geological Conservation Review Sites and Habitats Directive Annex II species).
High	Receptor has very limited or no capacity to accommodate changes or influences. The receptor possesses key characteristics which contribute significantly to the distinctiveness, rarity and character of the resource, is of high importance that is national in scale (e.g., designated sites such as Sites of Scientific Interest (SSSIs)).
Medium	Receptor has a limited capacity to accommodate changes or influences. Receptor characteristics do not make a significant contribution to local character or distinctiveness and are of low importance and are not designated.
Low	Receptor has a moderate capacity to accommodate changes or influences. Receptor characteristics do not make a significant contribution to local character or distinctiveness and are of very low importance and are not designated.
Very low	Receptor is generally tolerant of and can accommodate changes or influences. Receptor characteristics do not make a significant contribution to local character or distinctiveness and are of very low importance and are not designated.

Magnitude of impact

26. The scale or magnitude of potential impacts (both beneficial and adverse) depends on the degree and extent to which the CWP Project activities may change the environment, which usually varies according to project phase (i.e., construction, operation and maintenance, and decommissioning).

27. Factors that have been considered to determine the magnitude of potential impacts include:

- Change, permanence, reversibility and recoverability relative to the baseline.
- The spatial extent over which the impact occurs.
- Duration and frequency.

28. The criteria for defining the magnitude of impacts to the marine geology, sediments and coastal processes follows the guidance presented by Brooks et al. (2018) and is listed in **Table 6-5**.

Table 6-5 Criteria for determination of magnitude of impact

Magnitude	Criteria
Very high	Significant change to key environmental characteristics that are well outside of the range of natural variability. The change occurs at timescales similar to CWP Project phases (e.g., O&M Phase) and extends outside the CWP Project.
High	Significant change to key environmental characteristics that are well outside of the range of natural variability. The change occurs at timescales similar to CWP Project phases (e.g., O&M Phase) but is limited to within the CWP Project only.
Medium	Change to key environmental characteristics that are similar to, or rarely exceed, the range of natural variability. The change occurs intermittently during CWP Project phases (e.g., O&M Phase) and is limited to within the CWP Project only.
Low	Very small changes to key environmental characteristics that are similar to baseline conditions. The change is only transient and is very limited spatially.
Very Low	No perceptible change, or change is within the natural variation.

Significance of effect

29. As set out in **Chapter 5 EIA Environmental Impact Assessment Methodology**, an Impact Assessment Matrix (IAM) is used to determine the significance of an effect. In basic terms, the potential significance of an effect is a function of the sensitivity of the receptor and the magnitude of the impact, as shown in **Table 6-6**.

30. The matrix provides a framework for the consistent and transparent assessment of predicted effects across all technical chapters. However, it is important to note that individual assessments are based on the application of expert judgement, through reference to empirical evidence and numerical modelling.

31. The matrix provides levels of effect significance ranging from imperceptible to profound as defined in the Environmental Protection Agency (EPA) (2022) EIAR Guidelines. For the purposes of this assessment, potential effects identified to be of moderate significance or above are considered to be significant in EIA terms and additional mitigation will be required. Effects identified as less than moderate significance are generally considered to be not significant in EIA terms.

Table 6-6 Impact assessment matrix for determination of significance of effect

Sensitivity of Receptor	Magnitude of Impact				
	Very High	High	Medium	Low	Very Low
Very High	Profound	Very Significant	Significant	Moderate	Minor / Moderate
High	Very Significant	Very Significant	Significant	Minor / Moderate	Minor
Medium	Significant	Significant	Moderate	Minor	Negligible / Minor
Low	Moderate	Minor / Moderate	Minor	Negligible / Minor	Negligible
Very Low	Minor / Moderate	Minor	Negligible / Minor	Negligible	Imperceptible

6.5 Assumptions and limitations

32. The following limitations are noted:

- **The reliance on models to characterise the hydrodynamic, wave and sediment transport regimes across the offshore development area:** Although models are very useful tools that can greatly assist the development of understanding in regard to the prevailing regimes across the region and the offshore development area, they remain only an approximation and simplification of reality, and are based on assumptions that simplify the real world in order to enable its simulation. Hence, it is recommended that caution is applied when utilising results obtained from models, and that expert judgement is applied.
- **Limited information available regarding baseline coastal processes:** Limited information exists within the public domain regarding the inshore sediment regime (e.g., alongshore drift direction, divergence and convergence points). Where limited information exists, assumptions must be made, relying upon professional judgement and understanding of the prevailing hydrodynamic, wave and sediment transport regimes occurring across the region.
- **The use of geophysical survey data from 2021:** This assessment has utilised geophysical survey data gathered in both 2014 and 2021, the limited changes noted between the two datasets indicates that the data remains valid for use for the assessment.

33. Whilst these limitations exist, the coupled hydrodynamic, wave and sediment transport model developed for the purposes of this assessment have been validated against available site specific measurement data in line with best industry practice and are considered to be appropriate for the purposes of assessing the potential impacts and therefore adequate with regards EIA requirements (see **Appendix 6.3** and **Appendix 6.4**).

6.6 Existing environment

34. The following sections describe the baseline conditions with respect to bathymetry, physical oceanographic regime, solid geology, surficial and sub surface sediments, sediment transport, and coastal processes and morphology.

6.6.1 Bathymetry

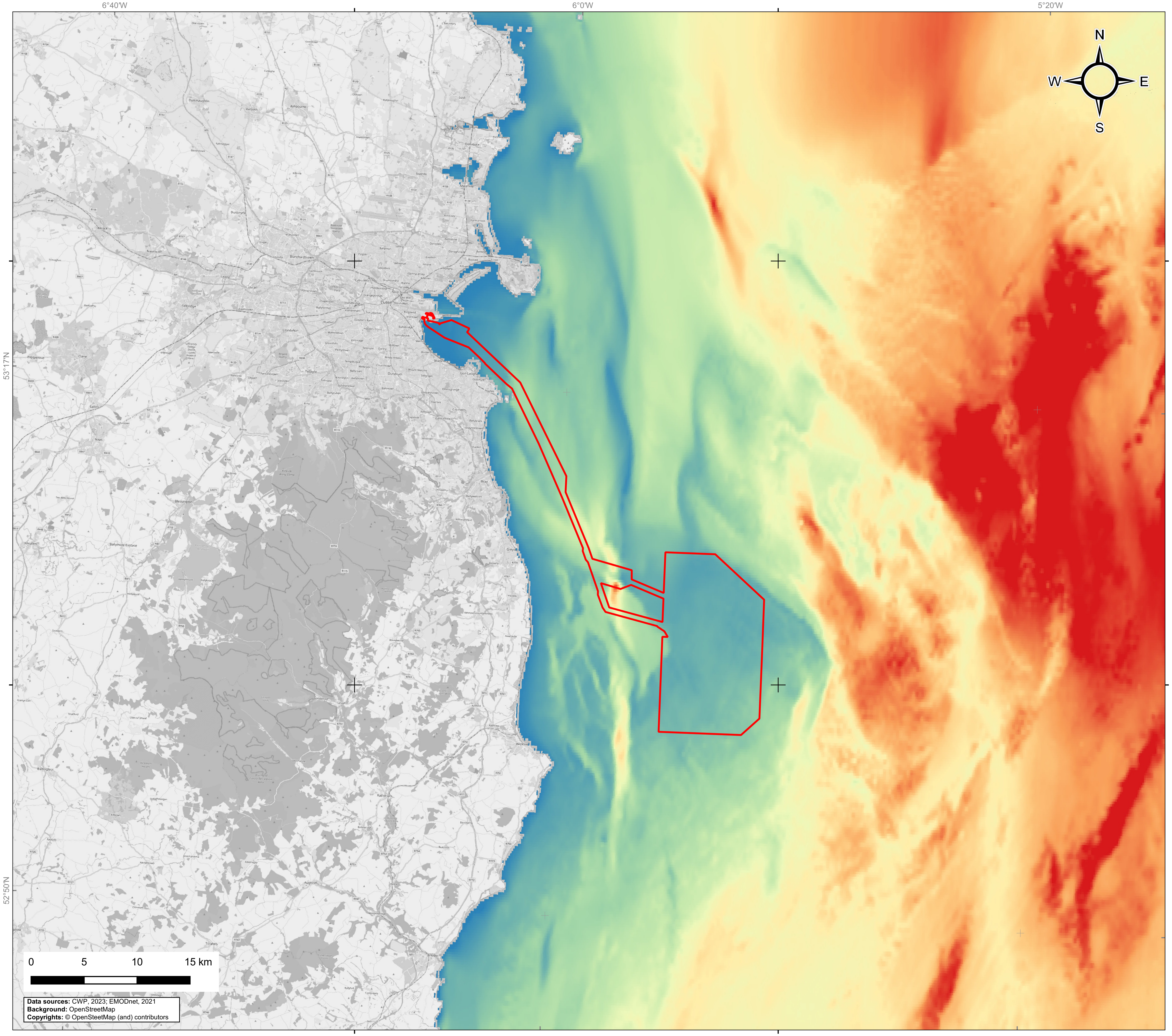
Regional Bathymetry

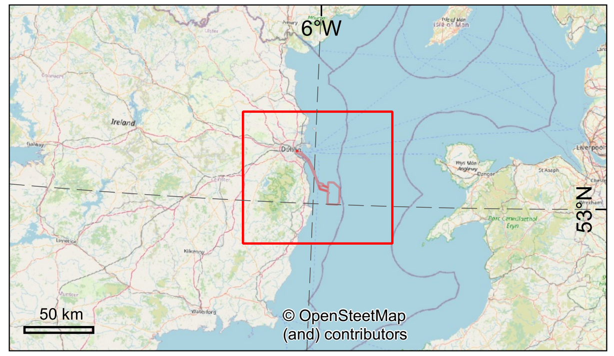
35. Information on the regional scale bathymetry is available through the interrogation of the coarse resolution EMODnet bathymetric database, which covers European waters. The database shows that the regional bathymetry nearshore is characterised by the presence of coast-parallel, north–south trending, offshore banks. These banks are generally 20 km from shore; typically stand in 20 to 40 m depth of water; and their elevations rise to within a few metres of the water surface. The banks form a punctuated line along the eastern Irish coast, and from north to south include Bennet, Kish, Frazer, Bray, Codling, India, Arklow, Glassgorman, Rusk, Blackwater / Moneyweights, Lucifer, Long and Holdens banks (**Figure 6-3**).

Local Bathymetry

36. Geophysical surveys conducted in 2021 (MMT, 2021) indicate that water level within the array site varies between -28 m and -6 m relative to the Lowest Astronomical Tide (LAT). The deeper water levels are observed towards the southeast, with shallower water depths observed towards the northeast. The central part of the array site generally sits at depths between -15 mLAT and -18 mLAT. Towards the west boundary, however, a large depression (the deepest region within the array site) is observed with depths reaching -28 mLAT. The east part of the array site sits at the edge of the Codling deep, a topographic depression on the seabed with depths that reach -120 mLAT. **Figure 6-4** displays the bathymetry across the array site.

37. The bathymetry along the offshore export cable corridor was investigated by utilising the data from the geophysical survey conducted in 2021 (G-Tec, 2021a, 2021b, 2021c, 2021d) (**Figure 6-4**). The data indicate that the bathymetry along the offshore export cable corridor varies greatly, gently sloping from the shallow intertidal zone until it reaches a depth of approximately -20 mLAT *c*. 2 km offshore from the landfall. The seabed gradient then steepens and reaches depths of *c*. -40 mLAT near the array site. Circa 6 km offshore, the route passes through a field of large bedforms (sandwaves with wave heights up to *c*. 4 m with superimposed megaripples) that stretches for approximately 2 km (see **Section Morphological Evidence for Sediment Transport Across the Offshore Development Area**).





Legend

Planning application boundary

Bathymetry [m VORF LAT]

- -125.00
- -111.11
- -97.22
- -83.33
- -69.44
- -55.56
- -41.67
- -27.78
- -13.89
- 0.00

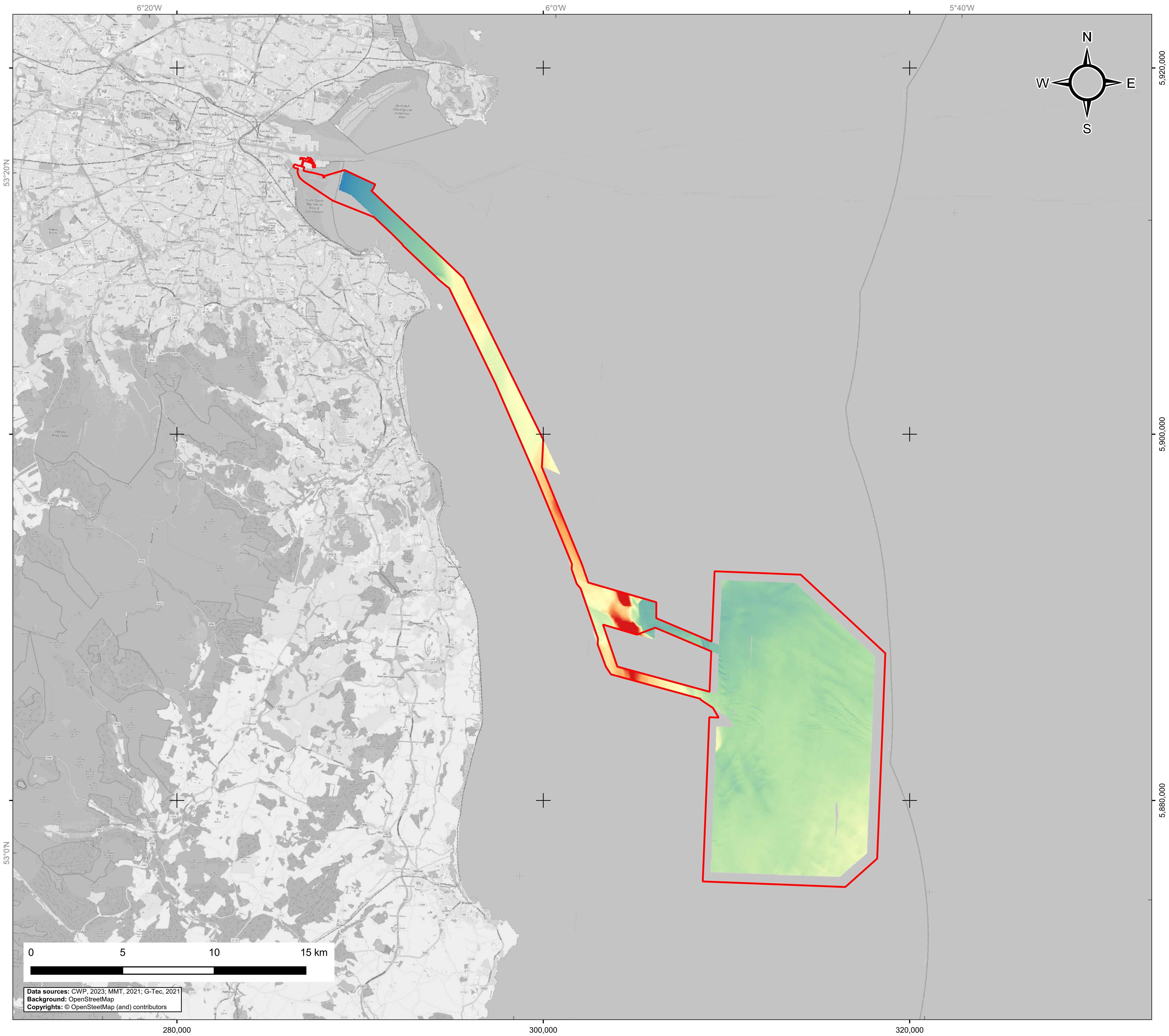
codling wind park	*Project:* Codling Wind Park	*Contractor:* Partrac.com	PARTRAC

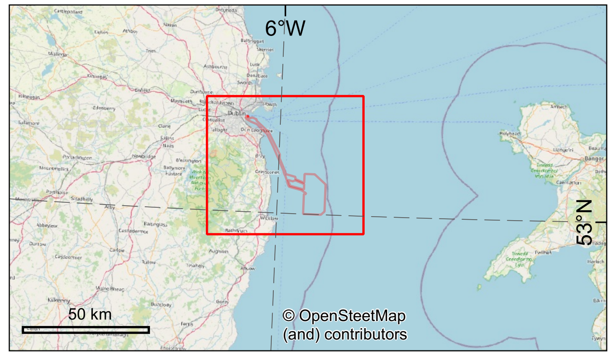
Figure 6.3
Regional bathymetry

CWP doc. number: CWP-PAR-ENG-08-01-MAP-0887

Internal descriptive code: OFFSH.ALL - PAB_BATHY.REGIONAL - EIAR.FIG.06.03	*Size:* A3 *Scale:* 1:350,000	*CRS:* EPSG 25830

Rev.	*Updates*	*Date*	*By*	*Chk'd*	*App'd*
00	Final for issue	2024/03/14	MG	JP	JP





Legend

Planning application boundary

Bathymetry [m VORF LAT]

- -60.0
- -44.8
- -29.7
- -14.5
- 0.7

Project: Codling Wind Park

Contractor: Partrac.com

Figure 6.4
Local bathymetry

CWP doc. number: CWP-PAR-ENG-08-01-MAP-0888

Internal descriptive code:	*Size:* A3	*CRS:*
WE - PAB..BATHY.LOCAL.MMT.21.GTEC.21 - EIAR.FIG.06.04	*Scale:* 1:200,000	EPSG 25830

Rev.	*Updates*	*Date*	*By*	*Chk'd*	*App'd*
00	Final for issue	2024/03/14	MG	JP/EA	JP/EA

6.6.2 Physical Oceanographic Regime

38. The physical oceanographic regime is defined as the behaviour of bulk water movements driven by the action of tides and non-tidal influences such as river flows and meteorological conditions (winds, atmospheric events and storm surges), and includes wave processes formed by the shearing action of wind on the water surface.

Regional Oceanographic Regime

39. The Irish Sea is a semi-enclosed body of water bounded by Ireland, southern Scotland, northwest England and Wales. The sea has restricted outlets to the Atlantic Ocean through the North Channel to the north and via St George's Channel to the south (**Plate 6-1**). The following describes the regional and local scale hydrodynamic and wave regime of the offshore development area. The oceanic tidal wave propagates into the Irish Sea basin from the Atlantic Ocean through both the North Channel and St George's Channel.

40. The tidal regime in the vicinity of the offshore development area is complex, due to the location of an amphidromic point at Courtown to the southeast of the Irish coast. The tidal regime is characterised by a standing wave, which is a function of the proximity of the amphidromic point and the interaction of the tidal waves propagating into the Irish Sea from both the north and the south. The amphidrome during spring tides is 'degenerate', being located inland, but at neap tides the position moves into the Irish Sea. This movement is due to proportionally more energy being absorbed from spring tides than from neap tides (Pugh, 1981). The tidal range progressively increases with distance from the amphidromic point, varying from a micro-tidal range in the south of the region to a meso-tidal range to the north of the region; across the Irish Sea ranges of tidal elevation vary between 1–9 m.

41. The tidal cycle is semi-diurnal in the Irish Sea and is dominated by the M2 and S2 tidal constituents (Pingree and Griffiths, 1978), with a common period of 12.4 hours. Due to the complexity of the tidal regime, the tidal range exhibits significant variations (e.g., during the spring–neap phase through to the nodal cycle [18.6 years]). The eastern seaboard of southeast Ireland is rather unusual in that it is an area characterised by comparatively fast flowing currents with a relatively small tidal range. Flow velocities vary significantly within the region, though typically depth-averaged flows exceed 1 m/s during the spring tidal phase (Howarth, 2005). Peak flow velocities observed range from 0.5 m/s to >2 m/s, which is a function of the broader tidal regime with local differences in flow velocity observed due to local topographic variability of the seabed.

42. The tidal regime is, on occasion, also affected by surges. The largest positive surges occur in the eastern Irish Sea, with maximum 50-year return period surge levels as shown in **Plate 6-2**, are predicted to be *c*. 2 m for the Lancashire and Cumbrian coasts of the UK, and up to *c*. 1 m on the Irish coast and across St George's Channel (Howarth, 2005). Despite the increase in water level from positive surges, surge currents in the Irish Sea are typically weak, predicted to increase (or on some occasions decrease) flow velocity away from the coast by up to 0.4 m/s (Flather, 1987), as shown in **Plate 6-3**. The complicated non-linear interactions between surge and tide may potentially yield a significant impact on the local sediment transport regime via an increase in local flow velocities and, during negative surges, the transmission of wave energy to the seabed.

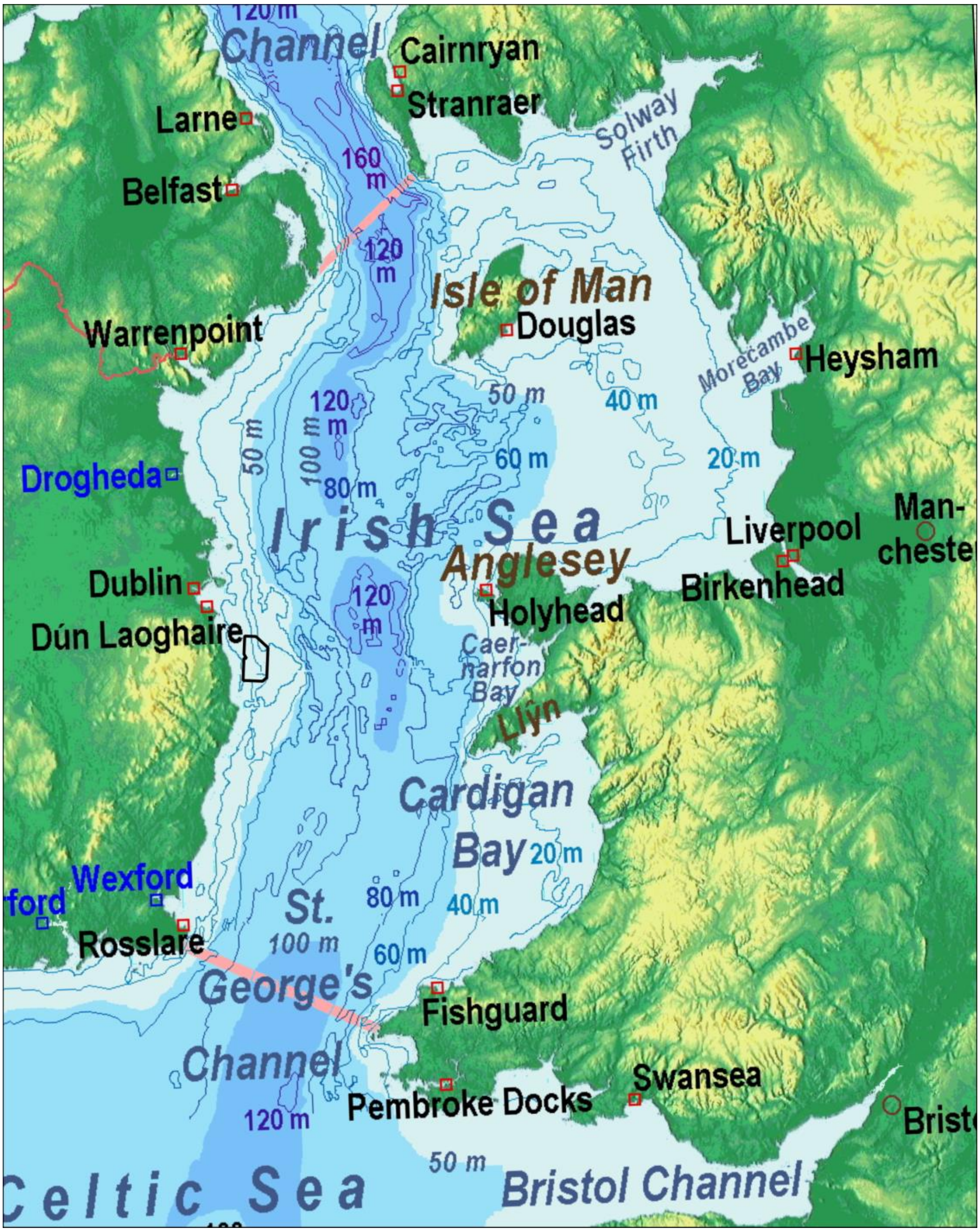


Plate 6-1 The Irish Sea, the location of the array site is highlighted in black

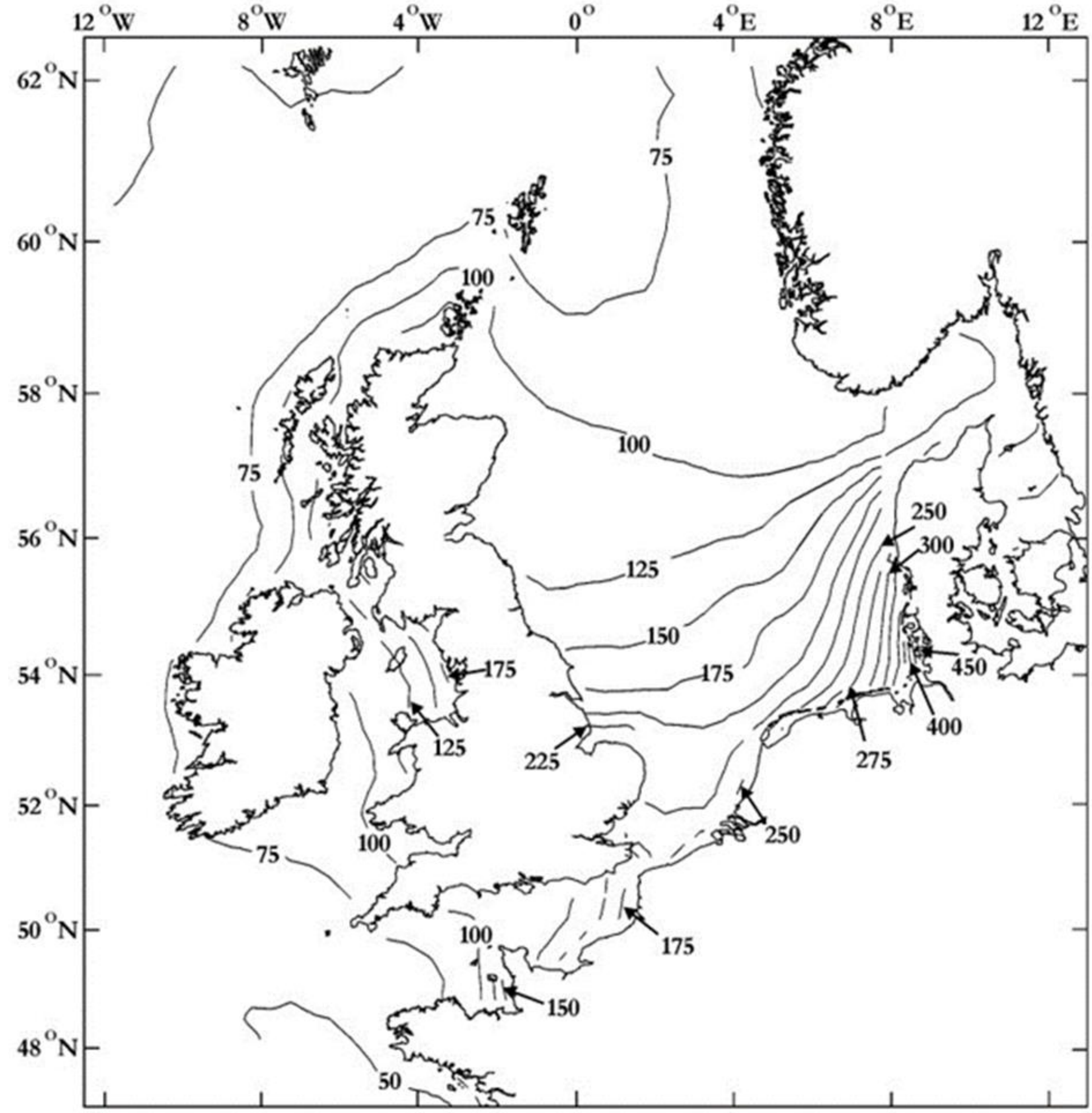


Plate 6-2 Isopleth contour map of 50-year return period storm surge elevations in cm (figure reproduced from Flather, 1987)

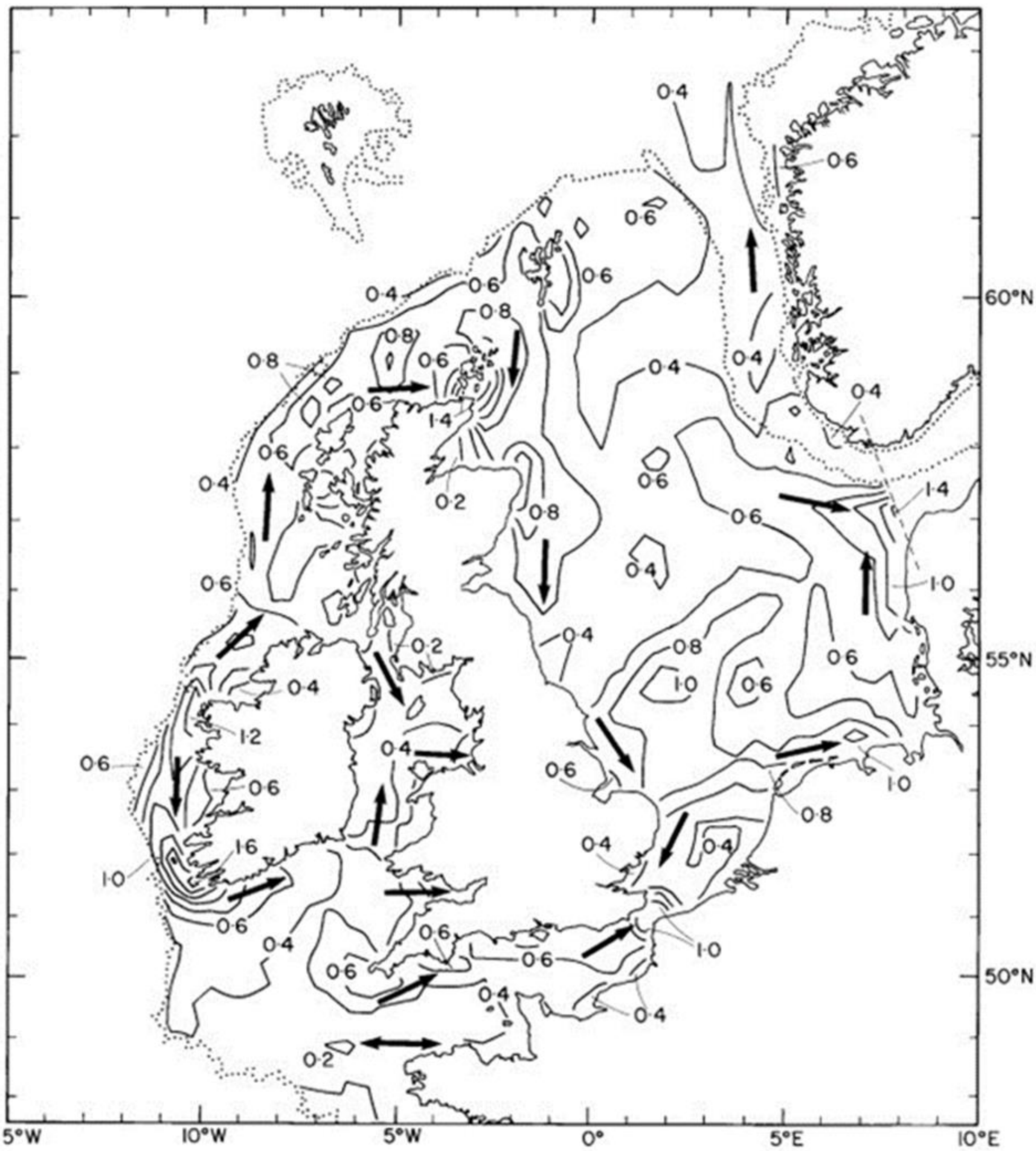


Plate 6-3 Isopleth contour map of 50-year return period storm surge currents in m/s (figure reproduced from Flather, 1987)

43. The present-day wave regime observed across the region is considered to have operated under similar climatic conditions over the last 4,000 to 6,000 years, as relatively little change in sea level has been observed during that time (Tooley, 1985). Generally, waves are locally wind-generated and of fairly short period, though on occasion, higher energy wave events (i.e., storms) occur. The magnitude of locally generated wind and swell waves depends on the duration and fetch of the wind. The southern Irish Sea (defined as the area from St George's Channel to the Isle of Man, including the offshore development area) is in an area exposed to westerly gales and frequent winter storms, with a fetch of over 100 km. However, wave energy propagation into the Irish Sea from Atlantic Storms is curtailed by headlands such as Carnsore Point, which acts to shelter the western side of the Irish Sea from the effect of these storms. Only two relatively narrow 'fetch windows' exist along the axes of St George's and North Channel. As such, bigger, swell waves (i.e., T_p of more than 8 seconds), which are more powerful drivers of sediment transport at the seabed, are generally observed near the entrances to the Irish Sea, at the southern end of St George's Channel and to the northern end of the North Channel (Howarth, 2005). Since energy is lost due to bed friction as waves propagate up the southern Irish Sea, this equates to peak wave heights of *c*. 8 m for a 50-year return period (**Plate 6-4**). As the fetch is limited, generally waves are locally wind-generated, and of fairly short period (i.e., T_p less than 8 seconds). Dependent on the associated wave height, waves characterised with periods of 8 seconds possess only a moderate capacity to influence sediment transport, which is typically limited to water depths less than 30 m (noting that depths across the offshore development area are typically between -28 m and -6 mLAT).

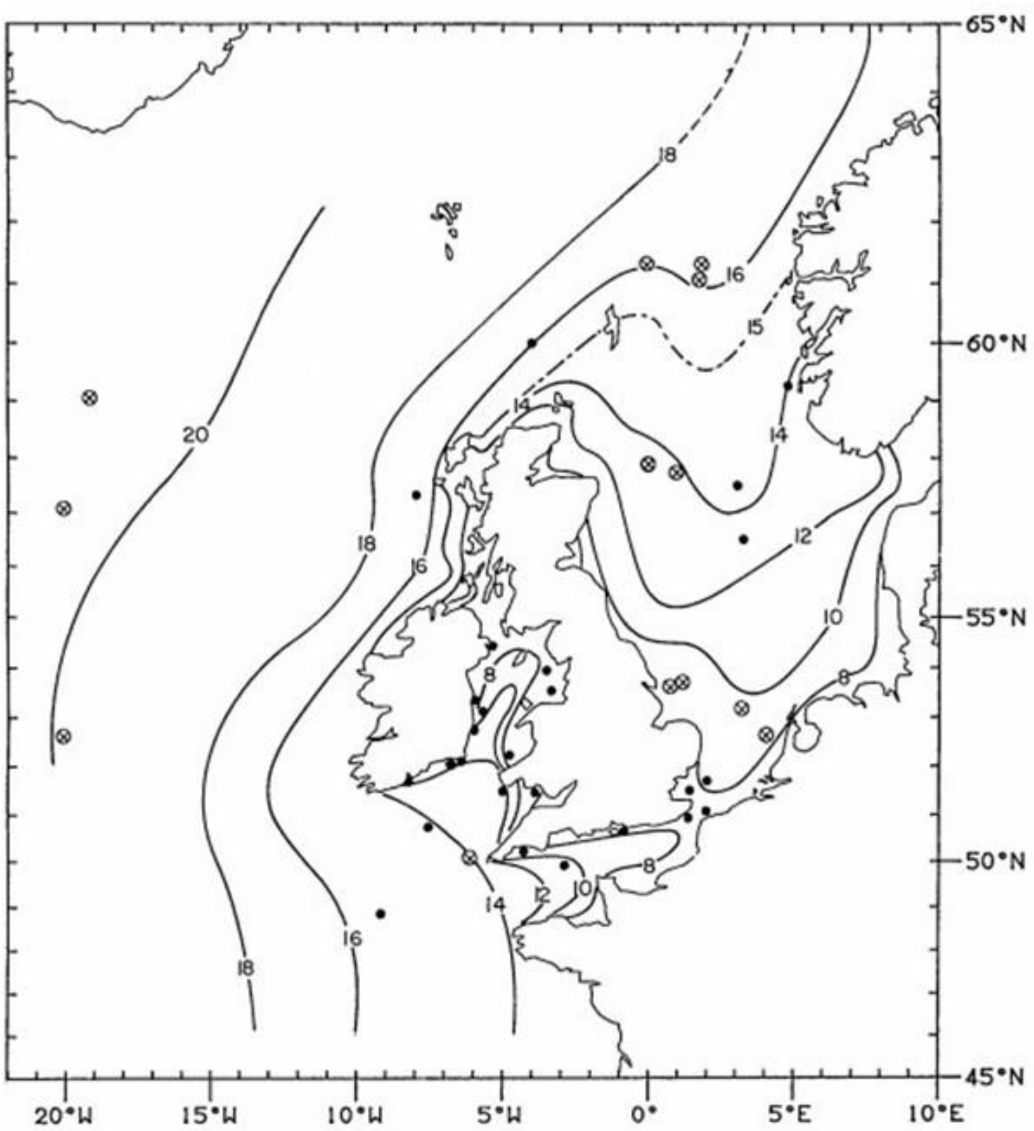


Plate 6-4 Isopleth contour map of indicative values of 50-year return period significant wave height (m). Figure reproduced from Carter (1993)

Local Oceanographic Regime

Water Levels

44. Dublin Port has the closest tide gauge station to the offshore development area; the station is owned and operated by the Dublin Port Company. It has been in operation since 1938 and is located at coordinates (53.3500, -6.2167 EPSG: 4326). **Plate 6-5** presents the water elevation data for the four model extraction points in the form of time series. **Table 6-7** presents the water elevation statistics for the Dublin Port tide gauge and each of the forementioned four model extraction points. Interrogation of these data indicate the coastal area is macrotidal, with the tidal range increasing towards the north of the offshore development area as the distance increases from the amphidromic point located near to Courtown, with the data extracted from model points to the north and south of the offshore development area predicting that the tidal range reduces from *c*. 2.2 m to 1.2 m, respectively (**Table 6-7** and **Plate 6-5**).

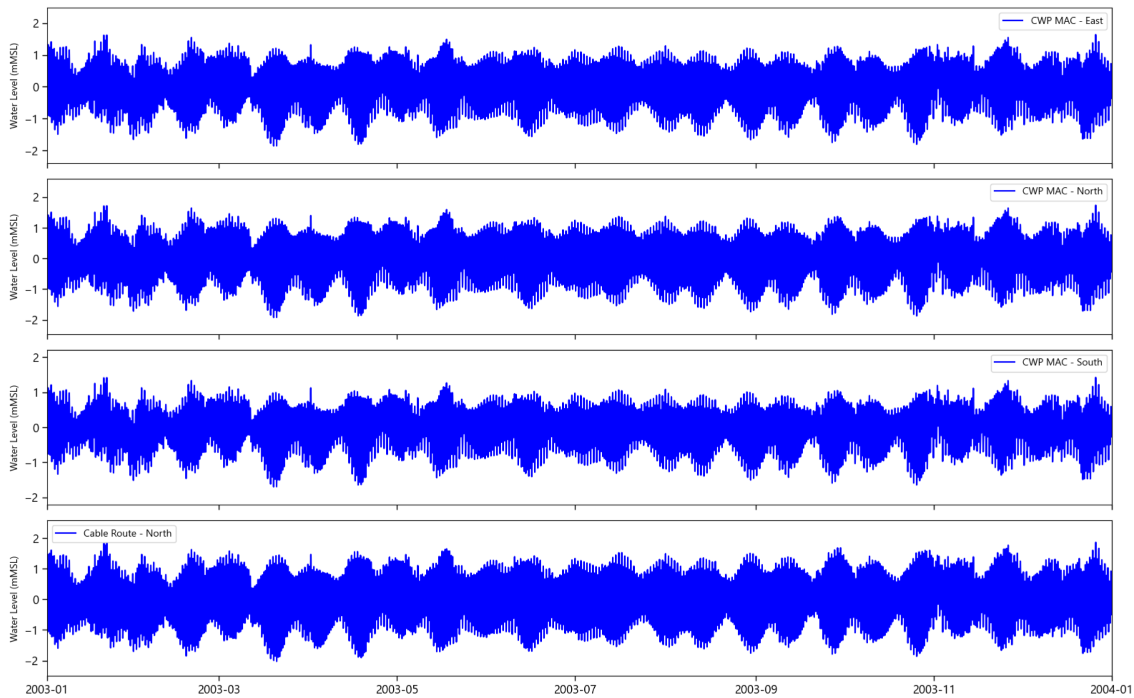


Plate 6-5 Water elevations predicted to occur at the four model extraction points plotted in the form of a timeseries. A representative period from the hindcast data record is presented (2003 to 2004)

Table 6-7 Water elevation statistics at the Dublin Port tidal gauge. Source: Dublin Port Company (2021)

Tidal levels	Dublin Port Tide gauge (m relative to CD)	Model Points (m relative to Chart Datum (CD))			
		CWP MAC East	CWP MAC North	CWP MAC South	CR North
HAT (Highest Astronomical Tide)	4.5	3.9	4.01	3.67	4.16
Lowest Astronomical Tide (LAT)	-0.1	0.62	0.54	0.79	0.48
Mean High Water Springs (MHWS)	4.1	3.37	3.45	3.2	3.54
Mean High Water Neaps (MHWN)	3.4	3.06	3.12	2.94	3.16
Mean Low Water Springs (MLWS)	0.7	1.46	1.39	1.59	1.32
Mean Low Water Neaps (MLWN)	1.5	1.96	1.89	2.06	1.81
Mean Spring Range (MSR)	3.4	1.91	2.06	1.61	2.22
Mean Neap Range (MNR)	1.9	1.11	1.23	0.88	1.35

Tidal Currents

45. **Plate 6-6** presents the depth-averaged current velocities extracted at the four-model extraction point locations; interrogation of this figure clearly shows the transition between the spring and neap tidal phase with lower velocities observed during the neap tidal phase. **Table 6-8** presents the key statistics. The data indicate that the highest velocities are observed near the southern edge of the array site, with a maximum depth-averaged velocity of 1.4 m/sec predicted. Towards the north of the array site current velocities reduce, with maximum velocities of 0.99 m/sec predicted to occur. The lowest velocities across the offshore development area were observed at the CR North model point, with a maximum velocity of 0.88 m/sec.

Table 6-8 Statistics obtained for the depth-averaged current velocities at the four model points

Parameter	CWP MAC East	CWP MAC North	CWP MAC South	CR North
Max (m/sec)	1.294	0.989	1.404	0.882
Mean (m/sec)	0.637	0.485	0.715	0.407
Min (m/sec)	0.001	0	0.001	0
SD (m/sec)	0.282	0.228	0.33	0.208
Water Depth (mLAT)	-17.03	-10.65	-18.53	-24.34

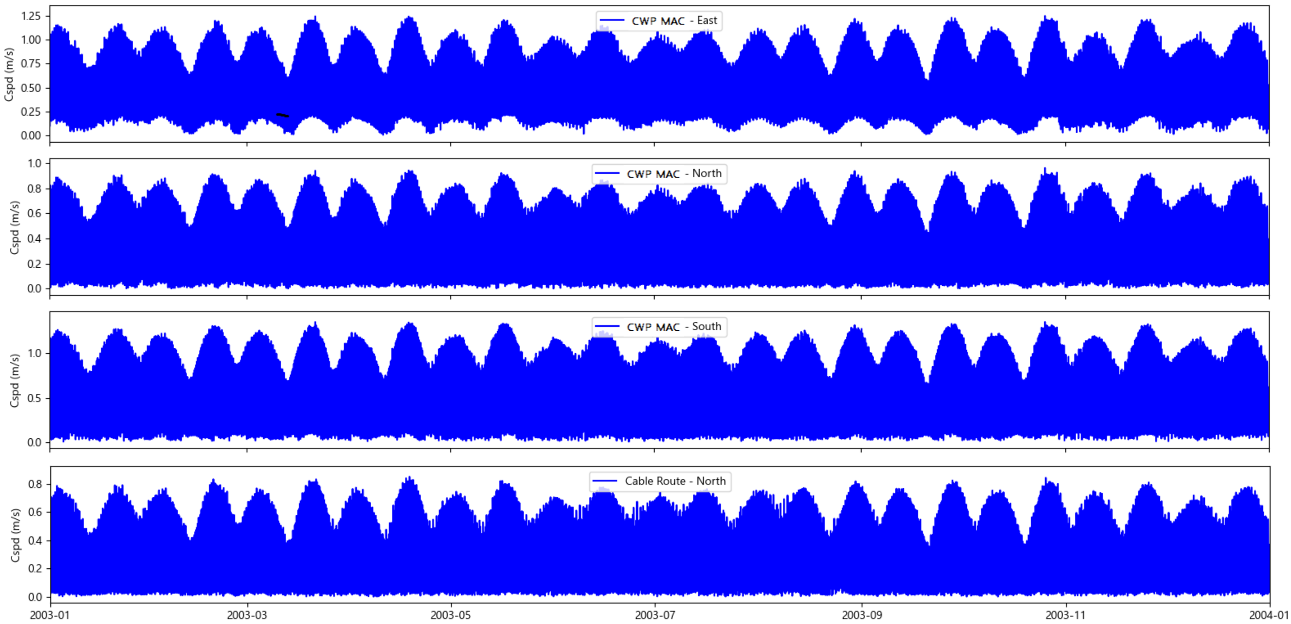


Plate 6-6 Depth-averaged current speeds predicted to occur at the four model extraction points plotted in the form of a timeseries. A representative period from the hindcast data record is presented (2003 to 2004).

46. Across the offshore development area, tidal currents flow broadly along a north–south axis, with flood tides flowing northward and ebb tides southward. The direction of flow at model points CR North and CWP MAC North display a strongly rectilinear tidal signal, comparatively; data extracted from model points CWP MAC East and CWP MAC South indicate a more complicated flow regime, with the direction of flow including components from the NE, NW, SE and SW, which is most likely a function of the complex local bathymetry (**Plate 6-7**). Further investigation of the tidal flows local to the offshore development area is possible through the interrogation of the frequency occurrence tables presented in **Plate 6-8** that present current velocities vs direction of flow. Presentation of data in this manner corroborates the previous findings, with the strong rectilinear tidal signal evident in the nearshore areas with currents of up to 1 m/s observed from both the N and S quadrants.

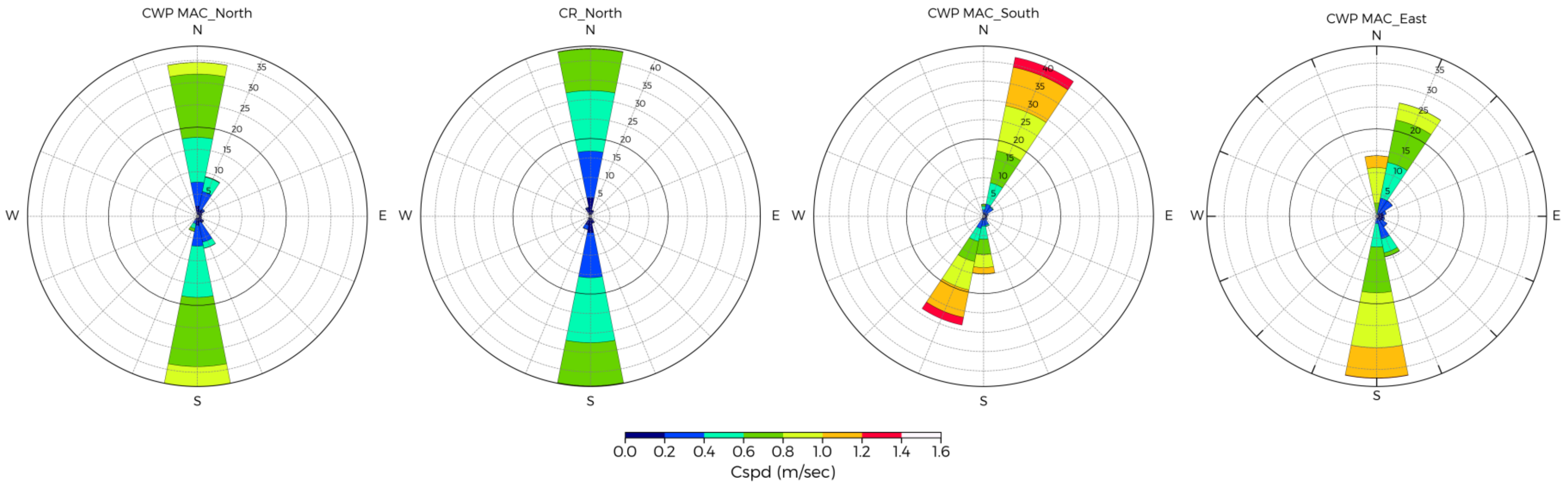


Plate 6-7 Current rose plots showing depth-averaged current speeds as a function of direction. Data presented are taken from the four model extraction points.

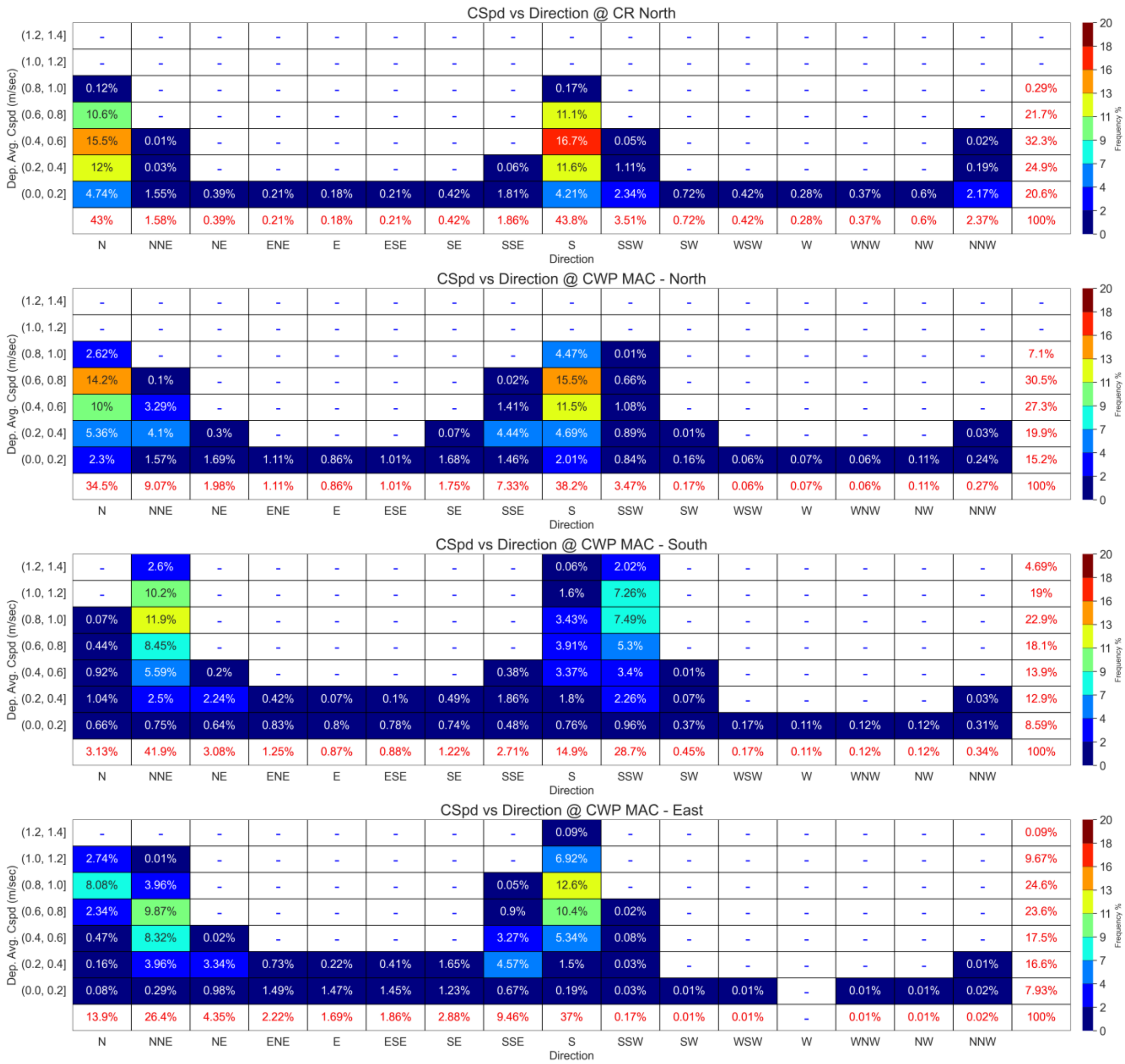
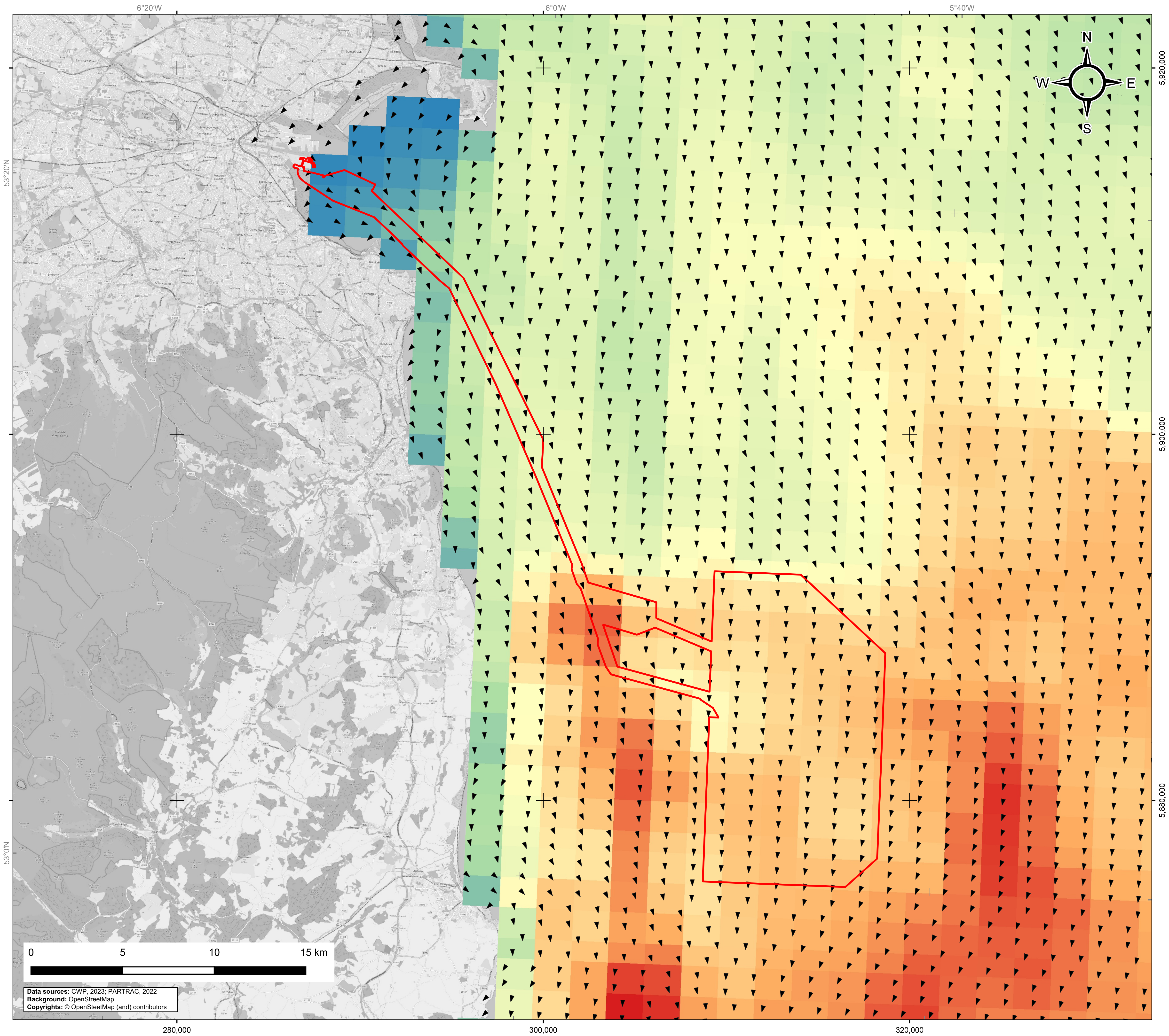
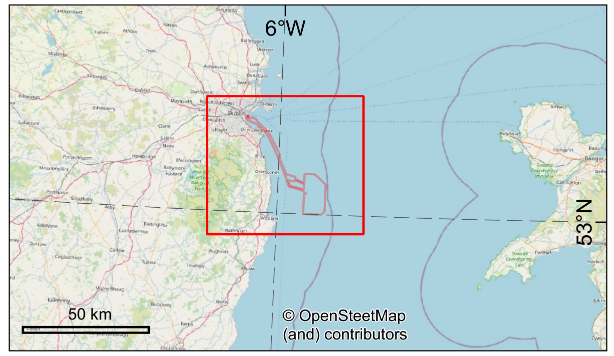


Plate 6-8 Frequency of occurrence of depth-averaged current speeds and direction of flow. Data presented are taken from the four model extraction points.

47. Current speeds also show considerable spatial variability across the offshore development area, with faster current speeds observed towards the south when compared to those in the north. This difference is postulated to be a function of the proximity of the local amphidromic point. **Figure 6-5, Figure 6-6, Figure 6-7** and **Figure 6-8** show the spatial variability in the form of vector plots during a peak spring ebb tide, peak spring flood tide, peak neap ebb tide and peak neap flood tide, respectively. Presentation of data in this manner shows significant spatial variability. During a peak spring ebb tide (the dominant phase of the tide), velocities of up to 2 m/s are observed towards the south of the array site (**Figure 6-5**), which reduces in magnitude during the neap phase (**Figure 6-7** and **Figure 6-8**).





Legend

- Planning application boundary
- Flow direction

Current speed (m/s)

- 0.0
- < 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0

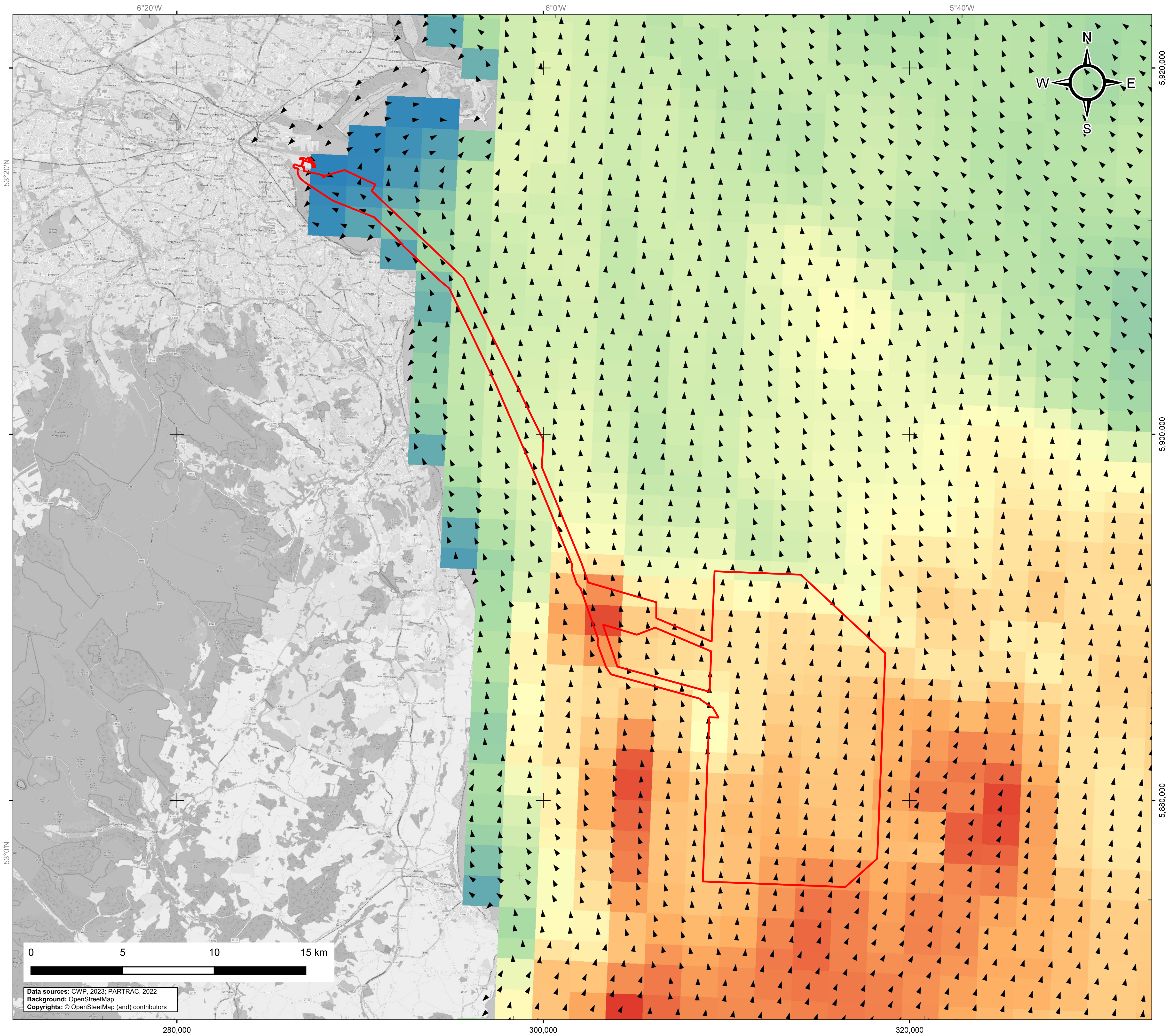
Project: Codling Wind Park	*Contractor:* Partrac.com

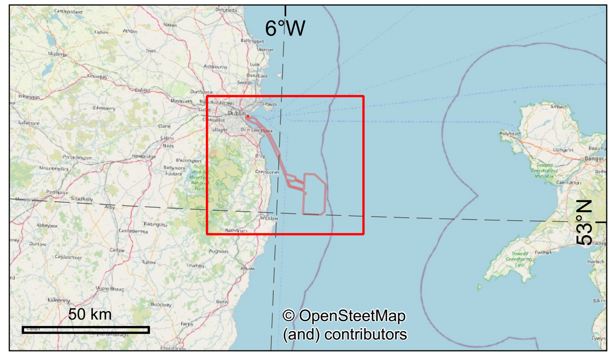
Figure 6.5
Peak spring ebb tide current speed and direction

CWP doc. number: CWP-PAR-ENG-08-01-MAP-0889

Internal descriptive code: WE - PAB_CURRENT.PSET - EIAR.FIG.06.05	*Size:* A3 *Scale:* 1:200,000	*CRS:* EPSG 25830

Rev.	*Updates*	*Date*	*By*	*Chk'd*	*App'd*
00	Final for issue	2024/03/14	MG	JP/EA	JP/EA





Legend

- Planning application boundary
- ► Flow direction

Current speed (m/s)

- 0.0
- < 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0

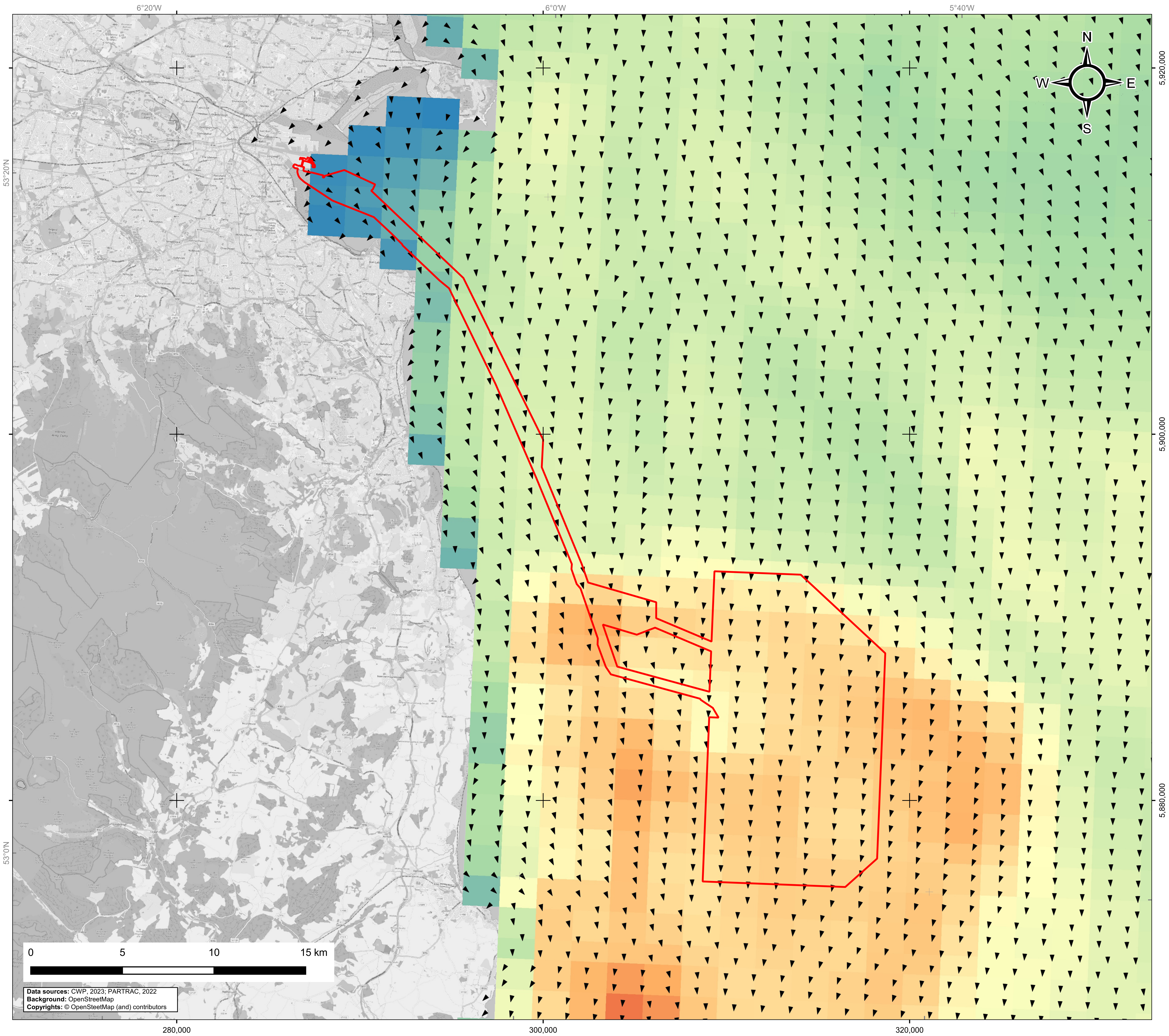
codling wind park	*Project:* Codling Wind Park	*Contractor:* Partrac.com

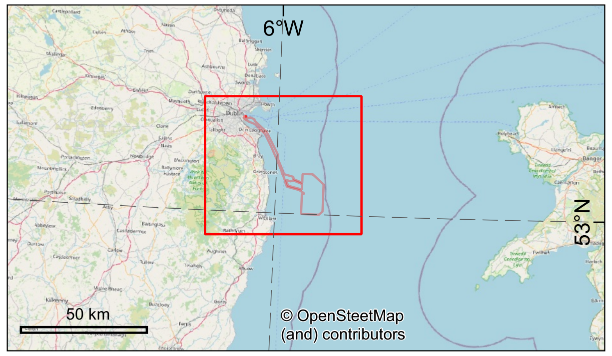
Figure 6.6
Peak spring flood tide current speed and direction

CWP doc. number: CWP-PAR-ENG-08-01-MAP-0890

Internal descriptive code: WE - PAB_CURRENT.PSFT - EIAR.FIG.06.06	*Size:* A3 *Scale:* 1:200,000	*CRS:* EPSG 25830

Rev.	*Updates*	*Date*	*By*	*Chk'd*	*App'd*
00	Final for issue	2024/03/14	MG	JP/EA	JP/EA





Legend

- Planning application boundary
- Flow direction

Current speed (m/s)

- 0.0
- < 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0

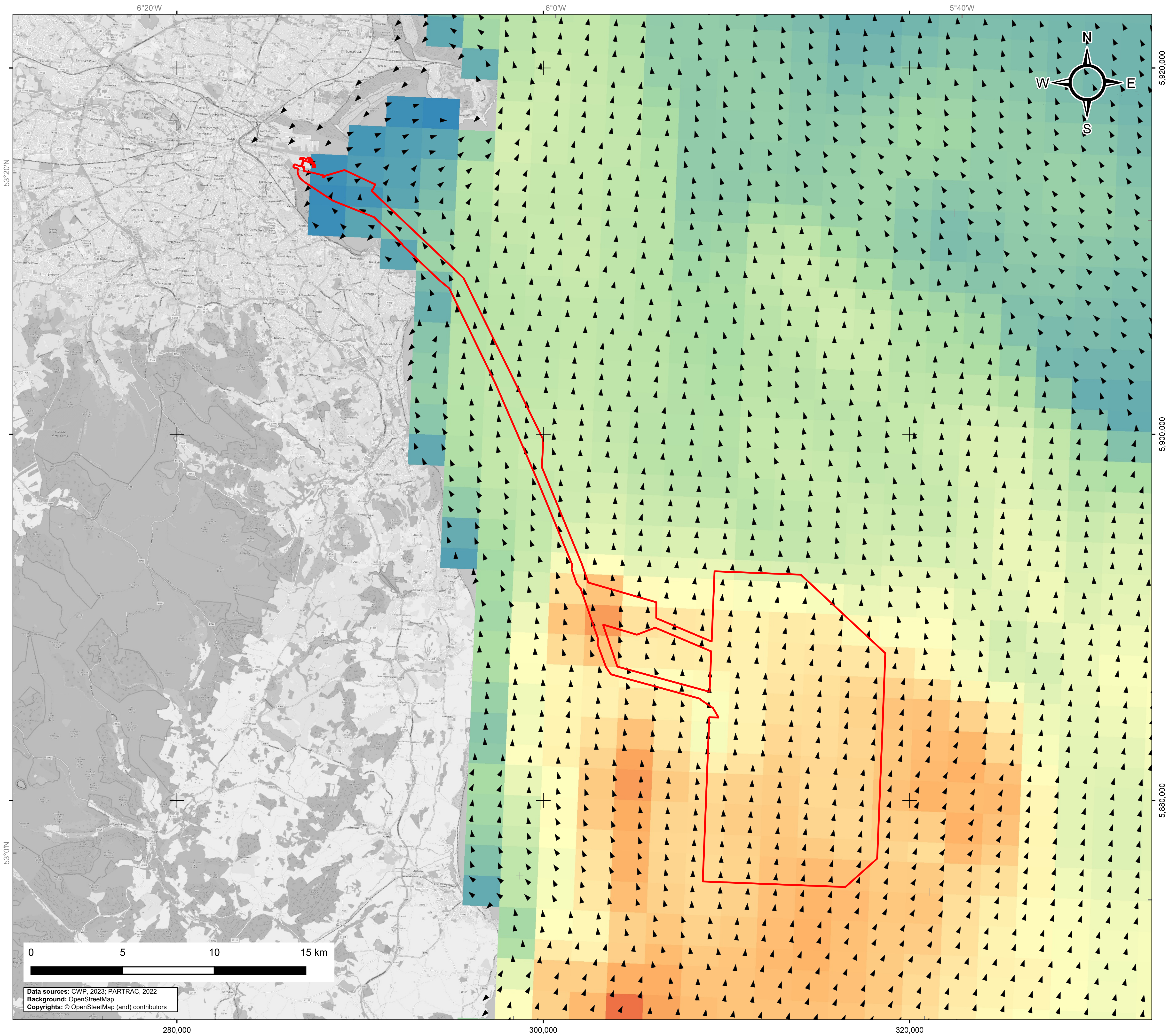
codling wind park	*Project:* Codling Wind Park	*Contractor:* Partrac.com

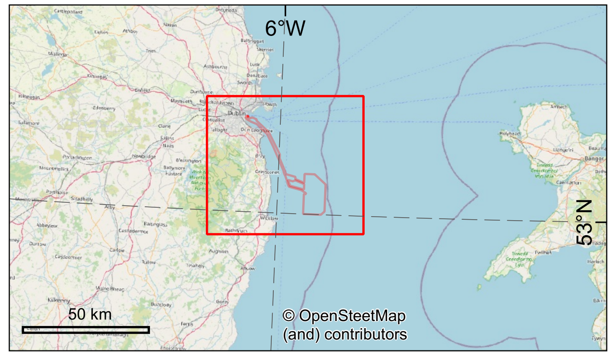
Figure 6.7
Peak neap ebb tide current speed and direction

CWP doc. number: CWP-PAR-ENG-08-01-MAP-0891

Internal descriptive code:	*Size:* A3	*CRS:*
WE - PAB_CURRENT.PNET - EIAR.FIG.06.07	*Scale:* 1:200,000	EPSG 25830

Rev.	*Updates*	*Date*	*By*	*Chk'd*	*App'd*
00	Final for issue	2024/03/14	MG	JP/EA	JP/EA





Legend

- Planning application boundary
- Flow direction

Current speed (m/s)

- 0.0
- < 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0

codling wind park

Project: Codling Wind Park

Contractor: Partrac.com

Figure 6.8
Peak neap flood tide current speed and direction

CWP doc. number: CWP-PAR-ENG-08-01-MAP-0892

Internal descriptive code: WE - PAB_CURRENT.PNFT - EIAR.FIG.06.08

Size: A3

Scale: 1:200,000

CRS: EPSG 25830

Rev.	*Updates*	*Date*	*By*	*Chk'd*	*App'd*
00	Final for issue	2024/03/14	MG	JP/EA	JP/EA

48. The tidal excursion distance is a function of the tidal curve (asymmetry) and represents the net horizontal distance a water particle moves during a half-tidal cycle (i.e., the distance over which a water particle travels during the flooding and ebbing tide; Savenije, 1989). Knowledge of these distances is a central tenet to the understanding of several areas, including the maximum distances suspended sediments may be transported within a given time interval. Nearshore, where tidal circulations are complex, the net excursion may not be significant. However, for the offshore region, where tides are stronger and display a more rectilinear relationship, a parcel of water can undergo significant horizontal displacement. Illustrative tidal excursion diagrams for model extraction points CWP MAC North and CWP MAC South during the neap and spring phase are presented in **Plate 6-9** and **Plate 6-10**, respectively. These show significant differences between excursion distances during the spring and neap tidal phase; the spring tides, which generate the greatest horizontal displacement, can extend along the tidal axis for some 5–6 km at model point CWP MAC North and up to 10 km at model point CWP MAC South, during a half spring tide (during the flood or ebb cycle). The neap tides show a displacement of between 4–6 km during a typical half cycle at both model points CWP MAC North and CWP MAC South.

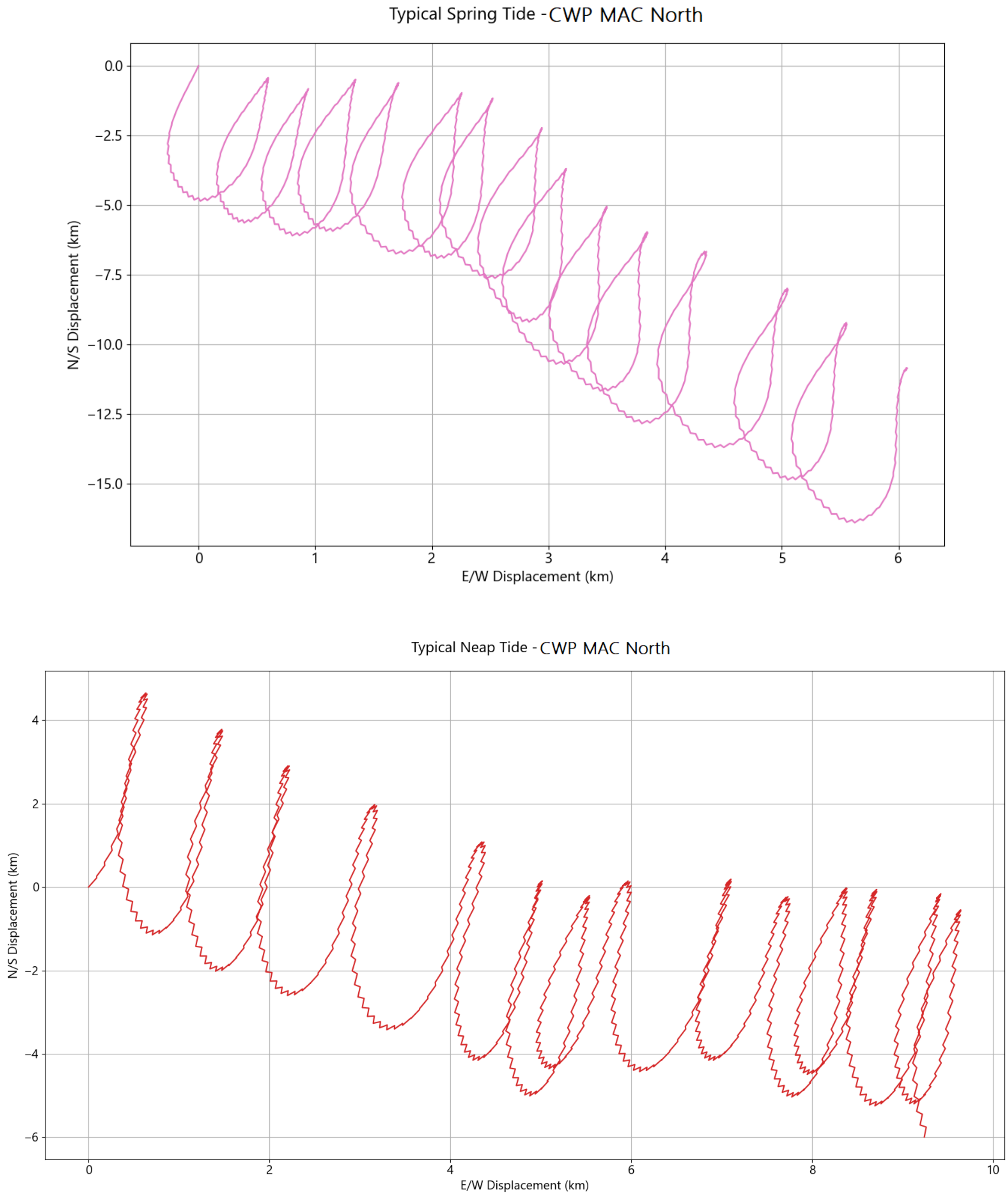


Plate 6-9 Illustrative tidal excursion (progressive vector) plot for model point CWP MAC North during the spring tidal phase (top panel) and the neap tidal phase (bottom panel)

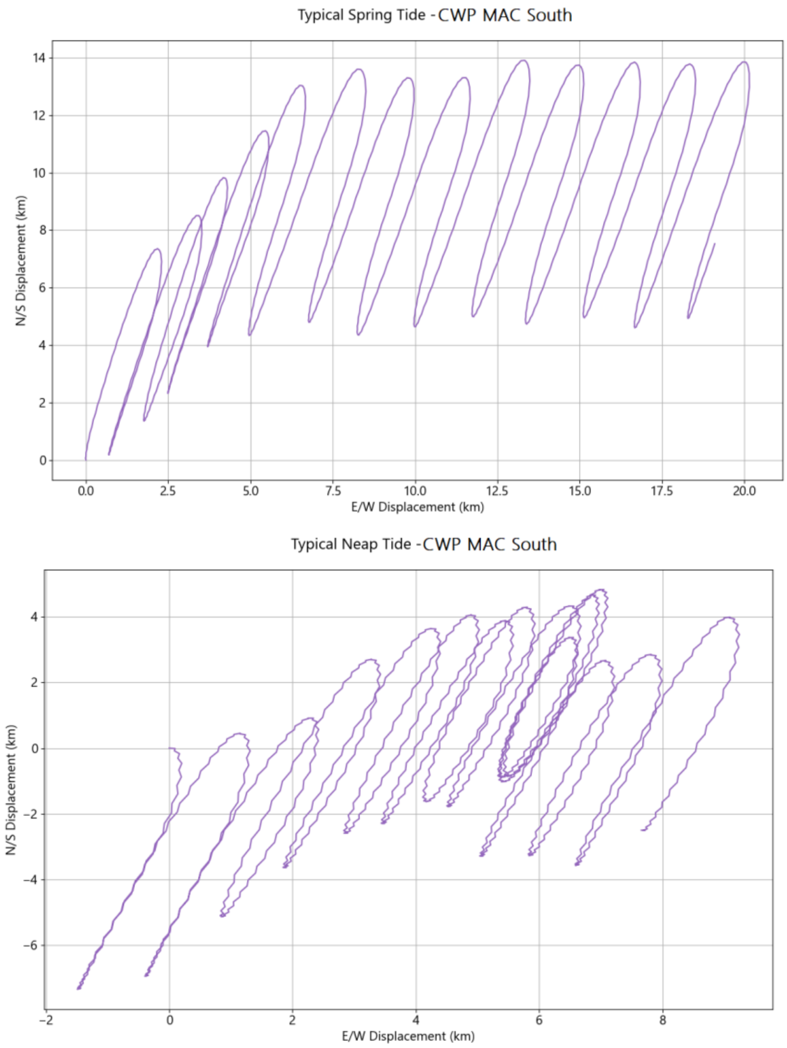


Plate 6-10 Illustrative tidal excursion (progressive vector) plot for model point CWP MAC South during the spring tidal phase (top panel) and the neap tidal phase (bottom panel)

49. A general appreciation of tidal asymmetry can be achieved via inspection of the rose plots presented in **Plate 6-7** and the frequency of occurrence tables shown in **Plate 6-8**, which show the relationship between current magnitudes and direction of flow. These data indicate that tidal currents in the offshore development area are broadly ebb dominant. Further evidence of this phenomenon can be derived from interrogation of water level and current speed data during the spring tidal phase to determine the velocity and duration coincident with the flood and ebb phase. **Plate 6-11** presents an example of this analysis carried out for a typical spring tide (~7 days) at model point CWP MAC East. The data show that ebb tides are always shorter in period but stronger in magnitude. Similar analyses were completed for the strongest spring tides and the weakest neap tides at model point CWP MAC East; the statistics obtained from this analysis are shown in **Table 6-9**. The foregoing analysis showed that the predicted ebb dominance is more pronounced during the spring tidal phase as opposed to the neap tidal phase where the relationship is, on occasions, reversed (i.e., the peak flood currents become stronger than their respective ebb currents and shorter in duration).

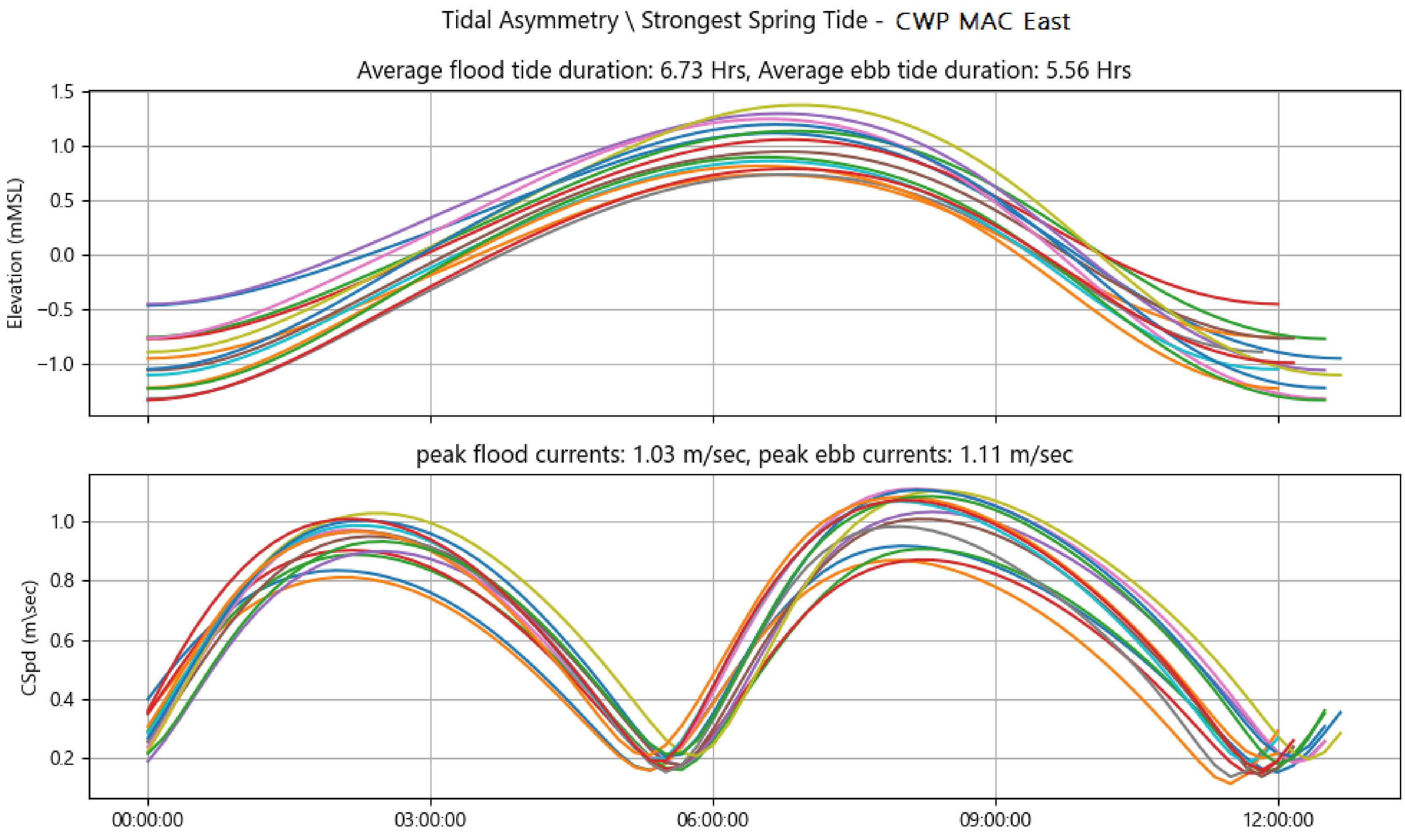


Plate 6-11 The predicted ebb dominance at model point CWP MAC East during a typical spring tide. Water elevations (above) and current speeds (below) are shown.

Table 6-9 Durations and magnitudes of depth-averaged currents for the 10 weakest neap and 10 strongest spring tides predicted to occur within the model hindcast data record, at model CWP MAC East

#	**Strongest Spring Tides**				
	Spring Peak Flood (m/sec)	Spring Peak Ebb (m/sec)	Spring Flood Duration (hh:mm)	Spring Ebb Duration (hh:mm)	Spring Total Duration (hh:mm)
1	1.11	1.29	06:40	05:50	12:30
2	1.14	1.28	06:40	05:50	12:30
3	1.12	1.28	06:40	05:50	12:30
4	1.12	1.28	06:40	05:50	12:30
5	1.13	1.28	06:40	06:00	12:40
6	1.07	1.28	06:30	06:00	12:30
7	1.13	1.27	06:40	05:50	12:30
8	1.11	1.27	06:40	06:00	12:40
9	1.08	1.27	06:40	05:50	12:30
10	1.13	1.27	06:40	05:50	12:30
#	**Weakest Neap Tides**				
	Neap Peak Flood (m/sec)	Neap Peak Ebb (m/sec)	Neap Flood Duration (hh:mm)	Neap Ebb Duration (hh:mm)	Neap Total Duration (hh:mm)
1	0.62	0.46	07:10	05:30	12:40
2	0.46	0.76	07:20	05:20	12:40
3	0.70	0.46	06:50	05:50	12:40
4	0.46	0.76	06:30	06:10	12:40
5	0.46	0.68	06:10	07:10	13:20
6	0.46	0.76	05:50	06:40	12:30
7	0.46	0.69	07:30	05:20	12:50
8	0.47	0.75	06:50	06:10	13:00
9	0.70	0.47	06:40	06:00	12:40
10	0.73	0.47	07:20	05:00	12:20

50. Superimposed upon the regular tidal behaviour are non-tidal effects, which predominantly originate from meteorological influences, such as persistent winds (which can generate wind-driven currents) or changes in atmospheric pressure, which drive negative or positive surge events that can generate surge-induced currents. Investigation of such behaviour is available through a tidal harmonic analysis of the water elevations (**Table 6-10** and **Plate 6-12** to **Plate 6-15**) and current velocity predictions obtained from the four model extraction points (**Table 6-11** and **Plate 6-16** to **Plate 6-19**). Through this analysis, predictions of tidal-only water levels and tidal-only current velocity magnitudes obtained through the harmonic analysis are subtracted from the modelled water elevations and current velocities to yield the surge levels and residual surge currents across the offshore development area. These analyses reveal that across the offshore development area, significant excess water levels due to storms and non-tidal behaviour are expected, positive surges of up to *c*. 1 m above and negative surges of up to *c*. 0.75 m below the normal water levels were predicted to occur. Surge currents are also expected to significantly impact tidal currents across the offshore development area, with an increase of *c*. 0.4 m/sec above tidal currents predicted.

Table 6-10 Statistics of water elevation (m) obtained from the tidal surge analysis performed using data from the four model extraction points

Parameter	CWP MAC East	CWP MAC North	CWP MAC South	CR North
Max (m)	0.93	0.93	0.74	0.92
Mean (m)	0	0	0	0
Min (m)	-0.77	-0.77	-0.55	-0.75
SD (m)	0.16	0.15	0.14	0.15

Plate 6-12 Surge water levels predicted to occur at model inspection point CR North. The water levels obtained from the model (top panel), the predicted tidal water elevations at the model inspection point (middle panel) and the residual (surge) water levels obtained from subtracting the modelled water levels from the tidal water levels (bottom panel). Note: analysis has been performed for the entire hindcast data record, a representative period (2015 to 2016) is presented here.

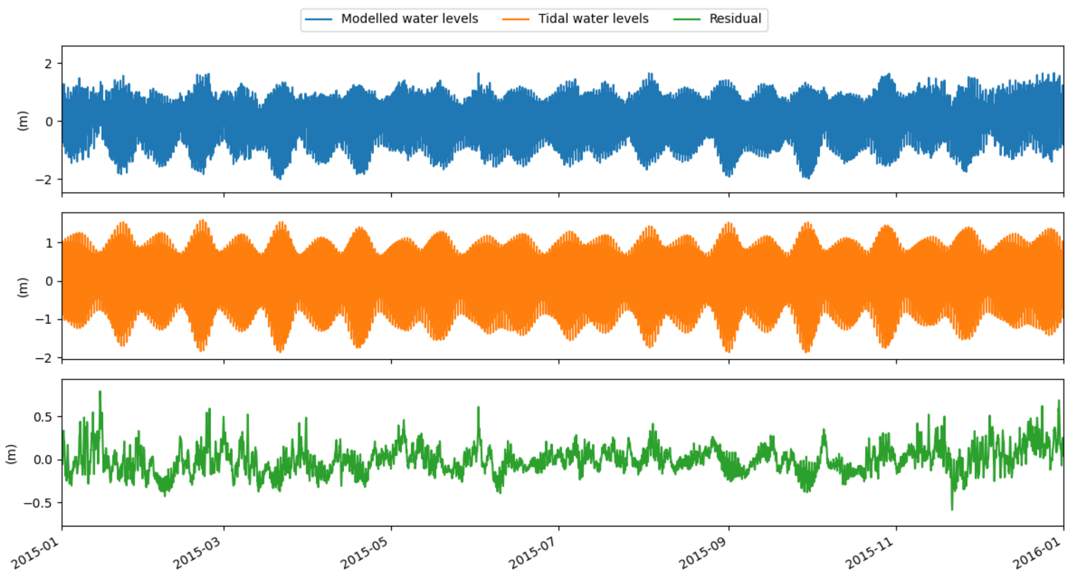


Plate 6-13 Surge water levels predicted to occur at model inspection point CWP MAC North. The water levels obtained from the model (top panel), the predicted tidal water elevations at the model inspection point (middle panel) and the residual (surge) water levels obtained from subtracting the modelled water levels from the tidal water levels (bottom panel). Note: analysis has been performed for the entire hindcast data record, a representative period (2015 to 2016) is presented here.

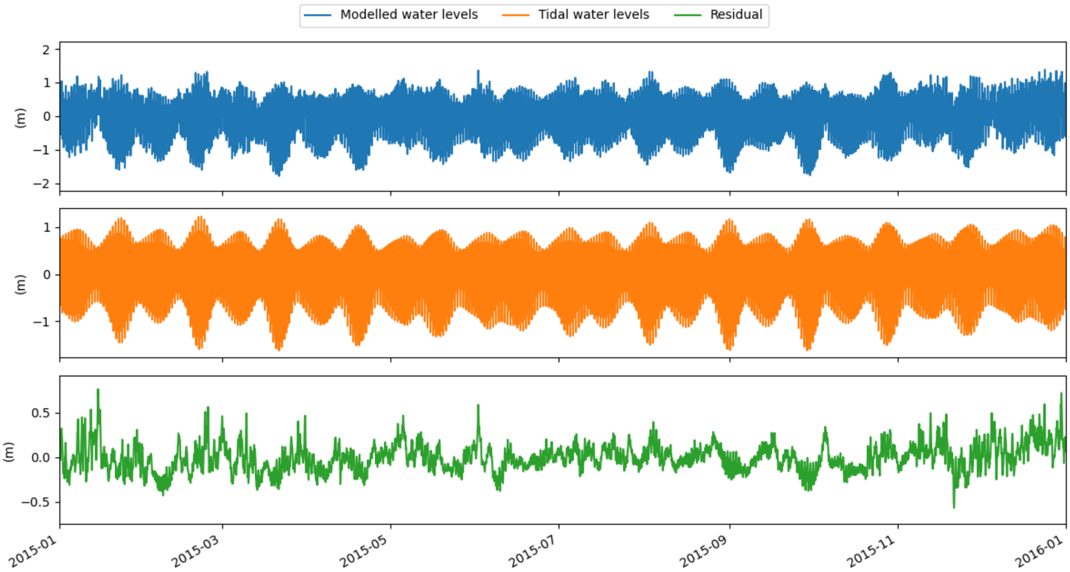


Plate 6-14 Surge water levels predicted to occur at model inspection point CWP MAC South. The water levels obtained from the model (top panel), the predicted tidal water elevations at the model inspection point (middle panel) and the residual (surge) water levels obtained from subtracting the modelled water levels from the tidal water levels (bottom panel). Note: analysis has been performed for the entire hindcast data record, a representative period (2015 to 2016) is presented here.

Plate 6-15 Surge water levels predicted to occur at model inspection point CWP MAC East. The water levels obtained from the model (top panel), the predicted tidal water elevations at the model inspection point (middle panel) and the residual (surge) water levels obtained from subtracting the modelled water levels from the tidal water levels (bottom panel). Note: analysis has been performed for the entire hindcast data record, a representative period (2015 to 2016) is presented here.

Table 6-11 Key statistics related to the predicted surge induced current speeds (m/sec) extracted from the four model inspection points across the entire hindcast data record

Parameter	CWP MAC East	CWP MAC North	CWP MAC South	CR North
Max (m/sec)	0.42	0.36	0.44	0.45
Mean (m/sec)	0.01	0.004	0.004	0.01
Min (m/sec)	-0.44	-0.36	-0.40	-0.45
SD (m/sec)	0.06	0.05	0.05	0.06

Plate 6-16 Predicted surge currents at point CR North. Current speeds obtained from the model (top panel), the predicted tidal currents at the point (middle panel) and the residual (surge) currents obtained from subtracting the modelled current speeds from the tidal currents (bottom panel).

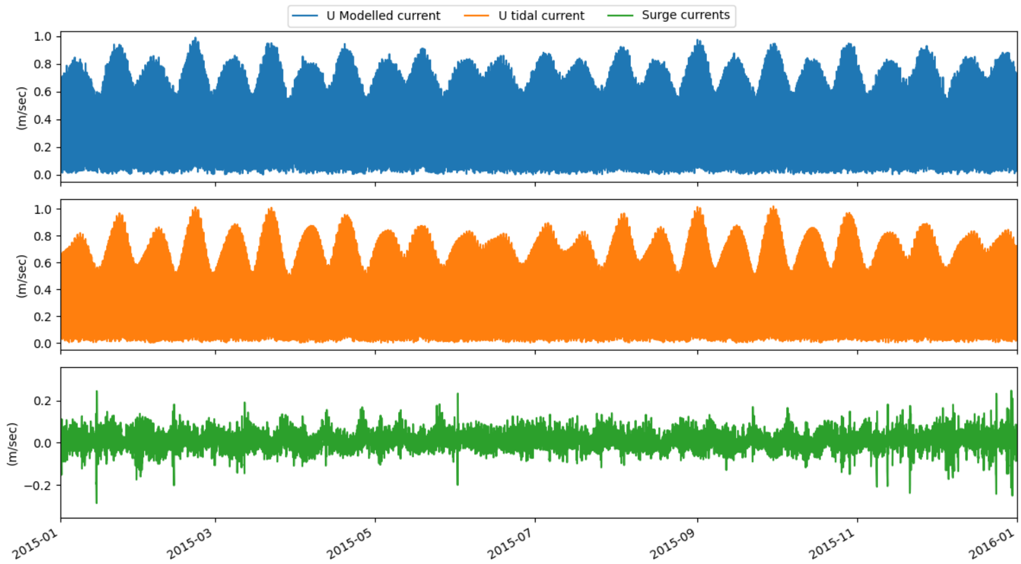


Plate 6-17 Predicted surge currents at point CWP MAC North. Current speeds obtained from the model (top panel), the predicted tidal currents at the point (middle panel) and the residual (surge) currents obtained from subtracting the modelled current speeds from the tidal currents (bottom panel).

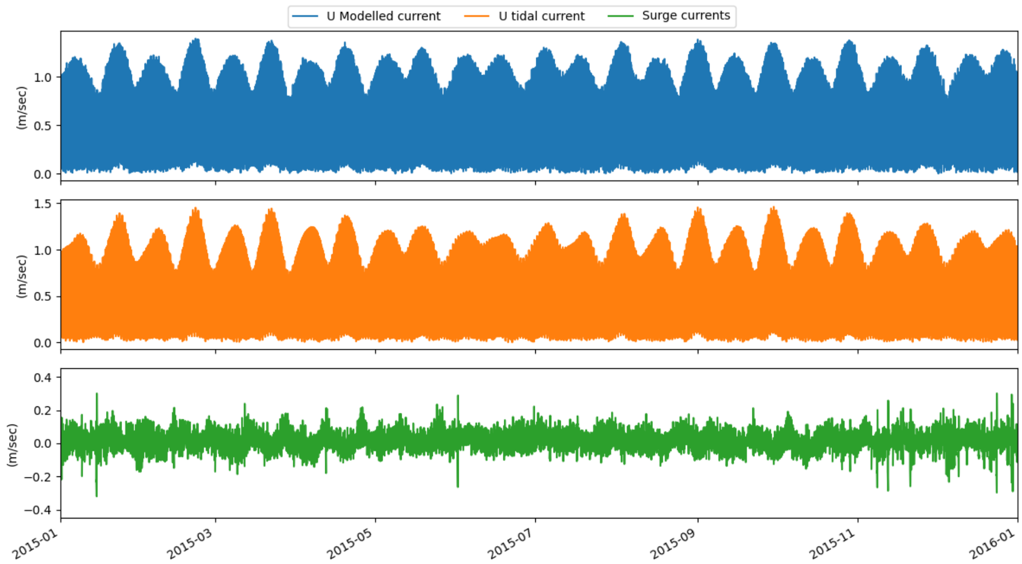


Plate 6-18 Predicted surge currents at point CWP MAC South. Current speeds obtained from the model (top panel), the predicted tidal currents at the point (middle panel) and the residual (surge) currents obtained from subtracting the modelled current speeds from the tidal currents (bottom panel).

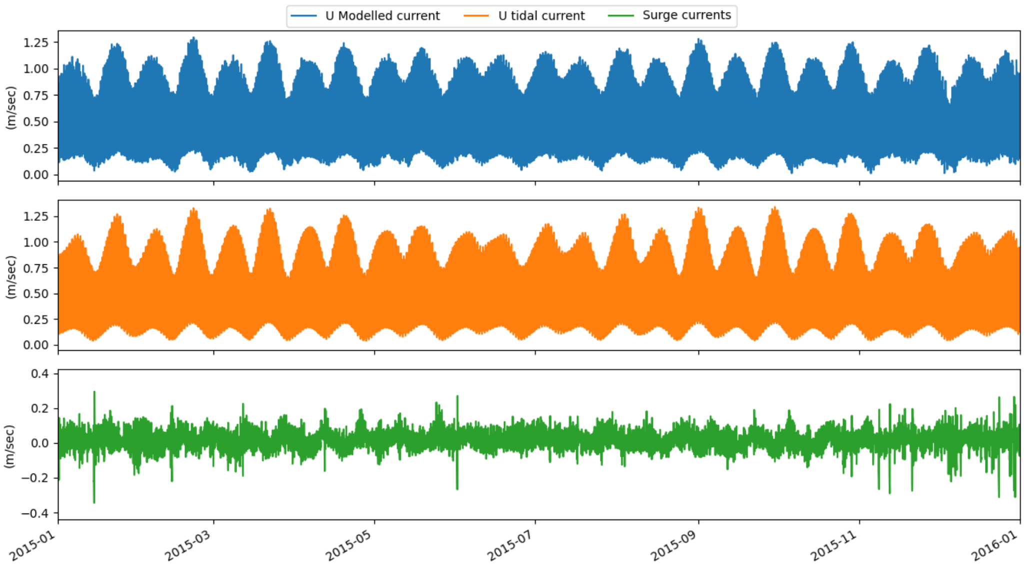


Plate 6-19 Predicted surge currents at point CWP MAC East. Current speeds obtained from the model (top panel), the predicted tidal currents at the point (middle panel) and the residual (surge) currents obtained from subtracting the modelled current speeds from the tidal currents (bottom panel).

Waves

51. Waves result from the transfer of wind energy to create sea states and the propagation of such energy across the water surface by wave motion. The amount of wind energy transfer, and thus wind-wave development, is a function of the available fetch distance across which the wind blows, wind speed, wind duration and the original sea state. The longer the fetch distance, the greater potential there is for the wind to interact with the water surface and generate waves. Since wind-generated waves originate from meteorological forcing, the wave regime is highly episodic and exhibits strong seasonal variation.

52. Using the data extracted from the four model inspection points, **Plate 6-20** and **Plate 6-21** present wave rose plots showing H_s (Significant Wave Height) \ T_z (Zero-Crossing Wave Period) \ T_p (Peak Wave Period) vs direction, respectively. The figures show that waves approach the offshore development area predominantly from the south. Further investigation of the wave regime across the offshore development area is available through the interrogation of **Plate 6-22**, **Plate 6-23** and **Plate 6-24**, which show frequency of occurrence tables with respect to H_s, \ T_z \ T_p and direction of wave approach, respectively, for each of the four model inspection points. These analyses indicate that the most frequently observed wave conditions in nearshore[1] areas were a wave height of less than 1 m, approaching the array site from the SSE and S quadrants. Offshore, wave approach is dominantly from the SSE, S and SSW quadrants. The coincident zero-crossing wave periods were dominantly less than 5 seconds and the peak wave periods were less than 9 seconds, indicating that predominantly waves are generated by local winds rather than ocean swell. The key statistics related to the wave regime are presented in **Table 6-12**.

1 In this context, nearshore is defined as those areas close to shore, where wave characteristics are modified as water depths shallow. Comparatively, offshore is defined as those areas where wave characteristics are not modified.

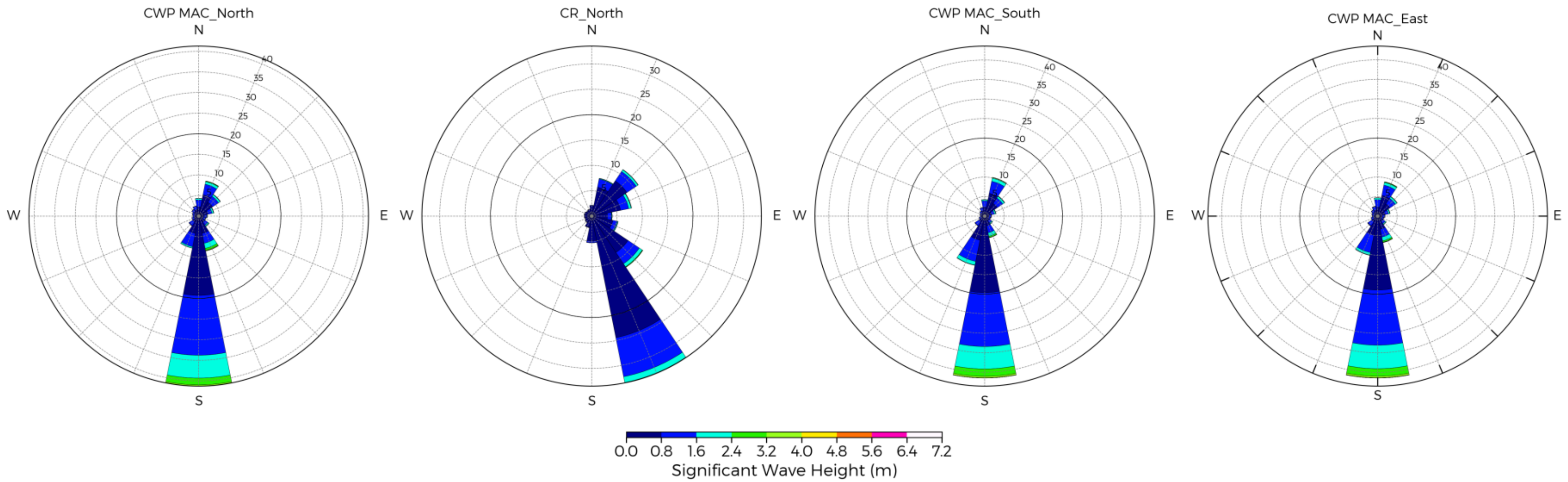


Plate 6-20 Wave rose plots showing H_s as a function of direction across the offshore development area. Data extracted from the modelled 20-year hindcast record for each model point.

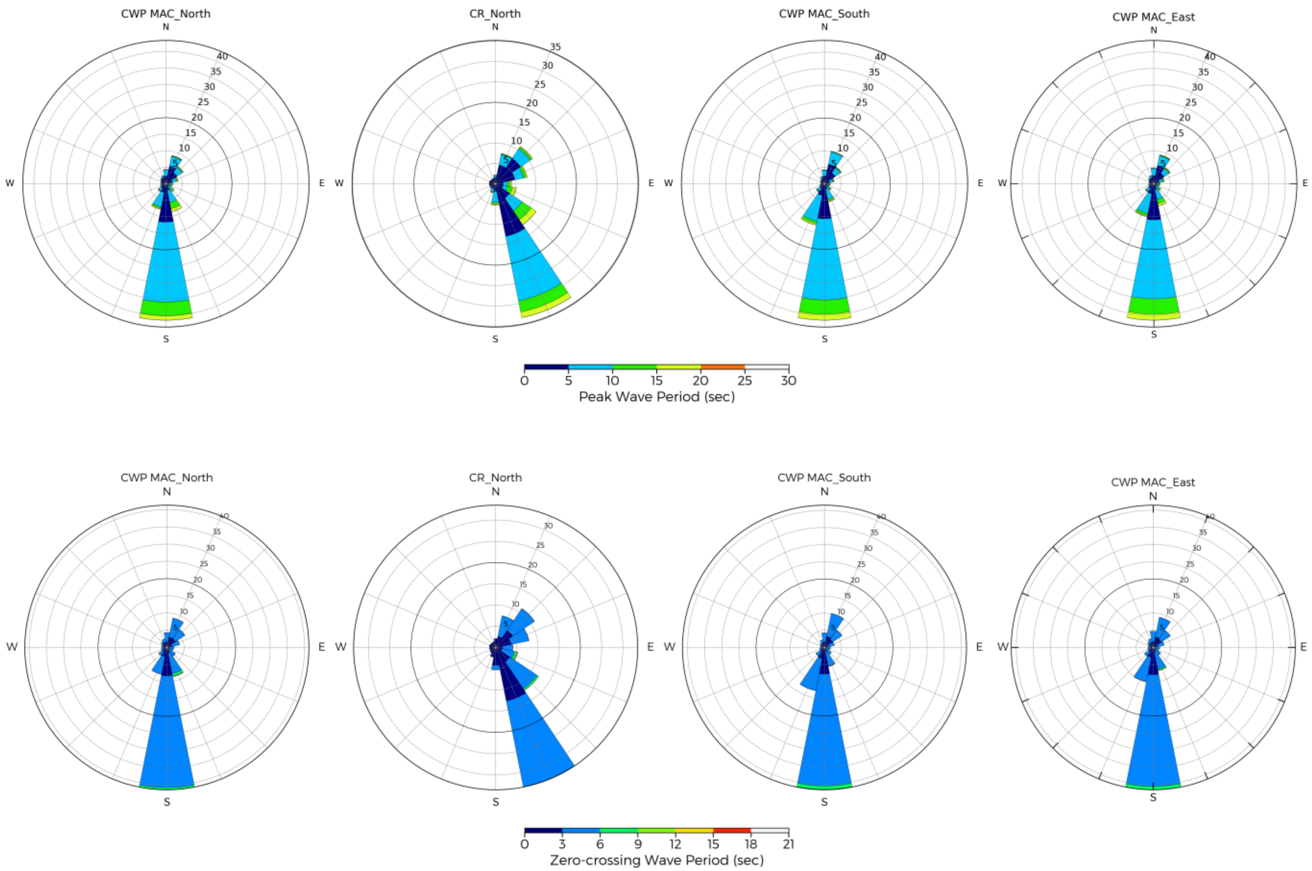


Plate 6-21 Wave rose plots showing T_p (upper panel) and the T_z (lower panel) a function of direction across the offshore development area. Data extracted from the modelled 20-year hindcast record for each model extraction point.

Hs vs Direction @ CR North

Significant Wave Height (Hs) [m]	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	
(5.0 , 6.0)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
(4.0 , 5.0)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
(3.0 , 4.0)	-	-	0.01%	0.02%	-	-	0.01%	-	-	-	-	-	-	-	-	-	0.04%
(2.0 , 3.0)	-	0.06%	0.14%	0.19%	0.05%	0.05%	0.34%	0.32%	-	-	-	-	-	-	-	-	1.15%
(1.0 , 2.0)	0.04%	0.97%	1.65%	1.31%	0.52%	0.65%	2.18%	5.35%	0.07%	0.01%	-	-	-	-	-	-	12.8%
(0.0 , 1.0)	2.07%	6.57%	9.24%	6.49%	3.46%	4.61%	9.59%	27.8%	5.19%	2.32%	1.56%	1.39%	1.49%	1.49%	1.3%	1.42%	86%
	2.12%	7.59%	11%	8.01%	4.03%	5.31%	12.1%	33.5%	5.26%	2.33%	1.57%	1.4%	1.49%	1.49%	1.3%	1.43%	100%

Direction

Hs vs Direction @ CWP MAC - North

Significant Wave Height (Hs) [m]	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	
(5.0 , 6.0)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
(4.0 , 5.0)	-	-	-	-	-	-	-	0.03%	0.03%	-	-	-	-	-	-	-	0.06%
(3.0 , 4.0)	-	0.05%	-	0.02%	-	-	0.01%	0.21%	0.47%	-	-	-	-	-	-	-	0.77%
(2.0 , 3.0)	0.09%	0.29%	0.19%	0.16%	0.04%	0.05%	0.16%	0.89%	3.39%	0.06%	0.01%	-	-	-	-	-	5.33%
(1.0 , 2.0)	1.35%	2.09%	1.48%	0.87%	0.4%	0.42%	0.77%	2.5%	13.6%	2.27%	0.66%	0.39%	0.24%	0.28%	0.36%	0.49%	28.1%
(0.0 , 1.0)	2.86%	6.26%	4.67%	2.7%	1.64%	1.35%	2.09%	4.99%	23.8%	5.58%	2.2%	1.32%	1.16%	1.33%	1.67%	2.06%	65.7%
	4.3%	8.69%	6.34%	3.76%	2.08%	1.82%	3.03%	8.62%	41.3%	7.91%	2.87%	1.71%	1.4%	1.61%	2.03%	2.56%	100%

Direction

Hs vs Direction @ CWP MAC - South

Significant Wave Height (Hs) [m]	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	
(5.0 , 6.0)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
(4.0 , 5.0)	-	-	-	-	-	-	-	0.01%	0.05%	-	-	-	-	-	-	-	0.06%
(3.0 , 4.0)	-	0.07%	0.01%	0.02%	-	-	-	0.1%	0.63%	-	-	-	-	-	-	-	0.83%
(2.0 , 3.0)	0.1%	0.36%	0.22%	0.14%	0.03%	0.05%	0.14%	0.63%	3.72%	0.24%	0.01%	-	-	-	-	-	5.64%
(1.0 , 2.0)	1.24%	2.58%	1.41%	0.7%	0.37%	0.35%	0.68%	1.82%	13.1%	4.34%	0.77%	0.3%	0.2%	0.22%	0.28%	0.45%	28.9%
(0.0 , 1.0)	2.89%	7.11%	4.54%	2.1%	1.37%	1.16%	1.63%	3.08%	23.9%	8.27%	2.26%	1.16%	0.96%	1.03%	1.28%	1.81%	64.6%
	4.23%	10.1%	6.18%	2.97%	1.77%	1.56%	2.45%	5.64%	41.5%	12.8%	3.04%	1.46%	1.16%	1.25%	1.56%	2.26%	100%

Direction

Hs vs Direction @ CWP MAC - East

Significant Wave Height (Hs) [m]	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	
(5.0 , 6.0)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
(4.0 , 5.0)	-	-	-	-	-	-	-	0.01%	0.06%	-	-	-	-	-	-	-	0.07%
(3.0 , 4.0)	-	0.06%	-	0.02%	-	-	-	0.12%	0.65%	-	-	-	-	-	-	-	0.86%
(2.0 , 3.0)	0.14%	0.31%	0.21%	0.14%	0.03%	0.05%	0.14%	0.69%	3.86%	0.14%	0.01%	-	-	-	-	0.01%	5.72%
(1.0 , 2.0)	1.57%	2.18%	1.4%	0.78%	0.39%	0.37%	0.72%	2.03%	13.6%	3.44%	0.83%	0.43%	0.28%	0.3%	0.41%	0.59%	29.3%
(0.0 , 1.0)	2.98%	6.4%	4.41%	2.3%	1.47%	1.22%	1.78%	4.04%	23.3%	6.65%	2.26%	1.29%	1.09%	1.23%	1.59%	2.01%	64%
	4.69%	8.95%	6.02%	3.25%	1.89%	1.65%	2.64%	6.89%	41.4%	10.2%	3.11%	1.73%	1.37%	1.54%	2%	2.61%	100%

Direction

Plate 6-22 Frequency of occurrence of H_s and direction. Data extracted from the modelled 20-year hindcast record for each model extraction point.

![codling wind park logo]

Tz vs Direction @ CR North

Zero-crossing Period (Tz) [s]	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	
(14.0 , 16.0)	-	-	-	-	-	0.01%	-	-	-	-	-	-	-	-	-	-	0.01%
(12.0 , 14.0)	-	-	-	-	0.01%	0.05%	-	-	-	-	-	-	-	-	-	-	0.05%
(10.0 , 12.0)	-	-	-	-	0.02%	0.15%	0.01%	-	-	-	-	-	-	-	-	-	0.18%
(8.0 , 10.0)	-	-	-	-	-	0.21%	0.08%	-	-	-	-	-	-	-	-	-	0.29%
(6.0 , 8.0)	-	-	-	-	0.02%	0.35%	0.39%	0.07%	-	-	-	-	-	-	-	-	0.83%
(4.0 , 6.0)	-	0.54%	1.09%	1.08%	0.55%	1.15%	3.55%	4.47%	-	-	-	-	-	-	-	-	12.4%
(2.0 , 4.0)	1.89%	6.97%	9.82%	6.78%	3.31%	3.26%	7.61%	28.3%	4.96%	1.88%	1.03%	0.78%	0.67%	0.69%	0.72%	1.03%	79.7%
(0.0 , 2.0)	0.22%	0.08%	0.13%	0.14%	0.12%	0.14%	0.49%	0.66%	0.29%	0.45%	0.54%	0.62%	0.81%	0.81%	0.58%	0.4%	6.48%
	2.12%	7.59%	11%	8.01%	4.04%	5.31%	12.1%	33.5%	5.26%	2.33%	1.57%	1.4%	1.49%	1.49%	1.3%	1.43%	100%

Tz vs Direction @ CWP MAC - North

Zero-crossing Period (Tz) [s]	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	
(14.0 , 16.0)	-	-	-	-	-	-	0.01%	-	-	-	-	-	-	-	-	-	0.01%
(12.0 , 14.0)	-	-	-	-	-	-	-	0.01%	-	-	-	-	-	-	-	-	0.01%
(10.0 , 12.0)	-	-	-	-	-	-	0.02%	0.04%	-	-	-	-	-	-	-	-	0.06%
(8.0 , 10.0)	-	-	-	-	-	-	0.01%	0.16%	0.01%	-	-	-	-	-	-	-	0.18%
(6.0 , 8.0)	-	-	-	-	-	-	0.03%	0.64%	0.6%	-	-	-	-	-	-	-	1.27%
(4.0 , 6.0)	0.39%	1.03%	0.71%	0.58%	0.22%	0.26%	0.74%	3.22%	15.8%	0.65%	0.06%	0.02%	0.01%	0.01%	-	0.02%	23.8%
(2.0 , 4.0)	3.85%	7.63%	5.53%	3.1%	1.82%	1.52%	2.16%	4.34%	24.4%	7.16%	2.72%	1.63%	1.33%	1.53%	1.95%	2.45%	73.1%
(0.0 , 2.0)	0.07%	0.04%	0.1%	0.07%	0.04%	0.04%	0.06%	0.2%	0.39%	0.11%	0.09%	0.06%	0.06%	0.06%	0.08%	0.09%	1.56%
	4.3%	8.69%	6.34%	3.76%	2.08%	1.82%	3.03%	8.62%	41.3%	7.91%	2.87%	1.71%	1.4%	1.61%	2.03%	2.56%	100%

Tz vs Direction @ CWP MAC - South

Zero-crossing Period (Tz) [s]	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	
(14.0 , 16.0)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
(12.0 , 14.0)	-	-	-	-	-	-	-	-	0.01%	-	-	-	-	-	-	-	0.01%
(10.0 , 12.0)	-	-	-	-	-	-	-	0.01%	0.04%	-	-	-	-	-	-	-	0.06%
(8.0 , 10.0)	-	-	-	-	-	-	-	-	0.15%	-	-	-	-	-	-	-	0.16%
(6.0 , 8.0)	-	-	-	-	-	-	-	0.04%	0.93%	0.01%	-	-	-	-	-	-	0.97%
(4.0 , 6.0)	0.38%	1.35%	0.77%	0.49%	0.19%	0.19%	0.48%	1.97%	17.1%	2.31%	0.07%	0.02%	0.01%	-	0.01%	0.02%	25.3%
(2.0 , 4.0)	3.8%	8.71%	5.3%	2.4%	1.54%	1.32%	1.93%	3.5%	22.9%	10.4%	2.89%	1.38%	1.1%	1.21%	1.49%	2.18%	72%
(0.0 , 2.0)	0.06%	0.06%	0.11%	0.08%	0.04%	0.04%	0.05%	0.12%	0.43%	0.14%	0.07%	0.06%	0.05%	0.04%	0.06%	0.06%	1.47%
	4.23%	10.1%	6.18%	2.97%	1.77%	1.56%	2.45%	5.64%	41.5%	12.8%	3.04%	1.46%	1.16%	1.25%	1.56%	2.26%	100%

Tz vs Direction @ CWP MAC - East

Zero-crossing Period (Tz) [s]	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	
(14.0 , 16.0)	-	-	-	-	-	-	-	0.01%	-	-	-	-	-	-	-	-	0.01%
(12.0 , 14.0)	-	-	-	-	-	-	-	0.01%	-	-	-	-	-	-	-	-	0.01%
(10.0 , 12.0)	-	-	-	-	-	-	-	0.07%	-	-	-	-	-	-	-	-	0.07%
(8.0 , 10.0)	-	-	-	-	-	-	-	0.12%	0.06%	-	-	-	-	-	-	-	0.18%
(6.0 , 8.0)	-	-	-	-	-	-	-	0.33%	0.94%	-	-	-	-	-	-	-	1.28%
(4.0 , 6.0)	0.52%	1.05%	0.7%	0.51%	0.2%	0.2%	0.55%	2.46%	16.7%	1.42%	0.1%	0.03%	0.02%	0.01%	0.01%	0.04%	24.6%
(2.0 , 4.0)	4.12%	7.85%	5.2%	2.66%	1.64%	1.41%	2.04%	3.75%	23.3%	8.68%	2.92%	1.64%	1.3%	1.48%	1.93%	2.5%	72.4%
(0.0 , 2.0)	0.05%	0.04%	0.11%	0.07%	0.04%	0.04%	0.05%	0.15%	0.4%	0.12%	0.09%	0.05%	0.05%	0.05%	0.06%	0.07%	1.45%
	4.69%	8.95%	6.02%	3.25%	1.89%	1.65%	2.64%	6.9%	41.4%	10.2%	3.11%	1.73%	1.37%	1.54%	2%	2.61%	100%

Plate 6-23 Frequency of occurrence of T_z and direction. Data extracted from the modelled 20-year hindcast record for each model extraction point.

Tp vs Direction @ CR North

Peak Period (Tp) [s]	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Total
(21.0, 24.0]	-	-	-	-	-	-	-	0.01%	-	-	-	-	-	-	-	-	0.02%
(18.0, 21.0]	0.01%	0.02%	0.04%	0.02%	0.04%	0.1%	0.17%	0.14%	0.03%	0.02%	0.02%	0.01%	0.01%	0.01%	0.01%	0.01%	0.66%
(15.0, 18.0]	0.07%	0.11%	0.22%	0.3%	0.34%	0.83%	1.34%	1.27%	0.27%	0.16%	0.08%	0.06%	0.05%	0.06%	0.06%	0.05%	5.3%
(12.0, 15.0]	0.05%	0.11%	0.31%	0.43%	0.57%	1.12%	1.76%	1.6%	0.2%	0.09%	0.05%	0.04%	0.03%	0.03%	0.04%	0.04%	6.47%
(9.0, 12.0]	0.03%	0.05%	0.13%	0.17%	0.18%	0.28%	1.28%	2.18%	0.32%	0.11%	0.07%	0.04%	0.03%	0.03%	0.02%	0.03%	4.95%
(6.0, 9.0]	0.08%	0.87%	0.98%	0.88%	0.34%	0.44%	1.82%	9.06%	1.36%	0.41%	0.15%	0.09%	0.07%	0.05%	0.04%	0.06%	16.7%
(3.0, 6.0]	1.67%	6.07%	8.44%	5.36%	2.18%	2.24%	4.73%	17.5%	2.78%	0.89%	0.3%	0.12%	0.08%	0.11%	0.18%	0.71%	53.4%
(0.0, 3.0]	0.22%	0.36%	0.91%	0.84%	0.39%	0.29%	1.01%	1.73%	0.28%	0.64%	0.9%	1.04%	1.21%	1.2%	0.93%	0.53%	12.5%
	2.12%	7.59%	11%	8.01%	4.04%	5.31%	12.1%	33.5%	5.26%	2.33%	1.57%	1.39%	1.48%	1.49%	1.3%	1.43%	100%

Tp vs Direction @ CWP MAC - North

Peak Period (Tp) [s]	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Total
(21.0, 24.0]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.01%
(18.0, 21.0]	0.01%	0.01%	0.02%	0.01%	0.01%	0.02%	0.03%	0.1%	0.13%	0.03%	0.01%	0.01%	0.01%	0.01%	-	-	0.41%
(15.0, 18.0]	0.03%	0.08%	0.13%	0.16%	0.14%	0.16%	0.25%	0.8%	1.26%	0.26%	0.09%	0.05%	0.04%	0.03%	0.03%	0.04%	3.54%
(12.0, 15.0]	0.05%	0.15%	0.23%	0.28%	0.25%	0.23%	0.37%	1.35%	1.98%	0.22%	0.07%	0.04%	0.03%	0.04%	0.04%	0.06%	5.38%
(9.0, 12.0]	0.03%	0.08%	0.11%	0.12%	0.12%	0.15%	0.26%	0.88%	4.44%	0.56%	0.14%	0.07%	0.03%	0.03%	0.02%	0.02%	7.07%
(6.0, 9.0]	0.66%	1.1%	0.66%	0.53%	0.22%	0.19%	0.49%	2.2%	14.1%	2.49%	0.52%	0.19%	0.11%	0.07%	0.07%	0.09%	23.6%
(3.0, 6.0]	3.3%	6.91%	4.72%	2.35%	1.22%	0.97%	1.45%	2.88%	18.1%	4.06%	1.62%	0.94%	0.81%	1.06%	1.51%	2.1%	54%
(0.0, 3.0]	0.21%	0.36%	0.47%	0.31%	0.12%	0.09%	0.18%	0.41%	1.29%	0.3%	0.43%	0.43%	0.37%	0.37%	0.35%	0.23%	5.93%
	4.3%	8.69%	6.34%	3.76%	2.08%	1.82%	3.03%	8.62%	41.3%	7.91%	2.87%	1.71%	1.4%	1.61%	2.03%	2.56%	100%

Tp vs Direction @ CWP MAC - South

Peak Period (Tp) [s]	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Total
(21.0, 24.0]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.02%
(18.0, 21.0]	0.01%	0.01%	0.01%	0.01%	0.01%	0.02%	0.03%	0.04%	0.24%	0.05%	0.02%	0.01%	0.01%	-	0.01%	0.01%	0.46%
(15.0, 18.0]	0.03%	0.09%	0.11%	0.13%	0.09%	0.1%	0.15%	0.26%	1.61%	0.43%	0.09%	0.06%	0.02%	0.03%	0.02%	0.04%	3.25%
(12.0, 15.0]	0.05%	0.13%	0.17%	0.16%	0.14%	0.14%	0.16%	0.42%	2.49%	0.37%	0.07%	0.04%	0.03%	0.02%	0.02%	0.03%	4.45%
(9.0, 12.0]	0.02%	0.09%	0.09%	0.08%	0.07%	0.09%	0.15%	0.35%	3.66%	0.81%	0.14%	0.05%	0.03%	0.02%	0.01%	0.03%	5.7%
(6.0, 9.0]	0.64%	1.42%	0.72%	0.44%	0.19%	0.18%	0.39%	1.81%	14.9%	4.54%	0.68%	0.2%	0.11%	0.08%	0.07%	0.1%	26.5%
(3.0, 6.0]	3.28%	8%	4.59%	1.87%	1.14%	0.94%	1.41%	2.49%	17.2%	6.28%	1.68%	0.78%	0.67%	0.85%	1.19%	1.89%	54.3%
(0.0, 3.0]	0.2%	0.38%	0.49%	0.27%	0.13%	0.09%	0.17%	0.27%	1.33%	0.36%	0.36%	0.33%	0.3%	0.25%	0.23%	0.17%	5.34%
	4.23%	10.1%	6.18%	2.97%	1.77%	1.56%	2.45%	5.64%	41.5%	12.8%	3.04%	1.46%	1.16%	1.25%	1.56%	2.26%	100%

Tp vs Direction @ CWP MAC - East

Peak Period (Tp) [s]	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Total
(21.0, 24.0]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.02%
(18.0, 21.0]	0.01%	0.02%	0.01%	0.01%	0.01%	0.02%	0.03%	0.1%	0.19%	0.04%	0.01%	0.01%	0.01%	-	-	0.01%	0.48%
(15.0, 18.0]	0.04%	0.11%	0.13%	0.16%	0.13%	0.14%	0.2%	0.64%	1.64%	0.34%	0.1%	0.05%	0.03%	0.03%	0.04%	0.04%	3.84%
(12.0, 15.0]	0.06%	0.16%	0.22%	0.25%	0.21%	0.19%	0.28%	1.04%	2.5%	0.34%	0.09%	0.04%	0.03%	0.04%	0.05%	0.05%	5.56%
(9.0, 12.0]	0.04%	0.08%	0.11%	0.1%	0.09%	0.11%	0.21%	0.48%	4.37%	0.74%	0.14%	0.08%	0.03%	0.03%	0.02%	0.02%	6.67%
(6.0, 9.0]	0.8%	1.07%	0.67%	0.49%	0.18%	0.17%	0.38%	1.84%	14.2%	3.46%	0.61%	0.21%	0.12%	0.08%	0.08%	0.11%	24.4%
(3.0, 6.0]	3.54%	7.12%	4.42%	1.99%	1.13%	0.94%	1.37%	2.49%	17.3%	5%	1.76%	0.98%	0.83%	1.06%	1.52%	2.16%	53.6%
(0.0, 3.0]	0.21%	0.38%	0.45%	0.25%	0.12%	0.08%	0.16%	0.3%	1.3%	0.31%	0.38%	0.36%	0.31%	0.3%	0.28%	0.22%	5.41%
	4.69%	8.95%	6.02%	3.25%	1.89%	1.65%	2.64%	6.9%	41.4%	10.2%	3.11%	1.73%	1.37%	1.54%	2%	2.61%	100%

Plate 6-24 Frequency of occurrence of T_p and direction. Data extracted from the modelled 20-year hindcast record for each model extraction point.

Table 6-12 A summary of the wave regime statistics across the offshore development area from the modelled 20-year hindcast record

	Statistic	H_s (m)	T_p (sec)	T_z (Sec)
CR North	Maximum	3.52	23.31	15.11
	Mean	0.55	6.25	3.15
	Minimum	0.00	0.00	0.88
	Standard deviation	0.45	3.88	0.99
CWP MAC East	Maximum	5.64	22.07	15.01
	Mean	0.91	6.48	3.53
	Minimum	0.00	0.00	0.90
	Standard deviation	0.64	3.43	0.96
CWP MAC North	Maximum	5.3	22.07	14.72
	Mean	0.88	6.39	3.51
	Minimum	0.00	0.00	0.90
	Standard deviation	0.63	3.38	0.96
CWP MAC South	Maximum	5.64	23.07	14.81
	Mean	0.90	6.31	3.53
	Minimum	0.00	0.00	1.01
	Standard deviation	0.64	3.22	0.92

53. In deep water, waves will move across the sea surface without major modification, but as they move into shallower water the orbital motion of the wave through the water column eventually reaches the seabed, whereupon frictional drag changes the shape of the wave. Refraction, shoaling (wave steepening) and eventually wave breaking will occur as the waves move progressively into shallower water and towards the shore. Several important modifications occur as waves begin to interact with the seabed. These include:

- Shoaling and refraction.
- Energy loss due to breaking.
- Energy loss due to bottom friction.
- Momentum and mass transport effects.

54. Inspection of the hindcast time series data reveal the impact of seabed bathymetry and coastline topography on the significant wave height and show how waves approaching the coastline from various directions are modified (dissipated). Offshore waves will reduce in height somewhere in the order of 40–50% by the time they reach inshore areas. In addition, the hindcast data indicates that the direction of wave approach has the potential to change by up to 120° as waves are modified by local bathymetry and coastal topography, however typically the direction of wave approach remains broadly the same. **Plate 6-25** shows a comparison of significant wave heights and wave direction broadly along the axis of wave approach between model inspection point CWP MAC South and CR North. **Plate 6-26** shows the results of the comparison between model points CWP MAC South vs CWP MAC North. At model point CR North (the Inshore point) the modal wave direction spectrum remains broadly the same due to the orientation of the coastline being parallel to the mean direction from which waves approach the site from the south. This results in nearer shore, significant wave heights being predicted to be lower, which is a function of water depth at the model inspection point location, but which is also postulated to be evidence that waves coming from the southerly quadrant have a reduced impact at the coastline apart from those waves whose direction is modified (**Plate 6-25**).

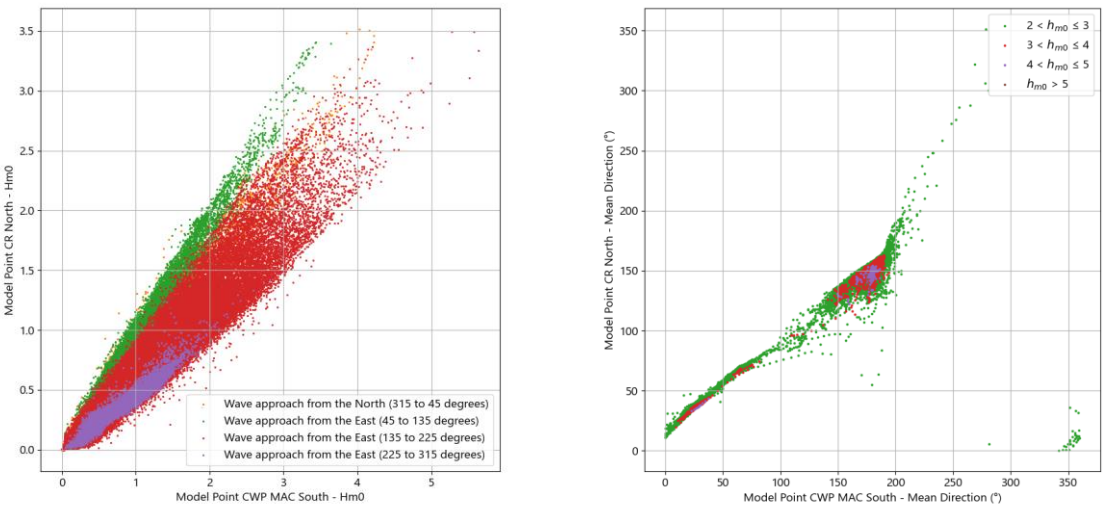


Plate 6-25 Modification of: (a) Significant wave height (H_s) from model point CWP MAC South to model point CR North for all offshore waves from the hindcast dataset (Left panel), (b) Wave approach from model point CWP MAC South to model point CR North for offshore waves from the directional sectors north, east, south and west (Right panel).

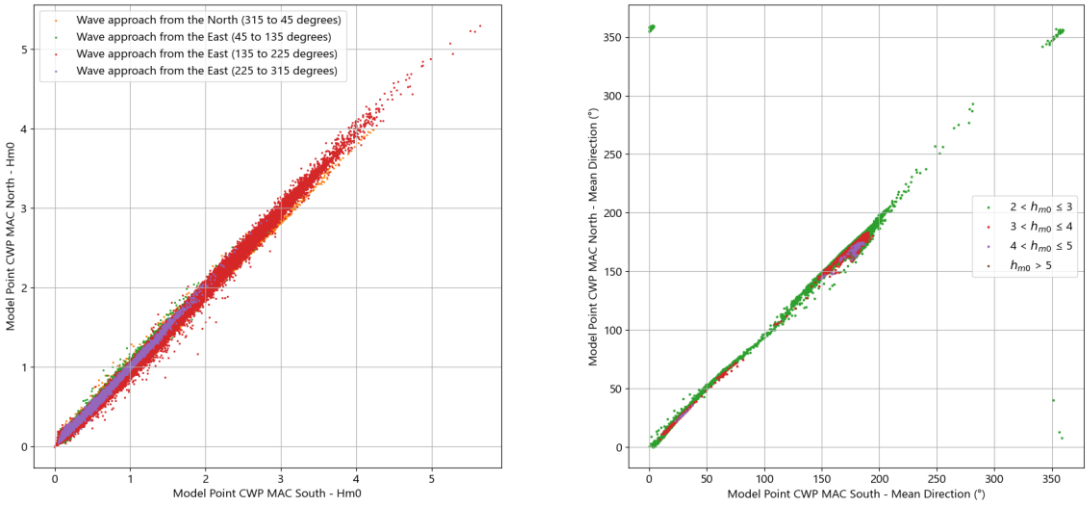


Plate 6-26 Modification of: (a) Significant wave height (Hs) from model point CWP MAC South to model point CWP MAC North for all offshore waves from the hindcast dataset (Left panel), (b) Wave approach from model point CWP MAC South to model point CWP MAC North for offshore waves from the directional sectors north, east, south and west (Right panel).

6.6.3 Solid Geology

55. The geological history of the Irish Sea dates to pre-Cambrian times, however, for present purposes it can most usefully be traced from the Devonian, Carboniferous and Permian periods in the late Palaeozoic period. The details of the formation of the Irish Sea basin through geological times is discussed in detail in Ziegler (1982) and Belderson (1964). The Irish Sea basin is thought to contain rocks from several geological systems, ranging from Precambrian schists and gneisses to Cretaceous chalk and Palaeogene basalts. These rock formations exist, or sub-crop, beneath a locally thick cover of Quaternary (<2.6 million years old) sediments. The properties of Quaternary sediment are highly variable laterally, and with depth, due to repeated fluctuations of ice sheet margins during the last glacial period, local to the offshore development area.

56. The 2013 and 2021 geophysical survey report of the offshore development area (Osiris Projects, 2013 and MMT, 2021) provides a detailed description of the local seabed geology. The bedrock at the southern end of the site consists of sandstones, siltstones, mudstones, and coals of Westphalian (carboniferous) age. Towards the north, these are expected to grade initially into sandstones of the Sherwood Sandstone Formation, and then into Triassic age bedrock (including: mudstones, siltstones and halites of the Mercia Mudstone Group). This bedrock is overlain mainly by stiff clay glacial deposits, with silt, sand, and gravels of Pleistocene age. These glacial deposits in turn are overlain by the more recent deposits comprising gravelly sands.

57. A seismic reflection survey was performed as part of the 2013 and 2021 survey. The results indicated that a layer of Holocene sediments persists across the array site, this layer is thickest where sandwaves have been observed, with an average thickness in these areas of *c*. 4.0 to 6.0 m. In areas where smaller bedforms (i.e., megaripples) are observed, the thickness of the Holocene layer is between 1.0 to 2.0 m. Comparatively, in areas of the seabed devoid of bedforms, the Holocene layer exists only as a veneer, with a thickness of less than 1 m. **Plate 6-27** below provides a schematic overview of the geological succession from north to south across the array site (Osiris Projects, 2013).

6.6.4 Surficial Sedimentology

58. Seabed sediment data across the region are available from several projects, including HabMap (Robinson et al., 2008) and the Southwest Irish Sea Survey [SWISS] (Wilson et al., 2001). The surficial sediments of the Irish Sea have also been mapped by British Geological Survey [BGS] (BGS, 2019) (**Figure 6-9**).

59. Across this region of the Irish Sea, the most common sediment type is sandy gravel (BGS, 2019). Pantin and Evans (1984) hypothesised that these sediments form a gravelly lag deposit which blankets the entire area except in places of exposed (underlying) relict Quaternary sediment or bare rock. Areas of gravel are also found to the north of Anglesey, offshore of St David's Head, and to the north of the offshore development area. These coarse deposits exist due to continuous reworking of the seabed sediments by tidal flows which act to winnow away finer materials. On top of these gravel areas, particularly on the shallower platforms, irregular patches of nominally mobile gravelly sands, sandy gravels and sands are found. These are commonly <0.3 m in thickness except in areas where they have coalesced into more extensive deposits and formed bedforms. Finally, a large area of sand containing flow transverse sandwaves is observed; from this area finer material has been winnowed away and transported north into the Western Irish Sea mud-belt, which is found within the depositional environments offshore of Dublin Bay, where flow velocities are reduced.

60. Seabed sediments within the planning application boundary are dominantly comprised of sand (>80% of the total area; Osiris Projects, 2013), with areas comprising a veneer of finer grained sands (<0.5 m thick) over a broad expanse of sandy gravels. Several isolated areas of boulders and cobbles were observed (**Figure 6-10**).

61. As part of the wider site investigation, geophysical survey and benthic seabed grab sampling campaigns were completed in 2021. An interpreted seabed sediments map for the CWP MAC application area, derived from the geophysical survey campaign conducted in 2013 and 2021, is presented in **Figure 6-11**. These survey datasets largely corroborate each other, indicating that the MAC application area is primarily composed of coarse-lag deposits (defined as areas where glacial sediments are reworked by wave and current processes resulting in the removal of the finer materials) made up of mainly gravelly Sands and / or sandy Gravels. The Particle Size Analysis (PSA) completed on 72 seabed grab samples acquired during the benthic survey campaign provide quantitative / qualitative data regarding the particle size distribution of surficial sediments. These data, which are presented as a spatial plot in **Figure 6-11**, indicate that across the investigated area, the seabed is dominantly composed of Gravel (more than 2 mm) with samples collected in the central parts of the CWP Project, along the Northern cable route, and closer to the coastline displaying a greater percentage of Sand (0.063–2.0 mm). These data compare favourably with the available data from the Marine Institute Ireland.

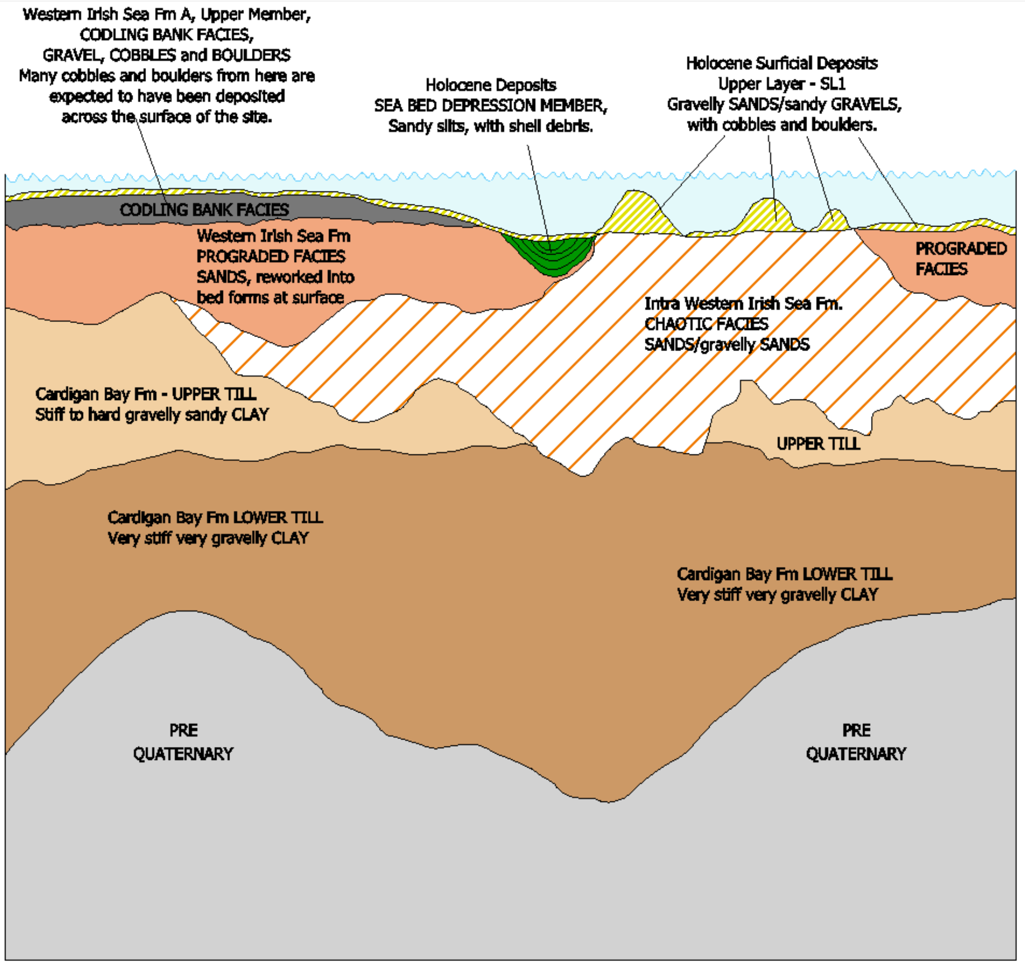
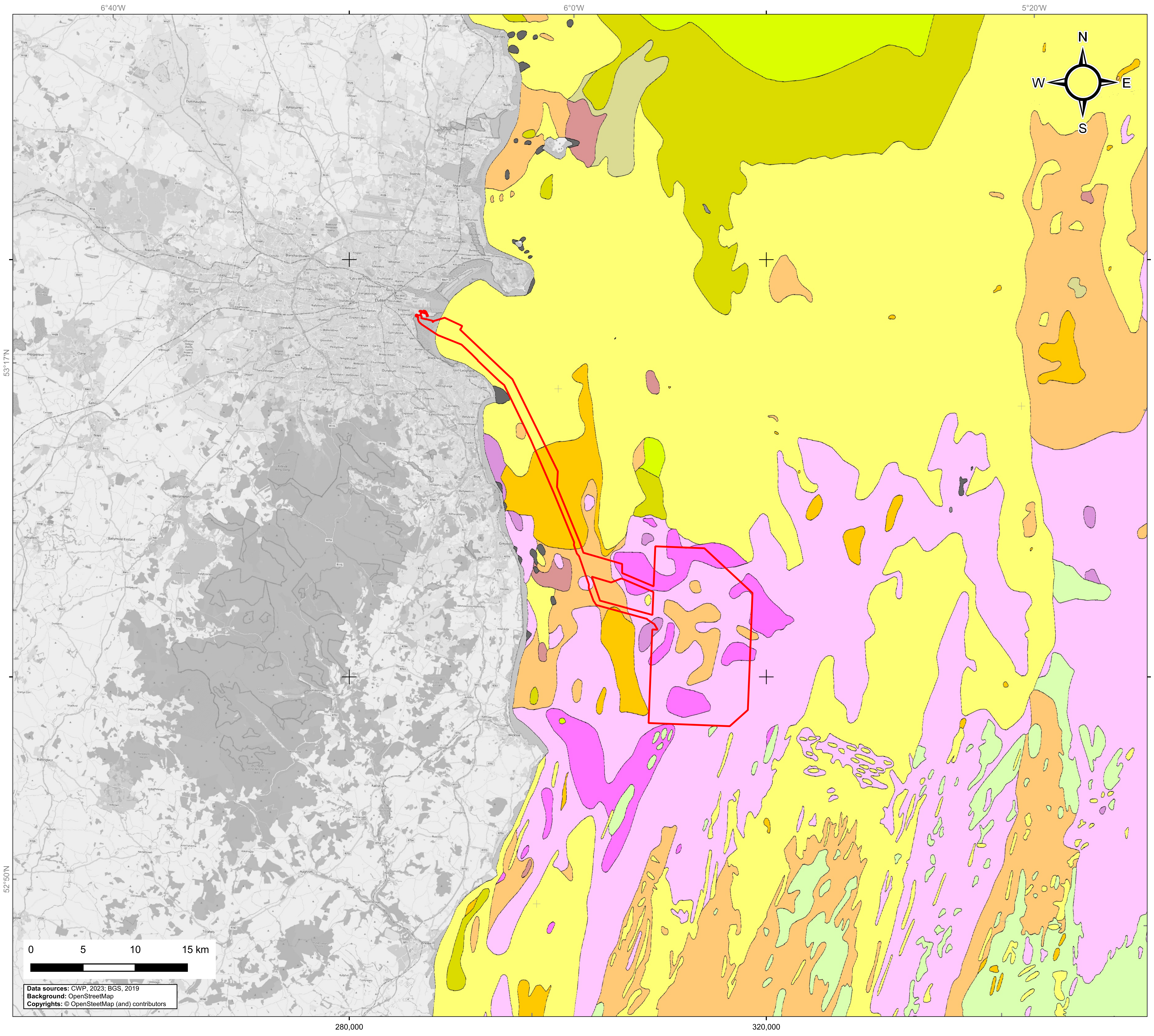
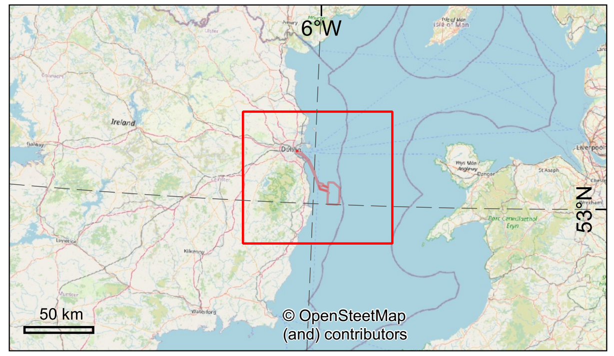


Plate 6-27 The interpreted geological succession across the CWP MAC application area. Figure reproduced from Osiris Projects (2013).



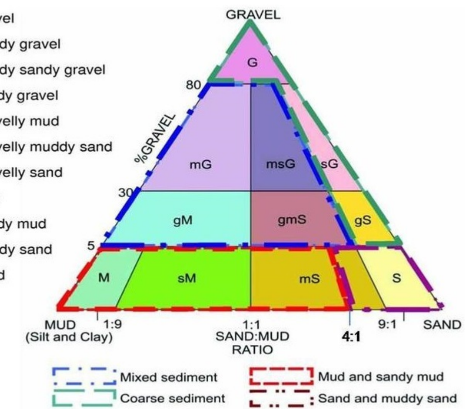


Legend

Planning application boundary

Surficial sediment distribution in the Irish sea, Classification according to FOLK triangle

- Gravel
- Muddy gravel
- Muddy sandy gravel
- Sandy gravel
- Gravelly mud
- Gravelly muddy sand
- Gravelly sand
- Mud
- Sandy mud
- Muddy sand
- Sand



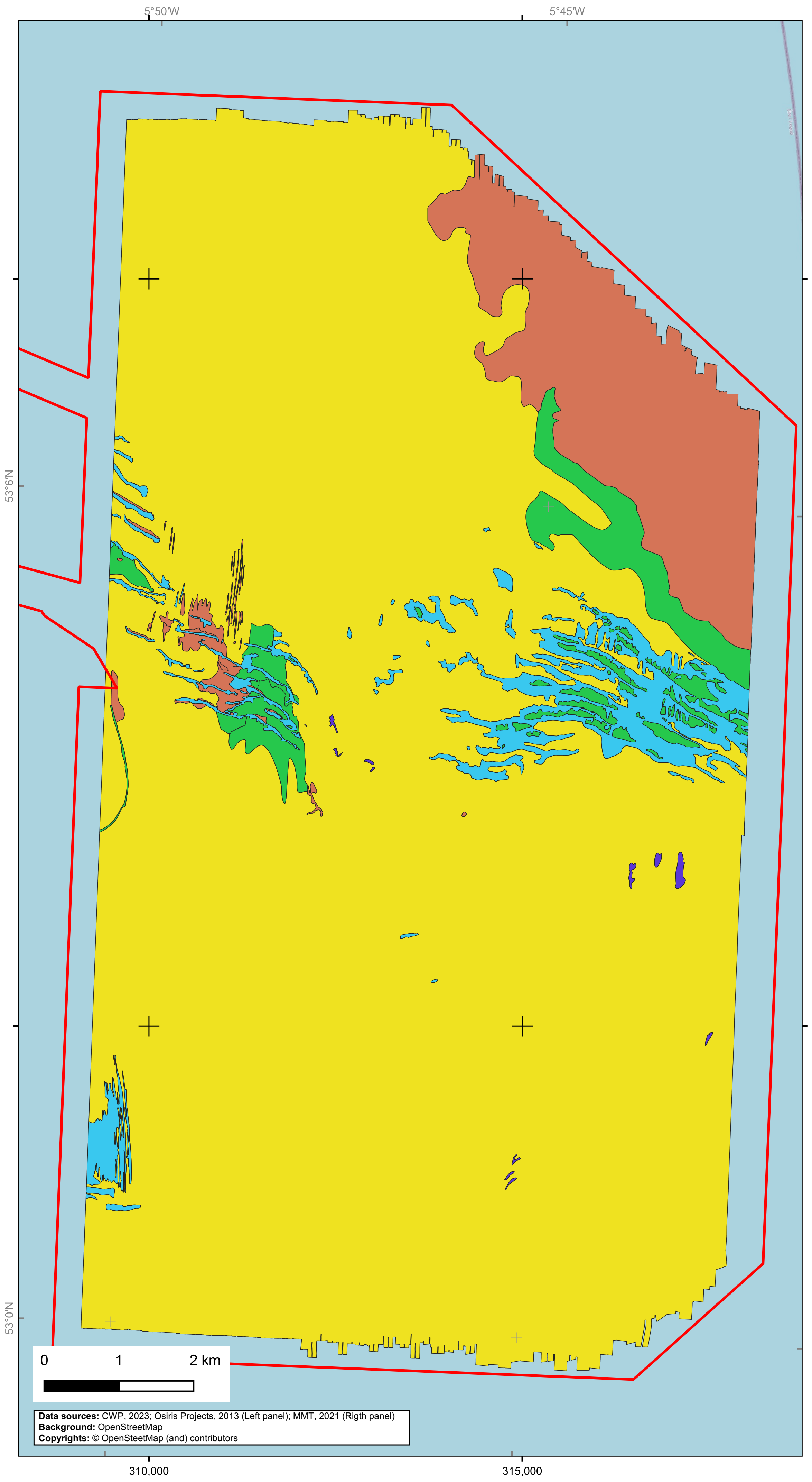
codling wind park	*Project:* Codling Wind Park	*Contractor:* Partrac.com	PARTRAC

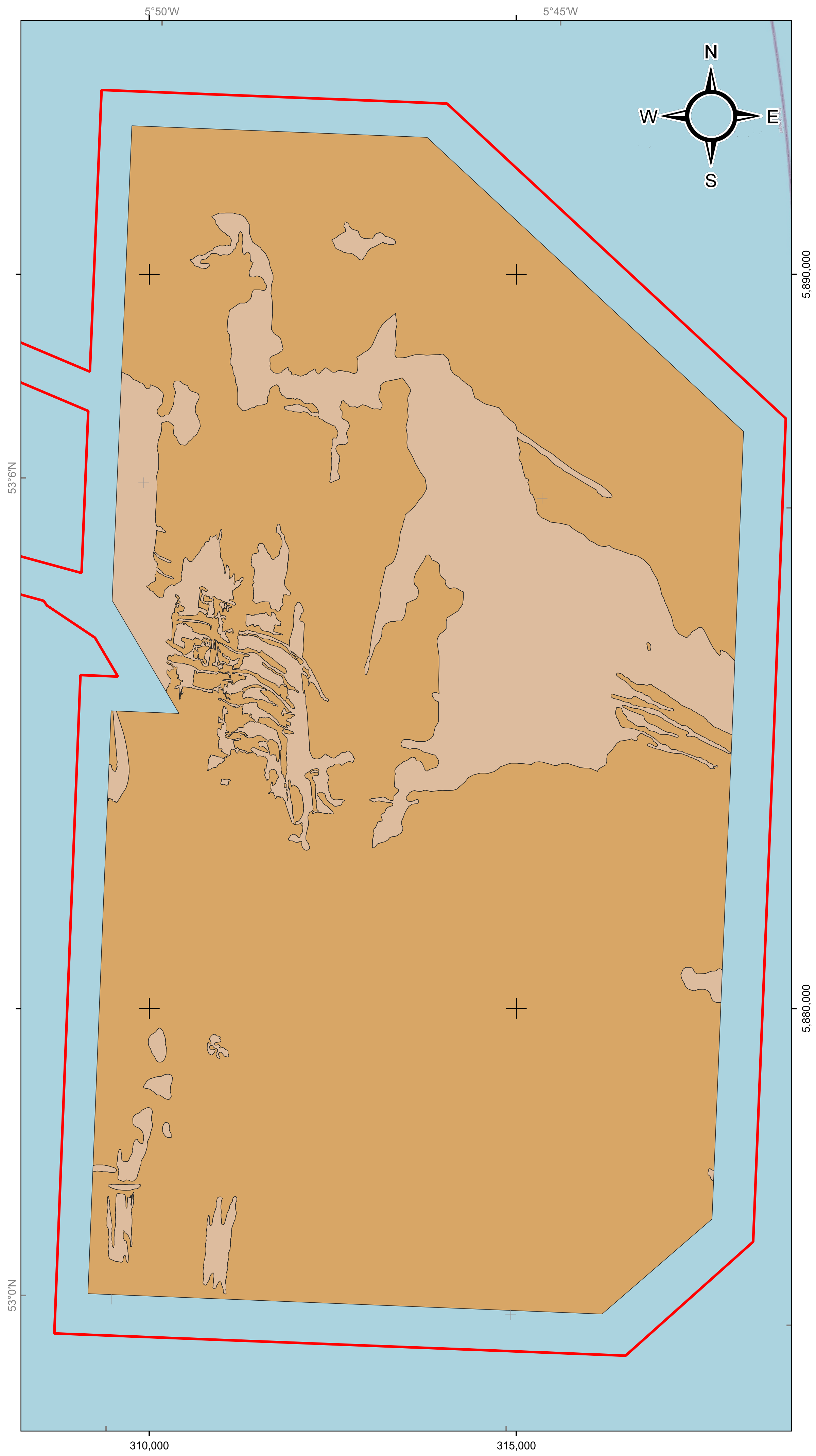
Figure 6.9
Surficial sediment distribution

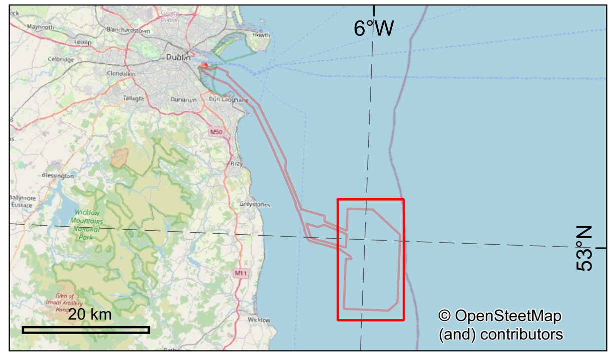
CWP doc. number: CWP-PAR-ENG-08-01-MAP-0893

Internal descriptive code: OFFSH.ALL - PAB..SURFICIAL SEDIMENTS. REGIONAL.BGS - EIAR.FIG.06.09	*Size:* A3 *Scale:* 1:350,000	*CRS:* EPSG 25830

Rev.	*Updates*	*Date*	*By*	*Chk'd*	*App'd*
00	Final for issue	2024/03/14	MG	JP/EA	JP/EA







Legend

- Planning application boundary

Seabed sediments (Left panel)

- Bed forms associated with coarser sediments
- GRAVEL - Sandy GRAVEL
- Gravelly SAND
- Patches of fine sediment - outcropping
- Veneer of SAND over sandy gravels

Seabed sediments (Right panel)

- Gravelly SAND supported coarse-lag sediments
- Sandy GRAVEL supported coarse-lag sediments

Project:	Contractor:
Codling Wind Park	Partrac.com

Figure 6.10
Seabed sediments at the Array site

CWP doc. number: CWP-PAR-ENG-08-01-MAP-0941

Internal descriptive code:	Size: A3	CRS:
WF - PAB..SURFICIAL.SEDIMENTS.LOCAL.OSIRIS.13.MMT.21 - EIAR.FIG.06.10	Scale: 1:70,000	EPSG 25830

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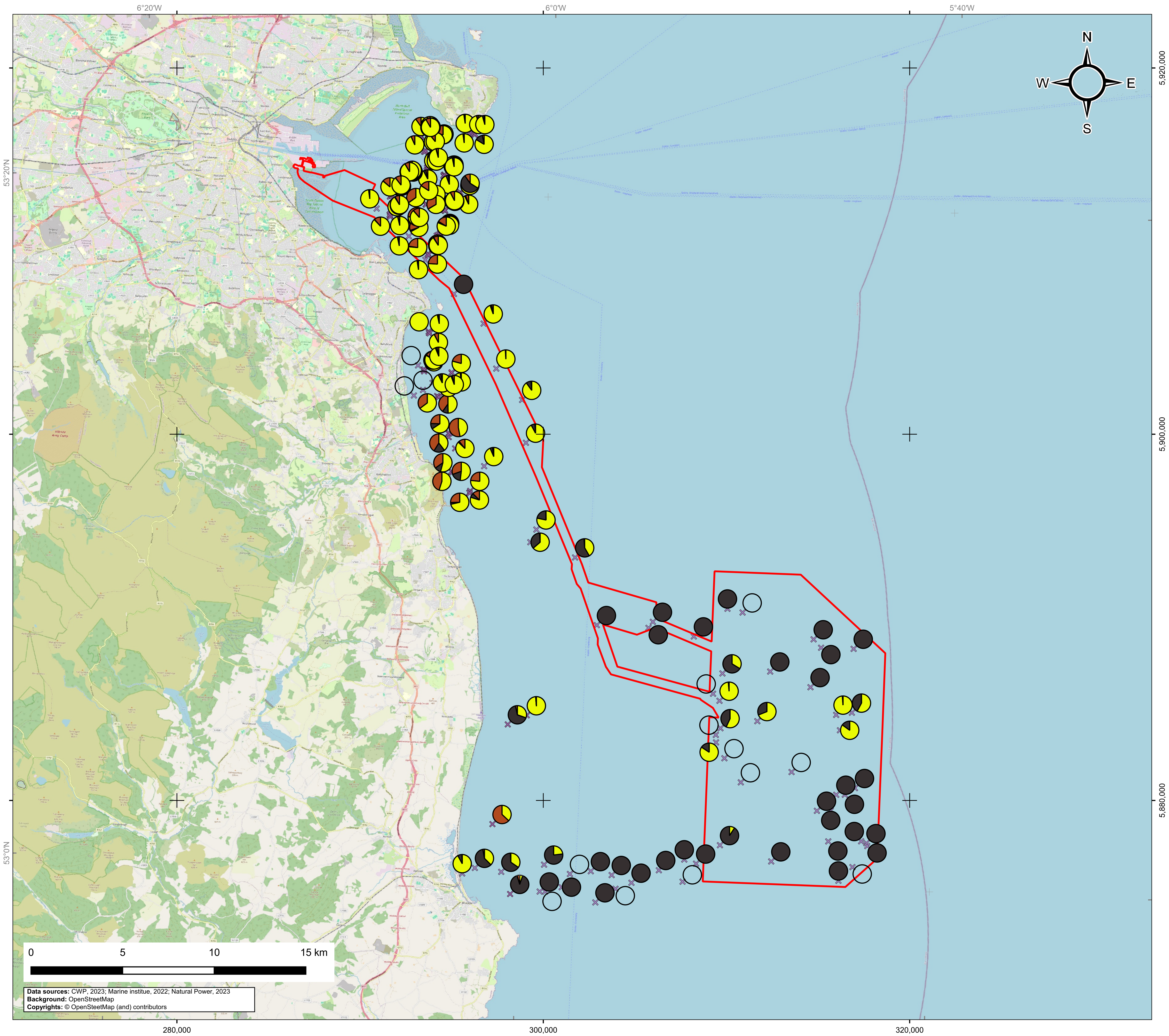
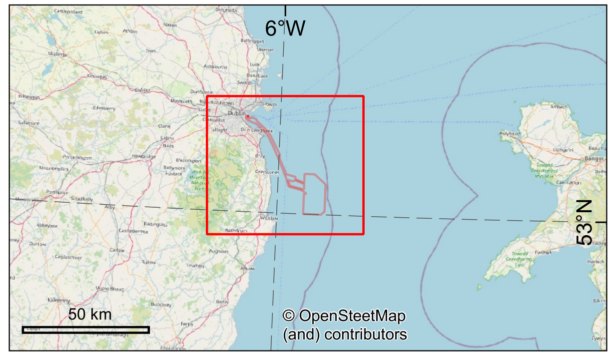
00	Final for issue	2024/03/14	MG	JP/EA	JP/EA





Legend

- Planning application boundary
- Surveyed locations. The associated pie charts represent the percentages of surficial particle sizes (hard ground is shown as an empty pie chart)
- Sand
- Gravel
- Mud

Project: Codling Wind Park

Contractor: Partrac.com

Figure 6.11
Surficial particle size at the Planning application area

CWP doc. number: CWP-PAR-ENG-08-01-MAP-0894

Internal descriptive code: WE - PAB..SURFICIAL.SEDIMENTS.LOCAL.MI..NP - EIAR.FIG.06.11

Size: A3

Scale: 1:200,000

CRS: EPSG 25830

Rev.	Updates	Date	By	Chk'd	App'd
00	Final for issue	2024/03/14	MG	JP/EA	JP/EA

6.6.5 Sediment Transport Regime

62. Seabed sediments are susceptible to resuspension by tidal currents and waves. Resuspension occurs when the frictional drag (the ‘bed stress’, t_0) exerted by currents and waves, separately (e.g., during summer months when waves are negligible) and in combination (e.g., during winter storms), exceeds the submerged weight of particles which act to retain particles on the bed. The stress at which sediment motion is first produced is called the ‘critical bed stress’, denoted t_{crit}. When $t_0 > t_{crit}$. sediments are mobilised, and for many coastal environments this is evident by an increase in the concentration of sediments in suspension. Sediments finer than ~0.2 mm are prone to being mobilised directly into suspension, those larger than 2 mm are usually transported as bedload and transport in this manner leads to the formation of bedforms, and for the intermediate sizes (and for mixed size sediments) the transport mode is commonly a combination of the two. The term [$t_0 > t_{crit}$] is defined as the ‘excess bed stress’, and lower values derived from this coefficient may be regarded as indicative of relatively low rates of sediment transport, likely evidenced by near bed sediment concentrations being only slightly above background, whereas larger values of excess stress can be considered to drive greater rates of sediment transport which would be indicated by significant elevation of suspended sediments within the water column.

63. Whereas tides exert a time varying bed stress on sediments associated with daily tidal and longer-term spring–neap variability, the superposition of waves on tides, namely during winter time periods, results in enhancement of the bed shear-stress acting on the seabed and surficial sediments. The boundary layers at the bed associated with waves and the current interact in a nonlinear fashion (i.e., the bed shear-stress acting on the bed due to the combination of waves and current is enhanced beyond the value which would result from a linear addition of the bed shear-stress due to waves, and the bed shear-stress due to current), and this has the effect of enhancing both the mean and oscillatory bed shear-stresses. Thus, when waves occur concurrently with peak tidal currents, the consequent bed stress can be a powerful driver of sediment transport.

Sediment Transport Regime at the Regional Scale

64. Codling Bank is one of the largest offshore banks in the Irish Sea. Codling Bank does not exist in isolation but rather forms part of a series of coast-parallel, north–south trending, offshore banks. These banks are generally about 10 km offshore, typically stand in 20 to 40 m depth of water and rise to within a few metres of the water surface. The banks form a punctuated line along the eastern Irish coast, and from north to south include Bennet, Kish, Frazer, Bray, India, Arklow, Glassgorman, Rusk, Blackwater / Moneyweights, Lucifer, Long and Holdens banks.

65. The location of sandbanks on continental shelves depends on the presence of tidal (or other) currents capable of moving sand and the availability, or supply, of sand. Dyer and Huntley (1999) state that most sandbanks on the European continental shelf (and elsewhere) appear to have been created during the post-glacial rise in sea level; they are features resulting from glacial action and retreat. The banks along the eastern Irish coast are of Holocene age, and the source of the bank material is from erosion and reworking of local fluvio-glacial and glacial deposits during the marine transgression during the last ice retreat. Wheeler et al. (2001) estimates stranding of the banks by rising sea levels around 5,000 BP, and bathymetric comparisons published by Wheeler et al. (2001) suggest that these banks are quasi-stable over time, broadly maintaining their position due to the interaction of the prevailing regimes; a conclusion which is contested by Coughlan et al. (2021). Uniquely within the context of these banks, Codling Bank is a stable formation which consists of glacial outwash sand and gravel moraine sediments deposited during the last ice age. The stability of Codling Bank was confirmed by Coughlan et al. (2021), who concluded that Codling Bank displayed sediment mobilisation frequency values for current and wave action which were very low (less than 1% and less than 5% per annum respectively). The lower mobilisation frequency for Codling Bank can be explained by the fact that the seabed substrate in the area is coarser (sandy gravel to gravel) than at other banks (e.g., Arklow, Bray or Kish Bank), resulting in a higher threshold for sediment mobilisation due to higher D50 values.

66. It is important to understand sediment transport pathways at the regional scale to characterise the rate and magnitude of sediment supply to the offshore development area. The regional sediment transport regime is broadly controlled by the area of divergence in the sediment transport pathway at the so-called St George's Channel Bedload Parting Zone (BPZ) to the north of the bank, which extends eastwards across the Irish Sea between approximately south of Dublin on the eastern Irish Coast and Anglesey in North Wales. Divergent zones are found at several locations around the British coast, where complex tidal interactions give rise to an area of enhanced bed shear stress (see Harris et al., 1995). In terms of judging regional sediment transport pathways, consideration must be given to the presence of the BPZ. Predominant regional sediment transport pathways and the approximate location of these BPZs are reported by several authors (e.g., Holmes and Tappin, 2005; Kenyon and Cooper, 2005; Van Landeghem et al., 2009 and 2012). The regional bedload transport pathways in the form of a schematic diagram are presented in **Plate 6-28**.

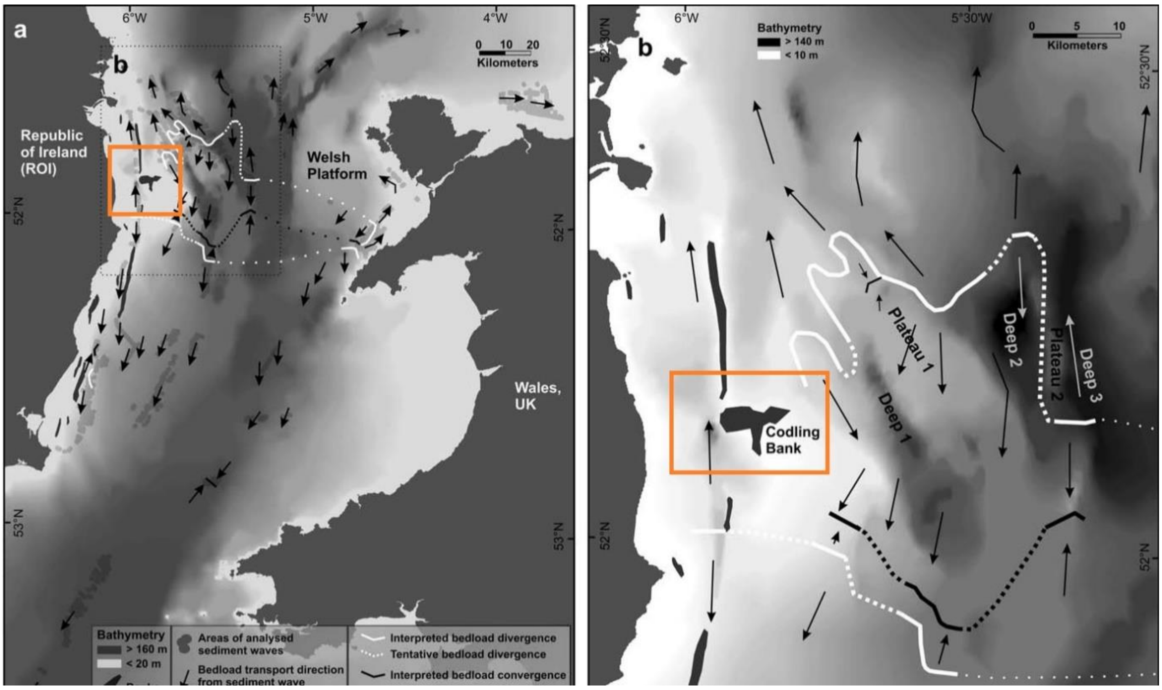


Plate 6-28 The regional bedload transport pathways in the Irish Sea (left) and a zoomed in image of the Bedload Parting Zone near the offshore development area. Image reproduced from Van Landeghem et al. (2009). For reference the array site is bounded in orange.

67. Within the Irish Sea, tidal flows interact with, and on occasion mobilise, unconsolidated seabed sediments, which are then entrained and transported by the flows, as long as the threshold for transportation is maintained. Where a flat seabed persists, comprised of (potentially) mobile sediments and impacted by flows which exceed the threshold of motion, the seabed may deform generating various types of bedforms, ranging in size from small ripples up to major sandbanks (depending on the composition of the seabed and supply of mobile sediment). In the Irish Sea many bedform types are observed (Mellet et al., 2015), and generally the region can be considered highly dynamic in terms of sediment transport. The various types of bedforms which exist, their typical migration speeds and the broader seabed morphology are indicative of complex interactions between tidal flows, seabed sediments and seabed features across the region (McCarron et al., 2019; Van Landeghem et al., 2009 and 2012).

68. Across the region, bedforms show a high degree of variability in regard to their size, shape and groupings on the seabed. The rate of migration of these bedforms (which usefully can be considered a proxy rate of sand supply to the region local to the offshore development area) is complex to determine over extended spatial scales, being a function of the local flow regime, water depth and seabed sediment characteristics. Van Landeghem et al. (2012) reports rates of up to 30 m per year (note: the maximum rate of migration was observed in the enclosed area in the vicinity of Codling Deep to the west of India Bank and on the shallow seabed to the west of Arklow Bank), with a mean rate of migration of *c.* 6 m per year occurring across the region (Mellett et al., 2015). This suggests that post-glacial features, such as the narrow basin and the fault between Codling Deep and Wicklow Trough, act to enhance flow velocity and thus enhance the rate of sediment transport. Interestingly, it was revealed migration rates were relatively consistent, suggesting bedforms, on a regional scale, migrate broadly in one direction and at a fairly constant rate, however, inspection of the migration pathways of individual bedforms reveals some irregular patterns, with either a higher rate of migration observed or a reversal in the direction of migration. The average migration rate of sandwaves within the Irish Sea is presented in **Plate 6-29**; this rate forms a useful proxy for the bedload transport rate across the region.

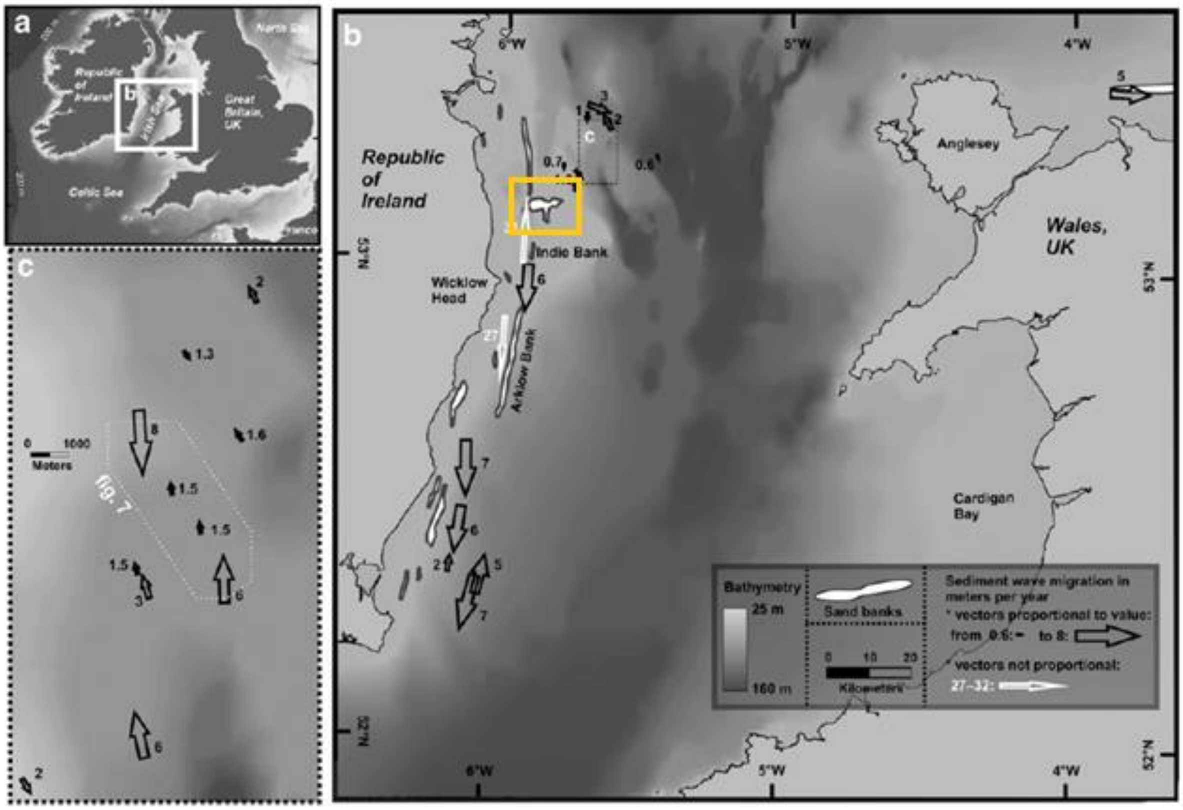


Plate 6-29 Average net sandwave migration rates per year calculated from repeated high resolution bathymetric data. Image reproduced from Van Landeghem et al. (2012). For reference the CWP offshore development area is bounded in orange.

Sediment Mobility Across the Offshore Development Area

69. The primary questions that arise in relation to characterising the baseline sediment transport regime across the offshore development area include:

- Are the tidal currents alone sufficient to generate sediment transport?
- If so, what is the percentage of time that flow conditions exist which are sufficiently powerful to generate transport?
- Are there differences in expected magnitude of transport rates across the site in relation to differing sediment types?
- Is the wave climate sufficient to generate sediment transport?
- If so, what are the critical wave heights and / or periods which do so, and thus is transport enhanced seasonally?
- What is the percentage of time that wave conditions exist which are sufficiently powerful to mobilise sediment?
- How do wave and tide currents combine to generate sediment transport, and how important is this?

70. To seek answers to the questions posed and assess the sediment mobility potential[2] of seabed sediments across the offshore development area, the critical threshold for sediment mobilisation due to currents (U_{cr}[3]) was determined for sediments ranging in size from clays through to fine gravel. Comparison of these thresholds for the individual sediment size classes against the modelled current velocities enables direct assessment of whether the prevailing current regime within the offshore development area is likely to mobilise these sized sediments. These analyses are presented in the form of time series in **Plate 6-30**. The percentage time where U_{cr} for each sediment class is exceeded is presented in **Table 6-13**. These data reveal a highly active sediment transport regime, with data retrieved from model inspection points CWP MAC East, CWP MAC South and CWP MAC North indicating currents that are acting upon the seabed are sufficient to mobilise finer sediment fractions up to very coarse sand (i.e., d_{100} less than 1 mm) *c*. 50% of the time. The currents observed across the offshore development area are rarely able to mobilise coarser sediment fractions (i.e., d_{100} of more than 1 mm).

2 These sediment size fractions (and the threshold mobility criteria, U_{cr}) do not accurately represent the sediment transport regime occurring across the array site, rather the analysis provides an indication of the mobility potential of sediments across the site. These analyses do not account for processes occurring at the bed, such as compaction and / or armouring of the bed, which act to reduce the mobility potential of seabed sediments and the dominantly mixed seabed composition. However, this approach enables a nominal but quantitative assessment of the mobility of various grain size fractions on the seabed under the forcing applied by local flow conditions. These data, considered with other available lines of evidence and within the context of its limitations, provides a useful tool by which to assess the mobility potential of an area of interest on the seabed.

3 U_{cr} was computed using the coefficients presented by Soulsby (1997).

Plate 6-30 Sediment mobility threshold depth-averaged current speeds compared against the depth-averaged modelled current speeds extracted from the 4 model inspection points. Each of the time series plotted displays the year for which the maximum current speed was observed for each point.

Table 6-13 Grain size information and shear stress thresholds applied as part of the stress exceedance analysis. Note: when comparing relative mobility between sites this is principally a function of water depth.

Location	Sediment type	Particle Size (mm) (d_{100})	Water Level (mMSL)	Threshold depth-averaged current speed required to mobilise entire sediment fraction (m/sec)	Total % time threshold exceeded (due to currents only)
CWP MAC East	Clay	0.004	14.62	0.250	87.17
	Coarse Silt	0.065	14.62	0.443	71.85
	Very fine sand	0.125	14.62	0.452	71.09
	Very coarse sand	1.000	14.62	0.596	58.11
	Small gravel	4.000	14.62	1.223	0.090
CWP MAC North	Clay	0.004	8.240	0.230	81.78
	Coarse Silt	0.065	8.240	0.408	63.79
	Very fine sand	0.125	8.240	0.417	62.76
	Very coarse sand	1.000	8.240	0.549	44.99
	Small gravel	4.000	8.240	1.127	0.00
CWP MAC South	Clay	0.004	16.12	0.253	87.69
	Coarse Silt	0.065	16.12	0.449	75.22
	Very fine sand	0.125	16.12	0.459	74.55
	Very coarse sand	1.000	16.12	0.604	64.12
	Small gravel	4.000	16.12	1.240	2.27
CR North	Clay	0.004	21.93	0.265	71.77
	Coarse Silt	0.065	21.93	0.469	43.09
	Very fine sand	0.125	21.93	0.479	41.42
	Very coarse sand	1.000	21.93	0.631	16.5
	Small gravel	4.000	21.93	1.296	0.00

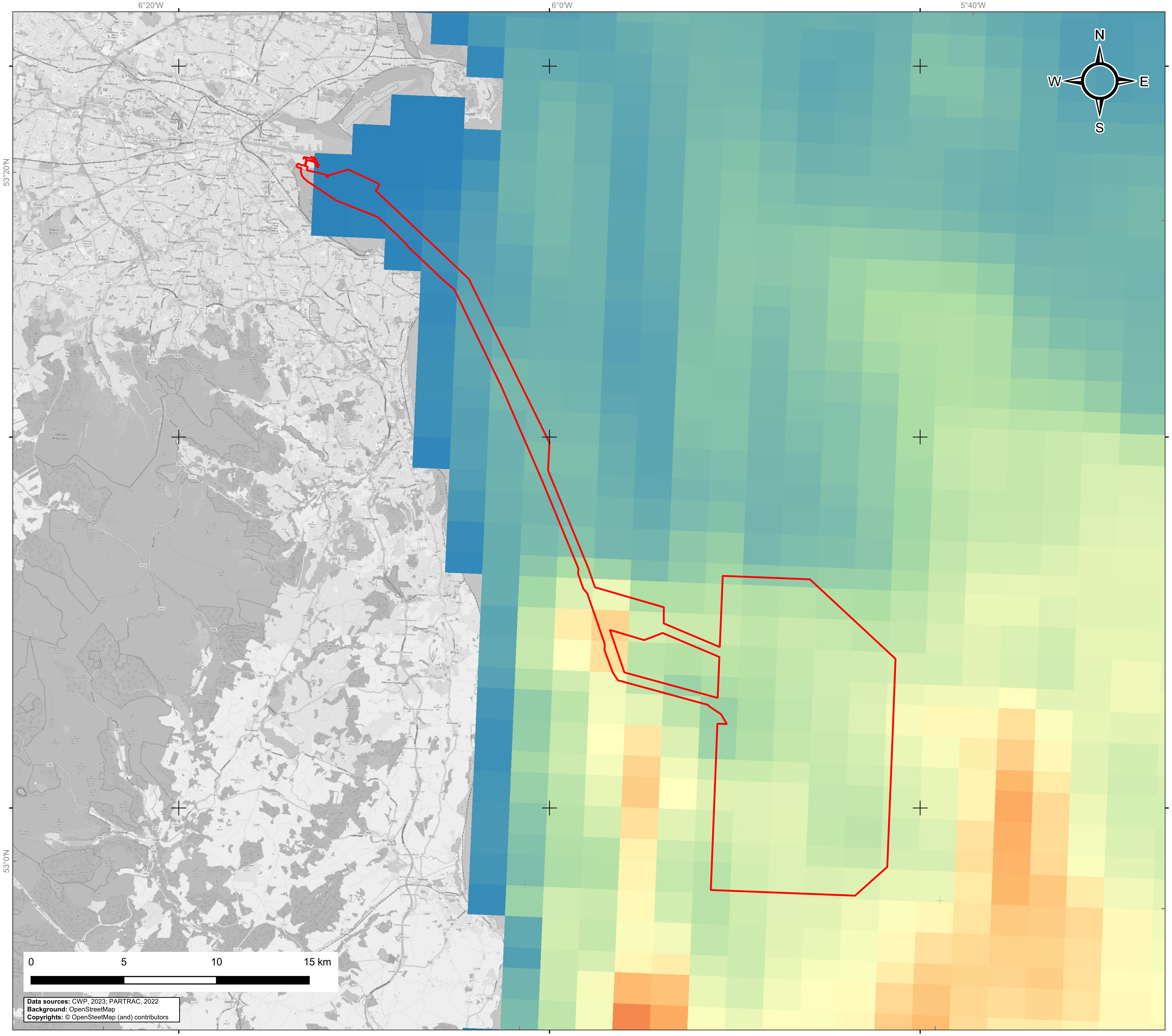
71. Wave-driven sediment transport processes are a function of the wave approach, wave height and (crucially) wave period. Whereas the energy of a wave is proportional to height, the period of the wave determines the depth of influence of wave energy. From consideration of the characteristics at each of the model inspection points it is possible to determine whether the waves will ‘feel’ the seabed at each location. Waves produce an oscillatory velocity in the water column. Whether the seabed ‘feels’ this flow therefore depends on the ratio of the water depth to wave height, and period. Wave energy will penetrate to the seabed where $H < 10 H_s$, where H is the water depth and H_s is significant wave height (Soulsby, 1997).

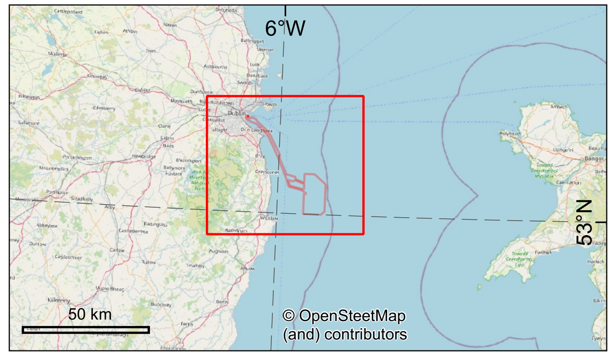
72. In the ensuing analyses this criterion has been used to determine the limiting significant wave height above which wave energy is expected to penetrate to the seafloor at each of the model inspection points (**Table 6-14**). These analyses indicate that shallower regions of the array site (i.e., the northern region) are susceptible to sediment mobilisation due to wave action, as can be postulated from the results obtained for model point CWP MAC North, where the limiting H_s for wave action at the seabed is exceeded *c*. 45% of the time. Deeper regions of the array site, however, are relatively less prone to such mobility as is evident at model points CWP MAC East and CWP MAC South, where the threshold for mobility was exceeded only *c*. 17% and *c*. 13% of the time, respectively. It is noteworthy that further inshore, despite shallowing water depth, waves exceed the H_s threshold for interaction with the seabed less frequently than for areas offshore; this is due to the wave modification effects in the nearshore regions (discussed in **Section Local Oceanographic Regime**). The seabed near model point CR North is rarely (less than 1% of the time) exposed to waves that are expected to impact the seabed, which is a function of the deeper water observed at this location.

Table 6-14 The limiting significant wave height required for waves to feel the seabed at the locations of model points. The percentage of time waves which exceed these limiting thresholds are detailed.

Model Point	Water depth (mMSL)	H_s where waves 'feel' the seafloor based upon Soulsby criterion (m)	Exceedance (%)
CWP MAC East	14.62	1.462	17.32
CWP MAC North	8.24	0.824	44.69
CWP MAC South	16.12	1.612	13.09
CR North	21.93	2.193	0.705

73. The shear stress acting on the seabed due to currents and waves varies spatially. To demonstrate this, **Figure 6-12** to **Figure 6-18** show the maximum bed shear stress impacting the seabed during different metocean conditions ranging from current only scenarios (**Figure 6-12** to **Figure 6-15**) to current and wave scenarios (**Figure 6-16** to **Figure 6-18**). The figures allow for the appreciation of the spatial variability of the shear stress impacting the seabed and reflects the shear stress dependency on water depths as stronger shear stresses are coincident with the shallowest areas of the offshore development area and vice versa. The maximum bed shear stresses across the offshore development area are observed during the peak spring ebb tide (**Figure 6-12**). The bed shear stresses predicted to occur during the worst storm conditions within the hindcast data record (shown in **Figure 6-16**) are marginally lower than the stresses observed during the peak spring tides, which indicates that currents form the primary driver of sediment transport across the offshore development area.





Legend

Planning application boundary

Shear stress (N/m²)

- 0.0000
- 0.0125
- 0.0250
- 0.0375
- 0.0500

codling wind park

Project: Codling Wind Park

Contractor: Partrac.com

Figure 6.12
Peak spring ebb tide seabed shear stress

CWP doc. number: CWP-PAR-ENG-08-01-MAP-0895

Internal descriptive code: WE - PAB. BED.SHEAR.STRESS.PSET - EIAR.FIG.06.12

Size: A3 | *Scale:* 1:200,000 | *CRS:* EPSG 25830

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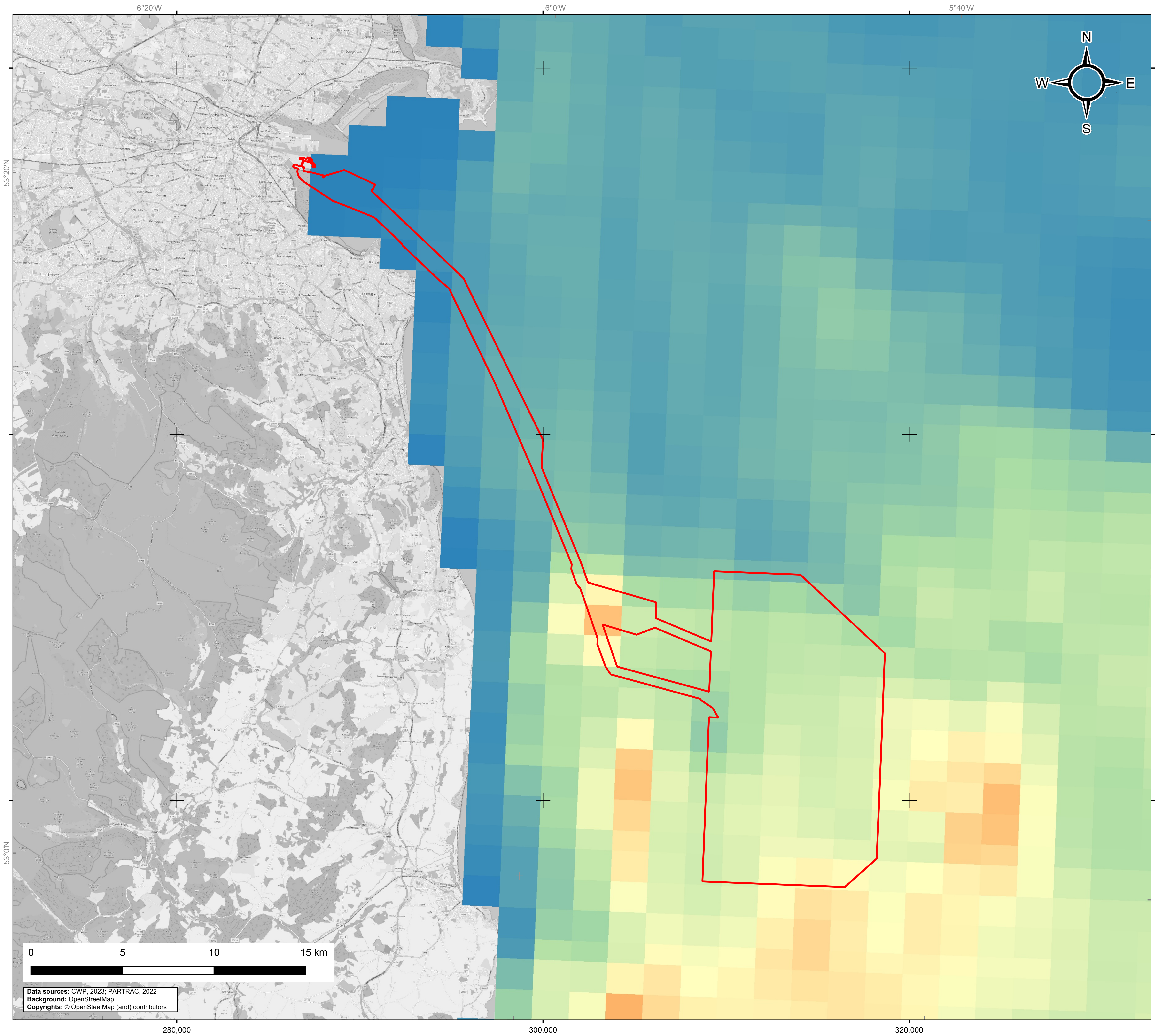

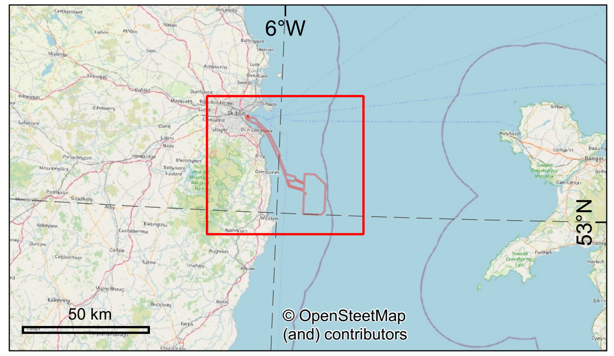

Legend

Planning application boundary

Shear stress (N/m²)

- 0.0000
- 0.0125
- 0.0250
- 0.0375
- 0.0500

codling wind park	*Project:* Codling Wind Park	*Contractor:* Partrac.com PARTRAC

Figure 6.13
Peak spring flood tide seabed shear stress

CWP doc. number: CWP-PAR-ENG-08-01-MAP-0896

Internal descriptive code:	*Size:* A3	*CRS:*
WE - PAB. BED.SHEAR.STRESS.PSFT - EIAR.FIG.06.13	*Scale:* 1:200,000	EPSG 25830

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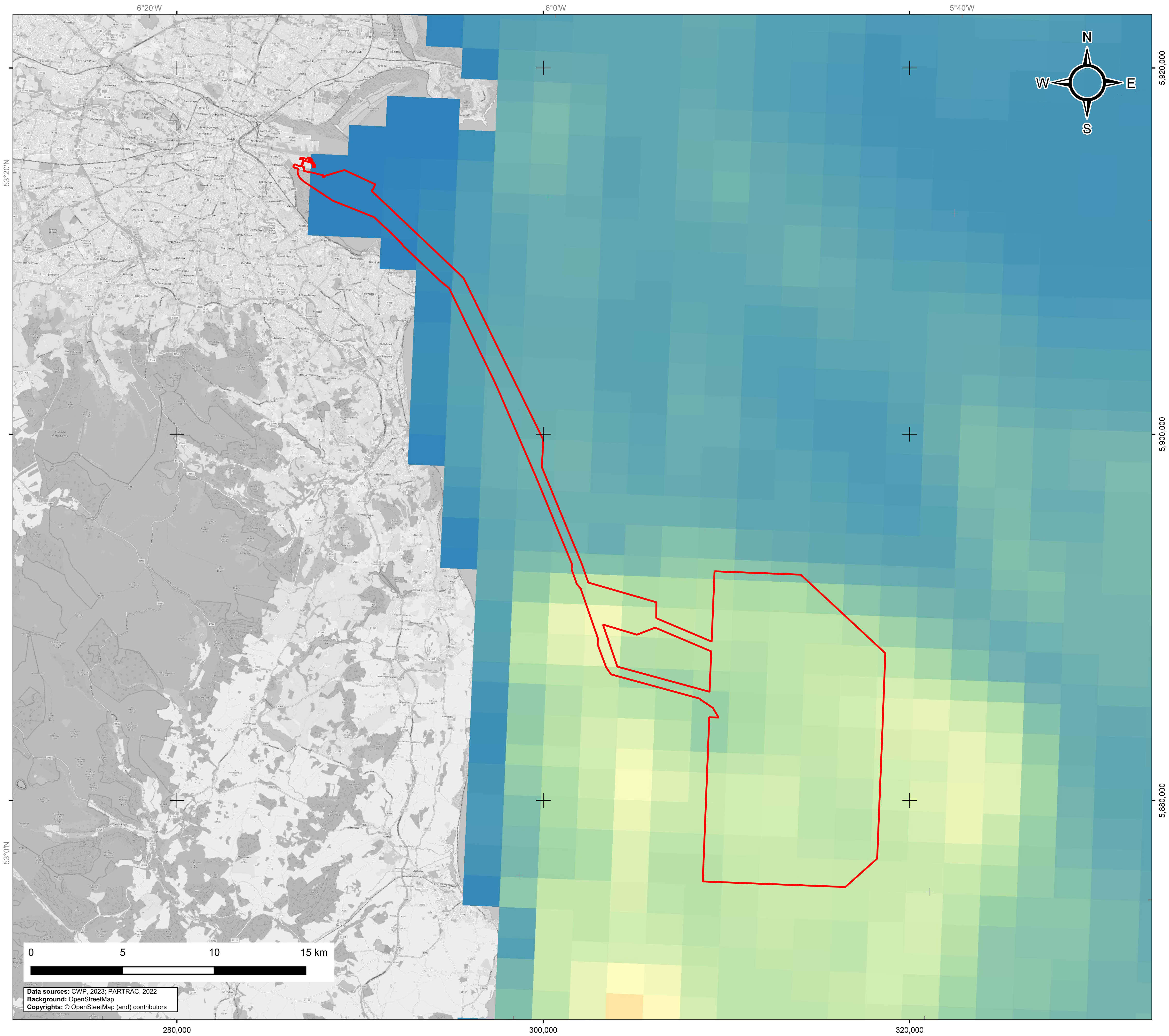
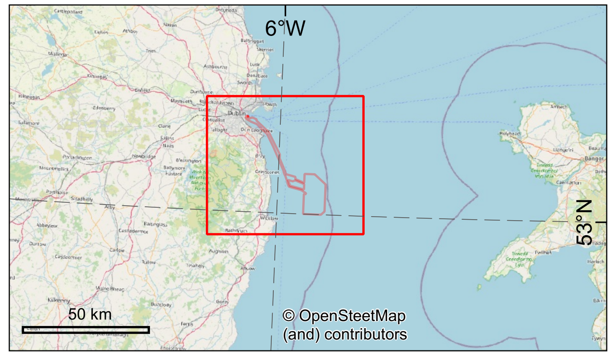
00	Final for issue	2024/03/14	MG	JP/EA	JP/EA





Legend

Planning application boundary

Shear stress (N/m²)

- 0.0000
- 0.0125
- 0.0250
- 0.0375
- 0.0500

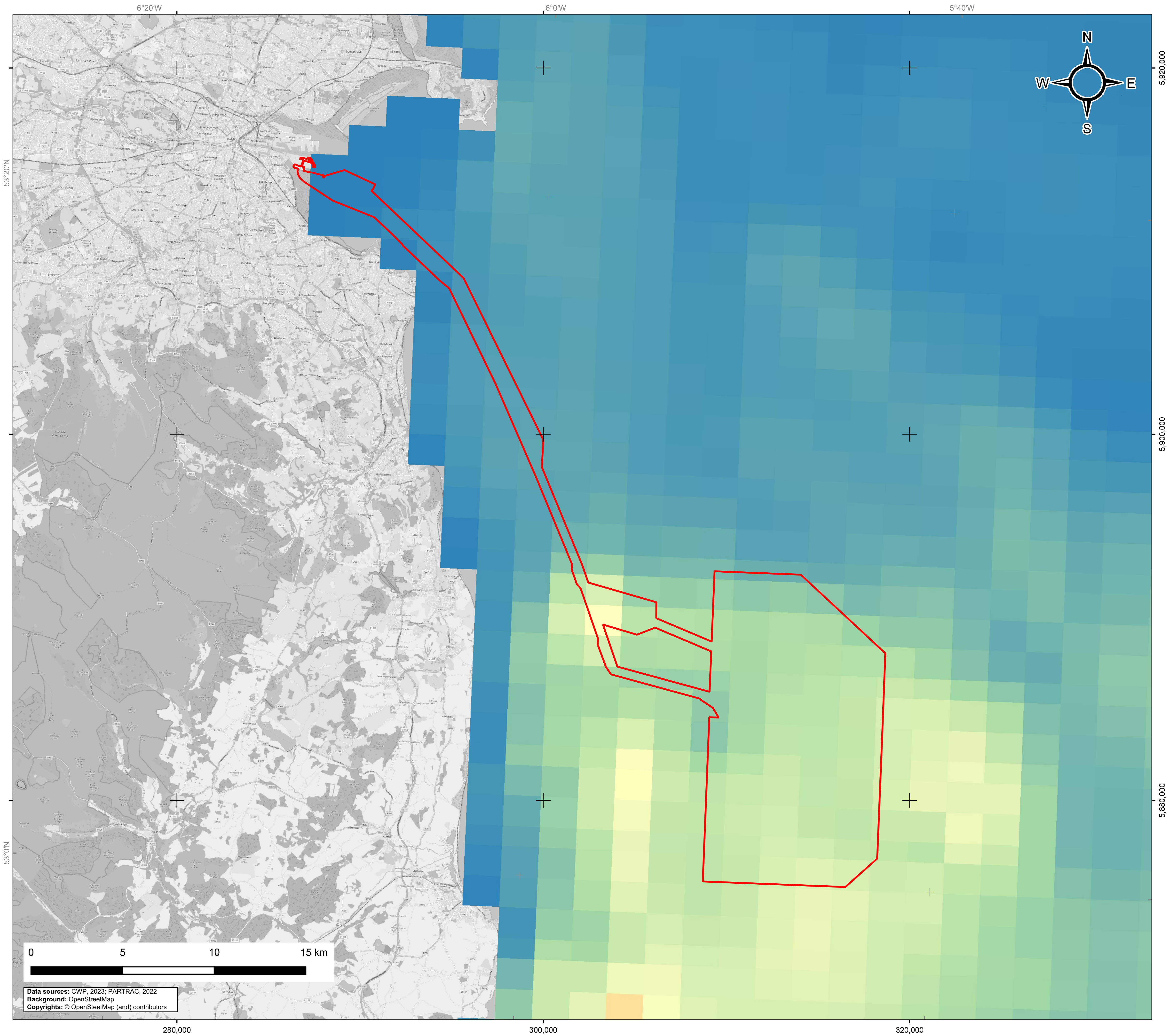
codling wind park	*Project:* Codling Wind Park	*Contractor:* Partrac.com PARTRAC

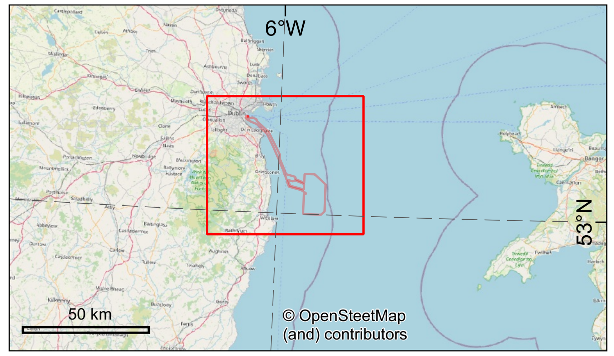
Figure 6.14
Peak neap ebb tide seabed shear stress

CWP doc. number: CWP-PAR-ENG-08-01-MAP-0897

Internal descriptive code:	*Size:* A3	*CRS:*
WE - PAB. BED.SHEAR.STRESS.PNET - EIAR.FIG.06.14	*Scale:* 1:200,000	EPSG 25830

Rev.	*Updates*	*Date*	*By*	*Chk'd*	*App'd*
00	Final for issue	2024/03/14	MG	JP/EA	JP/EA





Legend

Planning application boundary

Shear stress (N/m²)

- 0.0000
- 0.0125
- 0.0250
- 0.0375
- 0.0500

codling wind park	*Project:* Codling Wind Park	*Contractor:* Partrac.com PARTRAC

Figure 6.15
Peak neap flood tide seabed shear stress

CWP doc. number: CWP-PAR-ENG-08-01-MAP-0898

Internal descriptive code: WE - PAB..BED.SHEAR.STRESS.PNFT - EIAR.FIG.06.15	*Size:* A3 *Scale:* 1:200,000	*CRS:* EPSG 25830

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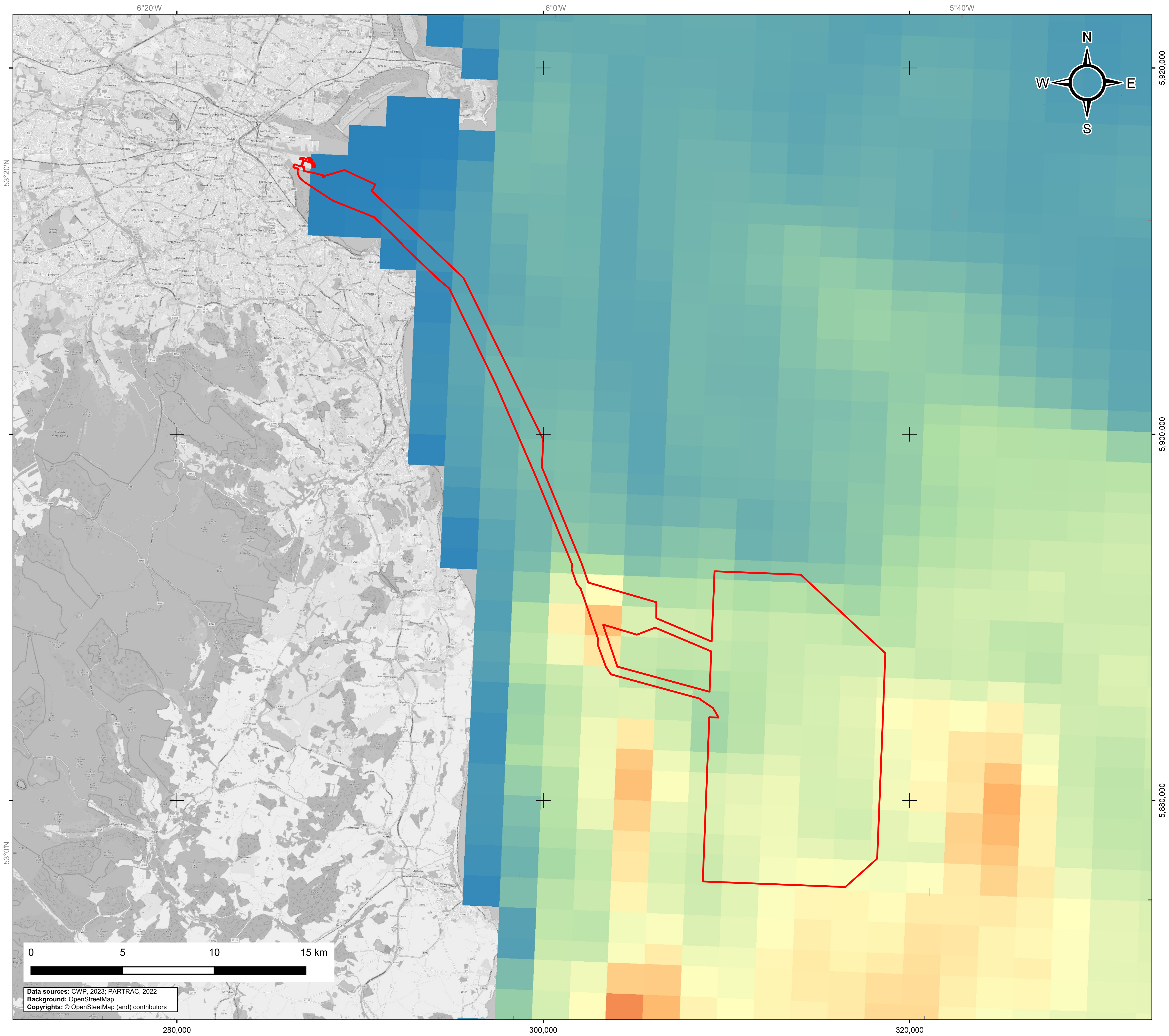
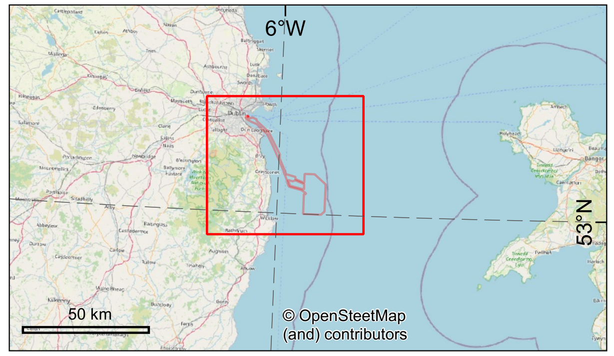
00	Final for issue	2024/03/14	MG	JP/EA	JP/EA





Legend

Planning application boundary

Shear stress (N/m²)

- 0.0000
- 0.0125
- 0.0250
- 0.0375
- 0.0500

Project: Codling Wind Park

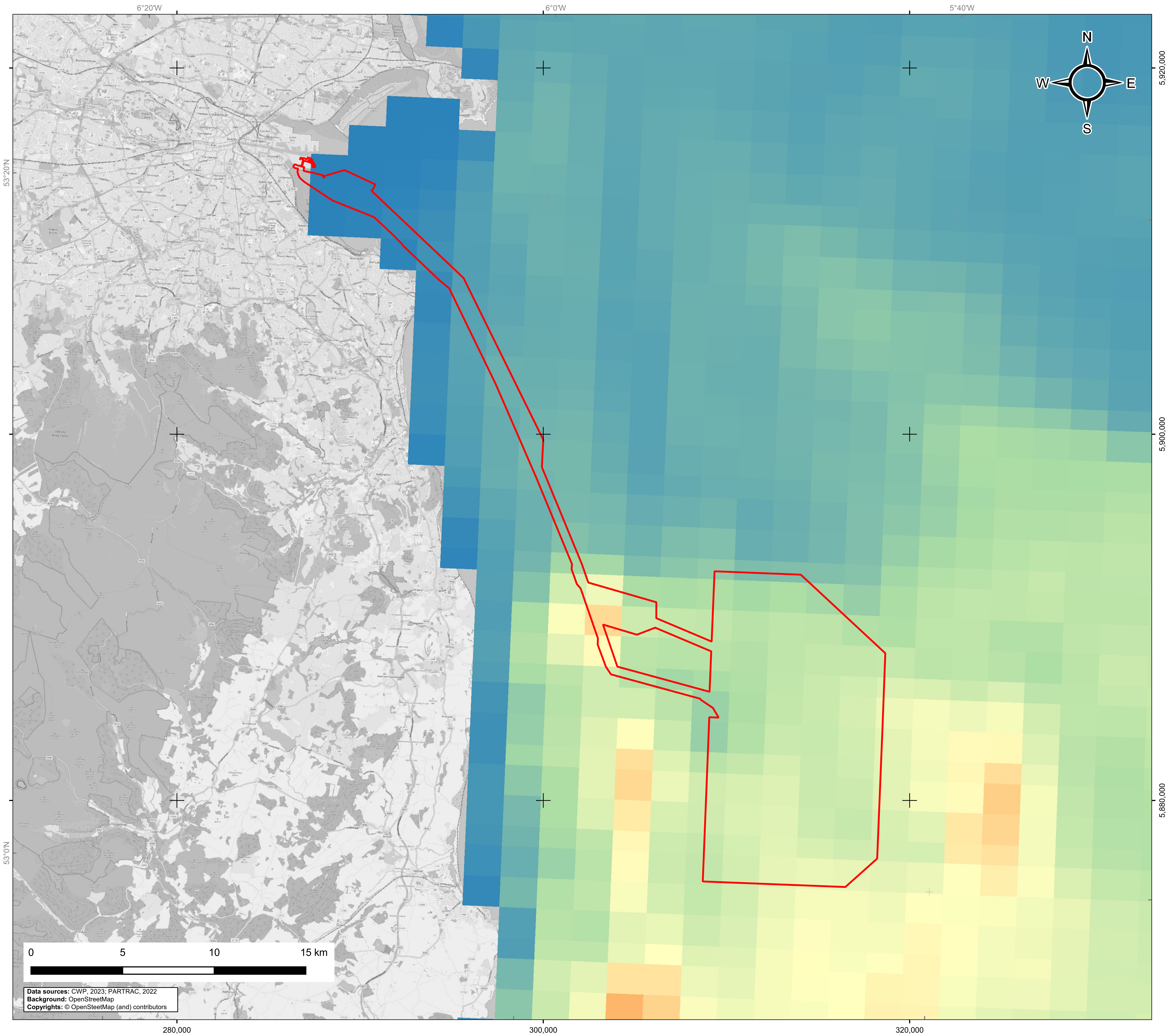
Contractor: Partrac.com

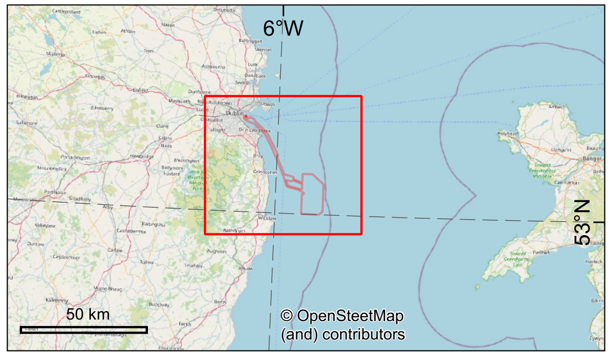
Figure 6.16
P100 wave seabed shear stress

CWP doc. number: CWP-PAR-ENG-08-01-MAP-0899

Internal descriptive code: WE - PAB..BED.SHEAR.STRESS.WAVE.P100 - EIAR.FIG.06.16	*Size:* A3 *Scale:* 1:200,000	*CRS:* EPSG 25830

Rev.	*Updates*	*Date*	*By*	*Chk'd*	*App'd*
00	Final for issue	2024/03/14	MG	JP/EA	JP/EA





Legend

Planning application boundary

Shear stress (N/m²)

- 0.0000
- 0.0125
- 0.0250
- 0.0375
- 0.0500

codling wind park

Project: Codling Wind Park

Contractor: Partrac.com

Figure 6.17
P90 wave seabed shear stress

CWP doc. number: CWP-PAR-ENG-08-01-MAP-0900

Internal descriptive code:	*Size:* A3	*CRS:*
WE - PAB. BED.SHEAR.STRESS.WAVE.P90 - EIAR.FIG.06.17	*Scale:* 1:200,000	EPSG 25830

Rev.	*Updates*	*Date*	*By*	*Chk'd*	*App'd*
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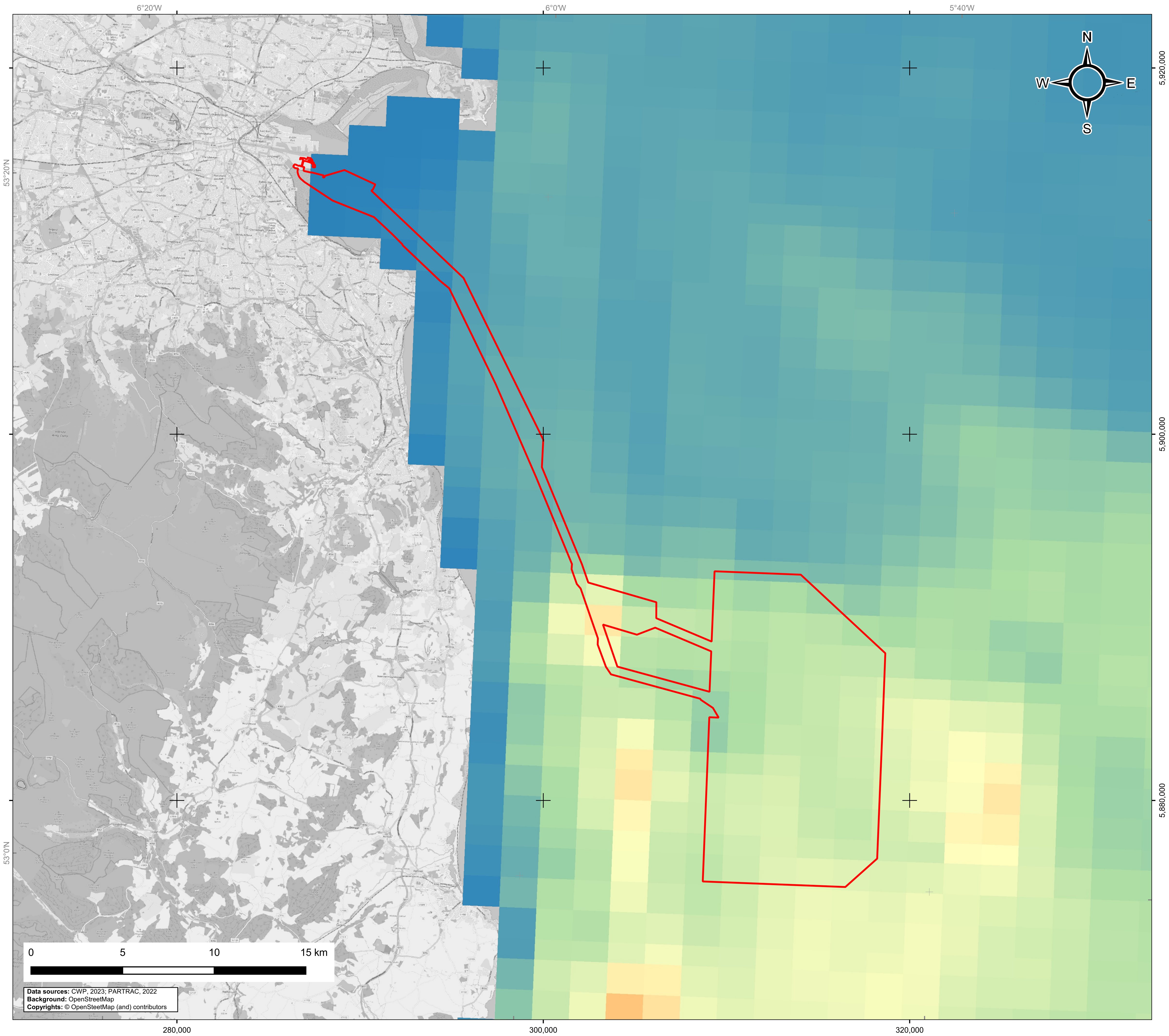
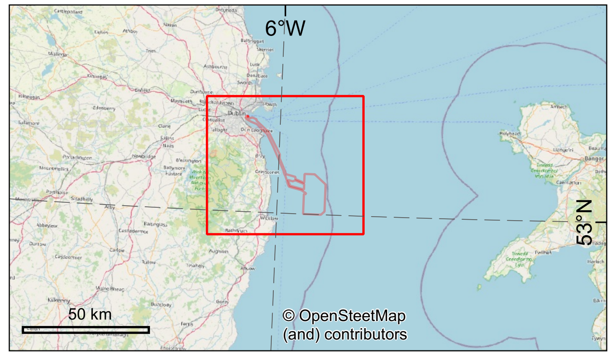




Legend

Planning application boundary

Shear stress (N/m²)

- 0.0000
- 0.0125
- 0.0250
- 0.0375
- 0.0500

codling wind park	*Project:* Codling Wind Park	*Contractor:* Partrac.com PARTRAC

Figure 6.18
P50 wave seabed shear stress

CWP doc. number: CWP-PAR-ENG-08-01-MAP-0901

Internal descriptive code:	*Size:* A3	*CRS:*
WE - PAB. BED.SHEAR.STRESS.WAVE.P50 - EIAR.FIG.06.18	*Scale:* 1:200,000	EPSG 25830

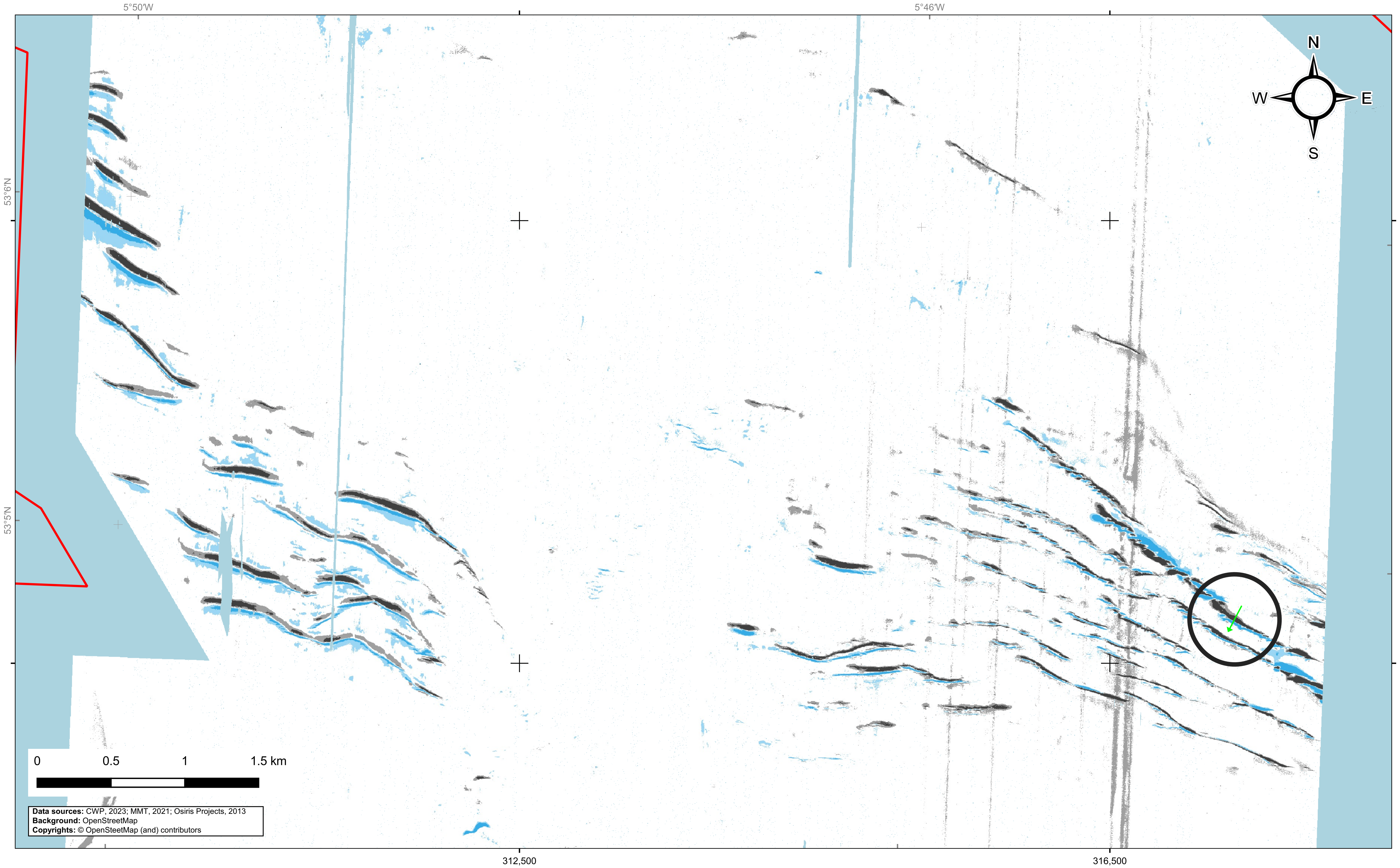
Rev.	*Updates*	*Date*	*By*	*Chk'd*	*App'd*
00	Final for issue	2024/03/14	MG	JP/EA	JP/EA

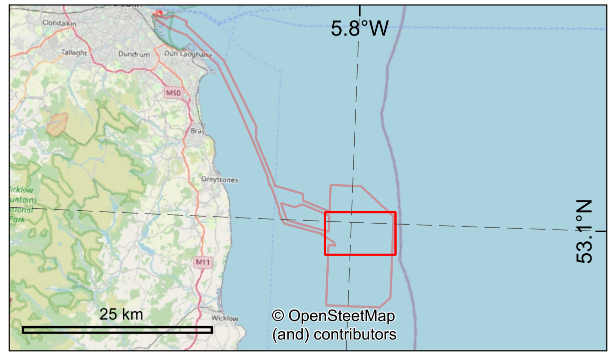
Morphological Evidence for Sediment Transport Across the Offshore Development Area

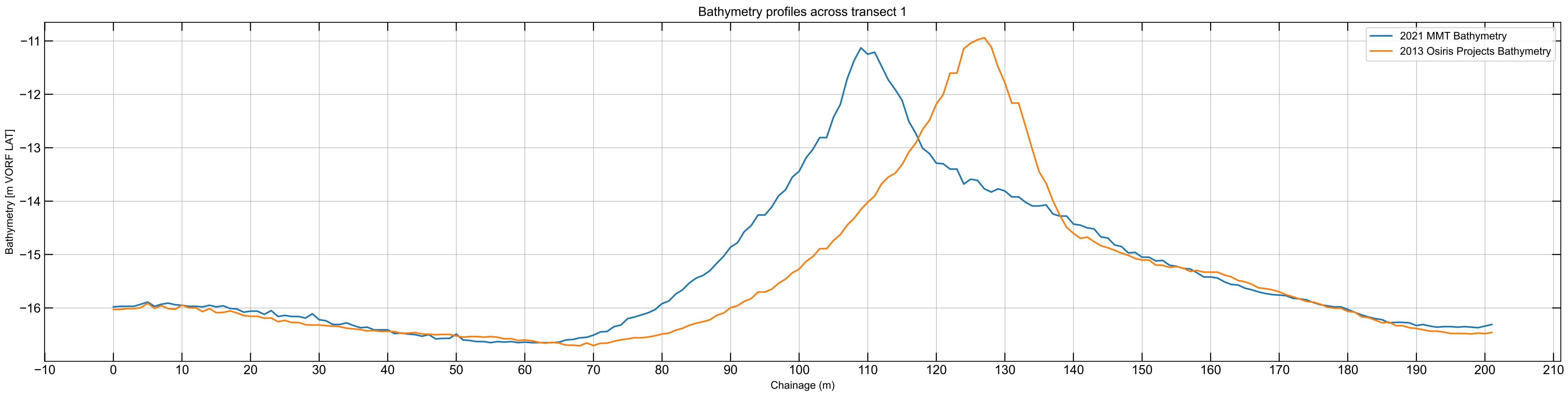
74. The historic morphological response of the seabed within the array site is accessible via comparison of the two bathymetric datasets, acquired in 2013 and 2021, respectively. Comparison of these data provides an opportunity to study the adjustment of the seabed level under the prevailing oceanographic conditions across the time period between surveys. Between these timesteps, within the array site, observed changes to the seabed elevation is limited, rarely exceeding the vertical tolerance of the data itself (**Figure 6-19**). This is unique for sandbanks on the eastern Irish seaboard (Coughlan et al., 2021), and a function of the grain size of sediments observed across the array site. The exception to this is in areas across the array site where a greater proportion of sand sized sediments are observed. These sand sized sediments are routinely mobilised under the prevailing regimes resulting in the formation of bedforms. The analyses performed indicate that changes to seabed elevation are primarily associated with the migration of these bedforms across the seabed.

75. Raised sediment features on the seabed are termed bedforms. The presence and persistence of bedforms on the seabed can provide indications as to the prevalence of sediment transport and predominant transport direction[s]. Bedforms produced by waves are generally symmetrical, whereas those formed by tidal flow are asymmetrical. The type of bedform which develops (i.e., ripples, megaripples, sandwaves or sandbanks) are a function of the flow velocity, sediment grain size (i.e., bed roughness) and water depth. Typically, small scale ripples form at relatively slow current speeds and where sediment is finer than *c*. 0.6 mm. As flow velocity increases, or where sediments are coarser grained, megaripples form and then sandwaves develop where the sediment supply is sufficient.

76. Across the offshore development area, the bathymetry is influenced by the presence of large scale subaqueous bedform features as observed in the 2013 and 2021 bathymetry data (**Figure 6-19**). These features only occur towards the shallower areas (the central and northern regions) of the array site, coincident with areas of the seabed comprised of sand sized sediments (**Figure 6-10**). Sandwaves and megaripples with wave heights of up to 4 m were observed in the central region of the array site along an approximately five-kilometre-wide band, running from northwest to southeast across most of the central region of the site. These features are broadly oriented west to east and west-northwest to east-southeast and are characterised by varying wavelengths of between 65 m and 340 m. Megaripples seen across this 5-km-wide-band have a similar orientation, with a varying wavelength between 2 m to 10 m. The orientation of the steeper faces of the sandwaves (towards the south) suggests residual migration from the north to north-northeast. **Figure 6-19** presents a comparative analysis of these data which indicates that sandwaves migrate towards the northeast at a rate of ~3.5 m/year in the west of the array site and ~2.0 m/year in the east. The presence of this morphology itself indicates a dynamic and non-cohesive seabed, limited mud and gravel fractions, and a generally higher current velocity regime (Stride, 1982; Amos and King, 1984) within the array site. However, the presence of these features is limited due to the prevailing gravel deposits which comprise the surficial sedimentology across the majority of the array site, restricting bedform formation.







Legend

Planning application boundary

Plotted transect

Transect 1

Bedchange [m] (+ve = accretion)

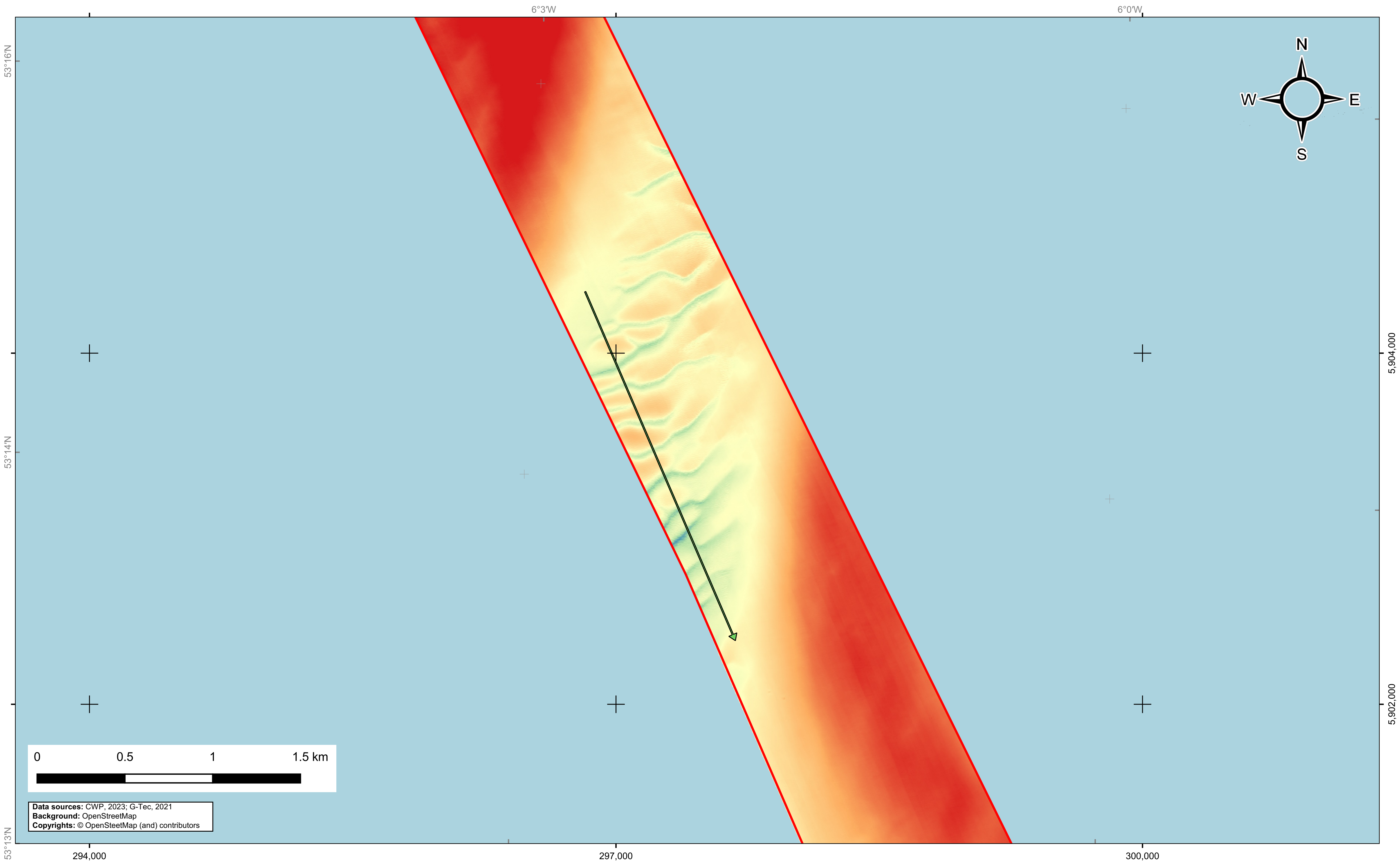
- <= -0.75
- -0.75 - -0.25
- -0.25 - 0.25
- 0.25 - 0.75
- > 0.75

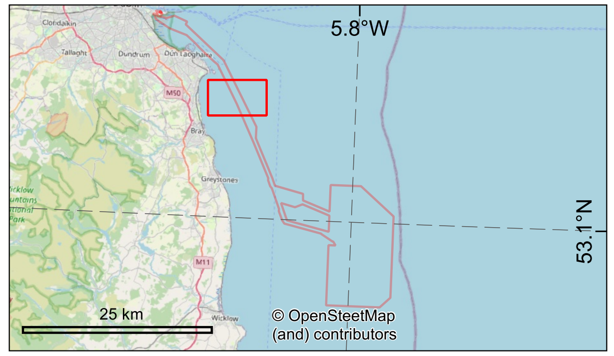
codling wind park	*Project:* Codling Wind Park	*Contractor:* Partrac.com PARTRAC

Figure 6.19
The seabed level change observed between 2013 and 2021 and a transect showing a comparison of sandwaves in the central eastern section of the site

CWP doc. number:	CWP-PAR-ENG-08-01-MAP-0929		
Internal descriptive code: WF - PLAN_PROF_SANDW.NE - EIAR.FIG.06.19	*Size:* A3 *Scale:* 1:30,000	*CRS:* EPSG 25830	

Rev.	*Updates*	*Date*	*By*	*Chk'd*	*App'd*
00	Final for issue	2024/03/14	MG	JP/EA	JP/EA





Legend

Planning application boundary

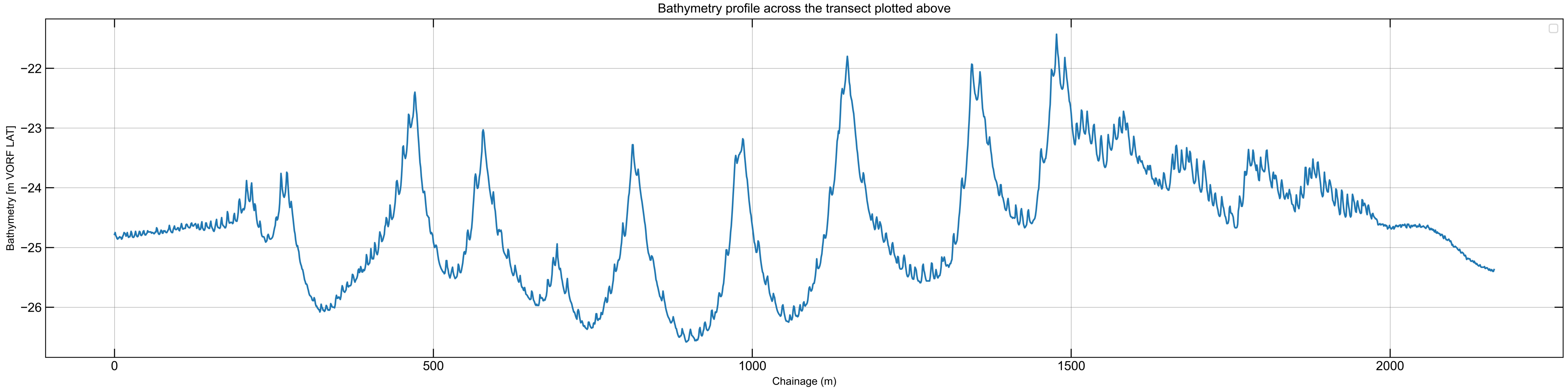
Plotted transect

Transect 1

Bathymetry [m VORF LAT]

- -30
- -28
- -25
- -23
- -20

Bathymetry profile across the transect plotted above



codling wind park	*Project:* Codling Wind Park	*Contractor:* Partrac.com

Figure 6.20

Plan and profile view of a group of sandwaves and megaripples within the offshore export cable corridor

CWP doc. number: CWP-PAR-ENG-08-01-MAP-0930

Internal descriptive code:	*Size:* A3	*CRS:*
ECRs - PLAN.PROF..SANDW.KP.16 - EIAR.FIG.06.20	*Scale:* 1:25,000	EPSG 25830

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00	Final for issue	2024/03/14	MG	JP/EA	JP/EA

Suspended Sediments

77. Suspended sediment is an important component of a sediment regime and requires consideration, especially within a dynamic system such as the Irish Sea. Sediment in suspension is generally derived from:

- Mobilisation and suspension of bed sediments at the site induced by waves and / or tidal currents.
- Fluvial inputs in the vicinity of the site.
- Regions external to the site (e.g., advection of turbid waters).

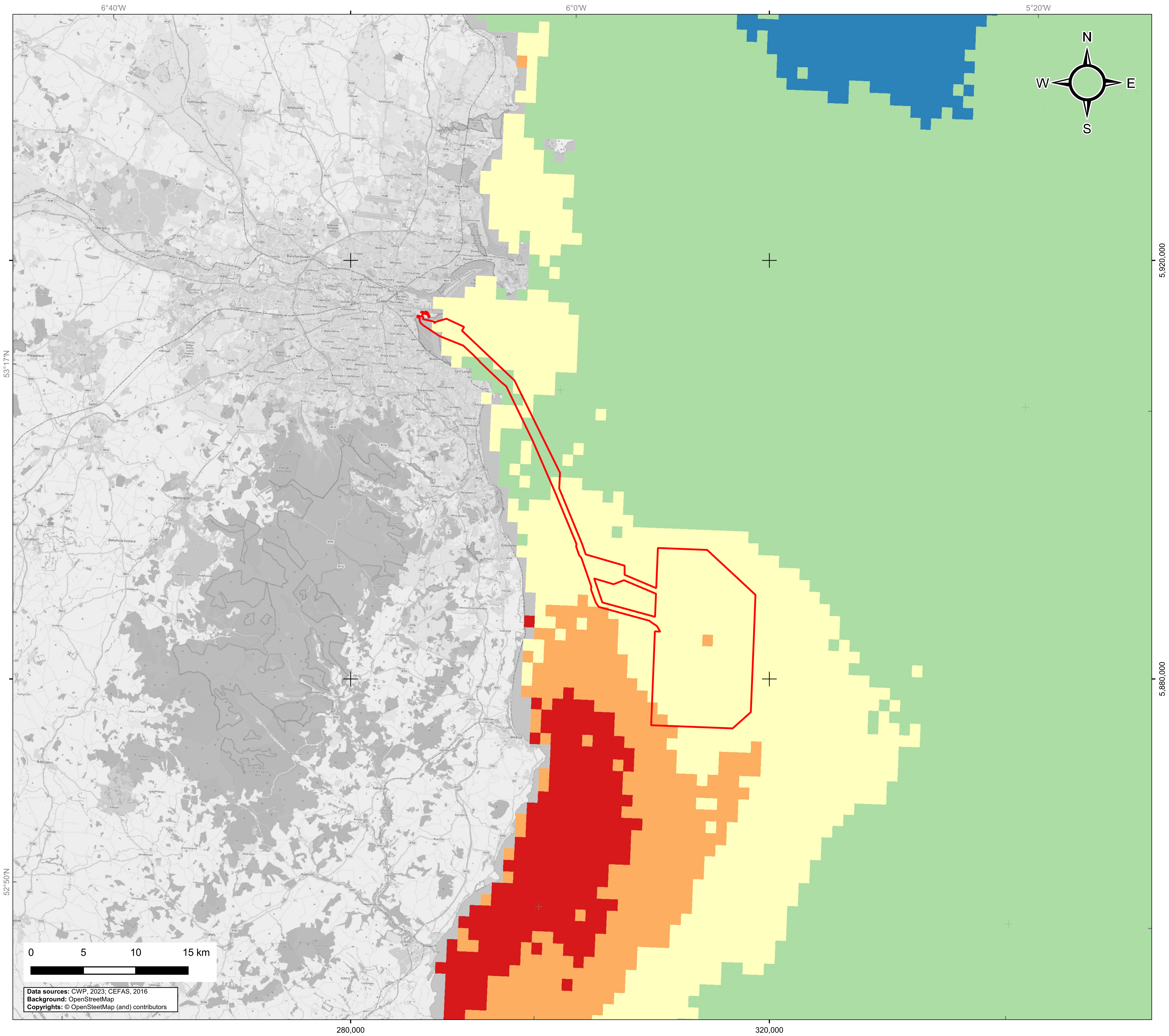
78. An appreciation of the magnitude of suspended sediments which typically occur across the region is possible through the interrogation of Suspended Particulate Matter (SPM) concentrations that were observed from satellite imagery (Cefas, 2016). **Figure 6-21** shows the mean concentrations obtained for the month of February (the month with the highest mean concentration), which indicates higher concentrations of SPM (and thus of suspended sediments) are typically observed in nearshore areas; postulated to be a function of input from riverine sources as well as the increased mixing resulting from the interactions with shallow water waves nearshore. Further offshore, concentrations reduce as nearshore processes begin to dissipate and water depths increase.

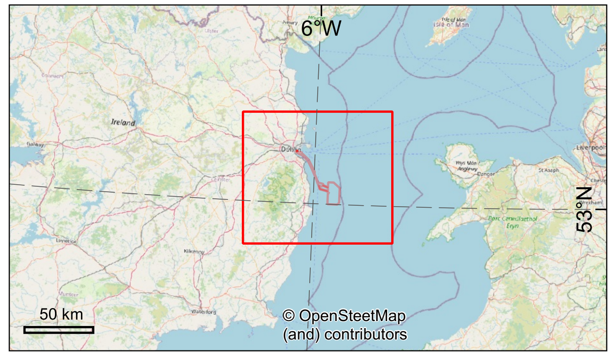
79. Local to the offshore development area, turbidity measurements[4] collected between November 2021 and May 2022 as part of the Metocean survey campaign (Techworks, 2021a, 2021b, 2021c) provide useful insight into the magnitude of turbidity observed under the prevailing regimes. **Plate 6-31** presents turbidity data with coincident wave and tidal flow data. Presentation of these data in this manner supports an assessment of the drivers of suspended sediment transport and the events which trigger elevated turbidity within the CWP MAC application boundary. Typically, through the observation period, baseline turbidity levels remain low[5] (less than five Nephelometric Turbidity Units (NTUs)) with slightly elevated turbidity values observed during the higher energy spring tidal phase in comparison to the neap tidal phase. Turbidity values were also elevated during higher energy wave events, with turbidity values decreasing following the occurrence of these events returning to typical baseline levels.

80. Useful corroborating data is also available from historic monitoring projects performed in 2017/18 in the region, where instruments were deployed in Dublin Bay in water depths of around 20 m (RPS, 2021). Turbidity measurements at four sites showed turbidity values were typically observed below 16 NTU, with 90% of the data remaining below 22 NTU throughout the observation period. Seasonal influences were evident in the data record (RPS, 2021).

4 The increased 'murkiness' of a water body due to either suspended particulates (both mineral and biological) in the water column, or discoloration of the water body, acts to reduce the depth of light penetration through the water. This phenomenon is referred to as *turbidity*. Turbidity data (nominally expressed in NTU or FNU units), is regularly used to estimate the total suspended solids (TSS) within the water column. Turbidity units have no intrinsic physical, chemical, or biological significance. They are a qualitative rather than a quantitative measurement. TSS (measured in milligrams per litre of water (mg/L) can be estimated from turbidity measurements by establishing the relationship between turbidity and suspended sediment using a linear regression analysis. These data are not available to the assessment and thus caution must be applied when considering these data.

5 The dataset shows a significant, and persistent, increase in the turbidity levels between 15/02/2022 and 08/03/2022. The reason for this cannot be verified but is postulated to most likely be a sensor issue.





Legend

Planning application boundary

Mean suspended particulate matter for the month of February between (1998 - 2015) (mg\l)

- ≤ 4
- 4 - 8
- 8 - 12
- 12 - 16
- > 16

codling wind park

Project: Codling Wind Park

Contractor: Partrac.com

PARTRAC

Figure 6.21
Suspended sediment concentration

CWP doc. number: CWP-PAR-ENG-08-01-MAP-0936

Internal descriptive code:	*Size:*	*CRS:*
OFFSH.ALL - PAB..SUSPENDED.SEDIMENTS.REGIONAL - EIAR.FIG.06.21	A3	EPSG 25830
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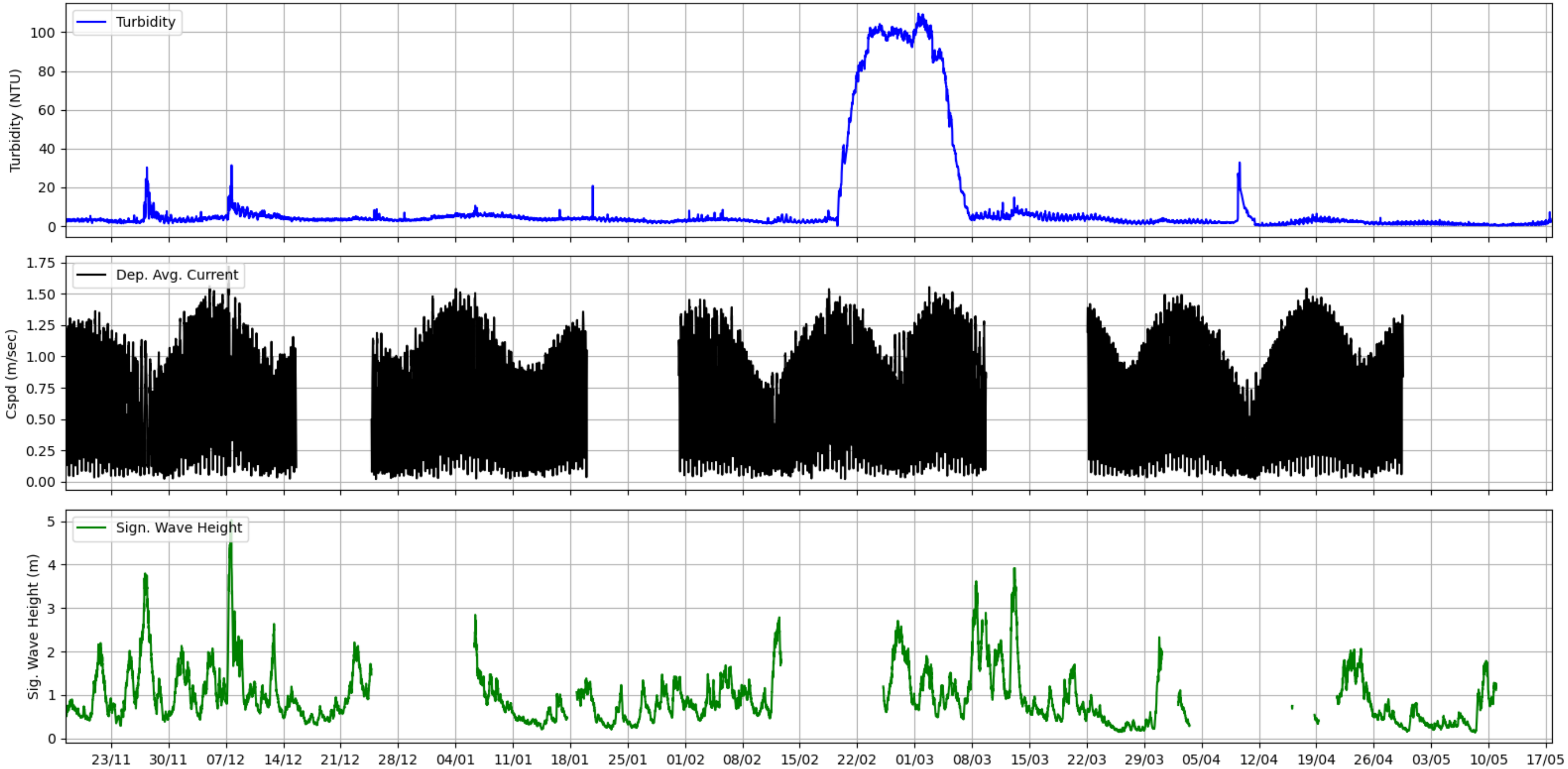


Plate 6-31 Observed turbidity values (in NTU) at the site (top panel). Coincident wave (bottom panel) and current (central panel) measurements are presented.

6.6.6 Coastal Processes

81. The Irish coastline proximal to the offshore development area is for the purposes of this assessment considered to extend from County Dublin in the North to County Wicklow to the South (**Figure 6-1**).

82. **Figure 6-22** shows the designated habitats at the coastline. The OECC traverses a SAC (i.e., North Dublin Bay SAC) and two Special Protection Areas (SPAs) (i.e., South Dublin Bay and River Tolka SPA and Ireland's Eye SPA). The North Dublin Bay SAC is designated in part due to its mudflats and sandflats and dune habitats, which are susceptible to changes to the prevailing Marine Geology, Sediments and Coastal Processes.

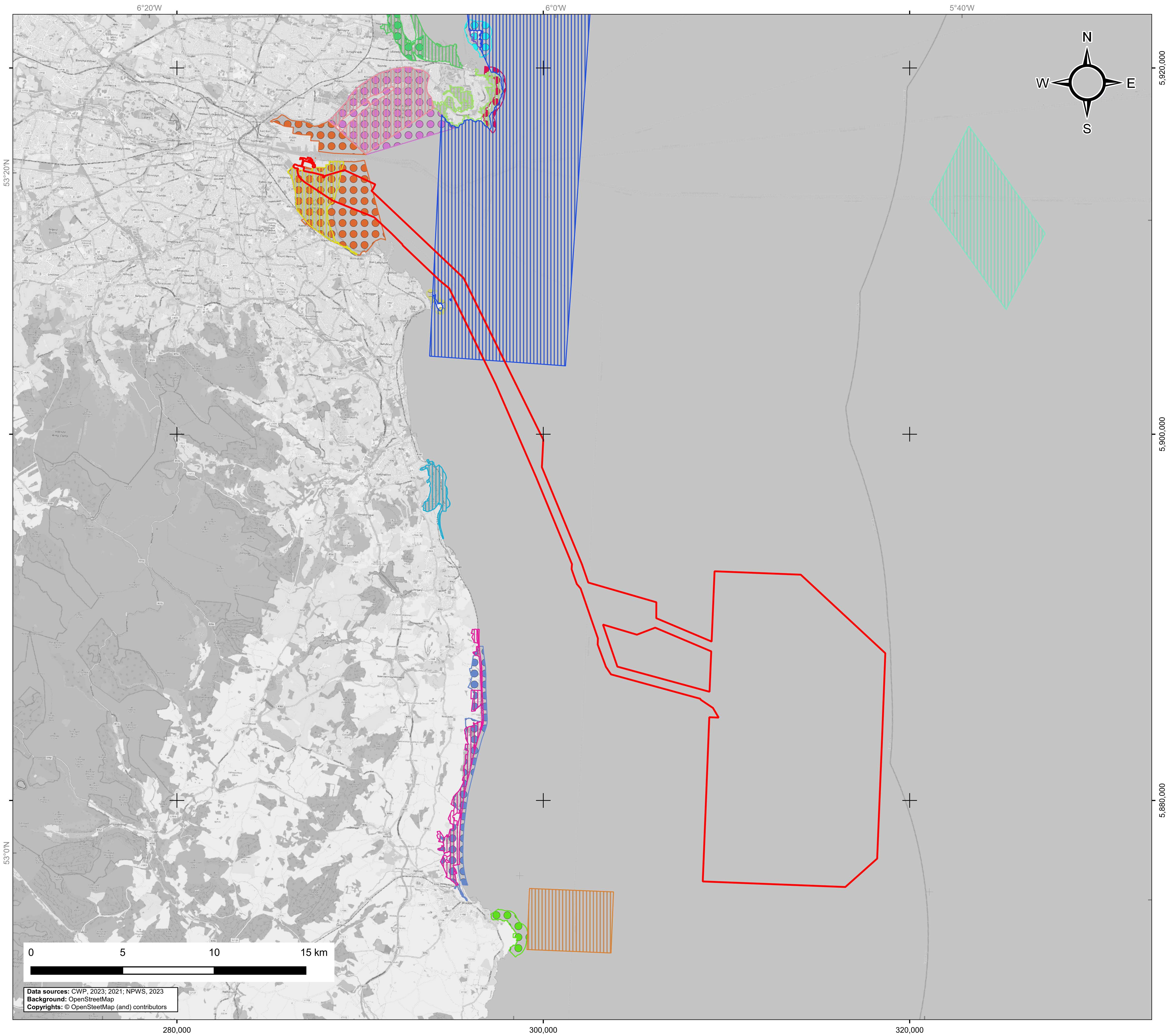
83. The geology of this stretch of the Irish coast can be split into three main parts (Irish Geological survey, 2013):

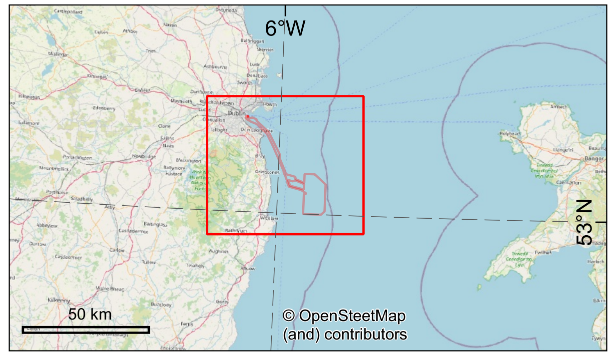
- To the north, the coast's bedrock is mainly Granite, and was formed during the Caledonian times.
- Between Wicklow and Greystones, the coast is comprised mainly of Greywacke & shale and is believed to have formed during the Palaeozoic and Cambrian times.
- South of Wicklow, the coast consists of Slate, schist and minor greywacke, and is believed to have originated during the Palaeozoic, Lower–Middle Ordovician times.

84. **Figure 6-23** and **Figure 6-24** provide a more detailed geological classification of the coastline (Irish geological survey, 2013). The makeup of the coastline is comprised mainly of two morphological units:

- Flat coasts: which are represented by low-lying extensions of sandy beaches, sand dunes, plains and spits and large sandy plains in the onshore area, and
- Cliffs: which are composed of hard rock and / or soft unconsolidated material resulting in a bay-like coastal profile (e.g., Dublin Bay).

85. To mitigate coastal erosion and recession, significant man-made alterations have been implemented at the coast. The Geological Survey of Ireland is currently leading a project that aims to identify areas within the Irish coastline that are at particular risk of coastal erosion or impacts due to sea level rise. The project utilises a method known as the Coastal Vulnerability Index (CVI) to determine the susceptibility of a stretch of coastline to erosion considering local morphology, cliff type, coastline orientation, regional coastal slope, tidal range and significant wave height. **Plate 6-32** presents a visual representation of the CVI for the area of interest (Caloca-Casado, 2018). These analyses show that most of the areas are characterised by a low or moderate CVI rating, except for a short 10 km strip towards the southwest of the CWP Project (between Wicklow and Greystones), which is considered to be more vulnerable to sea level rise and erosion / recession. As part of this assessment, data collected between 1952 and 2017 were utilised to determine the yearly shoreline erosion or accretion rates; the results (presented in **Plate 6-33**) indicate that most of the coastline within the area of interest displays comparatively moderate accretion / erosion rates of between -0.2 m/year to 0.2 m/year (Caloca-Casado, 2018), which is attributed to being a function of the fetch limited wave regime.





Legend

Planning application boundary

Special areas of conservation

- Baldoyle Bay SAC
- Bray Head SAC
- Codling Fault Zone SAC
- Howth Head SAC
- Ireland's Eye SAC
- North Dublin Bay SAC
- Rockabill to Dalkey Island SAC
- South Dublin Bay SAC
- The Murrough Wetlands SAC
- Wicklow Reef SAC

Special protection areas

- Baldoyle Bay SPA
- Dalkey Islands SPA
- Howth Head Coast SPA
- Ireland's Eye SPA
- North Bull Island SPA
- South Dublin Bay and River Tolka Estuary SPA
- The Murrough SPA
- Wicklow Head SPA

Project: Codling Wind Park

Contractor: Partrac.com

Figure 6.22
Offshore and shoreline designated protected areas

CWP doc. number: CWP-PAR-ENG-08-01-MAP-0937

Internal descriptive code: WE - PAB..PROTECTED.AREAS.OFFSH - EIAR.FIG.06.22

Size: A3
Scale: 1:200,000

CRS: EPSG 25830

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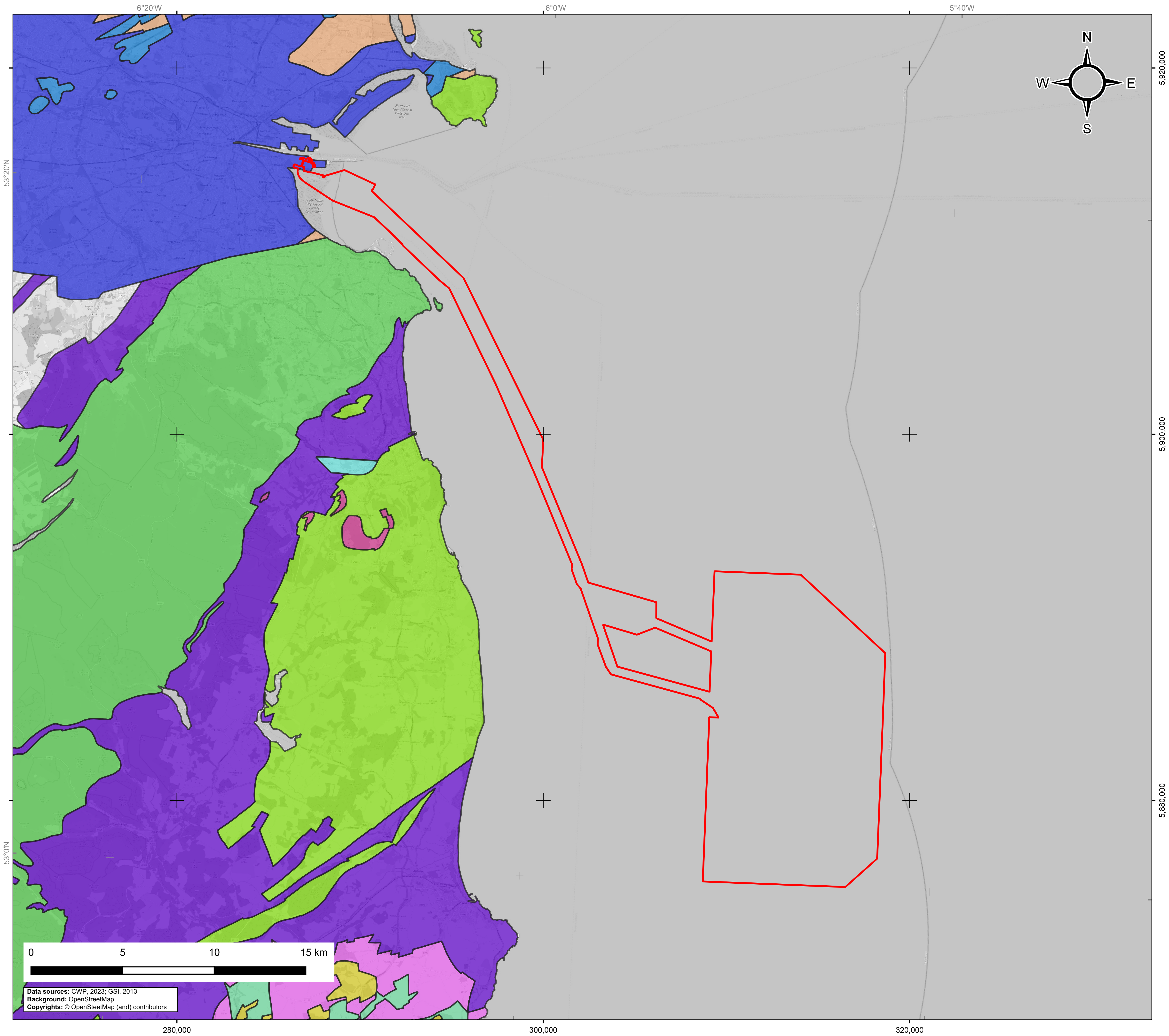

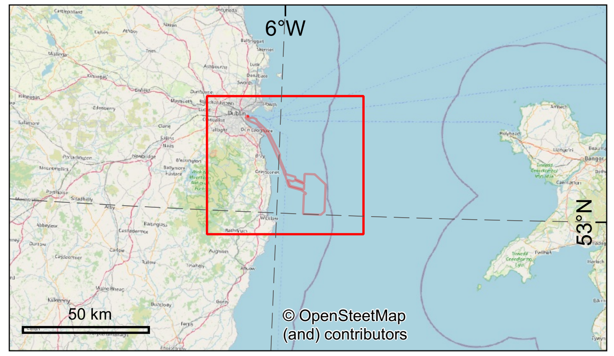

Legend

Planning application boundary

Onshore bedrock geology

- 30, Marine; Quartzite & minor slate
- 32, Marine; Greywacke & shale
- 34, Rhyolite and rhyolitic tuff
- 35, Deep marine; Slate, schist & minor greywacke
- 38, Rhyolite, rhyolitic tuff & slate
- 39, Deep marine; Slate, shale, minor sandstone & siltstone
- 5, Gabbro, dolerite & diorite
- 61, Marine shelf & ramp facies; Argillaceous dark-grey bioclastic limestone, subsidiary shale
- 62, Waulsortian mudbank; Pale-grey massive limestone
- 65, Marine basinal facies (Tober colleen & Lucan Fms - "Calp"); Dark-grey argillaceous & cherty limestone & shale
- 8, Granite, granodiorite

codling wind park

Project: Codling Wind Park

Contractor: Partrac.com

PARTRAC

Figure 6.23
Onshore bedrock geology

CWP doc. number: CWP-PAR-ENG-08-01-MAP-0938

Internal descriptive code: WE - PAB_GEOLOGY.BEDROCK.ONSH - EIAR.FIG.06.23

Size: A3

Scale: 1:200,000

CRS: EPSG 25830

Rev.	Updates	Date	By	Chk'd	App'd
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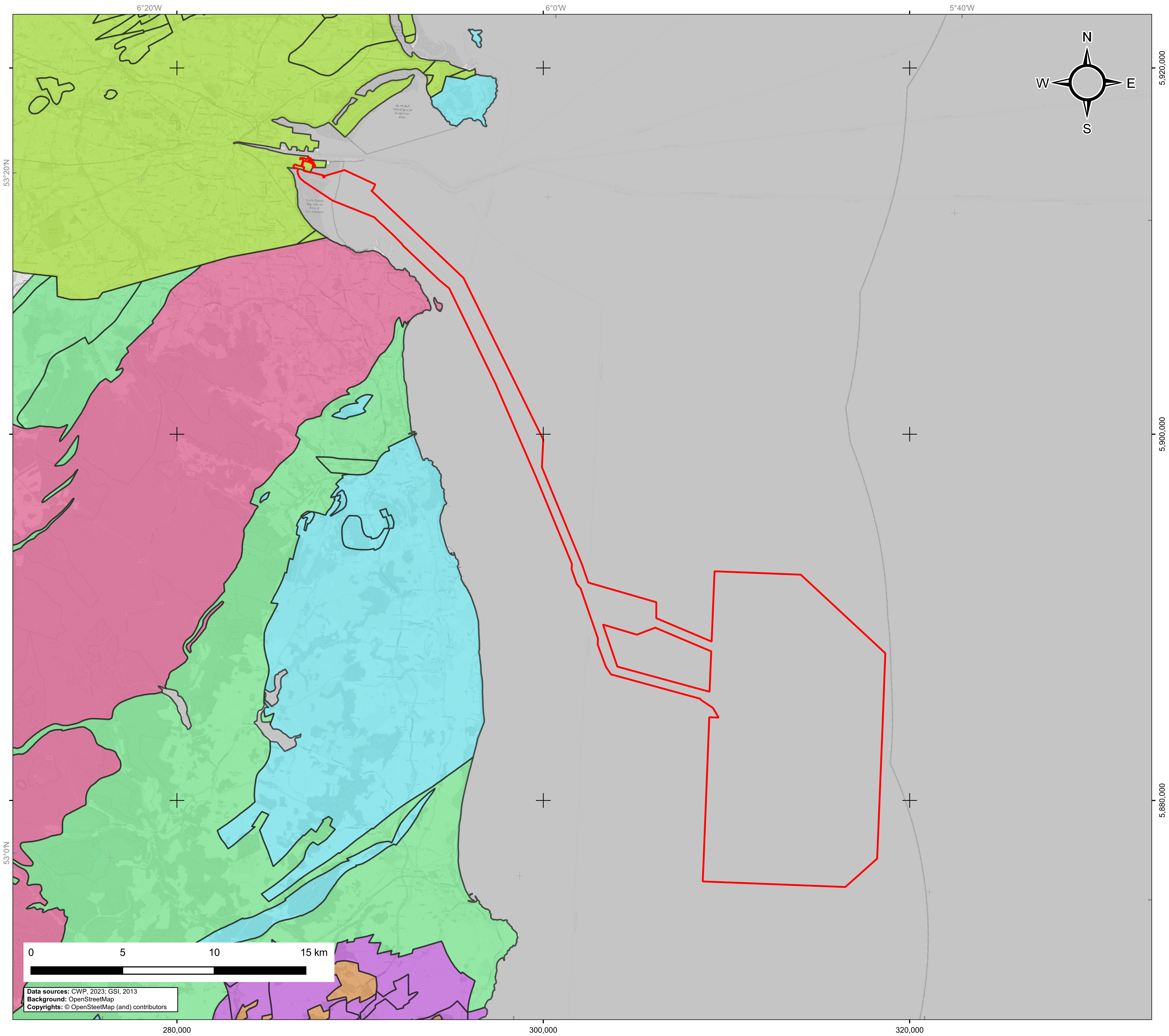

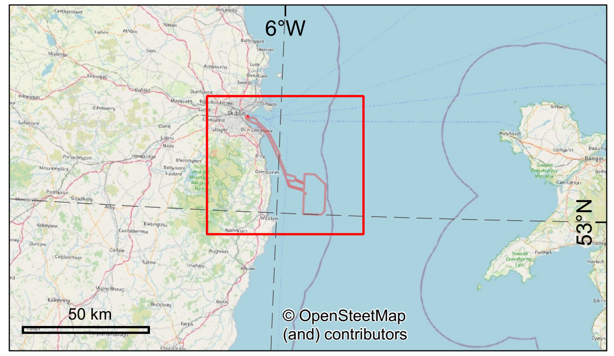

Legend

Planning application boundary

Age of the onshore bedrock geology

- Caledonian (Silurian - Devonian)
- Lower Palaeozoic
- Palaeozoic, Cambrian
- Palaeozoic, Carboniferous, Mississippian
- Palaeozoic, Lower - Middle Ordovician
- Palaeozoic, Middle - Upper Ordovician

codling wind park

Project: Codling Wind Park

Contractor: Partrac.com

Figure 6.24
Age of the onshore bedrock geology

CWP doc. number: CWP-PAR-ENG-08-01-MAP-0939

Internal descriptive code:	*Size:* A3	*CRS:*
WE - PAB. GEOLOGY.BEDROCK.AGE.ONSH - EIAR.FIG.06.24	*Scale:* 1:200,000	EPSG 25830

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00	Final for issue	2024/03/14	MG	JP/EA	JP/EA

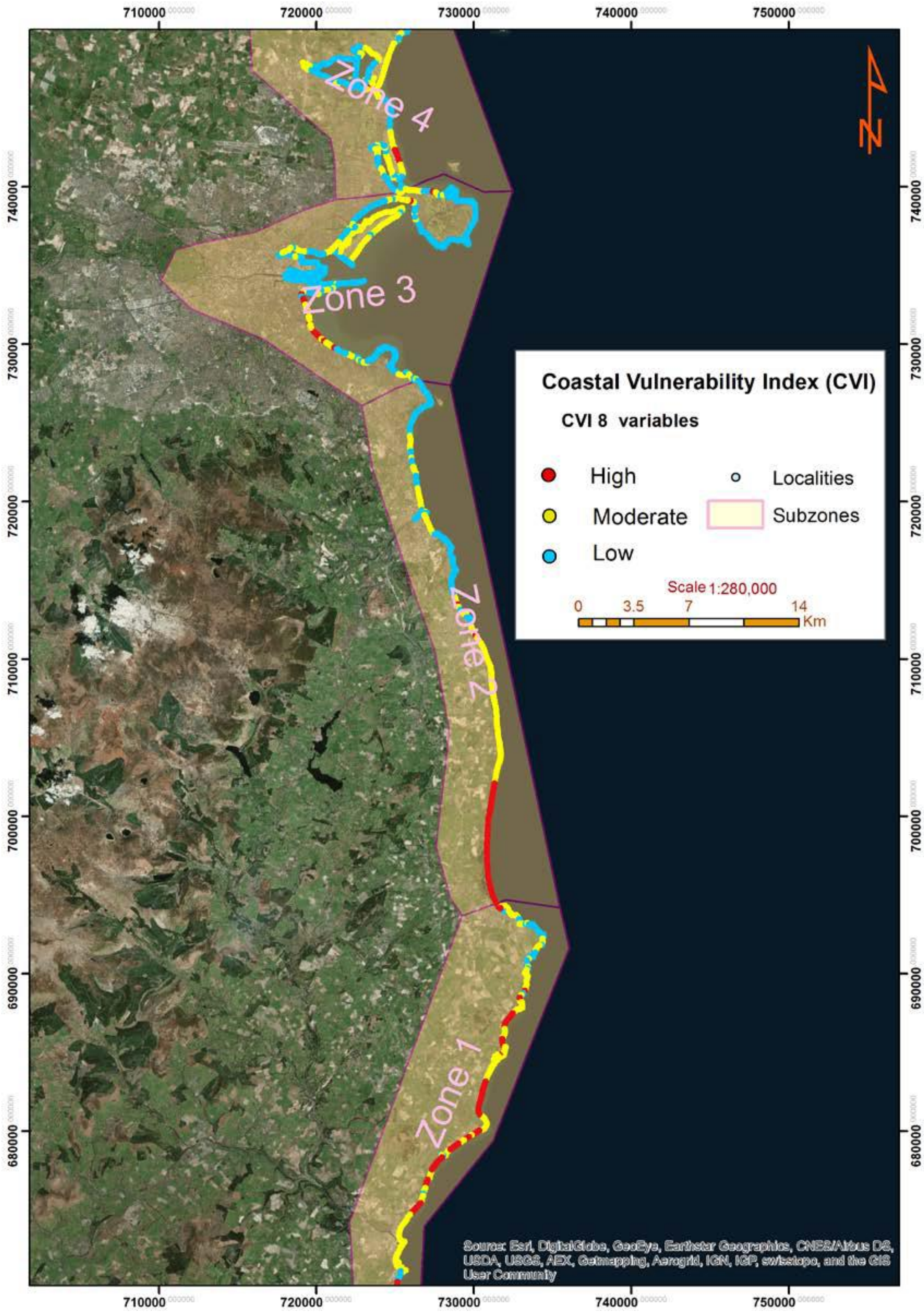


Plate 6-32 Coastal vulnerability index within proximity to the offshore development area as presented by Caloca-Casado (2018)

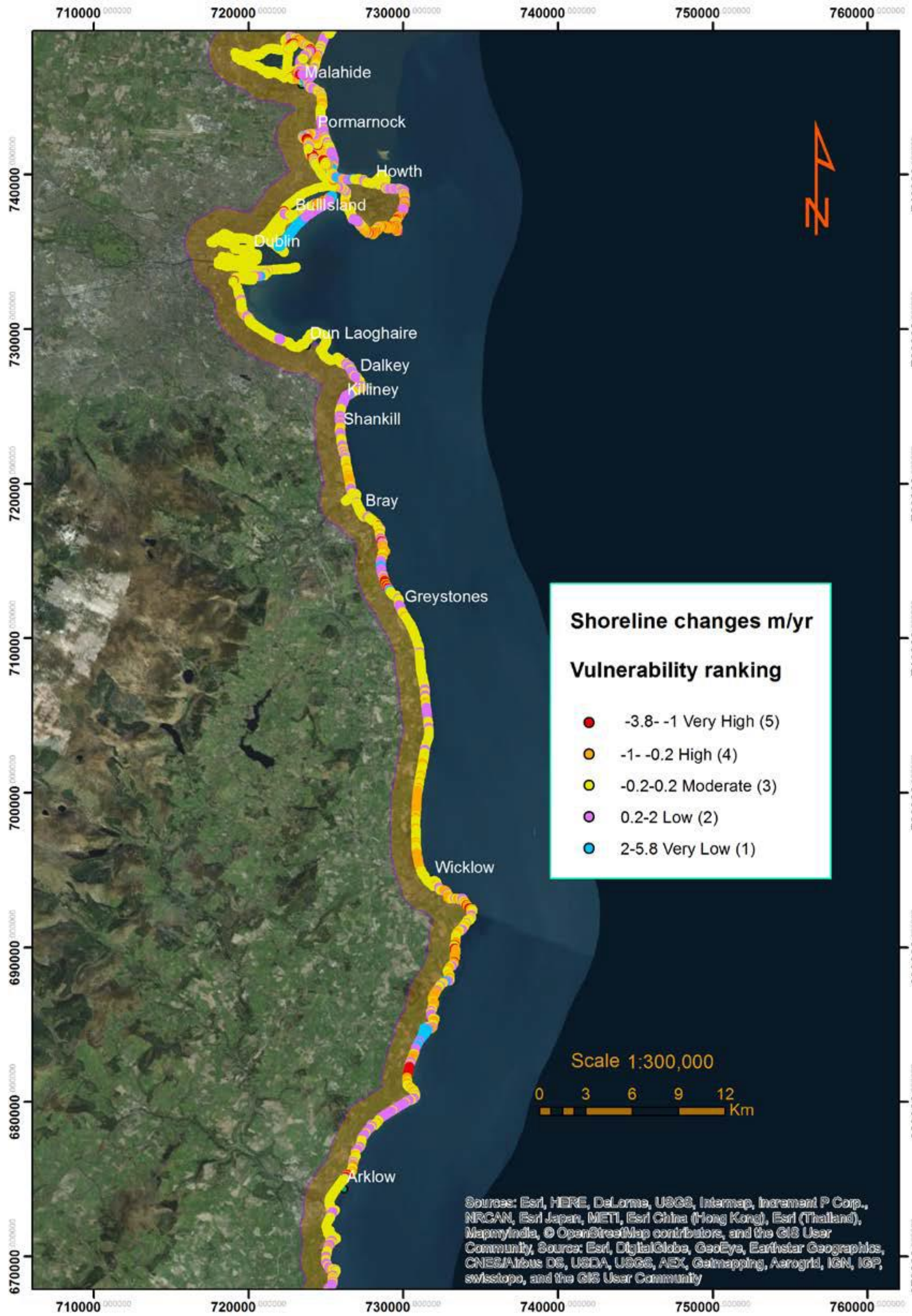


Plate 6-33 Yearly shoreline change rates (Caloca-Casado, 2018)

6.6.7 River Liffey and Dublin Bay

86. The river Liffey is a river in eastern Ireland that flows through the centre of Dublin to its mouth within Dublin Bay. The river Liffey is a major river in the Irish River networks with a total catchment area of ~1300 km^2 and a total length of 138 km. It flows predominately in a northwesterly direction from the Pollaphuca Reservoir and outflows to the Irish sea at Dublin Bay (Fehily Timoney & Company, 2007). The river flow is controlled by three hydroelectric power stations operating along the river as well as a number of minor private installations. Significant reservoir facilities can also be found at Pollaphuca.

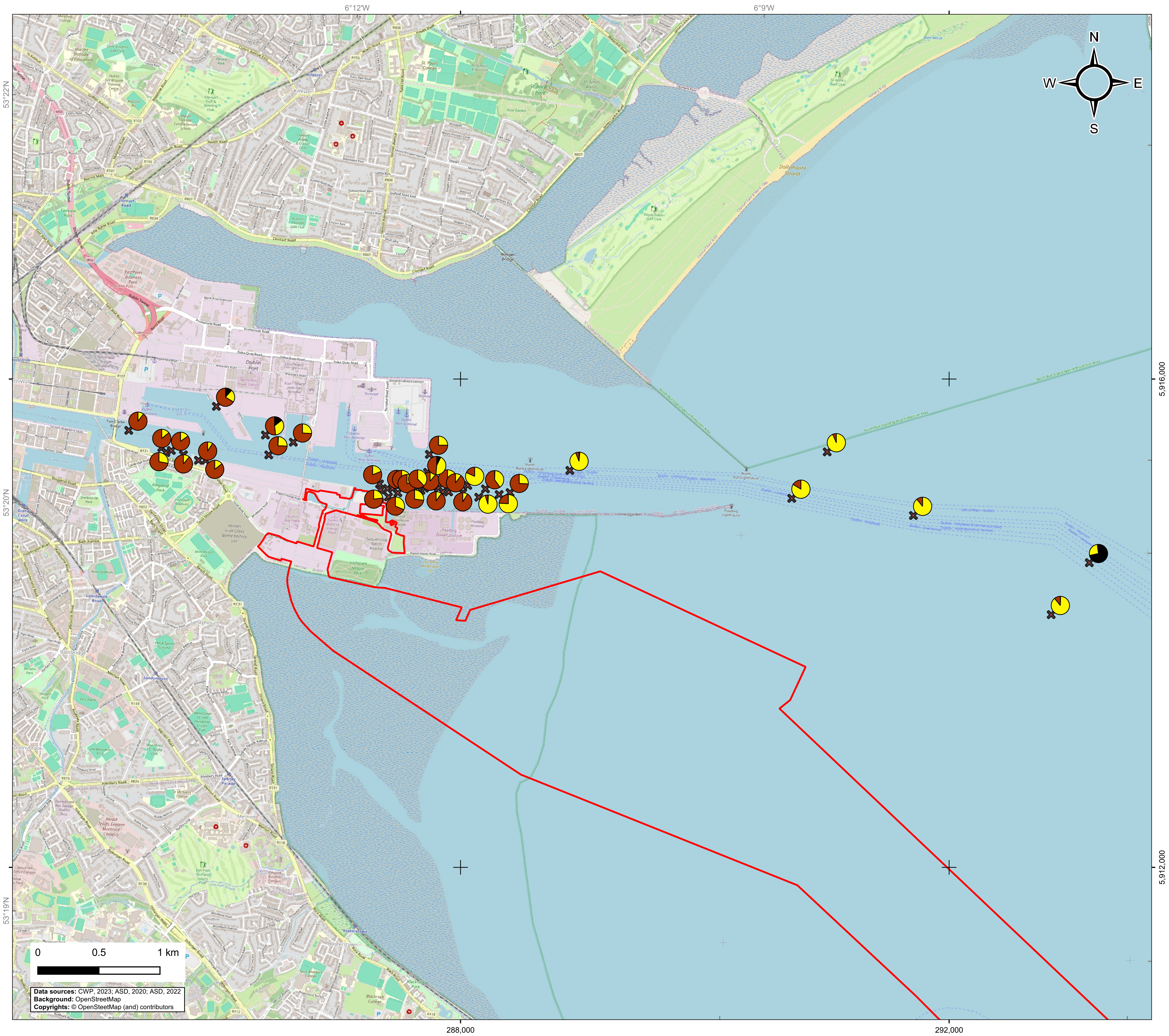
87. The river has been heavily industrialised at its mouth, with Dublin Port located on either side of the river Liffey alongside other facilities. A description of the tidal and wave regime within the subtidal area of the river is presented by in **Appendix 6.4 Codling Wind Park Hydraulic Modelling Support**.

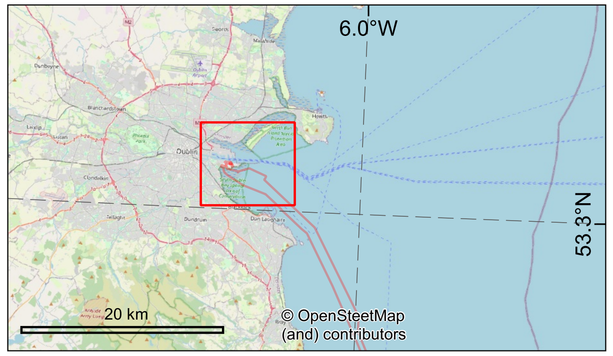
88. Information on the sediment composition within the subtidal area of the Dublin Port is available from a benthic and fisheries survey campaign completed in 2020. Analyses of a total of 15 samples indicated that that the bed is largely comprised of Mud and sandy Mud patches within the upper sheltered parts of the river channel, with the sediment further downstream comprised of sandier patches as is shown in **Figure 6-25** (Aquatic services, 2020). Only one sample, located approximately 6 km offshore, was classified as sandy Gravel (Aquatic services, 2020).

89. A second sediment sampling campaign was completed in 2022 to support the Dublin Port Company (DPC) with an application for a Dumping at Sea Permit (Aquatic Services, 2022). A total of 24 samples were collected within the subtidal area of the river Liffey and areas immediately downstream. The campaign further corroborates the findings obtained from the previous benthic and fisheries campaign conducted in 2020 and shows that the sediment composition is formed of Mud and sandy Mud fractions. Further downstream and near the main channel mouth, a larger Sand fraction can be observed in the collected samples. **Figure 6-25** shows the locations of the sediment samples collected during both campaigns as well as the observed sediment composition.

90. The DPC previously performed extensive monitoring of water quality at Dublin Port as part of the Alexandra Basin Redevelopment (ABR) Project. A total of four water quality stations measuring turbidity, temperature, salinity and dissolved oxygen (the location of which is shown in **Plate 6-34**) were deployed between January 2017 and January 2019 (RPS, 2019).

91. Summary statistics of the turbidity measurements obtained from the above-mentioned campaign are presented in **Table 6-15**. **Plate 6-35** presents the data in the form of a timeseries (RPS, 2019). The data indicated that the total suspended solids (TSS) levels within the port area and the lower Liffey remain relatively low (averaging *c*. 7 mg/l at Eastlink, Northbank and Tolka stations and rising to *c*. 20 mg/l at Poolbeg). These levels of TSS concentrations are expected to fluctuate seasonally.





Legend

- Planning application boundary
- Surveyed locations. The associated pie charts represent the percentages of surficial particle sizes
- Gravel (%)
- Sand (%)
- Mud (%)

codling wind park	Project: Codling Wind Park	Contractor: Partrac.com PARTRAC

Figure 6.25
Surficial particle size at Liffey channel

CWP doc. number:	CWP-PAR-ENG-08-01-MAP-0940		
Internal descriptive code: DU.BAY - PAB_SURFICIAL_SEDIMENTS_LOCAL_ASD - EIAR.FIG.06.25	Size: A3 Scale: 1:30,000	CRS: EPSG 25830	

Rev.	Updates	Date	By	Chk'd	App'd
00	Final for issue	2024/03/14	MG	JP/EA	JP/EA

Plate 6-34 DPC Measurement Locations (RPS, 2019)

Table 6-15 Turbidity measurements obtained during the ABR monitoring campaign in mg/l (RPS, 2021)

Parameter	Northbank	Poolbeg	Eastlink	Tolka
Mean	2.6	7.4	2.4	3.3
Maximum	39.5	190.3	9	52.5
Minimum	0	0	0	0
5th percentile	0	0	0	0
95th percentile	8.6	34.3	7.1	12.6

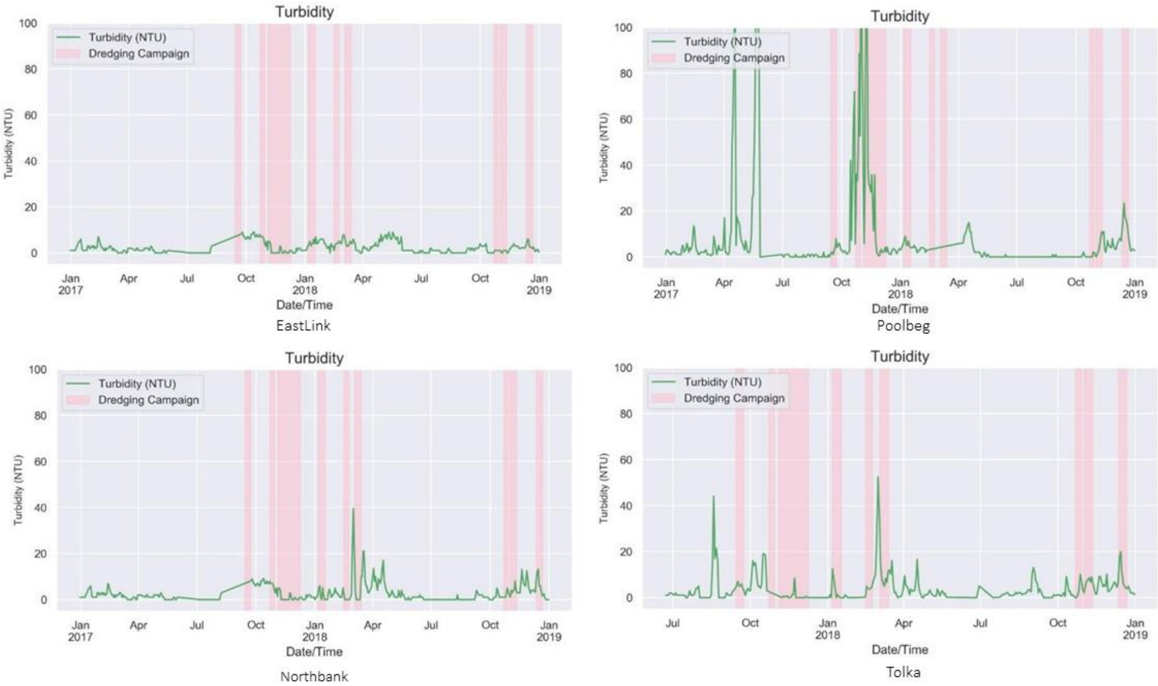


Plate 6-35 Turbidity measurements in Dublin Bay presented in the form of a time series (Figure reproduced from RPS, 2021)

6.6.8 Climate Change and Natural Trends

92. Climate change gives rise to global effects which are anticipated to be manifested by rising mean sea levels. Within the literature there is general agreement that water levels will rise during the lifetime of the CWP Project.

93. Information on the rate and magnitude of anticipated relative sea level change during the 21st Century is available from the World Bank Climate Change Knowledge Portal Tool (World Bank Group, 2022). The projected sea level changes are associated with three different forcing scenarios, being Representative Concentration Pathway (RCP) 2.6, 4.5 and 8.5 which are presented in **Plate 6-36**. Current estimates are that over the next century the Irish Sea (Wicklow coast) will experience a rise in sea level of between 0.1–0.5 m (**Table 6-16**). Sea levels are predicted to rise at a greater rate during the second half of this century, though higher rates of rise have been observed in Dublin Bay in recent years (Shoari et al., 2022).

Table 6-16 The predicted rise in water level for the 'low', 'medium' and 'high' emissions scenarios

Scenario	10th	50th	90th
RCP2.6	0.14 m	0.22 m	0.36 m
RCP4.5	0.20 m	0.26 m	0.42 m
RCP8.5	0.25 m	0.35 m	0.54 m

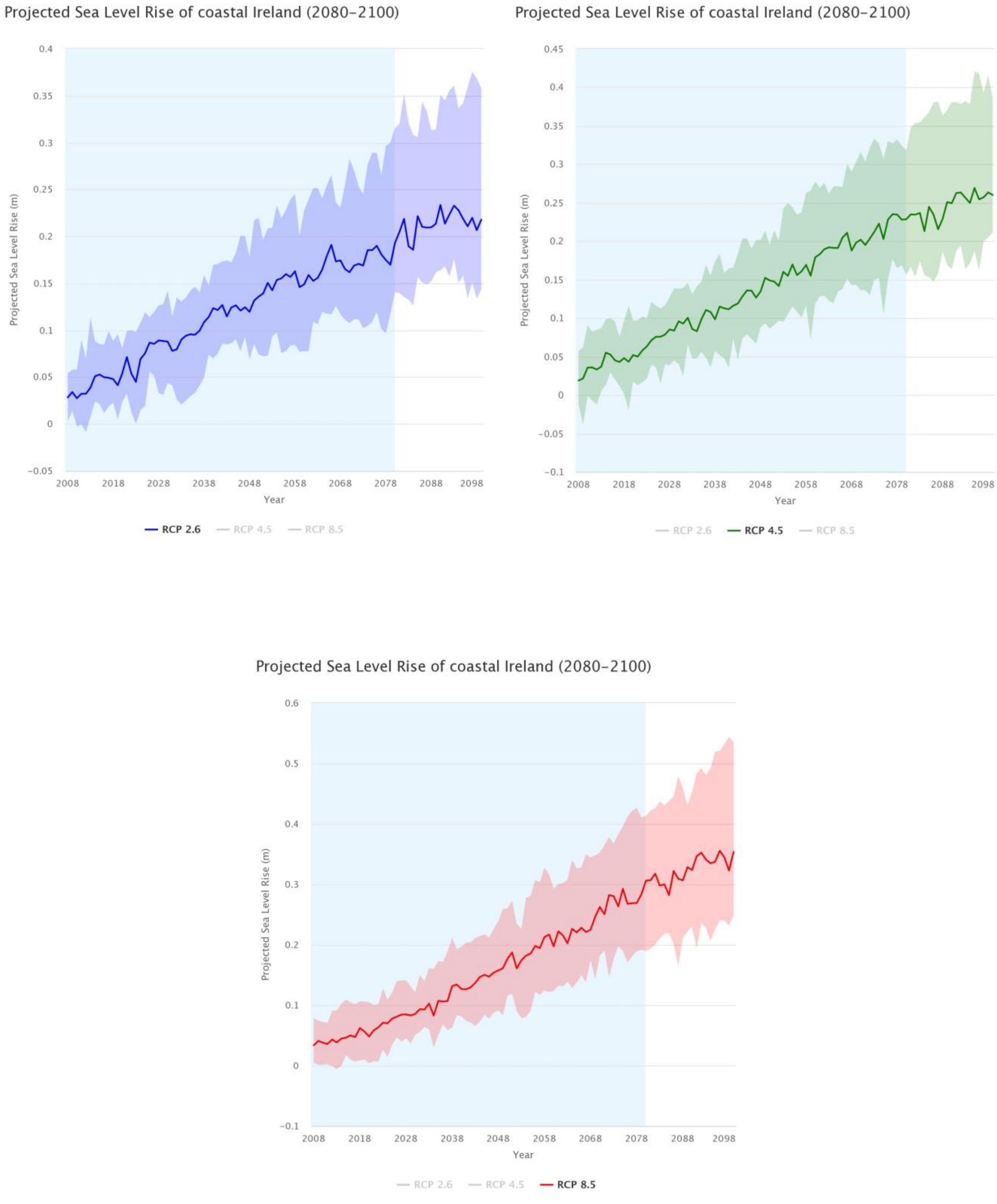


Plate 6-36 The three RCP 2.6, 4.5 and 8.5 emission scenarios presented in the form of a time series of time against mean sea level change. Plot reproduced from World Bank Group (2022).

6.6.9 Predicted Future Baseline

94. Unusually energetic and infrequent metocean events (e.g., storms) give rise to extreme values of significant wave heights and wave periods. It is widely expected that climate change will result in global effects which are anticipated to be manifested at regional scales by increased storminess and rising mean sea level (Lowe et al., 2009).

95. A hypothesised increase in the frequency and magnitude of storm events will increase the potential for sediment mobility and resuspension within the Maritime Area Consent Boundary due to the increased likelihood of wave conditions that are sufficient to penetrate to the seabed. Several reviews have been undertaken relevant to understanding the potential effects of climate change on relative storminess. For example, Feser et al. (2015) presented a field of evidence showing significant changes in storminess have occurred in the North Atlantic over the last century over the North Atlantic and northwestern Europe. These findings were corroborated by Alexandersson et al. (2000), who found relative storminess increased in the late 20th Century. Although a decline in storminess was noticed in the early 2000s (e.g., Matulla et al., 2007), the general observations of an increase in storminess in the North Atlantic is also corroborated by similar studies into the long-term wave climate of the North Sea (e.g., Beniston et al., 2007).

96. In addition to an increase in storminess within the Irish Sea, it is anticipated that mean sea level is likely to rise during the lifetime of the CWP Project. This change is widely accepted to include contributions from global eustatic (water volume) changes in mean sea level and regionally varying vertical (isostatic) adjustments of the land / seabed. Information on the rate and magnitude of anticipated relative sea level change during the 21st Century is available from the predictions published by the World Bank (World Bank Group, 2022). The predicted rises in sea level are anticipated to have a limited effect on the prevailing oceanographic and sediment transport regimes. At the coast, sea level rise could lead to an increase in the rate and / or magnitude of observed coastal recession. The impact on wider coastal processes is inherently linked to the anthropogenic response and the mitigation that may (or may not) be implemented at the coastline.

6.7 Scope of the assessment

97. An EIA Scoping Report for the offshore infrastructure was published on 6 January 2021. The Scoping Report was uploaded to the CWP Project website and shared with regulators, prescribed bodies and other relevant consultees, inviting them to provide relevant information and to comment on the proposed approach being adopted by the Applicant in relation to the offshore elements of the EIA.

98. Based on responses to the Scoping Report, further consultation and refinement of the CWP Project design, potential impacts to Marine Geology, Sediments and Coastal Processes scoped into the assessment are listed below in **Table 6-17**.

Table 6-17 Potential impacts scoped into the assessment

Impact No.	Description of impact	Notes
Construction		
Impact 1	Temporary disturbance of the seabed resulting from pre-installation methods and effects, geotechnical survey, cable and monopile installation leading to increases in suspended sediment concentrations and associated deposition.	Impacts associated with the temporary disturbance of the seabed due to pre-installation methods and effects, geotechnical survey, cable and monopile installation leading to increases in SSC from the

Impact No.	Description of impact	Notes
		construction of the CWP Project are assessed in **Section 6.10**.
Impact 2	Temporary disturbance of the seabed resulting from pre-sweeping / sandwave levelling activities leading to increases in suspended sediment concentrations and associated deposition.	Impacts associated with the temporary disturbance of the seabed resulting from pre-sweeping / sandwave levelling activities leading to increases in SSC from the construction of the CWP Project are assessed in **Section 6.10**.
Impact 3	Alteration to seabed morphology during seabed preparation.	Impacts associated with the alteration to seabed morphology from the construction of the CWP Project are assessed in **Section 6.10**.
Impact 4	Localised alteration to the hydrodynamic, wave and sediment regimes and coastal processes.	Impacts associated with the alteration of the hydrodynamic, wave and sediment regimes and coastal processes from the construction of the CWP Project are assessed in **Section 6.10**.
Operation and Maintenance		
Impact 1	Localised alteration of hydrodynamic and wave conditions across the site and effects on the sediment transport regime and coastal processes.	Impacts associated with the alteration of the hydrodynamic, wave and sediment regimes and coastal processes from the operation of the CWP Project are assessed in **Section 6.10**.
Impact 2	Scour around installed structures and associated sediment transportation and deposition leading to changes in seabed composition, structure or morphology.	Impacts associated with scour around installed structures and associated sediment transportation and deposition and impacts upon seabed composition, structure and morphology from the operation of the CWP Project are assessed in **Section 6.10**.
Impact 3	Operation and maintenance.	Impacts associated with the operation and maintenance of the CWP Project are assessed in **Section 6.10**.
Decommissioning		
Impact 1	Temporary increases in suspended sediment concentration during removal of foundations and / or cables.	Impacts associated with the temporary disturbance of the seabed leading to increases in SSC from the decommissioning of the CWP Project are assessed in **Section 6.10**.
Impact 2	Localised alteration of hydrodynamic and wave conditions across the site and effects on the	Impacts associated with the alteration of the hydrodynamic, wave and sediment regimes and coastal

Impact No.	Description of impact	Notes
	sediment transport regime and coastal processes.	processes from the decommissioning of the CWP Project are assessed in **Section 6.10**.
Impact 3	Alteration to seabed morphology during decommissioning.	Impacts associated with the alteration to seabed morphology from the decommissioning of the CWP Project are assessed in **Section 6.10**.

6.8 Assessment parameters

6.8.1 Background

99. Complex, large-scale infrastructure projects with a terrestrial and marine interface, such as the CWP Project, are consented and constructed over extended timeframes. The ability to adapt to changing supply chain, policy or environmental conditions and to make use of the best available information to feed into project design promotes environmentally sound and sustainable development. This ultimately reduces project development costs and therefore electricity costs for consumers and reduces CO_2 emissions.

100. In this regard the approach to the design development of the CWP Project has sought to introduce flexibility where required, among other things to enable the best available technology to be constructed and to respond to dynamic maritime conditions, at the same time specifying project boundaries, project components and project parameters wherever possible, whilst having regard to known environmental constraints.

101. **Chapter 4 Project Description** describes the design approach that has been taken for each component of the CWP Project. Wherever possible the location and detailed parameters of the CWP Project components are identified and described in full within the EIAR. However, for the reasons outlined above, certain design decisions and installation methods will be confirmed post-consent, requiring a degree of flexibility in the planning consent.

102. Where necessary, flexibility is sought in terms of:

- Up to two options for certain permanent infrastructure details and layouts such as the Wind Turbine Generator (WTG) layouts.
- Dimensional flexibility, described as a limited parameter range, i.e., upper and lower values for a given detail such as cable length.
- Locational flexibility of permanent infrastructure, described as Limit of Deviation (LoD) from a specific point or alignment.

103. The CWP Project had to procure an opinion from An Bord Pleanála to confirm that it was appropriate that this application be made and determined before certain details of the development were confirmed. An Bord Pleanála issued that opinion on 25 March 2024 (as amended in May 2024), and it confirms that the CWP Project could make an application for permission before the details of certain permanent infrastructure described in **Section 4.3** of **Chapter 4 Project Description** is confirmed.

104. In addition, the application for permission relies on the standard flexibility for the final choice of installation methods and O&M activities.

105. Notwithstanding the flexibility in design and methods, the EIAR identifies, describes and assesses all of the likely significant impacts of the CWP Project on the environment.

6.8.2 Options and dimensional flexibility

106. Where the application for permission seeks options or dimensional flexibility for infrastructure or installation methods, the impacts on the environment are assessed using a representative scenario approach. A 'representative scenario' is a combination of options and dimensional flexibility that has been selected by the author of this EIAR chapter to represent all of the likely significant effects of the project on the environment. Sometimes, the author will have to consider several representative scenarios to ensure all impacts are identified, described and assessed.

107. For the marine geology, sediments and coastal processes, this analysis is presented in **Appendix 6.2**, which identifies one or more representative scenarios for each impact, with supporting text to demonstrate that no other scenarios would give rise to new or materially different effects, taking into consideration the potential impact of other scenarios on the magnitude of the impact or the sensitivity of the receptor(s) that is being considered.

108. **Table 6-18** and **Table 6-19** below present a summarised version of **Appendix 6.2** and describes the representative scenarios on which the construction and O&M phase marine geology, sediments and coastal processes assessment has been based. Where options exist, for each receptor and potential impact, the table identifies the representative scenario and provides a justification for this.

6.8.3 Limit of deviation

109. Where the application for permission seeks locational flexibility for infrastructure, the impacts on the environment are assessed using a LoD. The LoD is the furthest distance that a specified element of the CWP Project can be constructed.

110. This chapter assesses the specific preferred location for permanent infrastructure. However, **Appendix 6.2** provides further analysis to determine if the proposed LoD for permanent infrastructure may give rise to any new or materially different effects, taking into consideration the potential impact of the proposed LoD on the magnitude of the impact.

111. For the marine geology, sediments and coastal processes this analysis is summarised in **Table 6-19**.

112. Where the potential for LoD to cause a new or materially different effect is identified, then this is noted in **Table 6-19** and is considered in more detail within **Section 6.6** of this chapter.

Table 6-18 Marine Geology, Sediments and Coastal Processes Representative scenarios assessment

Impact	Representative scenario details	Value		Notes / Assumptions
		WTG Option A	WTG Option B	
Construction				
Impact 1: Temporary disturbance of the seabed resulting from pre-installation methods and effects, cable and monopile installation leading to increases in suspended sediment concentrations, and associated deposition.	Installation methods and effects			The temporary disturbance of the seabed can increase local suspended sediment concentrations during pre-installation methods and effects: cable and monopile installation (source), the sediments liberated during construction are transported in the direction of the prevailing tidal flow (pathway) and are then deposited on the seabed (receptor). Offshore, WTG Option A forms the representative scenario as this represents the greatest level of temporary seabed disturbance and therefore the greatest volume of liberated sediment and Option B would not give rise to a materially different impact. Therefore, WTG Option A forms the presentational basis of the assessment for Impact 1 in this chapter. It should be noted that the pre-lay grapnel run along IAC and OECC footprint is equivalent to the IAC and OECC cable installation footprint. For boulder clearance, the use of a displacement plough forms the presentational basis of this assessment as this represents the greatest level of temporary sediment disturbance. The use of a subsea grab is typically used for relocating larger boulders or boulders located on a slope and thus would result in a lower level of disturbance and
	Boulder clearance: array site seabed clearance area (m^2)	2,556,000–2,934,000	–	
	Boulder clearance: OECC seabed clearance area (m^2)	2,220,000–2,616,000	–	
	Pre-lay grapnel run along IAC (m^2)	1,911,000–2,214,000	–	
	Pre-lay grapnel run along OECC (m^2)	1,890,000–2,187,000	–	
	IAC and interconnector cable installation: Total seabed disturbed (m^2)	1,911,000–2,214,000	–	
	Offshore export cable installation: Total seabed disturbed (m^2)	1,890,000–2,187,000	–	
	Total area of seabed in transition zone affected by installation of cables using either open cut trenching or a shallow	108,000	–	

Impact	Representative scenario details	Value		Notes / Assumptions
		WTG Option A	WTG Option B	
	water trenching tool (m^2)			would not give rise to a materially different impact, or an impact of greater magnitude. For cable installation, the use of jetting forms the presentational basis of this assessment, as it typically results in greater sediment suspension, introducing the potential for distribution of greater volumes of material over a larger spatial area than other cable laying techniques which may be employed during construction. The use of other methods would result in a lower level of disturbance and would not give rise to a materially different impact, or an impact of greater magnitude. Similarly, within the transition zone, the shallow water wheeled jet trenching system will form the presentational basis of this assessment. For monopile installation activities WTG Option A forms the representative scenario, as this represents the anticipated greatest volume of disturbed sediment. Therefore, Option A forms the presentational basis of the assessment for Impact 1 monopile installation activities in this chapter. The total volume of disturbed sediment (drill arisings) for monopile installation activities based on this representative scenario is calculated to be 24,516 m^3. The total area of disturbed sediment for construction activities based on this representative scenario is calculated to be 10,059,000 m^2. The total volume of drill arisings is 24,516 m^3.
	Total area of disturbed sediment for offshore construction activities (m^2)	**10,059,000**	–	
	Total volume of WTG monopile drill arisings (m^3)	**24,516**	–	
	Boulder clearance methods	Displacement plough	–	
	Cable installation options	Jetting including open cut for landfall	–	

Impact	Representative scenario details	Value		Notes / Assumptions
		WTG Option A	WTG Option B	
Impact 2: Temporary disturbance of the seabed resulting from pre-sweeping / sandwave levelling activities leading to increases in suspended sediment concentrations, and associated deposition	Installation methods and effects			The temporary disturbance of the seabed can increase local suspended sediment concentrations during pre-sweeping / sandwave levelling and subsequent dredge disposal activities (source). The sediments liberated during these activities are transported in the direction of the prevailing tidal flow (pathway) and are then deposited on the seabed (receptor). WTG Option B forms the representative scenario as this represents the greatest level of temporary seabed disturbance. WTG Option A would result in a lower level of disturbance and does not give rise to a materially different impact. Therefore, Option B forms the presentational basis of the assessment for Impact 2 in this chapter. For pre-sweeping / sandwave levelling, the TSHD method forms the presentational basis of this assessment as this has the potential to liberate greater volume of sediment during dredging and disposal activities compared to the use of mass flow excavation and therefore would result in a lower level of disturbance and does not give rise to a materially different impact, or an impact of greater magnitude. The total area of disturbed sediment for pre-sweeping / sandwave levelling activities based on this representative scenario is calculated to be 476,050 m^2.
	Pre-sweeping / sandwave levelling: array site sandwave clearance total area (m^2)	–	220,000–277,500	
	Pre-sweeping / sandwave levelling: OECC sandwave clearance total area (m^2)	–	198,550	
	Total area disturbed during pre-sweeping / sandwave levelling (m^2)	**–**	**476,050**	
	Pre-sweeping / sandwave levelling methods	–	Trailer Suction Hopper Dredger (TSHD)	

Impact	Representative scenario details	Value		Notes / Assumptions
		WTG Option A	WTG Option B	
Impact 3: Alteration to seabed morphology during seabed preparation	See Impact 2 for relevant project details			During seabed preparation, pre-sweeping / sandwave levelling (source) will directly impact upon seabed morphology (receptor). WTG Option B forms the representative scenario as this represents the greatest area of seabed level alteration. WTG Option A would result in a lower level of disturbance, as it has a smaller area of seabed alteration and does not give rise to a materially different impact. Therefore, Option B forms the presentational basis of the assessment for Impact 3. For pre-sweeping / sandwave levelling methods, the TSHD and mass flow excavation methods are anticipated to have the same impact on the seabed morphology and therefore a representative scenario is not required. The total area of altered seabed for pre-sweeping / sandwave levelling activities based on this representative scenario is calculated to be 476,050 m^2.
Impact 4: Localised alteration to the hydrodynamic, wave and sediment regimes and coastal processes	Temporary infrastructure			During construction, specifically during the installation of WTG structures, offshore substation (OSS), scour protection, cable installation and installation of cable protection, anchoring of vessels and deployment of jack-up vessels on site and the use of temporary structures at the landfall (source) has the potential to alter the hydrodynamic,
	Vessel anchoring parameters: Total impact area for WTG and OSS installation (m^2)	280,800	–	

Impact	Representative scenario details	Value		Notes / Assumptions
		WTG Option A	WTG Option B	
	Vessel anchoring parameters: Total impact area for inter-array and interconnector cable installation (m^2)	371,520	–	wave and sediment regimes with potential downstream effects on local coastal processes (receptors). WTG Option A forms the representative scenario for the design parameters assessed for vessel anchoring during construction and installation. This is because, in terms of localised alteration to the hydrodynamic, wave and sediment regimes and coastal processes this represents the greatest total impacted area, and therefore WTG Option A forms the presentational basis of the assessment for Impact 4 in this chapter. WTG Option B would result in a lower level of disturbance and does not give rise to a materially different impact. At the landfall, cable ducts will be installed by open cut. The total impacted area based on this representative scenario is calculated to be **1,296,040 m^2**.
	Vessel anchoring parameters: Total impact area export cable installation (m^2)	630,720	–	
	Total impacted area due to vessel anchoring for array site and offshore export cable corridor (m^2)	**1,283,040**	–	
	Installation method and effects			
	Total seabed disturbed by cofferdam (m^2)	6,100		
	Total area of seabed in transition zone affected by support structures (m^2)	6,900		
	Total impacted area for landfall construction activities (m^2)	**13,000**		

Impact	Representative scenario details	Value		Notes / Assumptions
		WTG Option A	WTG Option B	
Operations and maintenance				
Impact 1: Localised alteration of hydrodynamic and wave conditions across the site and effects on the sediment transport regime and coastal processes	Permanent infrastructure			The alteration of hydrodynamic and wave conditions across the site and indirect effects on the sediment transport regime and coastal processes due to the installation of permanent wind farm infrastructure (source) has the potential to directly alter the hydrodynamic, wave and sediment regimes including effects on local coastal processes (receptor). For permanent infrastructure offshore and at the onshore substation, WTG Option A forms the representative scenario as this represents the greatest total seabed area take. Therefore, Option A forms the presentational basis of the assessment for Impact 1 in this chapter. WTG Option B would result in a lower level of disturbance and does not give rise to a materially different impact. The total impacted area based on this representative scenario is calculated to be **599,620 m^2.** At the onshore substation, the total length of perimeter structures based on this representative scenario is calculated to be 300 m.
	Total WTG monopile seabed area take (with scour protection) across the array site (m^2)	273,000	–	
	Total OSS monopile seabed area take (with scour protection) across the array site (m^2)	10,920		
	Total area of seabed covered by cable protection (m^2)	208,600	–	
	Total area of seabed covered by export cable protection (m^2)	105,000		
	Total seabed area take (m^2)	**597,520**	–	
	Onshore substation: length of combi-wall below the High Water Mark (HWM) (requiring marine piling) (m)	150		

Impact	Representative scenario details	Value		Notes / Assumptions
		WTG Option A	WTG Option B	
	Onshore substation: Total length of new revetments (m)	150		
	Total length of perimeter structures (m)	**300**		
	Area of reclaimed land at onshore substation (m^2)	1,800		
Impact 2: Scour around installed structures and associated sediment transportation and deposition leading to changes in seabed composition, structure or morphology.	See Impact 1 for relevant project details.			Scour around implemented scour protection systems (e.g., edge scour) and scour around other seabed infrastructure (e.g., cable protection) and associated sediment transportation and deposition (source) can lead to changes in seabed composition, structure and morphology (receptor). For permanent infrastructure offshore and at the onshore substation, WTG Option A forms the representative scenario as this represents the greatest total seabed area take. Therefore, Option A forms the presentational basis of the assessment for Impact 1 in this chapter. WTG Option B would result in a lower level of disturbance and does not give rise to a materially different impact. The total impacted area based on this representative scenario is calculated to be **597,520 m^2.**

Impact	Representative scenario details	Value		Notes / Assumptions
		WTG Option A	WTG Option B	
				At the onshore substation, the total length of perimeter structures based on this representative scenario is calculated to be 300 m.
Impact 3: Operation and maintenance	Temporary infrastructure			A single representative scenario has been adopted for Impact 3, as the number of vessels required for maintenance are the same under Option A and B.
	Jack-Up Vessels (JUVs) peak vessel numbers	2		
	Service Operation Vessel peak vessel numbers	1		
	CTVs peak vessel numbers	6		
	Cable maintenance vessels peak vessel numbers	2		
	Auxiliary vessel peak vessel numbers	3		
	JUVs annual rounds	3		
	Service Operation Vessel annual rounds	**26**		
	CTVs annual rounds	**1,152**		
	Cable maintenance vessels annual rounds	**1**		

Impact	Representative scenario details	Value		Notes / Assumptions
		WTG Option A	WTG Option B	
	Auxiliary vessel annual rounds	**27**		
Decommissioning				
Impact 1: Temporary increases in suspended sediment concentration during removal of foundations and / or cables. **Impact 2**: Localised alteration of hydrodynamic and wave conditions across the site and effects on the sediment transport regime and coastal processes. **Impact 3**: Alteration to seabed morphology during decommissioning.	It is recognised that legislation and industry best practice change over time. However, for the purposes of the EIA, at the end of the operational lifetime of the CWP Project, it is assumed that all offshore infrastructure will be removed where practical to do so. In this regard, for the purposes of a representative scenario for decommissioning impacts, the following assumptions have been made: • The WTGs and OSS topsides will be completely removed. • Following WTG and OSS topside decommissioning and removal, the monopile foundations will be cut below the seabed level, to a depth that will ensure the remaining foundation is unlikely to become exposed. This is likely to be approximately 1 m below seabed, although the exact depth will depend upon the seabed conditions and site characteristics at the time of decommissioning. • All cables and associated cable protection in the offshore environment will be wholly removed. It is likely that equipment similar to that which is used to install the cables may be used to reverse the burial process and expose them. Therefore, the area of seabed impacted during the removal of the cables is anticipated to be the same as the area impacted during the installation of the cables. • Generally, decommissioning is anticipated to be a reverse of the construction and installation process for the CWP Project and the assumptions around the number of vessels on site and vessel round trips is therefore the same as described for the construction phase of the offshore components. Given the above it is anticipated that for the purposes of a representative scenario, the impacts will be no greater than those identified for the construction phase.			

Table 6-19 Marine Geology, Sediments and Coastal Processes Limits of Deviations assessment

Project component	Limit of deviation	Conclusion from Appendix 6.2
Offshore project components		
WTGs / OSS/ monopile foundations/ monopile scour protection	100 m from the centre point of each WTG and OSS location.	No potential for new or materially different effects where the structure location is adjusted within the defined limit of deviation.
IACs / interconnector cables	100 m either side of the preferred alignment of each IAC and interconnector cable. 200 m from the centre point of each WTG location.	No potential for new or materially different effects where the alignment of the IAC and interconnector cable is adjusted within the defined limit of deviation.
Offshore export cables	250 m either side of the preferred alignment within the array site. The offshore export cable corridor (OECC) outside of the array site.	No potential for new or materially different effects where the alignment of the export cable is adjusted within the defined limit of deviation.
Intertidal cable ducts and intertidal offshore export cables (non-ducted sections)	The OECC	No potential for new or materially different effects where the structure location is adjusted within the defined limit of deviation.
Location of onshore substation revetment perimeter structure	Defined LoD boundary for sheet piling at the toe of the revetment	No potential for new or materially different effects where the structure location is adjusted within the defined limit of deviation.

6.9 Primary mitigation measures

113. Throughout the evolution of the CWP Project, measures have been adopted as part of the evolution of the project design and approach to construction, to avoid or otherwise reduce adverse impacts on the environment. These mitigation measures are referred to as 'primary mitigation'. They are an inherent part of the CWP Project and are effectively 'built in' to the impact assessment.

114. Primary mitigation measures relevant to the assessment of marine geology, sediments and coastal processes are set out in **Table 6-20**. Where additional mitigation measures are proposed, these are detailed in the impact assessment (**Section 6.10**). Additional mitigation includes measures that are not incorporated into the design of the CWP Project and require further activity to secure the required outcome of avoiding or reducing impact significance.

Table 6-20 Primary mitigation measures

Project Element	Description
All offshore infrastructure	Positions of WTGs and OSSs have been informed by a wide range of site specific data, including metocean data (e.g., wind speed and direction), geophysical and geotechnical survey data (e.g., bathymetry), environmental data (e.g., benthic surveys and archaeological assessment) and stakeholder consultation. Designing and optimising the layout of the WTGs has considered multiple constraints identified from analysis of these datasets, alongside the consideration of layout principles taken from relevant guidance on the design of OWFs. A summary of the key actions taken to avoid or otherwise reduce impacts is provided below: • The WTG layout options include Search and Rescue (SAR) access lanes to allow a SAR resource to fly on the same orientation continuously through the array site. This is provided to minimise risks to surface vessels and / or SAR resource transiting through the array site. • Archaeological exclusion zones (AEZs) around known features of archaeological interest have been avoided. No works that impact the seabed will be undertaken within the extent of an AEZ during the construction, operational or decommissioning phases. • The locations of offshore infrastructure have been developed to avoid known sensitive ecological habitats, including areas with suitable conditions for *Sabellaria spinulosa*, which can form reefs under some circumstances. Whilst reefs were not identified during the characterisation surveys, as an ephemeral feature it will be necessary to validate the results in advance of construction. A pre-construction geophysical survey will therefore be undertaken to facilitate the micro-siting around sensitive habitats, such as *Sabellaria spinulosa*.

Project Element	Description
	• The WTG layout options have been developed to avoid or minimise interaction with known areas of high fishing density, where possible. As avoidance is not always possible, the layouts have also been developed to increase the potential for coexistence. • A paleochannel (the remnants of a river or stream channel that flowed in the past) in the centre west of the array site has been avoided.
Offshore cables	The Applicant will, where practicable, bury all cables within the offshore development area: • IACs and interconnector cables will have a minimum depth of cover of 1.0 m; and • Offshore export cables will have a minimum depth of cover of 1.4 m. In cases where burial is inadequate due to unforeseeable seabed conditions, and at cable crossings, cable protection will be implemented as mitigation to avoid risks to other marine operations.
All offshore infrastructure	Bedform clearance operations will be undertaken only where necessary, thereby minimising sediment disturbance and alteration to seabed morphology.
All offshore infrastructure	Disposal of dredged material will occur in suitable locations within the offshore development area, and in accordance with the requirements under a disposal at sea licence which will be sought separately. This has the benefit of minimising impacts on seabed morphology and the wider sediment regime.
Offshore construction vessels	During WTG installation, equipment such as jack-up vessels (if required) are expected to remain in any one location for a limited period of time (hours to a few days). This will ensure any impacts on the prevailing hydrodynamic, wave and sediment regimes and coastal processes are minimised.
All offshore infrastructure All onshore infrastructure	A Rehabilitation Schedule is provided as part of the planning application. This has been prepared in accordance with the MAP Act (as amended by the Maritime and Valuation (Amendment) Act 2022) to provide preliminary information on the approaches to decommissioning the offshore and onshore components of the CWP Project. A final **Rehabilitation Schedule** will require approval from the statutory consultees prior to the undertaking of decommissioning works. This will reflect discussions held with stakeholders and regulators to determine the exact methodology for decommissioning, taking into account available methods, best practice and likely environmental effects.

6.10 Impact assessment

6.10.1 Construction phase

115. The potential environmental impacts arising from the construction of the CWP Project are listed in **Table 6-17**, along with the parameters against which each construction phase impact has been assessed. A description of the potential effect on marine geology, sediments and coastal processes receptors caused by each identified impact is given below.

Impact 1: Temporary disturbance of the seabed resulting from pre-installation methods and effects, cable and monopile installation leading to increases in suspended sediment concentrations, and associated deposition.

116. The potential exists for SSC to be enhanced due to construction activities; these activities include:

- Pre-installation method and effects:
  - Boulder clearance.
  - Pre-lay grapnel run.
- Cable installation activities including activities at the cable landfall.
- Monopile installation activities:
  - Drill arisings in the event that drilling of foundations is required.

Pre-Installation Methods and Effects

117. Along the OECC and inter-array cable (IAC) routes, where boulders have been identified during pre-construction surveys, it may be necessary to clear these prior to construction. The representative scenario assessed is the use of a displacement plough, which moves boulders from the route using a V-shaped design configured with a boulder board, forming a swathe clear of small boulders. In addition to boulder clearance, to snag, recover and remove any seabed obstructions a PLGR will be conducted. To do this, a grapnel hook will be towed by a vessel at a speed that ensures that the grapnel(s) stay in continuous contact with the seabed. The depth of penetration of the seabed by the grapnel is approximately 40–80 cm. The width of seabed disturbance along the PLGR is estimated to be 3 m, which is encompassed by the 15 m width of seabed disturbance for the cable installation works.

118. Along the OECC and IAC routes, where surficial sediments are dominantly comprised of coarser sediments (i.e., coarse sands and gravels which comprise >80% of surficial sediment samples analysed (Osiris Projects, 2013)), it is considered unlikely that SSCs would be enhanced significantly beyond natural (background) levels during boulder clearance activities performed using a displacement plough. In the limited areas of the seabed where surficial sediments include finer sediments comprising 'mud' (i.e., silt and clay sized sediments), boulder clearance via a displacement plough is likely to suspend only a small volume of material. This material would then be locally redistributed by the prevailing tidal flows. The spatial extent of the dispersion of fine sediments would depend on the timing of operations, with suspended sediments distributed across a greater spatial extent (i.e., potentially hundreds of m) during periods of higher flow velocity (i.e., spring tides). However, the action of the plough is unlikely to liberate a large volume of sediment upwards into the water column. Those sediments which are liberated into suspension, due to the generally coarse nature of the surficial sediments, will display limited dispersion (i.e., 10s of m). Similarly, the PLGR will only disturb a small volume of dominantly coarse sediments. Consequently, these impacts would be highly localised and temporary in nature, with sediments liberated being rapidly deposited (within 10s of m) and integrated into the prevailing sediment regime.

Cable Installation Activities

119. Several cable installation methods are proposed: cable burial can be achieved by ploughing, jet or mechanical trenching and it is likely that a combination of these techniques will be employed during cable installation operations to account for different water depths and seabed conditions along the IAC and OECC. Typically, a 2 m maximum trench depth will be sought increasing to 3 m where the OECC crosses the approaches to Dun Laoghaire harbour and the RWE cable (see **Appendix 6.3**). In addition, as part of nearshore cable installation operations, trench excavation will be conducted sub-aerially and a shallow water wheeled jet trenching system will be utilised over a distance of approximately 2 km to the location where the Cable Laying Vessel (CLV) is able to commence conventional cable burial.

120. A consequence of cable installation will be the liberation of sediment into suspension within the water column, just above the seabed. Jetting typically results in greater sediment suspension, introducing the potential for distribution of greater volumes of material over a larger spatial area than other cable laying techniques which may be employed during construction, and thus is assessed as the representative scenario. This method involves fluidising the material to form a narrow trench into which the cable is laid. The jetting process results in a large proportion of the fluidised sediment from the trench being liberated into suspension in the water column above the bed and dispersed in the direction of the prevailing currents. The subsurface and surficial geological and geomorphological seabed characteristics determine the sediment type disturbed during cable burial operations.

121. Assessment was achieved using results of numerical modelling performed for the representative scenario within IAC array, OECC and the export cable within the nearshore transition zone (see **Appendix 6.3**). These analyses predict the magnitude (i.e., the size, concentration and spatial extent) of sediment plumes generated during cable installation activities. Based on the foregoing analyses, the predicted transport of sediment plumes generated during cable installation activities across the MAC application boundary indicated the finest sediments will potentially be transported up to 5–6 km in the offshore region, and less than 2 km in the nearshore area. Maximum SSC values of up to 40 mg/l were predicted, however these plumes are transient, rapidly decreasing as sand sized sediments deposit to the bed and finer sediments are dispersed. The thickness of the deposit on the seabed away from the trenching activities were predicted to be less than 2 cm. Deposited sediments would be reworked and rapidly integrated into the prevailing sediment transport regime. Consequently, enhanced SSC and the predicted deposition thickness due to cable installation would not be discernible above the potential natural variation observed during storm events. Elevated SSCs were predicted to reduce to baseline levels within *c*. 10 to 15 days following trenching operations.

Monopile Installation

122. Monopiles are most likely to be driven into the seabed. However, where ground conditions dictate, Wind Turbine Generator (WTG) locations may be drilled into the seabed. Where this is the case, a bespoke reverse circulation drill will be used which mobilises drill arisings deposited adjacent to the WTG foundation. These drill arisings, which will be comprised of disaggregated Holocene and consolidated Quaternary sediments will be dispersed in the direction of the prevailing flow during this activity. In an analogous fashion to cable installation activities, drilling will cause localised suspended sediment plumes. Though these sediment plumes will be smaller in magnitude compared to those generated during cable installation, comprising a significantly lower volume of sediment, the sediments are likely to be comparatively finer.

123. Modelling performed indicates finer sediments within suspended sediment plumes will potentially be transported up to 5–6 km in the offshore region from their source within the array site. As the volumes of drill arisings do not exceed 2,322 m^3 per WTG foundation, maximum SSC values of < *c*. 40 mg/l are predicted. These plumes are transient, rapidly decreasing in concentration as sand sized sediments deposit to the bed and finer sediments are dispersed. The thickness of the deposit on the seabed away from the monopile location is predicted to be less than 10 cm, based on the results of the modelling performed (see **Appendix 6.3**). Deposited sediments would be reworked and rapidly integrated into the prevailing sediment transport regime. Consequently, enhanced SSC and the predicted deposition thickness due to cable installation would not be discernible above the potential natural variation observed during storm events. Elevated SSCs were predicted to reduce to baseline levels within *c*. 10 to 15 days following trenching operations.

124. The effects of the expected increase in SSC and sediment accumulation on the seabed associated with pre-installation methods and effects, cable installation and monopile installation activities have been assessed separately by other EIA topics in relation to other sensitive receptors. These include:

- **Chapter 7 Marine Water Quality**
- **Chapter 8 Subtidal and Intertidal Ecology**
- **Chapter 14 Marine Archaeology and Cultural Heritage**.

Receptor sensitivity

125. The receptors in the study area affected by enhanced SSC and sediment deposition on the seabed include the wider seabed, its morphology and underlying geology, the prevailing hydrodynamic and wave regime and the sediment transport regime and coastal processes. The sensitivity of these receptors is assessed as low.

Magnitude of impact

126. Due to the dominantly coarse nature of the surficial sediments to be disturbed, low volumes of sediments likely to be liberated into the water column and the highly localised and transient nature of the operations to be performed, the liberation, transport and subsequent deposition of sediments during pre-installation method and effects (i.e., boulder clearance and the PLGR) is considered to be highly limited. Consequently, as sediments are not being removed from the local sediment cell and thus are remaining within the local sediment budget, the potential effect on the marine geology, sediments and coastal processes is considered to be of low magnitude.

127. Due to the dominantly coarse nature of the sediments liberated during cable trenching, the majority of the sediments liberated during these activities are predicted to be deposited locally (e.g., less than 2 km from the OECC). It is anticipated that under the prevailing hydrodynamic regime, liberated sediments which are finer (i.e., fine sands, silts and clays) would be readily remobilised and redistributed, especially in shallower regions where waves regularly stir the seabed. Consequently, as sediments are not being removed from the local sediment cell and thus are remaining within the local sediment budget, sediments liberated during these operations will be rapidly integrated into the prevailing sediment transport regime. Consequently, the potential effect on marine geology, sediments and coastal processes is considered to be of low magnitude.

128. Where ground conditions dictate WTG locations require drilling, due to the dominantly coarse nature of the surficial sediments to be disturbed, low volumes of sediments are likely to be liberated into the water column. Consequently, the dispersion of the liberated sediments is anticipated to be highly localised and considered to be highly limited. Consequently, as sediments are not being removed from the local sediment cell and thus are remaining within the local sediment budget, the potential effect on the marine geology, sediments and coastal processes is considered to be of low magnitude.

129. Where liberated sediments are transported towards the coast during operations in the export cable transition zone (rather than in the alongshore or offshore direction), they may be delivered to intertidal regions and integrated into the dynamic nearshore regime. As the predicted sediment plumes in the nearshore region were predicted to be transported less than 2 km from the OECC, and the works will be performed during quiescent conditions, the volume of sediment redistributed in the nearshore would be analogous to the volumes of sediment mobilised into suspension during higher energy storm events. Thus, the effects on coastal processes of enhanced SSCs during cable installation activities in the nearshore are also considered to be limited as the volume of sediments mobilised would reflect those observed due to natural variation. These sediments would be rapidly integrated into the prevailing sediment transport regime. Consequently, the potential effect on coastal processes is considered to be of low magnitude.

Significance of the effect

130. The sensitivity of the marine geology, sediments and coastal processes receptors in the study area is considered to be low and the magnitude of the impact for all receptors is considered to be low. Therefore (as per the matrix in **Table 6-6**), a **Negligible / Minor** effect is predicted for all marine geology, sediments and coastal processes receptors associated with pre-installation methods and effects, cable installation and monopile installation activities. These effects are not significant in EIA terms. Where flexibility in the proposed design exists there is no other scenario which would lead to a materially different effect significance.

Additional mitigation

131. Based on the predicted level of effect it is concluded that no additional mitigation is required beyond the embedded mitigation described in **Section 6.9**.

Impact 2: Temporary disturbance of the seabed resulting from pre-sweeping / sandwave levelling activities leading to increases in suspended sediment concentrations and associated deposition.

132. Several areas of mobile bedforms (sandwaves and megaripples) have been identified along the IAC and the offshore export cable corridor (OECC). The migration of mobile bedforms may cause the cable to become over-buried (leading to overheating) and / or cable exposure (Whitehouse et al., 2000). To be able to bury the cable to sufficient depth, mobile bedforms are cleared or reduced in height. Where dredging is required, the use of a TSHD dredger is proposed. When dredging is undertaken using a TSHD, sediment can be released into the water column by a wide range of mechanisms (see **Plate 6-37**). These include:

- Overflow from the hopper.
- Disturbance of the seabed by the draghead.
- Erosion of the bed caused by vessel propellers.

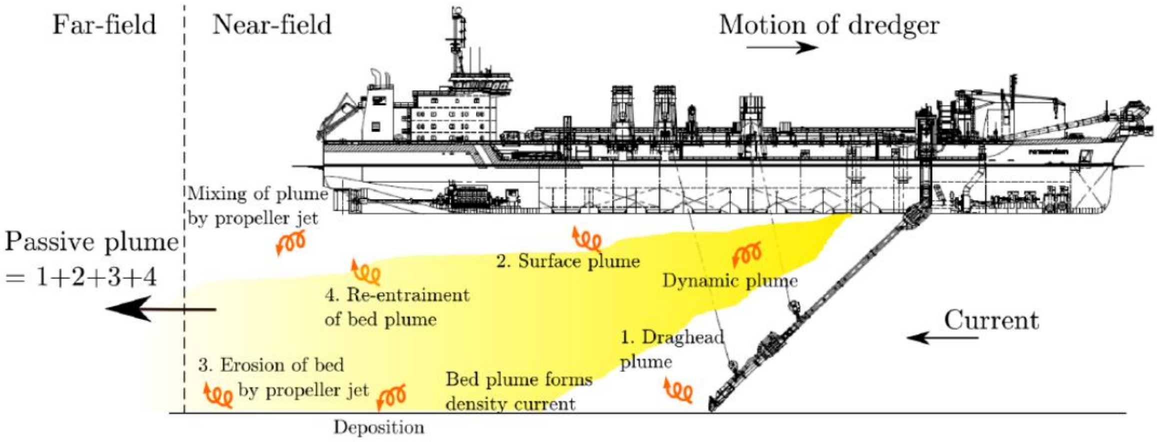


Plate 6-37 Mechanisms for release of sediment from TSHD dredging. Figure reproduced from Becker et al. (2015).

133. The release mechanisms influence the near and far field impact of the plume created. Sediment released close to the seabed will settle quickly, generating higher SSCs and a deposit on the seabed of greater thickness. Comparatively, sediment released at the surface will be dispersed across a greater spatial extent. Each mechanism will also be associated with a different rate of release and may or may not occur sequentially at each dredge location.

134. The release of material from within the vessel (i.e., via discharge of the overflow) comprises a sediment–water mixture; finer sediment, which has not settled out in the vessel, may be discharged along with the excess water. Finer sediments released at the surface have the potential to be dispersed in the direction of the prevailing flow over significant distances (e.g., tens of kilometres), being deposited and remobilised variously through the tidal cycle. The dispersion of these sediments would be greater where release occurred during the periods of higher flow velocity (i.e., during the spring tidal phase). However, as these bedform features (sandwaves and megaripples) are inherently dominantly comprised of coarser (sand and gravel sized) sediments, once these materials are dredged into the vessel, it is highly likely that material will rapidly settle, with limited fine sediment available for release via overflow.

135. A further potential input into the passive plume created during the activity of dredging is disturbance / agitation of the seabed at the drag head. Again, as the features to be swept are dominantly comprised of coarse sediments, the volume of material which is likely to be suspended due to disturbance / agitation at the bed is considered to be low. Further, materials which are suspended are also likely to be rapidly deposited locally to the dredge operations, limiting the volume of sediment being removed from the local sediment budget. These sediments would be reworked and reincorporated within the sediment transport regime by local seabed processes.

136. Sediment arising from dredging for the purposes of pre-sweeping will be disposed of in suitable areas within the MAC application boundary. Numerical (plume dispersion) modelling has been employed to investigate potential effects associated with the disposal of the dredge material on near and far field SSCs and changes in seabed elevation due to deposition. In total, four representative scenario model runs, encompassing disposal of the greatest material volumes to be dredged from the IAC array (*c*. 832,500 m^3) and OECC (*c*. 595,650 m^3) was conducted. The model setup and parameterisation of the simulations performed is described in **Appendix 6.3**.

137. Suspended sediment plumes created during dredge disposal operations are predicted to enhance SSC levels in the near (i.e., to the point of release) and far field (i.e., up to *c*. 10 km) from the point of release). The maximum predicted SSC values at any time during the model scenarios were approximately 150 mg/l. Though the plume trajectory is dependent on release timings and release locations, the results of the scenarios performed can be considered representative of disposals within the MAC application boundary. The suspended sediment plumes are predicted during the simulation testing to be dispersed towards the east quadrant (i.e., offshore), except for disposal of dredge arisings along the export cable during scenario 1, where a dominantly westward (inshore) propagation was observed. Enhanced SSCs are transient, and concentrations are predicted to reduce to baseline levels no more than 25 days after the disposal activity. Away from the disposal location, the predicted thickness of the sediment deposited during the simulations were negligible (less than 10 cm).

138. The predicted transport of sediment plumes and subsequent deposition during dredge and disposal activities within the MAC application boundary can be summarised as follows:

- Peak SSC of 150 mg/l predicted to occur within 1 km from the release point, but coarser sediment expected to deposit quickly (almost immediately) with significant reductions of SSC within hours of disposal at each location.
- Beyond 1 km from release, the passive plume which is transported beyond this is likely to generate SSC in the region of approximately 20 to 60 mg/l, in the direction of the prevailing flow out to a distance of up to approximately 10 km.
- SSC is predicted to reduce to baseline levels within days to weeks following completion of the operations.

139. The effects of the expected increase in SSC and sediment accumulation on the seabed associated with pre-installation methods and effects, cable installation and monopile installation activities have been assessed separately by other EIA topics in relation to other sensitive receptors. These include:

- **Chapter 7 Marine Water Quality**
- **Chapter 8 Subtidal and Intertidal Ecology**
- **Chapter 14 Marine Archaeology and Cultural Heritage**

Receptor sensitivity

140. The receptors in the study area affected by enhanced SSC and sediment deposition on the seabed include the wider seabed, its morphology and underlying geology, the prevailing hydrodynamic and wave regime and the sediment transport regime and coastal processes. The sensitivity of these receptors is assessed as low.

Magnitude of impact

141. Due to the nature of the sediments to be dredged during pre-sweeping, it is anticipated that the effects associated with the dredging operation in respect to increases in suspended sediment concentrations and associated deposition are considered to be of low magnitude, as the effects have a localised spatial extent relative to the IAC and OECC and are temporary in nature.

142. Based on the results of the model simulations performed, considered and interpreted in light of the foregoing analysis presented in this chapter, it is anticipated that the effects upon the identified receptors with respect to the disposal of dredge material within the MAC application boundary are predicted to be of medium magnitude. Though elevated, transient, values of SSC are predicted which intermittently may exceed the bounds of natural variation; as is demonstrated by the model simulations, the effects have a localised spatial extent relative to the MAC application boundary and are temporary in nature (with timescales similar to the duration of disposal activities, i.e., intermittent effects observed over a matter of weeks / months).

143. The effect on the thickness of the sediment deposit on the seabed of these activities reflects natural variability. Deposited sediments would be reworked and rapidly integrated into the prevailing sediment transport regime, and thus the impact of dredge and disposal activities in respect to increases in suspended sediment concentrations and associated deposition are considered to be of low magnitude.

144. The downstream effect on coastal processes is also considered to be of low magnitude, as liberated sediments will be rapidly integrated into the sediment transport regime and redistributed by local seabed processes.

Significance of the effect

145. The sensitivity of the marine geology, sediments and coastal processes receptors in the study area is considered to be low and the magnitude of the impact for the dredging operation and thickness of the deposit on the seabed for all receptors is considered to be low. Therefore (as per the matrix in **Table 6-6**), a **Negligible / Minor** effect is predicted for marine geology, sediments and coastal processes receptors associated with the temporary disturbance of the seabed during pre-sweeping / sandwave levelling activities.

146. The sensitivity of the marine geology, sediments and coastal processes receptors in the study area is considered to be low. The magnitude of the impact with respect to the disposal of dredge material within the MAC application boundary for the receptors including the wider seabed, its morphology and underlying geology and the prevailing sediment transport regime is considered to be medium. Therefore (as per the matrix in **Table 6-6**), a **Minor** effect is predicted for marine geology, sediments and coastal processes receptors associated with the disposal of dredged sediments. These effects are not significant in EIA terms. Where flexibility in the proposed design exists there is no other scenario which would lead to a materially different effect significance.

Additional mitigation

147. Based on the predicted level of effect it is concluded that no additional mitigation is required beyond the embedded mitigation described in **Section 6.9**.

Impact 3: Alteration to seabed morphology during seabed preparation

148. The alteration to seabed morphology relates to impacts to seabed features, bedforms and topography. The potential exists for impacts to occur which affect the local morphology and bedform features during the construction phase, these activities include:

- Bedform clearance.
- Dredge disposal operations.

Bedform Clearance

149. Dredging to remove or lower the relative height of bedforms will alter their shape and geometry, directly affecting the bedforms, seabed morphology and topography. To assess the impacts to these receptors it is important to understand the recovery potential of levelled sandwaves. This process is controlled by the following factors:

- The dimensions of the dredged area (relative to the overall sandwave height).
- The alignment of the dredged channel relative to the crest axis.
- The magnitude of sediment transport at the dredge location which can drive infilling of the dredge area.

150. The rate at which bedforms recover post dredging is a function of the sediment transport magnitude in the area and bedform migration patterns. Where greater sediment transport and / or significant bedform migration is observed, bedform recovery would occur over a shorter time period. Studies to examine how bedform features were altered and the length of time pre-swept cable trenches continue to persist post sweeping were undertaken for the environmental assessment of the NEMO Link Interconnector installed in the southern North Sea between the UK and Belgium (HR Wallingford, 2013). The studies revealed that the features, and local processes, would not suffer any permanent alteration and that the trench would infill within a matter of weeks, leading to the reformation of the bedform features. However, more recent evidence from a monitoring campaign targeting bedform recoverability at Race Bank OWF, critiqued by RPS (2018) as part of their submission for the Hornsea 3 OWF, indicated recovery to a new natural equilibrium state occurred over the medium to long term (in the order of months to years). These studies provide useful information regarding the likely timescales of bedform reformation following clearance as, despite not being located in Irish waters, the processes responsible for sandwave recovery are consistent between the projects.

151. The foregoing analysis of sediment mobility at locations within the MAC application boundary show discrete areas of sandwaves, with wave heights of up to 4 m observed with superimposed megaripples (see **Section 6.6**). Though this is evidence of a dynamic sediment regime, the wider assessment of seabed mobility presented in **Section 6.6** concluded that these features are isolated in regions where sandier sediments are observed. Across the regions of the MAC application boundary characterised by surficial sediments of a coarser nature (i.e., coarse sand and gravel) seabed mobility is negligible and these areas are devoid of bedforms. Dredged sediments are to be disposed of locally, maintaining the local sediment budget and surficial sediment character in those areas. As the baseline assessment of the sediment transport regime indicated sand sized sediments (i.e., those sediment grain sizes that comprise mobile bedforms) are routinely mobilised under the prevailing regimes, and there is sufficient supply of sediment to the region, infilling of the dredged areas and / or the reformation of megaripples and sandwaves is predicted to occur over the short to medium term (weeks to months). However, the migration of megaripples and sandwaves into these areas is expected to be limited, which may slow the rate of sandwave recovery in these areas.

152. Clearance of up to 4 m of sediment (i.e., removal of sediment coincident with the maximum observed sandwave heights) will affect local hydrodynamics, altering local flow patterns and wave effects on the seabed. However, as these features are typically isolated within the wider seabed topography, these effects are predicted to be highly localised and temporary as the seabed reaches a new dynamic equilibrium following these operations. The changes to the prevailing hydrodynamic and wave regimes and thus seabed morphology would be similar to the natural variability of flow patterns and wave effects observed within dynamic seabed environments characterised by migrating bedforms, the geometry of which alters in response to storms and thus can display significant seasonal variation.

Dredge Disposal Operations

153. Due to the relatively coarse nature of the sediment which comprises these bedforms, disposal operations will generate a low-profile accumulation of sediment on the seabed local to the dredge disposal location. Due to the mobility of sand sized sediments under the prevailing regime (see **Section 6.6**), deposited sediment will be entrained and dispersed by local seabed processes over a short period of time. This will promote the regeneration of bedforms locally and the return to a state of dynamic equilibrium and baseline seabed processes.

Receptor sensitivity

154. The receptors in the study area affected by the alteration to seabed morphology include the wider seabed, its morphology and underlying geology, the prevailing hydrodynamic and wave regime and the sediment transport regime. The sensitivity of these receptors is assessed as low.

Magnitude of impact

155. The impacts upon bedforms, seabed sediments and local morphodynamics as a result of bedform clearance and dredge disposal operations will be of medium magnitude, principally as timescales for full recovery of these features are difficult to predict and are likely to extend beyond the period of cable installation. These impacts are limited to the morphology within the OECC and array site and thus impacts are highly localised. It is predicted that although the seabed will not return to its exact baseline state, it is likely only a short duration until the mobile seabed will have reached a new natural state of equilibrium (timescale anticipated to be a matter of weeks to months).

156. The potential effects to tidal flow patterns and wave effects at the seabed are considered to be of low magnitude, have a localised spatial extent (limited to the OECC and array site) and only a short duration, occurring only until the seabed has reached a new natural state of dynamic equilibrium (timescale anticipated to be a matter of weeks to months).

Significance of the effect

157. The sensitivity of the marine geology, sediments and coastal processes receptors, including the wider seabed, its morphology and underlying geology, is considered to be low and the magnitude of the impact with respect to the clearance of bedforms within the MAC application boundary for the receptors including the wider seabed, its morphology and underlying geology and the prevailing sediment transport regime, is considered to be medium. Therefore (as per the matrix in **Table 6-6**), a **Minor** effect is predicted for marine geology, sediments and coastal processes receptors, which is not significant in EIA terms. Where flexibility in the proposed design exists there is no other scenario which would lead to a materially different effect significance.

158. The sensitivity of the marine geology, sediments and coastal processes receptors including the prevailing hydrodynamic and wave regime is considered to be low and the magnitude of the impact with respect to the clearance of bedforms within the MAC application boundary for the receptors including prevailing hydrodynamic and wave regime is considered to be low. Therefore (as per the matrix in **Table 6-6**), a **Minor / Negligible** effect is predicted for marine geology, sediments and coastal processes receptors, which is not significant in EIA terms. Where flexibility in the proposed design exists, there is no other scenario which would lead to a materially different effect significance.

Additional mitigation

159. Based on the predicted level of effect it is concluded that no additional mitigation is required beyond the embedded mitigation described in **Section 6.9**.

Impact 4: Localised alteration to the hydrodynamic, wave and sediment regimes and coastal processes

160. The following activities have the potential to affect the prevailing hydrodynamic, wave and sediment transport regimes and coastal processes during the construction phase, these include:

- Vessel anchoring during installation of WTG structures, Offshore Substation (OSS) and scour or cable protection.
- Partially installed WTG structures, OSS and scour protection.
- Temporary infrastructure at the cable landfall, including a cofferdam and support structures in the transition zone (i.e., tensioner platforms, rollers and raised equipment storage platform).

Vessel anchoring during installation of WTG structures, OSS and scour protection

161. Where construction vessels involved in installing turbine or OSS and scour or cable protection are anchored on site or utilise jack-up legs which are inserted into the seabed, when these are removed, an indentation proportional to the dimensions of the object may remain. The depth of penetration of anchors and spud cans is 5 m and 5 to 15 m, with a footprint of 225 m^2 and 300 m^2, respectively. The dimensions and geometry of the depression will reduce over time, proportional to the rate of sediment transport across the MAC application area.

162. As sediment is not being removed or added to the sediment budget, the presence of a depression and the displacement of sediment locally does not affect the sedimentary environment in the area of effect. In areas where the sediments are routinely mobilised under the prevailing regimes, infill of these areas will occur across timescales similar to those anticipated for bedform recovery (i.e., weeks to months). The disturbed surface would be reworked to a new equilibrium condition, a process which would be accelerated by higher energy wave events. In areas where the sediments are coarser and are not routinely mobilised under the prevailing regimes, the effects would be longer lasting but through time the disturbed surface would be reworked to a new equilibrium condition. Across the area, seabed disturbance due to vessel anchoring may be highly variable with depressions and ridges observed across the area following construction. These features, due to their scale and magnitude in terms of the wider seabed profile, are not anticipated to interrupt the prevailing hydrodynamic, wave and sediment regimes.

163. During anchoring, scour can arise around jack-up legs and anchors, due to flow acceleration around the fixed structures. Scour potential is a function of the surficial sediment characteristics, tidal forcing, structure size and the duration the structure (in this instance the legs of the jack-up vessels and anchors) are fixed to the seabed. It is anticipated that these vessels will be moved promptly once operations at a single location are completed, and as such, these impacts are anticipated to be of short duration. Due to the dominantly coarse nature of the sediments observed across the MAC application boundary and the generally limited seabed mobility, the total volumes of sediment eroded due to scour and the changes to the sediment structure and morphology are expected to be limited. Immediately following the removal of the obstruction, the disturbed surface would be reworked to a new equilibrium condition by local seabed processes.

164. The presence of partially installed structures on the seabed has an analogous impact on marine geology, sediments and coastal processes as those described in the operational phase (**Section 6.10.2**), but with a reduced magnitude as the extent of the installed infrastructure is reduced. Where foundations are installed without scour protection in place, localised scouring could occur. To mitigate for this, it is anticipated that installation operations will seek to implement scour protection during installation of foundations and thus, the impact on the local sediment regime is expected to be limited.

Cable landfall

165. At the landfall, the representative scenario includes assessment of the cofferdam at the shoreline and temporary support structures in the transition zone including tensioner platforms, rollers and raised equipment storage platform. Due to the scale and design of this temporary infrastructure it is anticipated that there will not be any significant wider impact on the prevailing coastal processes. The construction of a temporary cofferdam may form a temporary obstruction to sediment transport, impacting local coastal processes temporarily. Following open cut cable duct installation, the temporary cofferdam will be removed, and the existing coastal revetment reinstated simultaneously. For the temporary structures in the transition zone, there may also be some localised and small-scale blocking of sediment transport and localised flow effects which may lead to localised scouring, but these effects will be highly localised and temporary (timescale similar to the duration of installation, i.e., a matter of months) and thus anticipated to be limited.

Receptor sensitivity

166. The receptors in the study area affected by the alteration to the hydrodynamic, wave and sediment regimes include the wider seabed, its morphology and underlying geology, the prevailing hydrodynamic and wave regime, and the sediment transport regime and coastal processes. Sensitivity of these receptors is assessed as low.

Magnitude of impact

167. It is anticipated construction phase vessels will be moved promptly once operations at a single location are completed and as such, these impacts are anticipated to be short term and highly localised. Consequently, the impact on marine geology, sediments and coastal processes receptors likely falls within the range of natural variability and thus the impact is considered to be of low magnitude.

168. The presence of partially installed structures on the seabed is anticipated to be short term and highly localised. Consequently, the impact on marine geology, sediments and coastal processes receptors is likely within the range of natural variability and thus the impact is considered to be of low magnitude.

169. The presence of temporary structures on the seabed at the landfall and within the transition zone is anticipated to be short term and highly localised. Consequently, the impact on marine geology, sediments and coastal processes receptors is likely within the range of natural variability and thus the impact is considered to be of low magnitude.

Significance of the effect

170. The sensitivity of the marine geology, sediments and coastal processes receptors in the study area is considered to be low and the magnitude of the impact for all receptors is also considered to be low. Therefore (as per the matrix in **Table 6-6**), a **Negligible / Minor** effect is predicted for all marine geology, sediments and coastal processes receptors, which is not significant in EIA terms. Where flexibility in the proposed design exists, there is no other scenario which would lead to a materially different effect significance.

Additional mitigation

171. Based on the predicted level of effect it is concluded that no additional mitigation is required beyond the embedded mitigation described in **Section 6.9**.

6.10.2 Operation and maintenance

172. The potential environmental impacts arising from the operation and maintenance of the CWP Project are listed in **Table 6-17**, along with the parameters against which each operation phase impact has been assessed. A description of the potential effect on marine geology, sediments and coastal processes receptors caused by each identified impact is given below.

Impact 1: Localised alteration of hydrodynamic and wave conditions across the site and effects on the sediment transport regime and coastal processes

173. The installation of the following infrastructure has the potential to directly affect the prevailing hydrodynamic and wave conditions across the site, with indirect effects on the sediment transport regime and coastal processes. These include:

- Foundations, scour protection, WTG monopiles and OSS monopiles.
- Cable protection.
- Combi-wall, new revetments, and an area of reclaimed land at the onshore substation.

Impacts Upon the Hydrodynamic and Wave Regime

174. During the operational phase, WTG structures and foundations have the potential to affect the hydrodynamic and wave regime impacting water levels, current speed and direction, wave height, period and direction. In the development of offshore wind globally, numerous studies have assessed the effects of WTG monopiles on the hydrodynamic and wave regime, the following broadly summarises their findings:

- No measurable effects on water levels are predicted. Changes to the instantaneous water level within, and outside, the offshore development area is negligible when compared to the natural range of variability observed in tidal levels, non-tidal levels and the potential effects of sea level rise.
- Localised effects on tidal currents are anticipated proximal to the turbine location, reducing promptly away from the turbine location. Such effects are within the scale of natural variability predicted during the spring, neap and lunar phases; and
- The anticipated effect on wave heights during operation is also considered to be small and generally restricted to offshore regions. Instantaneous effects on wave height proximal to the turbine may be up to *c*. 20%, but more typically between less than 5% to 10%.

175. The assessment of potential changes to water levels, currents and waves is based upon the analysis of spatial and temporal results from the coupled hydrodynamic and wave model, with and without the WTG layout present, over representative typical (P50) and high (P90 and P100) energy events. The impact of the CWP Project during operation is predicted to have only a small effect on the prevailing hydrodynamic and wave regimes, both at locations proximal to the individual turbines and at locations nearer to shore (see **Appendix 6.3**). The construction of the CWP Project was predicted to have a negligible impact on the wave parameters assessed (i.e., wave height, period and direction) with less than 1% difference between pre and post construction conditions predicted. Comparatively, the construction of the CWP Project was predicted to have a slightly greater effect on tidal currents with up to *c*. 3% difference in current speed and up to *c*. 5% difference in current direction predicted at locations proximal to the individual turbines. These effects were predicted to have a negligible difference on the tidal regime away from the array site, with less than 1% difference between pre and post construction estimates for current speed and direction predicted closer to shore. The effect of construction on water level across the array site and at the inshore locations nearer to the coastline is predicted to be less than 1% difference between pre and post construction estimates. These differences fall within the natural variability in terms of wave, current and water level conditions anticipated over the lifetime of the CWP Project.

176. During the operational phase WTG monopile foundations and scour protection may affect the direction and amplitude of tidal currents due to the creation of areas of flow reduction, acceleration and increased turbulence. Near bed flows are also likely to be impacted by an increase in bed roughness due to the presence of rock protection. This may cause the formation of wakes and eddies that will exist in the flow downstream of features. Within the extent of the CWP Project (in the near field), the effect on tidal currents will be evident as a series of narrow and discrete wake features extending downstream along the tidal axis from each foundation. Negligible effects on the wider current regime beyond the MAC application boundary are anticipated.

177. Inter-array and interconnector cable protection has the potential to raise the seabed level by up to 1.25 m, creating a discontinuous linear feature on the seabed, positioned on occasion in a shore normal direction and on occasion in a shore parallel direction. The installation of protection influences the local flow field, creating areas of flow acceleration, deacceleration and turbulence. The scale of the turbulent features corresponds to the size and geometry of the structure and thus only small-scale features are anticipated.

178. The potential impacts of the infrastructure associated with the onshore substation relevant to this assessment (i.e., the presence of a combi-wall, new revetments and an area of reclaimed land) on the local hydrodynamic and wave regime have been assessed using a numerical modelling approach (see **Appendix 6.4**). The findings of this exercise indicated that the impact on the hydrodynamic and wave regime were deemed to be imperceptible within the bounds of natural variability (**Plate 6-38**).

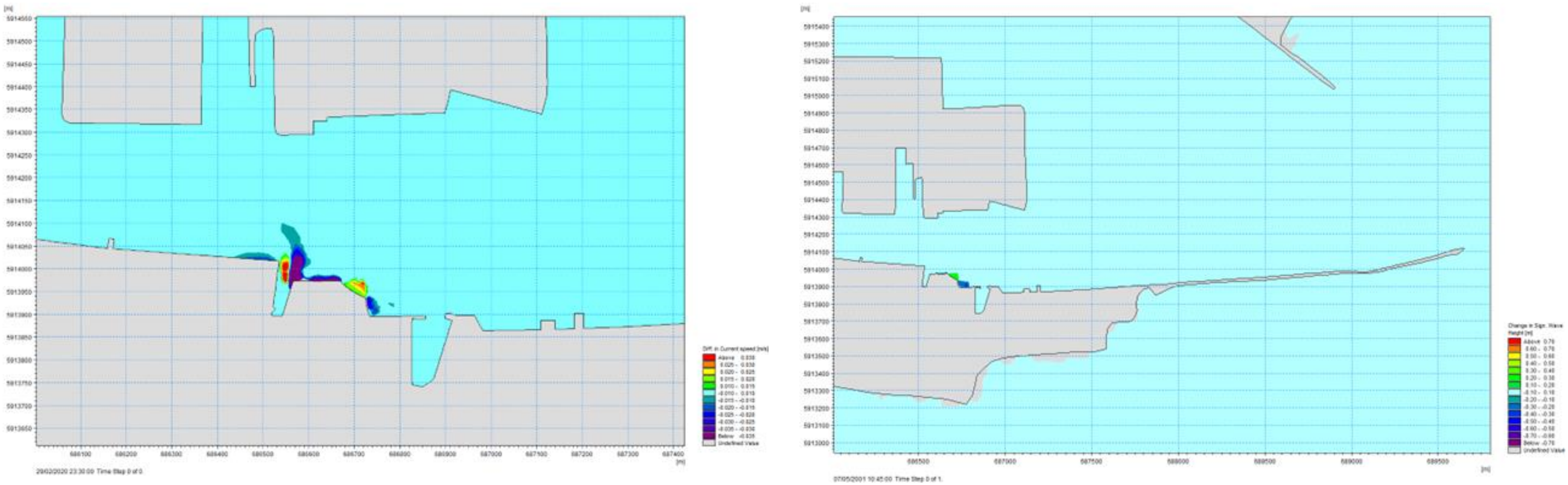


Plate 6-38 Differences in spring tidal flow patterns (depth-averaged) across an entire tidal cycle (left panel) and in wave heights during a north easterly storm event (right panel) as a result of the CWP Project

Impact on the Sediment Transport Regime and Coastal Processes

179. Foundations act as a barrier to existing sediment transport pathways impacting the natural distribution of sediments within the sediment cell. This may lead to effects at the coastline if the offshore sediment budget is altered and less sediment is available for delivery to the nearshore. The embedded mitigation, which includes for suitable spacing between turbines as part of the WTG layout and carefully designed scour protection, sloped to limit sediment accumulation proximal to the turbine, results in the WTG foundations having a negligible impact on regional sediment transport pathways. Alteration to these regimes will be highly localised and form a new dynamic equilibrium.

180. During the operational phase, the installation of monopiles has been demonstrated to have a negligible effect on the local wave regime and only a very small effect on the direction and magnitude of tidal currents. With respect to coastal processes, it is the potential changes to the highest current speeds and directions that are of most importance due to the consequential effects on patterns of sediment transport. As currents and waves drive sediment transport, and there are no anticipated changes to sediment composition and sediment supply due to the construction of the CWP Project, given no significant effect on the driving parameters, there can be no corresponding difference in the potential rates and directions of sediment transport through the site. Similarly, cable protection measures on the seabed have the potential to alter the sediment transport direction and magnitude, but the footprint of the proposed measures is very small compared to the CWP Project area (<2% of the total array site) limiting the potential for such changes. Consequently, apart from localised effects on seabed morphology, Codling Bank as a whole is anticipated to remain broadly in its existing state of dynamic equilibrium.

181. At the onshore substation, marine piling, new revetments and land reclamation to -2 m Chart Datum (CD) are to be installed. The potential impact of this infrastructure on the local hydrodynamic and wave regime are deemed to be imperceptible. Consequently, it is concluded that the potential impacts on local sediment transport processes, bed morphology and coastal processes, will also be imperceptible.

Receptor sensitivity

182. The marine geology, sediments and coastal processes receptors in the study area affected by the CWP Project during the operational phase are the prevailing hydrodynamic, wave and sediment transport regimes, seabed morphology and coastal processes. The sensitivity of these receptors is assessed as low.

Magnitude of impact

183. The effects of the offshore infrastructure on the hydrodynamic, wave and sediment transport regimes will persist for the lifetime of the CWP Project but are highly localised and of very low magnitude. The impact on coastal processes is also considered to be of very low magnitude.

184. Given the anticipated scale (spatially and geometrically) of the cable protection, the near-field impact on near bed flows due to the presence of eddies and turbulence in the local flow field are likely to be highly localised and of very low magnitude.

185. The localised effects on marine geology, sediments and coastal processes of marine works at the onshore substation are considered to be imperceptible and thus of very low magnitude.

Significance of effect

186. The sensitivity of the marine geology, sediments and coastal processes receptors in the study area is considered to be low and the magnitude of the impact for all receptors is also considered to be very low. Therefore (as per the matrix in **Table 6-6**), a **Negligible** effect is predicted for all marine geology, sediments and coastal processes receptors, which is not significant in EIA terms. Where flexibility in the proposed design exists, there is no other scenario which would lead to a more significant effect.

Additional mitigation

187. Based on the predicted level of effect it is concluded that no additional mitigation is required beyond the embedded mitigation described in **Section 6.9**.

Impact 2: Scour around installed structures and associated sediment transportation and deposition leading to changes in seabed composition, structure or morphology

188. The interaction between the hydrodynamic and wave regime and the WTG foundations and scour protection, OSS and cable protection has the potential to cause localised scouring of sediment, leaving a depression with possibly different sedimentary composition and / or altering seabed structure and / or morphology, which will persist in some form until the structure is removed during the decommissioning phase or a new dynamic equilibrium is formed.

189. The presence of structures in the near-bed boundary layer creates a complex local flow disturbance acting on the seabed, including:

- Acceleration of the flow over the berm crests, and an accompanying up / downstream reduction in near bed pressure.
- Flow separation up and downstream of the berms and the formation of vortices.
- A local increase in turbulent intensity.
- Amplification of local bed stress, including on the edges of the berm structure.
- Secondary flow patterns (helical flow).
- Localised disruption to flow direction.

190. These flow disturbances have the potential to result in extensive scouring in the vicinity of these structures. Scour potential is a function of the seabed and sub-surface characteristics, hydrodynamic regime and the geometry (and extent) of the structure. Immediately post-construction, due to localised effects on the flow field, there is potential for scouring to develop around the foundations and at the edge of installed scour protection and the non-burial cable protection. The extent of scour observed is dependent upon the hydrodynamic and wave conditions (e.g., the potential for scour will be enhanced during spring tidal phase, during which time greater flow velocity magnitudes are observed, or during periods of wave action). Free scour effects on the seabed will generally scale with the obstruction (e.g., for monopiles a simplified empirical approach assumes that the scour depth is approximately 30% of the monopile diameter), however scour protection will mitigate scour effects around foundations and are typically also designed to limit any edge scour. Consequently, any scour is anticipated to be highly localised. Furthermore, the presence of a scoured depression does not necessarily imply a difference in sedimentary environment in the area of effect with limited effect on seabed composition, structure or morphology anticipated.

Receptor sensitivity

191. The receptors in the study area affected by the CWP Project during the operational phase due to scour around installed structures and associated sediment transportation and deposition leading to changes in seabed composition, structure or morphology include the wider seabed, its morphology and underlying geology. Sensitivity of these receptors is assessed as low.

Magnitude of impact

192. Scour protection around WTG foundations and monopiles and non-burial cable protection limit the potential for scour around this infrastructure and thus affects are highly localised and temporary until a new dynamic equilibrium is formed. Consequently, a low magnitude impact is anticipated.

Significance of effect

193. The sensitivity of the marine geology, sediments and coastal processes receptors in the study area are considered to be low and the magnitude of the impact for all receptors is also considered to be low. Therefore (as per the matrix in **Table 6-6**), a **Negligible / Minor** effect is predicted for all marine geology, sediments and coastal processes receptors, which is not significant in EIA terms. Where flexibility in the proposed design exists, there is no other scenario which would lead to a more significant effect.

Additional mitigation

194. Based on the predicted level of effect it is concluded that no additional mitigation is required beyond the embedded mitigation described in **Section 6.9**.

Impact 3: Operation and maintenance

195. During maintenance and repair operations the local hydrodynamic, wave and sediment regime, seabed structure and morphology may be affected due to:

- Cable recovery and reburial and the vessel anchoring during these operations.
- WTG major component replacement and the use of JUVs during these operations.

196. Cable maintenance may include the need to rebury exposed cables, cable repairs and replacements requiring vessels anchoring on site during operations. Cable repair / replacement is likely to require cable deburial, recovery to the surface, repair and reburial. Where cable repair / replacement is required, it is likely that near bed SSCs may be elevated compared to baseline levels as cable sections would be exposed and recovered to the surface. The redistribution of liberated sediments is a function of their hydraulic properties and highly dependent on conditions at the time of repair. It is anticipated that any release and redistribution of sediment will be limited, short term and highly localised.

197. Though during the removal of the cable the total volume of sediment displaced is likely to be low, the potential exists for a shallow trench to form on the seabed immediately following removal of the section of the cable to be repaired. The scale and geometry of this trench is considered to be within the scale of natural variability of the local seabed topography. Following repair, the cable will be reburied using similar methods utilised during construction, with vessels anchoring on site during operations. As such, it is anticipated that the effects and subsequent impacts upon seabed sediments are as described in the assessment of impacts during the construction phase.

198. For WTG major component replacement, similarly to those impacts assessed during the construction phase for the presence of partially installed structures on the seabed. JUVs utilise jack-up legs which are inserted into the seabed. When these are removed, an indentation proportional to the dimensions of the object may remain. The depth of penetration of spud cans is 5–15 m, with a footprint 300 m^2. The dimensions and geometry of the depression will reduce over time, proportional to the rate of sediment transport across the MAC application area. As sediment is not being removed or added to the sediment budget, the presence of a depression and the displacement of sediment locally does not affect the sedimentary environment in the area of effect. In areas where the sediments are routinely mobilised under the prevailing regimes, infill of these areas will occur across timescales similar to those anticipated for bedform recovery (i.e., weeks to months). The disturbed surface would be reworked to a new equilibrium condition, a process which would be accelerated by higher energy wave events. In areas where the sediments are coarser and are not routinely mobilised under the prevailing regimes, the effects would be longer lasting but through time the disturbed surface would be reworked to a new equilibrium condition.

Receptor sensitivity

199. The receptors in the study area affected by operations conducted for maintenance and repair during the operational phase include the wider seabed, its morphology and underlying geology. Sensitivity of these receptors is assessed as low.

Magnitude of impact

200. With respect to the marine geology, sediments and coastal processes receptors, impacts are considered to be of low magnitude, have a localised spatial extent and only a short duration (timescale similar to the duration of installation, i.e., a matter of weeks / months).

Significance of effect

201. The sensitivity of the marine geology, sediments and coastal processes receptors in the study area are considered to be low and the magnitude of the impact for all receptors is also considered to be low. Therefore (as per the matrix in **Table 6-6**), a **Negligible / Minor** effect is predicted for all marine geology, sediments and coastal processes receptors, which is not significant in EIA terms. Where flexibility in the proposed design exists, there is no other scenario which would lead to a materially different effect significance.

Additional mitigation

202. Based on the predicted level of effect it is concluded that no additional mitigation is required beyond the embedded mitigation described in **Section 6.9**.

6.10.3 Decommissioning phase

203. For the purposes of the assessment, it is assumed that decommissioning will be complete removal to revert to baseline seabed conditions.

Impact 1: Temporary increases in suspended sediment concentration during removal of foundations and / or cables

204. The options for decommissioning will likely include removal of foundations and removal of the entire cable, or sections of the cable.

205. Similar to those impacts assessed during the construction phase, during decommissioning, impacts may occur due to temporary disturbance of the seabed leading to increases in SSC and associated deposition. As such, the corresponding potential impacts resulting from decommissioning are considered to be equivalent to or lesser in nature than those considered for construction activities.

Receptor sensitivity

206. The marine geology, sediments and coastal processes receptors in the study area affected by temporary increases in suspended sediment concentration during removal of foundations and cables during the decommissioning phase include the wider seabed, its morphology and underlying geology. Sensitivity of these receptors is assessed as low.

Magnitude of impact

207. The impacts upon the wider seabed, its morphology and underlying geology as a result of decommissioning operations will be of low magnitude, as impacts are predicted to be highly localised and short term. Though it is predicted that although the seabed will not return to its exact baseline state, it is likely only a short duration until the mobile seabed will have reached a new natural state of equilibrium (timescale anticipated to be a matter of weeks to months). These localised changes to seabed morphology are not anticipated to drive significant effects at the sandbank scale, with the structure and composition of Codling Bank anticipated to broadly remain in its current state of equilibrium.

Significance of effect

208. The sensitivity of the marine geology, sediments and coastal processes receptors in the study area are considered to be low and the magnitude of the impact for all receptors is also considered to be low. Therefore (as per the matrix in **Table 6-6**), a **Negligible / Minor** effect is predicted for all marine geology, sediments and coastal processes receptors, which is not significant in EIA terms. Where flexibility in the proposed design exists, there is no other scenario which would lead to a more significant effect.

Additional mitigation

209. Based on the predicted level of effect it is concluded that no additional mitigation is required beyond the embedded mitigation described in **Section 6.9**.

Impact 2: Localised alteration of hydrodynamic and wave conditions across the site and effects on the sediment transport regime and coastal processes

210. The options for decommissioning will likely include removal of foundations and WTG and OSS monopiles and removal of the entire cable, or sections of the cable.

211. Similar to those impacts assessed during the construction phase, during decommissioning, impacts may occur due to localised alteration of hydrodynamic and wave conditions across the site and effects on the sediment transport regime and coastal processes. As such, the corresponding potential impacts resulting from decommissioning are considered to be equivalent to or lesser in nature than those considered for construction activities.

Receptor sensitivity

212. The marine geology, sediments and coastal processes receptors in the study area affected by localised alteration of hydrodynamic and wave conditions across the site and effects on the sediment transport regime and coastal processes include the hydrodynamic, wave and sediment regimes and wider seabed, its morphology and underlying geology and coastal processes. Sensitivity of these receptors is assessed as low.

Magnitude of impact

213. The impacts upon the hydrodynamic and wave conditions across the site and effects on the sediment transport regime and coastal processes as a result of decommissioning operations will be of low magnitude, as impacts are predicted to be highly localised and short term. The hydrodynamic regime will broadly return to its baseline state following decommissioning.

Significance of effect

214. The sensitivity of the marine geology, sediments and coastal processes receptors in the study area are considered to be low and the magnitude of the impact for all receptors is also considered to be low. Therefore (as per the matrix in **Table 6-6**), a **Minor / Negligible** effect is predicted for all marine geology, sediments and coastal processes receptors, which is not significant in EIA terms. Where flexibility in the proposed design exists, there is no other scenario which would lead to a more significant effect.

Additional mitigation

215. Based on the predicted level of effect it is concluded that no additional mitigation is required beyond the embedded mitigation described in **Section 6.9**.

Impact 3: Alteration to seabed morphology during decommissioning

216. The options for decommissioning will likely include removal of foundations and removal of the entire cable or removal of sections of the cable.

217. Similar to those impacts assessed during the construction phase, during decommissioning, impacts may occur due to alteration to seabed morphology. As such, the corresponding potential impacts resulting from decommissioning are considered to be equivalent to or lesser in nature than those considered for construction activities.

Receptor sensitivity

218. The marine geology, sediments and coastal processes receptors in the study area affected by alterations to the seabed morphology during the decommissioning phase include the wider seabed, its morphology and underlying geology. Sensitivity of these receptors is assessed as low.

Magnitude of impact

219. The impacts upon the wider seabed, its morphology and underlying geology as a result of decommissioning operations will be of low magnitude, as impacts are predicted to be highly localised and short term. Though it is predicted that although the seabed will not return to its exact baseline state, it is likely only a short duration until the mobile seabed will have reached a new natural state of equilibrium (timescale anticipated to be a matter of weeks to months). These localised changes to seabed morphology are not anticipated to drive significant effects at the sandbank scale, with the structure and composition of Codling Bank anticipated to broadly remain in its current state of dynamic equilibrium.

Significance of effect

220. The sensitivity of the marine geology, sediments and coastal processes receptors in the study area are considered to be low and the magnitude of the impact for all receptors is also considered to be low. Therefore (as per the matrix in **Table 6-6**), a **Negligible / Minor** effect is predicted for all marine geology, sediments and coastal processes receptors, which is not significant in EIA terms. Where flexibility in the proposed design exists, there is no other scenario which would lead to a more significant effect.

Additional mitigation

221. Based on the predicted level of effect it is concluded that no additional mitigation is required beyond the embedded mitigation described in **Section 6.9**.

6.11 Cumulative impacts

222. A fundamental component of the EIA is to consider and assess the potential for cumulative effects of the CWP Project with other projects, plans and activities (hereafter referred to as ‘other development’).

223. **Appendix 6.1** presents the findings of the Cumulative Effects Assessment (CEA) for marine geology, sediments and coastal processes, which considers the residual effects presented in **Section 6.15** alongside the potential effects of other proposed and reasonably foreseeable other development.

224. In summary, the CEA for marine geology, sediments and coastal processes does not identify potential for significant cumulative effects resulting from the CWP Project alongside other development. As such, cumulative effects on marine geology, sediments and coastal processes receptors would result in **not significant** effects in EIA terms.

6.12 Transboundary impacts

225. The closest transboundary water to the CWP Project is identified by the UK Exclusive Economic Zone (EEZ) line located approximately 50 km to the east of the CWP Project. Due to the distance between the CWP Project and the transboundary waters, and the typically localised effects on marine geology, sediments and coastal processes, no transboundary impacts are anticipated.

6.13 Inter-relationships

226. The inter-related effects assessment considers the potential for all relevant effects across multiple topics to interact, spatially and temporally, to create inter-related effects on a receptor group. This includes the findings of the individual assessment chapters to describe potential additional effects that may be of greater significance when compared to individual effects acting on a receptor group.

227. The term 'receptor group' is used to highlight the fact that the proposed approach to the inter-relationships assessment has assessed every individual receptor considered in this chapter, but instead focuses on groups of receptors that may be sensitive to inter-related effects.

228. **Chapter 5 EIA Methodology** provides a matrix to show at a broad level where across the EIAR interactions between effects on different receptor groups have been identified.

229. The potential inter-related effects that could arise in relation to marine geology, sediments and coastal processes are presented in **Table 6-21**. If there are additional effects, these are considered additively and qualitatively using expert judgement.

Table 6-21 Inter-related effects (phase) assessment for Marine Geology, Sediments and Coastal Processes

Impact / Receptor	Related chapter	Phase Assessment
Indirect impact on water quality due to enhanced suspended sediment concentrations	**Chapter 7 Marine Water Quality**	The effects on water quality resulting from these impacts are assessed in detail in **Chapter 7 Marine Water Quality**.
Indirect impacts on tidal and sub-tidal habitats resulting from: • Enhanced SSC and associated deposition.	**Chapter 8 Subtidal and Intertidal Ecology**	The effects on habitat resulting from these impacts is assessed in detail in **Chapter 8 Subtidal and Intertidal Ecology**.

Impact / Receptor	Related chapter	Phase Assessment
• Loss of seabed and changes to seabed morphology. • Scour around structures. • Changes to the hydrodynamic and wave regimes.		
Indirect impacts on Marine Archaeology and culturally significant projects due to: • Scour induced effects on sediment transport and deposition. • Changes to the sediment transport regime. • Loss of seabed and changes to seabed morphology.	**Chapter 14 Marine Archaeology and Cultural Heritage**	The effects resulting from these impacts is assessed in detail in **Chapter 14 Marine Archaeology and Cultural Heritage**.

6.14 Potential monitoring requirements

230. Monitoring requirements for the CWP Project will be described in the **In Principle Project Environmental Monitoring Plan** (IPPEMP) submitted alongside the EIAR and further developed and agreed with stakeholders prior to construction.

231. The assessment of impacts on marine geology, sediments and coastal processes receptors as a result of the construction, operation and maintenance and decommissioning phases of the CWP Project are predicted to be not significant in EIA terms. Based on the predicted impacts it is concluded that no specific monitoring is required.

6.15 Impact assessment summary

232. This chapter of the EIAR has assessed the potential environmental impacts on marine geology, sediments and coastal processes from the construction, operation and maintenance, and decommissioning phases of the CWP Project.

233. This section, including **Table 6-22**, summarises the impact assessment undertaken and confirms the significance of any residual effects, following the application of additional mitigation.

234. In summary, this EIAR chapter:

- Details the EIA scoping and consultation process undertaken and sets out the scope of the impact assessment for marine geology, sediments and coastal processes;
- Identifies the key legislation and guidance relevant to the assessment of marine geology, sediments and coastal processes with reference to the latest updates in guidance and approaches;
- Confirms the study area for the assessment and presents the impact assessment methodology for marine geology, sediments and coastal processes;

- Describes and characterises the baseline environment for marine geology, sediments and coastal processes established from desk studies, project survey data and consultation;
- Defines the project design parameters for the impact assessment and describes any embedded mitigation measures relevant to the assessment of marine geology, sediments and coastal processes;
- Presents the assessment of potential impacts on marine geology, sediments and coastal processes and identifies any assumptions and limitations encountered in compiling the impact assessment; and
- Details any additional mitigation and / or monitoring necessary to prevent, minimise or reduce potentially significant effects identified in the impact assessment.

235. Consultation with statutory and non-statutory organisations is a key part of the EIA process. Consultation with regard to marine geology, sediments and coastal processes has been undertaken to inform the approach to, and scope of, the assessment. To date, no significant issues have been raised during the consultation process relevant to marine geology, sediments and coastal processes.

236. The approach followed reflects best practice and guidance and assesses the magnitude and significance of change caused directly to the following:

- Sediments (e.g., composition, particle size);
- Hydrodynamics (e.g., tidal and currents including meteorological effects) and waves;
- Sedimentary environment (e.g., sediment resuspension, transport pathways, patterns and rates and sediment deposition);
- Sedimentary structures (e.g., channels, banks, large scale bedforms);
- Suspended Sediment Concentrations (SSC); and
- Coastal processes.

237. For all assessed impacts a minor or negligible minor effect is predicted for all marine geology, sediments and coastal processes receptors, which is not significant. Where flexibility in the proposed design exists, there is no other scenario which would lead to a more significant effect. Beyond the primary mitigation measures implemented within the project design, no additional mitigation is required.

Table 6-22 Summary of potential impacts and residual effects

Potential Impact	Receptor	Receptor Sensitivity	Magnitude of Impact	Significance of effect	Additional Mitigation	Residual effect
Construction						
Impact 1: Temporary disturbance of the seabed resulting from pre-installation methods and effects, cable and monopile installation, leading to increases in suspended sediment concentrations and associated deposition.	Wider seabed, its morphology and underlying geology, the prevailing hydrodynamic and wave regime and the sediment transport regime and coastal processes.	Low	Low	Negligible / Minor **(Not significant)**	No additional mitigation required	Negligible / Minor **(Not significant)**
Impact 2: Temporary disturbance of the seabed resulting from pre-sweeping / sandwave levelling activities, leading to increases in suspended sediment concentrations and associated deposition.	Wider seabed, its morphology and underlying geology, the prevailing hydrodynamic and wave regime and the sediment transport regime and coastal processes.	Low	Low or Medium	Negligible / Minor or Minor **(Not significant)**	No additional mitigation required	Negligible / Minor or Minor **(Not significant)**

Potential Impact	Receptor	Receptor Sensitivity	Magnitude of Impact	Significance of effect	Additional Mitigation	Residual effect
Impact 3: Alteration to seabed morphology during seabed preparation.	Wider seabed, its morphology and underlying geology, the prevailing hydrodynamic and wave regime and the sediment transport regime.	Low	Low or medium	Negligible / Minor or Minor **(Not significant)**	No additional mitigation required	Negligible / Minor or Minor **(Not significant)**
Impact 4: Localised alteration to the hydrodynamic, wave and sediment regimes and coastal processes.	Wider seabed, its morphology and underlying geology, the prevailing hydrodynamic and wave regime and the sediment transport regime and coastal processes.	Low	Low	Negligible / Minor **(Not significant)**	No additional mitigation required	Negligible / Minor **(Not significant)**

Potential Impact	Receptor	Receptor Sensitivity	Magnitude of Impact	Significance of effect	Additional Mitigation	Residual effect
Operation and Maintenance						
Impact 1: Localised alteration of hydrodynamic and wave conditions across the site and effects on the sediment transport regime and coastal processes.	Prevailing hydrodynamic, wave and sediment transport regimes, seabed morphology and coastal processes.	Low	Very low	Negligible **(Not significant)**	No additional mitigation required	Negligible **(Not significant)**
Impact 2: Scour around installed structures and associated sediment transportation and deposition, leading to changes in seabed composition, structure or morphology.	Wider seabed, its morphology and underlying geology.	Low	Low	Negligible / Minor **(Not significant)**	No additional mitigation required	Negligible / Minor **(Not significant)**
Impact 3: Operation and maintenance	Wider seabed, its morphology and underlying geology.	Low	Low	Negligible / Minor **(Not significant)**	No additional mitigation required	Negligible / Minor **(Not significant)**

Potential Impact	Receptor	Receptor Sensitivity	Magnitude of Impact	Significance of effect	Additional Mitigation	Residual effect
Decommissioning						
Impact 1: Temporary increases in suspended sediment concentration during removal of foundations and / or cables.	Wider seabed, its morphology and underlying geology.	Low	Low	Negligible / Minor **(Not significant)**	No additional mitigation required	Negligible / Minor **(Not significant)**
Impact 2: Localised alteration of hydrodynamic and wave conditions across the site and effects on the sediment transport regime and coastal processes.	Hydrodynamic, wave and sediment regimes and wider seabed, its morphology and underlying geology and coastal processes.	Low	Low	Negligible / Minor **(Not significant)**	No additional mitigation required	Negligible / Minor **(Not significant)**
Impact 3: Alteration to seabed morphology during decommissioning.	Wider seabed, its morphology and underlying geology.	Low	Low	Negligible / Minor **(Not significant)**	No additional mitigation required	Negligible / Minor **(Not significant)**

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