WP1 Reference Site Technical Report - Summary Report

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This project is closely coordinated with the IEA Wind TCP Task 49 – Integrated Design of floating wind Arrays (IDeA)[1]

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0.1	14/10/2024	First draft for internal review	Greg Bohan	Dallán Friel, Mitra Kami Delivand
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[1] https://iea-wind.org/task49/

Executive Summary

This report has been prepared by the Integrated Design of Floating Wind Arrays Ireland (IDEA-IRL) team as part of Work Package (WP) 1 – Reference Sites.

WP1 of IDEA-IRL focusses on defining the metocean, geotechnical, socio-ecological factors and other site-specific conditions for a range of hypothetical reference sites that are representative of the types of conditions in which the initial phase of commercial scale floating wind may be deployed internationally.

This report is a summary report to draw together the various appendix reports which together make up WP1-D1: Reference site technical report.

This report discusses the process undertaken by IDEA-IRL to identify the key site conditions to be defined to inform the design of reference floating wind farm arrays for the IDEA-IRL project (namely metocean conditions, geotechnical conditions, and port infrastructure suitability), as well as the Building Block concept developed for the project which can be used to synthesise purpose-built site representations, whereby different conditions from multiple reference sites can be combined and used to inform different reference site designs.

Detail is given on how reference sites were selected for the project, including an update on Irish offshore wind policy as it relates to the site selection process, which discusses the accelerated move to a plan-led / centralised system for project development in Ireland, as set out by the Phase 2 Policy Statement, as well as ongoing work on the South Coast Designated Maritime Area Plan, and the Future Framework.

This process led to the selection of 7 reference sites for the IDEA-IRL project, for which 10 reference floating wind farms array will be prepared by WP2. These sites are:

- Moneypoint Offshore One
- M5 wave buoy
- Kinsale Gas Field - Alpha Platform
- Ulsan Floating Wind farm
- Sørlige Nordsjø II - phase 2
- Utsira Nord
- Humboldt SW

The report goes on to summarise relevant metocean, geotechnical and port infrastructure conditions for the sites, as they are required for this project.

The relevant details will be shared with WP2, which will prepare reference floating offshore wind farm arrays for the project, for delivery in 2025. Relevant conditions will also be made publicly available on an open-access repository.

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Table of Acronyms

AHTS	Anchor Handling Tug Supply Vessel
BOEM	Bureau of Ocean Energy Management
CIV	Cable Installation Vessels
DMAP	Designated Maritime Area Plan
ECMWF	European Centre for Medium-Range Weather Forecasts
EMODnet	European Marine Observation and Data Network
ERA5	ECMWF Reanalysis version 5
ESS	Extreme Sea State
FLOW	Floating offshore wind
FOWA	Floating Offshore Wind Array
GDG	Gavin and Doherty Geosolutions
GWEC	The Global Wind Energy Council
HAT	Highest Astronomical Tide
HFRNet	High-frequency Radar National Network Current Measurements
HLV	Heavy-lift Vessel
HYCOM	Hybrid Coordinate Ocean Model
IDEA	Integrated Design of Floating Wind Arrays - IEA Wind Task 49
IDEA-IRL	Mirror project to IDEA with a focus on the Irish market and additional scope
IEA	International Energy Agency
IRENA	The International Renewable Energy Agency
INFOMAR	Integrated Mapping for the Sustainable Development of Ireland's Marine Resource
LAT	Lowest Astronomical Tide
MAC	Maritime Area Consent
MAP Act	Maritime Area Planning Act 2021
MARA	The Maritime Area Regulatory Authority
MBES	Multibeam Echosounder
mBSF	Meters BelowSeafloor
MO	Metocean
MSL	Mean Sea Level
MSP	Marine Spatial Planning
NDBC	National Data Buoy Center
NEATL	North East Atlantic Model
nm	Nautical Miles
NMPF	National Marine Planning Framework
NOAA	National Oceanic and Atmospheric Administration
NOW-23	2023 National Offshore Wind dataset
NSS	Normal Sea State
O&M	Operations and Maintenance
ORE	Offshore Renewable Energy

OREDPII	DRAFT Offshore Renewable Energy Development Plan II
ORESS	Offshore Renewable Energy Support Scheme
OWF	Offshore Wind Farm
ROMS	Regional Ocean Modelling System
SC-DMAP	South Coast Designated Maritime Area Plan for Offshore Renewable Energy
SEAI	Sustainable Energy Authority of Ireland
SPMT	Self-propelled Modular Transporter
T&I	Transport and Installation
TCP	Technology Collaboration Programme
UCS	Uniaxial Compressive Strength
WEA	Wind Energy Area
WP	Work package (of the IDEA project, often followed by a number)
WTG	Wind Turbine Generator

1 Introduction

This report has been prepared by the Integrated Design of Floating Wind Arrays Ireland (IDEA-IRL) team as part of Work Package (WP) 1 – Reference Sites.

WP1 of IDEA-IRL focusses on defining the metocean, geotechnical, socio-ecological factors and other site-specific conditions for a range of hypothetical reference sites that are representative of the types of conditions in which the initial phase of commercial scale floating wind may be deployed internationally.

This report is a summary report to draw together the various appendix reports which together make up WP1-D1: Reference site technical report. This report is entitled 'WP1-D1: WP1 Reference Site Technical Report - Summary Report', with the appendices to this report listed below:

- **Appendix A:** IDEA-IRL_WP1_D1A: Reference site technical report A: Reference site 1 preliminary metocean site conditions assessment (Moneypoint) [1]
- **Appendix B:** IDEA-IRL_WP1_D1B: Reference site technical report B: Reference site 2 preliminary metocean site conditions assessment (M5 Buoy) [2]
- **Appendix C:** IDEA-IRL_WP1_D1C: Reference site technical report C: Reference site 3 preliminary metocean site conditions assessment (Kinsale Alpha) [3]
- **Appendix D:** IDEA-IRL_WP1_D1D: Reference site technical report D: Reference site 4 preliminary metocean site conditions assessment (Ulsan) [4]
- **Appendix E:** IDEA-IRL_WP1_D1E: Port Infrastructure Requirements [5]
- **Appendix F:** IDEA-IRL_WP1_D1F: Reference Site Ground Conditions [6]

The intention of this deliverable is to define relevant site conditions, based on the chosen project reference sites, which can be fed to WP2 (Reference Farms) of the project. WP2 will then use the defined conditions as inputs to the design bases of reference floating offshore wind arrays (FOWAs) for the IDEA-IRL project reference sites.

The development of these reference site conditions drew on existing open access datasets and ongoing research projects, and the reference site conditions will also be made open-source and available to the wider research community to facilitate future multidisciplinary FOWA research.

The relevant site conditions considered in WP1 D1 to inform FOWA design are metocean (MO) conditions, ground conditions and port infrastructure requirements. Further detail on this is given in Section 2.

It should be noted that this work has been undertaken in parallel with a similar workstream for the International Energy Agency (IEA) Wind Technology Collaboration Programme (TCP) Task 49 – Integrated Design of floating wind Arrays (IDEA) project [2], which is also defining reference site conditions to inform the design of FOWAs for the IDEA project, with collaboration and input from multiple international researchers. IDEA-IRL has been an active contributor to this WP for the international project also, through the support of the SEAI.

There is overlap in the reference sites being considered for both projects, with additional sites being considered for IDEA-IRL. Of the 7 reference sites, for which reference FOWA designs will be prepared for IDEA-IRL, 3 are being used by both the IDEA-IRL and IDEA project (Humboldt, Sørlige Nordsjø II - phase 2 and Utsira Nord). For the remaining 4 sites (Moneypoint offshore one, M5 Wave Buoy, Kinsale Alpha Platform, and Ulsan), reference FOWAs will be prepared exclusively for IDEA-IRL.

Where relevant site conditions have been defined as part of the IEA Wind Task 49 IDEA work, they are referenced in this work and not defined again by IDEA-IRL. Where the site conditions have not been defined for the IEA Wind Task 49 and are required for IDEA-IRL project, they have been defined in this report and/or associated appendices. This is explained further in Section 4.

The structure of this report is as follows:

- Introduction (this section)
- Outline of key conditions to inform FOWA design
- An Overview of 'the Building Block Concept'
- Detail on the reference site selection process and the chosen reference sites, including an update on Irish offshore wind policy as it relates to site selection
- Summary of MO conditions at the reference sites
- Summary of Port infrastructure requirements for floating offshore wind
- Summary of ground conditions at the chosen reference sites
- Conclusion

For a full understanding of this WP and the relevant conditions, this report should be read in conjunction with IEA Wind Task 49: Reference Site Conditions for Floating Wind Arrays report, published in September 2024 [7], as well as the various appendices to this report.

[2] Please note that in this report, the IEA Wind TCP Task 49 international research project is referred to as the IDEA project, while the Irish project is referred to as the IDEA-IRL project. The IDEA website can be found here: https://iea-wind.org/task49/ , while the IDEA-IRL website can be found here: https://www.marei.ie/project/idea-irl-integrated-design-floating-wind/

2 Key Site Conditions to Inform FOWA Design

At the beginning of this project, in collaboration with the IDEA team, the following classes of key site conditions were identified as most relevant to informing the design of FOWAs. These conditions are the site parameters that a developer would collect and use to inform the project design phase and coastal infrastructure developers would seek to identify near prospective development areas. These are the parameters that will be provided to WP2 to inform the designs of reference FOWAs:

- **MO conditions:** MO conditions are a key design input for FOWAs. They are directly linked to energy yields and can result in structural failure through extreme events and the accumulation of structural fatigue for the FOWA infrastructure. The evaluation of metocean conditions at specific sites considers wind, waves (wind and wave characteristics as well as joint wind/wave probability distributions), and currents, among others. This includes statistical analysis of both normal operating conditions, and extreme conditions, both of which are used for design analysis, and operational planning such as transportation and installation activities.
- **Seabed/ground conditions:** The seabed conditions define suitable technologies and costs for fixing and anchoring the floating offshore wind turbines to the seabed. Of primary consideration here is the soil type and strength, but the slope and roughness of the seabed also influence the design of the mooring system. An understanding of ground conditions is key to mitigating risks throughout project development, and ground conditions will also inform export and inter-array cable routes.
- **Port Infrastructure:** Coastal infrastructure, with a focus on port infrastructure, can also play an important role in FOWA design, and initial site selection. This impacts the options and availability of vessels for integration, installation and maintenance, and can also impact manufacturing location and construction methodology.

Three other areas that were identified by the project as important to site selection, design, and development of FOWAs are Socioeconomic Impact, Regulations and Permissions, and Environmental Impact:

- **Socioeconomic Impact:** Socioeconomic Impact is and will be a very important topic for the sustainable development of offshore wind and floating offshore wind. Offshore wind provides a huge opportunity to bring socioeconomic benefits to local communities and society at large, through employment, infrastructure upgrades, investment, energy security, the generation of clean electricity etc. This can be particularly beneficial to local coastal communities hosting offshore wind farms, that might otherwise be lacking in major local employers or investors. Manging this correctly will be key to the acceptance of offshore wind and floating offshore wind in the future.
- **Regulations and Permissions:** According to the International Renewable Energy Agency (IRENA) and the Global Wind Energy Council (GWEC) 'Permitting is a key bottleneck for OW – highlighted by manufacturers, developers and investors, and seen in every region of the world, and with projects of every size. Overcoming this bottleneck would have a transformative effect on the rapid rollout of offshore wind' [8]. GWEC says that typically, OWFs globally take up to nine years to move from early development stage to full

commissioning. The bulk of this time is spent in the permitting and consenting stage, with projects then generally being constructed very quickly, typically in two years, depending on project size [9]. Having fit for purpose consenting and permitting regimes in place will be key for the future development of floating offshore wind, and may impact where and how developers chose to site and design projects.

- **Environmental Impact:** Environmental impact is also a key consideration mainly for initial site selection, but also for project design in many cases. Offshore wind projects are built in complex natural marine environments, and introduce new technical installations, foreign materials, noise, light, and traffic to areas. The impacts to the local environment are highly dependent on the regional marine flora and fauna and local ecosystems, and for a more emerging technology like floating offshore wind, exact impacts are still not fully understood.

While Socioeconomic Impact and Regulations and Permissions are key factors for the development of floating offshore wind, they are not considered as relevant 'site conditions' for WP1, insofar as they are not considered by WP2 in reference FOWA design.

With regards to socioeconomic impact, this is something that may be considered in maritime spatial planning (MSP) and site selection. A robust MSP framework should ensure that relevant stakeholders are involved and consulted with during and after the site selection. However, the anticipated influence of socioeconomic impacts on technical design choices is limited once a site has been selected. Thus, the reference projects will not consider socioeconomic impact in design.

Similarly, while permitting is a key aspect of the development of floating offshore wind, it is not seen as a key input to the technical design of a floating offshore wind project, as required by WP2. Thus, it is not considered in the reference designs.

With regards to environmental impact, this is also a factor that would be considered in MSP, with areas of particular ecological/environmental sensitivity generally excluded from development or not designated suitable for development.

Permitting and MSP are discussed in greater detail as part of WP4 of IDEA-IRL [10].

3 The Building Block Concept

As explained in [7], this WP provides reference sites for the techno-economic design of FOWAs. The approach used allows for a ‘building-block’ approach to synthesise purpose-built site representations, whereby different conditions from multiple reference sites can be combined and used to inform different reference site designs.

Figure 3-1 summarises the six identified classes with relevant factors for FOWAs, identified in collaboration with IDEA. As discussed in Section 2, three classes describe key parameters for the FOWA design while the remaining three classes are important for the site selection but less relevant in the techno-economic design for the purposes of this work.

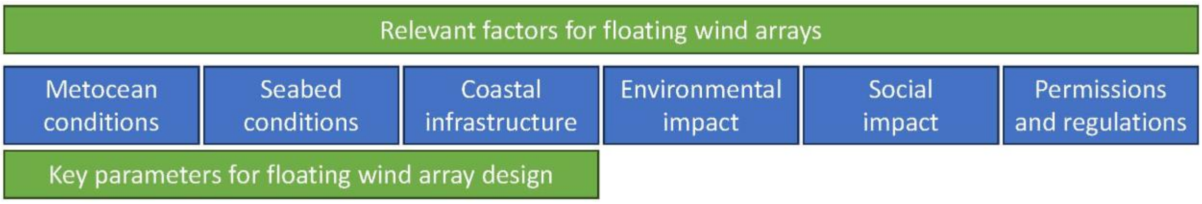


Figure 3-1: Categorisation into classes with relevant factors for site selection and design of floating wind arrays [7]

In each of the classes describing key parameters for floating wind array design, building blocks can be used to describe the characteristic properties and their degree of variation, as summarized in Figure 3-2. The motivations behind the three classes for FOWA design are briefly outlined below.

MO conditions: We select multiple sites for detailed analysis that represent a range of conditions across the pipeline of floating wind farm projects. Wind conditions and sea states are separated, and each location considers both the severity of wind and waves—e.g., one site may have a moderate wave condition but severe wind condition. MO conditions are discussed in Section **Error! Reference source not found.**, and Appendix Reports A – D.

Coastal infrastructure: Minimum port infrastructural requirements are provided for three types of ports – an integration port used for assembling and marshalling activities, a floater manufacturing port, and an operations and maintenance (O&M) port used to provide continuous support services to the project. This is discussed further in Section 6 and Appendix E Report (IDEA-IRL_WP1_D1E).

Seabed conditions: For one specific type of anchor, certain soil conditions might be favourable while others might be unfavourable. In [7], recommendations are not given on site-specific data required for detailed design. Instead, a set of “synthetic cases” that provide the different parameters required for design under each case/soil condition are described. In Work Package 2, a specific case can be chosen based on the anchor type used. While this approach can be used for the design of reference sites, for IDEA-IRL, site-specific ground conditions data is provided to inform design of the reference FOWAs. This is discussed in Section 7, and Appendix F Report (IDEA-IRL_WP1_D1F).

Figure 3-2 belowFigure 4-1, from [7], illustrates the key parameters needed for techno-economic design, and how these can be varied as interchangeable building block that describe the characteristic properties and their degree of variation. This allows multiple variations of FOWA designs to be made using different combinations of conditions.

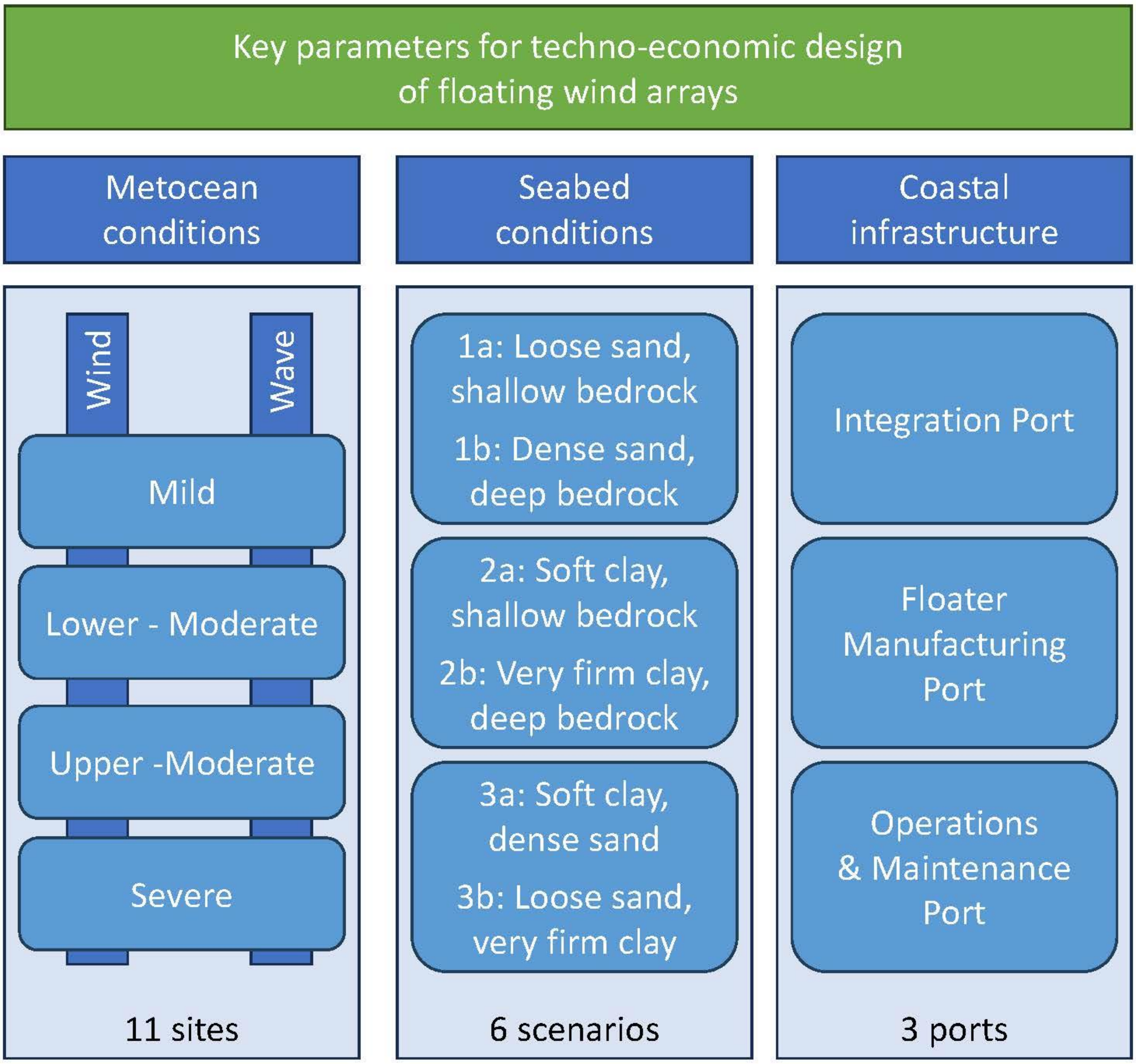


Figure 3-2: Building block concept for the synthesis of reference sites for techno-economic design of floating wind arrays, as illustrated in [7]

4 Site Selection

To deliver a set of fully defined reference sites representative of the international global floating wind deployment pipeline, a database of existing and proposed locations for floating arrays was first constructed as part of the international IDEA project. The 4C Offshore [11] database of floating offshore wind projects provided a base for this database. This map identified a total of 581 floating offshore wind (FLOW) farms organized into the following development status:

- Concept/early planning
- Consent application submitted
- Consent authorized
- Development zone
- Fully commissioned
- Partial generation/under construction
- Preconstruction
- Under construction.

Using expert knowledge from consortia members within IDEA, one to three sites per country were selected to represent the general range of metocean conditions expected in each region. This resulted in a database of 69 representative sites (Figure 4-1). For these 69 representative sites, the European Centre for Medium-Range Weather Forecasts ERA5 [12] was leveraged to identify a number of “severity” categories that could be used to describe the metocean conditions characterizing the global pipeline. This process is explained in detail in [7].

With the objective of having realistic input parameters for design, 11 commercial/prototype floating sites were selected by the project partners for more detailed analyses focused on the metocean conditions (Table 4-1). The selection criteria aimed to select sites that cover a wide range of countries, water depths, and metocean conditions. Metocean analyses were conducted for these sites, as detailed in Section 4 of [7], and the relevant report appendices.

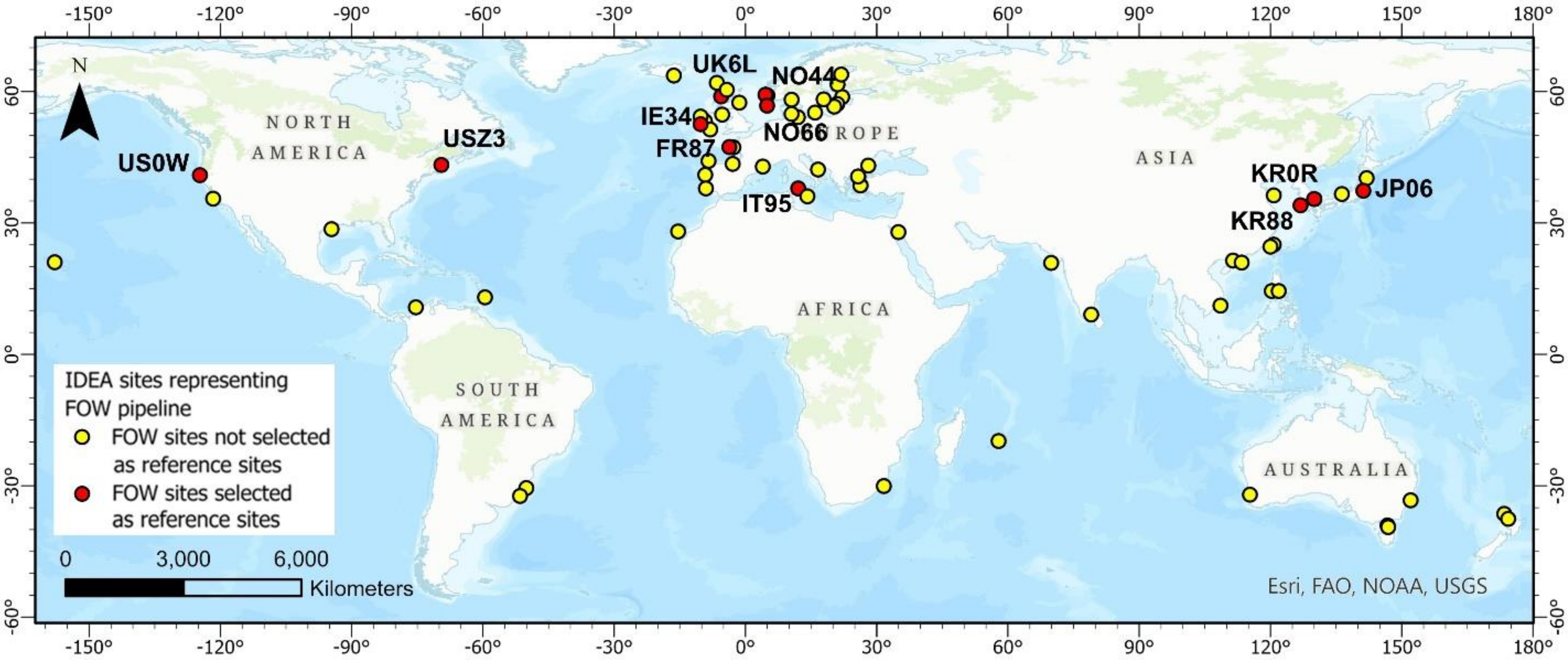


Figure 4-1 - Overview of the 11 reference sites in red selected for metocean analyses by the IDEA project (Humboldt, Gulf of Maine, Moneypoint Offshore One, Havbredey, Sud de la Bretagne II, Utsira Nord, Sørlige Nordsjø II, Hannibal, Geomundo, Ulsan, Fukushima)

Table 4-1- Details of the 11 Reference Sites studied in more detail, as chosen by IDEA [7]

Case Number	4C Offshore ID	Site	Latitude [deg]	Longitude [deg]	Water Depth [m] (GEBCO)	Wind Condition Severity (ERA5)	Wave Condition Severity (ERA5)	Distance from Shore [km]
1	IT95	Hannibal (Italy/Mediterranean)	37.84	12.072	-353	Lower-Moderate	Mild	35.0
2	US0W	Humboldt (U.S.)	40.93	-124.71	-707	Lower-Moderate	Lower -Moderate	43.8
3	KR0R	Ulsan (South Korea)	35.45	129.95	-188	Severe	Upper Moderate	32
4	IE34	Moneypoint Offshore One (Ireland)	52.52	-10.28	-102	Upper-Moderate	Severe	23.4
5	UK6L	Havbredey (UK)	58.86	-5.54	-91	Severe	Severe	41.6
6	JP06	Fukushima (Japan)	37.31	141.25	-90	N/A	N/A	19.4
7	NO44	Utsira Nord (Norway)	59.28	4.54	-273	Upper-Moderate	Upper-Moderate	42.4
8	USZ3	Gulf of Maine (U.S.)	43.25	-69.50	-148	Lower-Moderate	Upper-Moderate	138
9	KR88	Geomundo (South Korea)	34.04	126.90	-70	Severe	Upper-Moderate	47.0
10	FR87	Sud de la Bretagne II (France)	47.33	-3.66	-94	Severe	Upper-Moderate	30.7
11	NO66	Sørlige Nordsjø II (Norway)	56.78	4.92	-60	Severe	Upper-Moderate	180.0

Based on further review, 3 sites were chosen by the IDEA project for the design of reference FOWAs WP2. These were chosen to give a representation of a wide range of metocean and geotechnical conditions, and water depths, with ‘deep’, ‘shallow’ and ‘intermediate’ depth sites chosen. The reference sites chosen by IDEA are listed below.

- ‘Deep’ reference site: Humbolt, California, USA (c. 700m depth)
- ‘Intermediate’ reference site: Utsira Nord, Norway (c. 270m depth)
- ‘Shallow’ reference site: Sørlige Nordsjø II, Norway (c. 60m depth)

Reference FOWAs are currently being designed by WP2 for each of the above sites for the IDEA project using the reference site conditions defined as part of WP1. GDG and IDEA-IRL lead the design of the intermediate depth site, which was seen as the most relevant to Ireland of the international case studies based on water depth and site conditions. The IDEA-IRL team is also inputting on the other international design cases. These IDEA designs will be considered as 3 reference FOWA designs for the IDEA-IRL project, once complete.

For the IDEA-IRL project, a total of 10 reference FOWA design variations are planned to be completed, in line with the project proposal. To give a wider range of site conditions, as well as more Irish specific cases, it was decided by IDEA-IRL to include additional reference sites to those listed above.

From an international perspective, it was decided to include the Ulsan site, which was seen as a good representation of Korean and Japanese site conditions, a region which was not covered by the other reference sites. The remaining reference sites we chosen to be representative of Irish site conditions, with the process behind selecting these set out below.

4.1 Irish Site Selection

4.1.1 Initial Site Selection – Moneypoint Offshore One

The process behind the selection of the first Irish reference site - Moneypoint Offshore One – is explained in WP1 D1A [1]. Reference site 1 was chosen to align with Ireland’s DRAFT Offshore Renewable Energy Development Plan II’s (OREDPII) broad area of interest ‘Mid-West Broad Area Floating Wind’ and utilises ‘Moneypoint Offshore One’ as a reference point for data collection. The draft OREDP II was consulted on from February to April 2023, with Reference site 1 chosen by IDEA-IRL shortly after this consultation period closed, and the report published in October 2023. This reference site was chosen, and MO analysis was completed, before the remaining Irish reference sites, to align with timelines for the international IDEA project, which commenced earlier than IDEA-IRL.

At the time of site selection, the Irish Government had recently created a distinct programme of work to provide systems to enable 2 GW of offshore wind for additional non-grid use to be in development by 2030. It was initially stated by Government in the Phase 2 Policy Statement [13] (March 2023) that this 2 GW would be exclusively floating wind, and it was thought that although the Broad areas of interest included in OREDP II were provided as example areas, future Irish floating offshore wind sites could be expected to align with these areas.

Given developments in Irish offshore wind since, with the accelerated move to a plan led system, a focus on the enactment of the South Coast Designated Maritime Area Plan for Offshore Renewable Energy (SC-DMAP), and a lack of clarity over plans for future floating wind development, it is currently unlikely that floating wind will be in development at commercial scale in Ireland in this timeline. In addition, the broad areas of interest included in the draft OREDP II, as well as the draft OREDPII itself, have not been progressed since WP1 D1A was prepared and submitted. The approach to Irish reference site selection was therefore refined for the selection of the remaining reference Irish sites, which is discussed below.

4.1.2 The Phase 2 Policy Statement and the South Coast DMAP

As outlined in [10], the Phase 2 Policy Statement confirmed that Phase 2 development will be Plan-Led, with projects to be developed within State identified individual Offshore Renewable Energy (ORE) Designated Areas, which will be designated according to the legislative provisions for DMAPs in the Maritime Area Planning Act 2021 (MAP Act). This approach will relate to all Phase Two auctions, and the policy statement also confirmed that all Phase 2 projects will be fixed bottom.

The first of these DMAPs - the Draft South Coast Designated Maritime Area Plan for Offshore Renewable Energy (SC-DMAP) – was consulted on from the 3rd May to 14 June 2024 [14]. A further consultation period was held over the month of August, but this was solely in relation to Workbook 1-Draft Environmental Data Log which was included as part of the consultation documents. The SC-DMAP was finalised in October 2024.

The SC-DMAP represents the first sub-national, forward planning maritime spatial plan for ORE in Ireland, with the plan prepared pursuant to the legislative provisions of the MAP Act, and to be consistent with Ireland's National Marine Planning Framework (NMPF).

The South Coast Designated Maritime Area Plan for Offshore Renewable Energy document [15] identifies four Maritime Areas (Figure 4-2, Table 4-2) within the wider geographical area within which proposed future deployments of ORE may proceed for further project level assessment. The four areas have been identified for future development of <u>fixed-bottom offshore wind</u>, but any project seeking to develop in one of the four Maritime Areas identified in the SC-DMAP, will be required to obtain a Maritime Area Consent (MAC) from the Maritime Area regulatory Authority (MARA), and to go through the development permission application and assessment process.

Site A (named Tonn Nua – 'New Wave' in Irish) is to be auctioned in ORESS2.1 (ORESS Tonn Nua), expected to commence pre-qualification at the end of Q1 2025. Subsequent programmes of deployment will take place within Maritime Areas B (named Lí Ban - The Mermaid Saint in Irish Mythology), C (named Manannán – a Sea God associated with Ireland and the Isle of Man) and D (named Danu - the mother of Irish gods) over the next approximately ten-year period through an orderly, strategic and managed process of development.

The South Coast Designated Maritime Area Plan for Offshore Renewable Energy document states that while all areas are chosen for fixed-bottom technology only, future DMAPs will be established in the coming years to identify prospective marine areas for deployment of floating wind 'beyond 2030'.

The document notes that floating offshore wind is an important emerging technology, which is expected to make a significant contribution towards meeting Ireland's future medium- and long-term renewable energy objectives, most significantly within deeper waters beyond the technological capabilities for fixed-bottom, but that the deployment of fixed-bottom is aligned with the accelerated achievement of Ireland's renewable energy and decarbonization objectives. Reasons given for this are that fixed offshore wind is a proven technology that has been delivered at scale in other jurisdictions and is supported by an existing global supply chain.

The document states that Government will establish two working groups to aid the accelerated emergence of floating offshore wind in Ireland in future DMAPs, comprising a State-Industry forum to facilitate collaborative engagement, and an additional technical group focused on delivering a floating offshore wind demonstrator project.

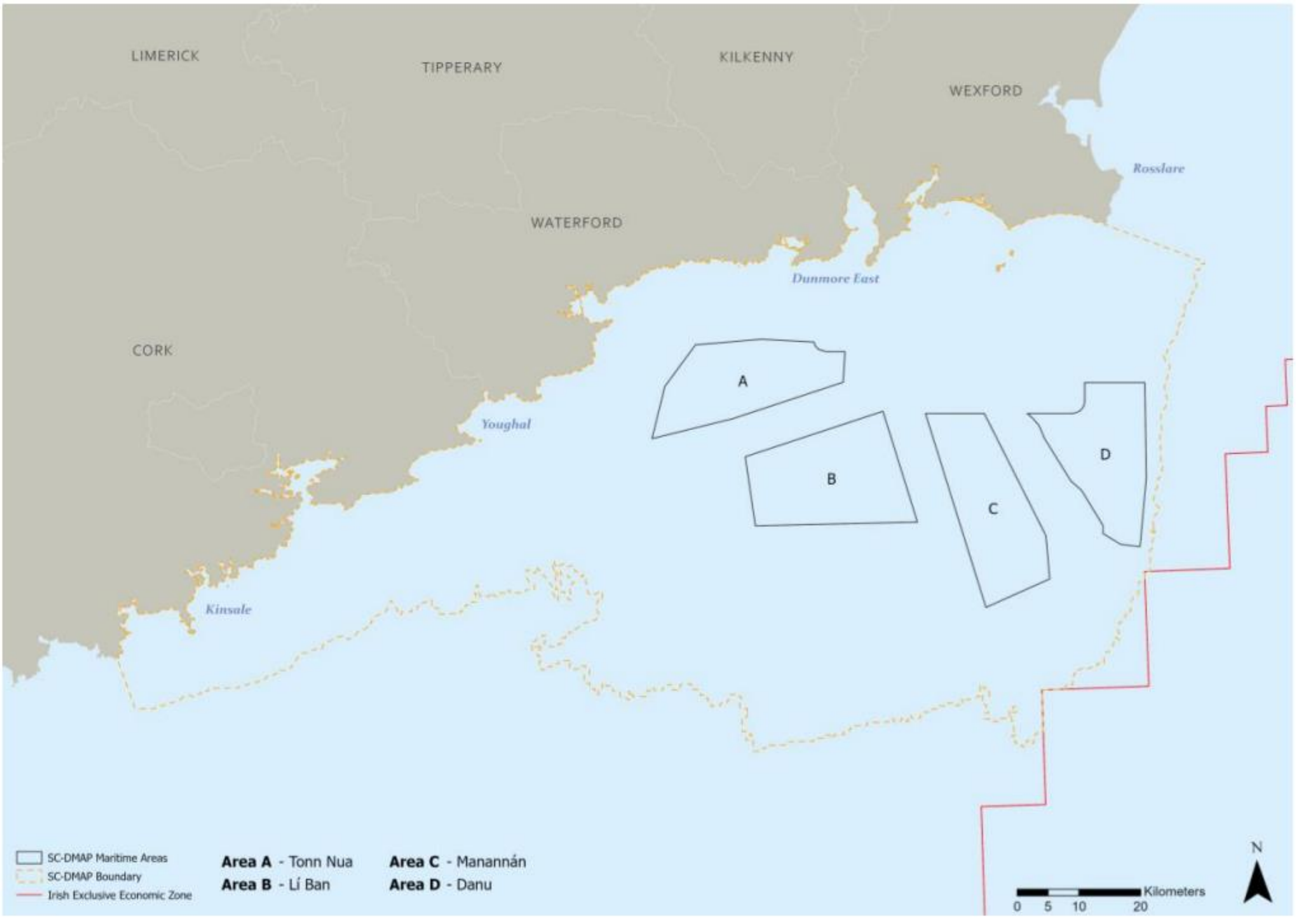


Figure 4-2 - Maritime Areas A to D proposed for offshore wind development in the SC-DMAP

Table 4-2 - Overview of Maritime Areas A to D

	Tonn Nua (A)	Lí Ban (B)	Manannán (C)	Danu (D)
Area (km2)	306	368	341	300
Distance to shore (km)	12.2	24	25	26
Min – Max & Mean Water Depth (m)	48 – 69, 57	65 – 76, 70	64 – 72, 69	48 – 94, 67
Average Wind Speed @ 150m (m/s)	10.4	10.4	10.4	10.4
Planned Capacity (GW)	0.9	1.1 – 1.5	1 – 1.4	0.9 – 1.3

4.1.3 The Future Framework

Future floating wind development in Ireland is expected to be guided by the Future framework.

Ireland's Future Framework for Offshore Renewable Energy [16] was published on 1st May 2024. The document essentially sets out the Government's views on the long-term plans for ORE development in Ireland post-2030, priority areas, and key actions to help deliver these plans, although at a very high level.

The document sets out 29 medium term actions for Government, to help deliver Ireland's longer term, plan-led, ORE ambitions of 20GW ORE by 2040 and 37GW by 2050. 7 priority actions are identified which are set out below Figure 4-3.

Key actions for Government in relation to floating wind set out in the Future Framework include:

- **2 -** Conduct a study to assess the potential to deploy floating offshore wind in Irish waters at scale, assessing capacity at key strategic locations in Ireland and taking account of the upcoming global auctions dedicated to floating wind, including in France, in 2024 (Q2 2024).
- **3 -** Investigate the feasibility of a floating offshore wind demonstrator site including optimal capacity (Q3 2024).
- **8 -** Assess the potential for accelerating the development of a West Coast DMAP and examine the cost and viability of initiating floating offshore wind projects in this DMAP as Ireland seeks to support the development of this sector (Q4 2024).

In line with this, it is understood that a roadmap for future DMAPs is being prepared by the Future Framework Working Group under the Offshore Wind Delivery Taskforce. A Floating Offshore Wind Demo group is also to be set up by DECC in the second half of this year, to address a key action of the Future Framework to investigate the feasibility of a floating demonstration project in Ireland.

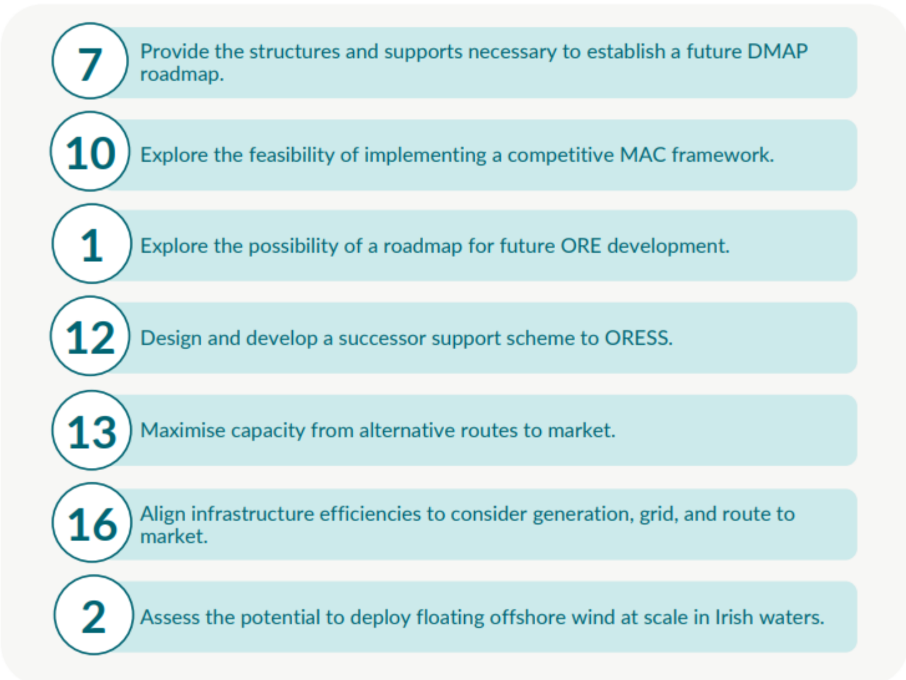


Figure 4-3 – Key actions outlined in the Future Framework

Considering all of the above, there is no exact clarity on when or where floating offshore wind will be developed in Ireland in the coming years. For IDEA-IRL, it was therefore decided to choose two additional reference sites off the Irish south coast (one on the south west, and one on the south east).

Reasons for this decision include:

- The east coast is seen as an area primarily for fixed-bottom Phase 1 development, and not expected to be a priority area for floating offshore wind
- A west coast site has been chosen for Reference Site 1, which will give a demonstration of Atlantic conditions
- The inclusion of a site on the north-west coast was considered, but this was not seen as a priority area for future floating offshore wind development at this stage
- The south coast is seen as an area of great interest for the future development of floating offshore wind in Ireland, where several projects had been planned under the developer-led regime, before the Phase 2 Policy Statement was released and the switch to a plan led delivery model was accelerated
- There was good data availability in the areas chosen

This resulted in the final list of 7 sites shown in Table 4-3 and Figure 4-4 – Overview of IDEA-IRL reference sitesFigure 4-4 being chosen for assessment by IDEA-IRL as part of WP1. Using conditions from these 7 sites, 10 reference FOWA designs will be prepared for IDEA-IRL.

Table 4-3 – IDEA-IRL reference sites overview

No.	Reference sites	Country	Region	Lat	Long	Approx Water depth [mMSL] (GEBCO)	MO Conditions defined by IDEA-IRL or IDEA (IEA Wind Task 49)	Reference FOWA Design being Led by IDEA-IRL or IDEA
1	Moneypoint Offshore One[3] [1]	Ireland	Atlantic Ocean	52.52	-10.28	-102	**IDEA-IRL (See Appendix A)**	**IDEA-IRL**
2	M5 wave buoy	Ireland	Celtic Sea	51.69	-6.70	-70	**IDEA-IRL (See Appendix B)**	**IDEA-IRL**
3	Kinsale Gas Field - Alpha Platform	Ireland	Celtic Sea	51.36	-7.95	-90	**IDEA-IRL (See Appendix C)**	**IDEA-IRL**
4	Ulsan Floating Wind farm[4]	South Korea	Sea of Japan	35.45	129.95	-188	**IDEA-IRL (See Appendix D)**	**IDEA-IRL**
5	Sørlige Nordsjø II - phase 2[5]	Norway	North Sea	56.78	4.92	-60	**IDEA (See** [7]**)**	**IDEA**
6	Utsira Nord[6]	Norway	North Sea	59.28	4.54	-273	**IDEA (See** [7]**)**	**IDEA-IRL with IDEA contribution**
7	Humboldt SW[7]	California, US	NW Coast of California - Pacific Ocean	40.928	- 124.71	-707	**IDEA (See** [7]**)**	**IDEA**

[3] Ref. coordinates used are according to 4C Offshore database accessed in Feb 2023
[4] Ref. coordinates used are according to 4C Offshore database accessed in Feb 2023
[5] Ref. coordinates used are according to 4C Offshore database accessed in Feb 2023
[6] Ref. coordinates used are according to 4C Offshore database accessed in Feb 2023
[7] Ref. coordinates used are according to 4C Offshore database accessed in Feb 2023

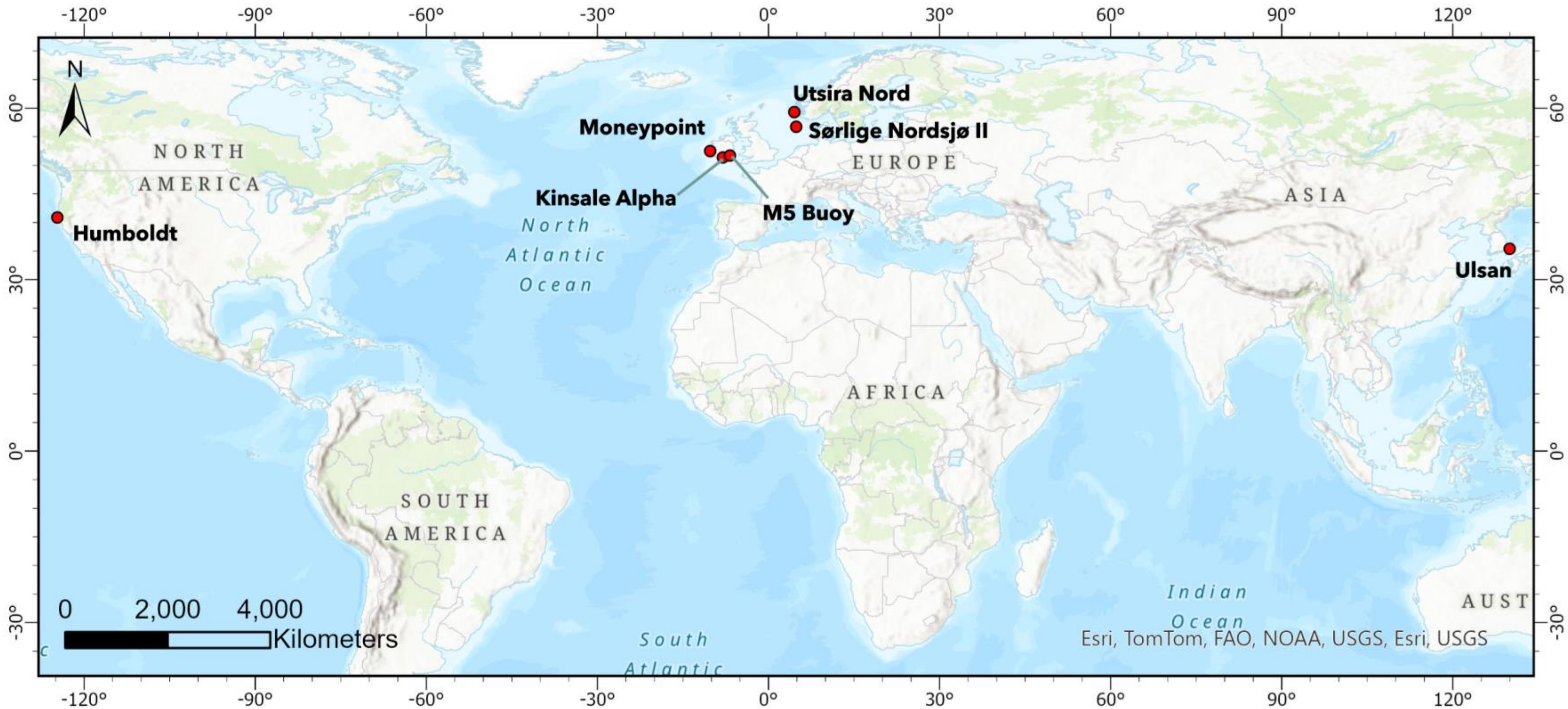


Figure 4-4 – Overview of IDEA-IRL reference sites

5 Metocean Conditions

As discussed earlier in this report, MO conditions will be a key input into the reference FOWA designs to be prepared by WP2. As part of WP1, metocean analyses were performed for the relevant sites. A summary of these is presented below, with further information available in the Appendices, and [7].

5.1 Moneypoint Offshore One

Reference site 1 was aligned with Ireland's OREDPII's broad area of interest 'Mid-West Broad Area Floating Wind' and utilises 'Moneypoint Offshore One' as a reference point for data collection. Moneypoint Offshore One, represents phase 1 of the proposed floating offshore wind farm development Moneypoint Offshore Wind Farm. It is located 16 km off the Clare/Kerry Coast in the Atlantic Ocean and is expected to reach a capacity of 400 MW. It will likely cover 70 km^2. The proposed development is owned by ESB, with Ørsted a 50/50 partner in the project.

To conduct a preliminary site characterisation study in the proximity of this site, a 43-year timeseries was utilised from the ERA5 reanalysis dataset for both wind and wave conditions, whereas a 10-year modelled timeseries was extracted for water levels and currents from the three-dimensional North East Atlantic Model (NEATL), an implementation of the Regional Ocean Modelling System (ROMS) model.

Normal, extreme and severe metocean statistics and parameters were generated from these datasets. Operability statistics, such as wind-wave persistence, were also generated. A summary of parameters most relevant to design are presented in Table 5-1. More detail can be found in Appendix A, IDEA-IRL WP1 D1A.

Table 5-1: Summary of metocean conditions at Moneypoint Offshore One

Variable	Value
High Still Water Level (50-year) (mMSL)	4.06
High Still Water Level (1-year) (mMSL)	2.76
Highest Astronomical Tide (HAT) (mMSL)	2.14
Lowest Astronomical Tide (LAT) (mMSL)	-2.25
Low Still Water Level (1-year) (mMSL)	-2.73
Low Still Water Level (50-year) (mMSL)	-2.94
Bottom current speed (m/s) (Normal Conditions)	Mean: 0.09 Max: 0.32 P25: 0.06 P50: 0.08 P75: 0.11
Bottom current speed (m/s) (1-year)	0.23

Bottom current speed (m/s) (50-year)	0.36
Mid current speed (m/s) (Normal Conditions)	Mean: 0.14 Max: 0.54 P25: 0.07 P50: 0.13 P75: 0.19
Mid current speed (m/s) (1-year)	0.44
Mid current speed (m/s) (50-year)	0.58
Surface current speed (m/s) (Normal Conditions)	Mean: 0.20 Max: 1.08 P25: 0.11 P50: 0.18 P75: 0.27
Surface current speed (m/s) (1-year)	0.67
Surface current speed (m/s) (50-year)	1.10
Wind speed (150 m above sea level) (m/s) mean	10.1
Wind speed (150 m above sea level) (m/s) max	41.3
Wind speed (150 m above sea level) (m/s) P95	18.9
Wind direction (150 m above sea level) (°) mean	245.4
Wind speed (10 m above sea level) – Weibull parameters	A = 8.7; k = 2.28
Wind speed (150 m above sea level) – Weibull parameters	A = 11.4; k = 2.19
Extreme 10-min wind speed (150 m above sea level) (m/s) (1-year)	27.4
Extreme 10-min wind speed (150 m above sea level) (m/s) (50-year)	44.2
Extreme 10-min wind speed (150 m above sea level) (m/s) (100-year)	46.7
Normal Sea State (NSS)	See relevant report section
Extreme Sea State (ESS) – Significant wave height (1-year) (m)	6.0

ESS – Peak wave period (1-year) (s)	$9.7 \leq 12.4$
ESS – Individual maximum wave height (1-year) (m)	11.2
ESS – Period of maximum wave height (1-year) (s)	$8.7 \leq 11.2$
ESS – Significant wave height (50-year) (m)	14.0
ESS – Peak wave period (50-year) (s)	$14.7 \leq 19.0$
ESS – Individual maximum wave height (50-year) (m)	26.0
ESS – Period of maximum wave height (50-year) (s)	$13.3 \leq 17.1$
Severe Sea State	See relevant report section

5.2 M5 wave buoy

Reference site 2 is off Ireland's south east coast and utilises the Marine Institute's M5 buoy as a reference point for data collection. It is located approximately 54.5 km from Kilmore Quay in County Wexford in the Celtic Sea.

To conduct a preliminary site characterisation study at this location, the following was utilised:

- 45-year time series from the ERA5 reanalysis dataset for both wind and wave conditions,
- 20-year measured wind time series from the M5 buoy,
- For wave variables, depending on the variable, data sets of up to 20-years from the M5 buoy.

The M5 data was found to possess gaps of various durations and in some cases insufficient length of data to study the long-term environmental trends. Therefore, the measured M5 dataset was used to calibrate the long-term numerically generated ERA5 dataset to remove any biases within the numerical dataset.

A 12-year modelled time series was extracted for water levels and currents from the three-dimensional NEATL, an implementation of the ROMS model.

Normal, extreme and severe metocean statistics and parameters were generated from these datasets. Operability statistics, such as wind-wave persistence, were also generated. A summary of the parameters most relevant to the design is presented in Table 5-2. More detail can be found in Appendix B, IDEA-IRL WP1 D1B.

Table 5-2: Summary of metocean conditions at M5 metocean buoy

Variable	Value
High Still Water Level (50-year) (mMSL)	3.48
High Still Water Level (1-year) (mMSL)	2.49
Highest Astronomical Tide (HAT) (mMSL)	1.95
Lowest Astronomical Tide (LAT) (mMSL)	-1.92
Low Still Water Level (1-year) (mMSL)	-2.41
Low Still Water Level (50-year) (mMSL)	-2.95
Bottom current speed (m/s) (Normal Conditions)	Mean: 0.08 Max: 0.30 P25: 0.04 P50: 0.07 P75: 0.12
Bottom current speed (m/s) (1-year)	0.25
Bottom current speed (m/s) (50-year)	0.32
Mid current speed (m/s) (Normal Conditions)	Mean: 0.16 Max: 0.62 P25: 0.08 P50: 0.14 P75: 0.22
Mid current speed (m/s) (1-year)	0.49
Mid current speed (m/s) (50-year)	0.61
Surface current speed (m/s) (Normal Conditions)	Mean: 0.21 Max: 1.06 P25: 0.12 P50: 0.19 P75: 0.28
Surface current speed (m/s) (1-year)	0.76
Surface current speed (m/s) (50-year)	1.35
Wind speed (150 m above sea level) (m/s) mean	13.1

Wind speed (150 m above sea level) (m/s) max	39.3
Wind speed (150 m above sea level) (m/s) P95	23.0
Wind direction (150 m above sea level) (°) mean	244.8
Wind speed (10 m above sea level) – Weibull parameters	A = 10.58; k = 2.58
Wind speed (150 m above sea level) – Weibull parameters	A = 15.39; k = 2.57
Extreme 10-min wind speed (150 m above sea level) (m/s) (1-year)	27.5
Extreme 10-min wind speed (150 m above sea level) (m/s) (50-year)	43.4
Extreme 10-min wind speed (150 m above sea level) (m/s) (100-year)	43.9
Normal Sea State (NSS)	See relevant report section
Extreme Sea State (ESS) – Significant wave height (1-year) (m)	7.56
ESS – Peak wave period (1-year) (s)	$10.82 \leq 13.94$
ESS – Individual maximum wave height (1-year) (m)	12.32
ESS – Period of maximum wave height (1-year) (s)	$9.74 \leq 12.55$
ESS – Significant wave height (50-year) (m)	11.24
ESS – Peak wave period (50-year) (s)	$13.20 \leq 17.00$
ESS – Individual maximum wave height (50-year) (m)	17.54
ESS – Period of maximum wave height (50-year) (s)	$11.88 \leq 15.30$
Severe Sea State	See relevant report section

5.3 Kinsale Gas Field - Alpha Platform

Reference site 3 utilises 'Kinsale Energies Alpha Platform' as a reference point for data collection. It is located 25.6 km from Roches Point in County Cork in the Celtic Sea.

To conduct a preliminary site characterisation study at this location, a 43-year time series was utilised from the ERA5 reanalysis dataset for wind and wave conditions, and a measured 40-year time series was utilised from the Kinsale Alpha Platform. The ERA5 dataset was used to gap-fill and assess the appropriateness of the measured data to the ERA5 dataset. A 12-year modelled time series was extracted for water levels and currents from the three-dimensional NEATL, an implementation of the ROMS model.

Normal, extreme and severe metocean statistics and parameters were generated from these datasets. Operability statistics, such as wind-wave persistence, were also generated. A summary of the parameters most relevant to the design is presented in Table 5-3. More detail can be found in Appendix C, IDEA-IRL WP1 D1C.

Table 5-3: Summary of metocean conditions at Kinsale Alpha Platform

Variable	Value
High Still Water Level (50-year) (mMSL)	3.71
High Still Water Level (1-year) (mMSL)	2.64
Highest Astronomical Tide (HAT) (mMSL)	2.03
Lowest Astronomical Tide (LAT) (mMSL)	-2.05
Low Still Water Level (1-year) (mMSL)	-1.58
Low Still Water Level (50-year) (mMSL)	-1.25
Bottom current speed (m/s) (Normal Conditions)	Mean: 0.11 Max: 0.32 P25: 0.07 P50: 0.11 P75: 0.15
Bottom current speed (m/s) (1-year)	0.28
Bottom current speed (m/s) (50-year)	0.32
Mid current speed (m/s) (Normal Conditions)	Mean: 0.21 Max: 0.69 P25: 0.11 P50: 0.19

	P75: 0.29
Mid current speed (m/s) (1-year)	0.58
Mid current speed (m/s) (50-year)	0.97
Surface current speed (m/s) (Normal Conditions)	Mean: 0.24 Max: 0.98 P25: 0.14 P50: 0.22 P75: 0.33
Surface current speed (m/s) (1-year)	0.83
Surface current speed (m/s) (50-year)	1.41
Wind speed (150 m above sea level) (m/s) mean	10.7
Wind speed (150 m above sea level) (m/s) max	42.4
Wind speed (150 m above sea level) (m/s) P95	20.3
Wind direction (150 m above sea level) (°) mean	245.5
Wind speed (10 m above sea level) – Weibull parameters	A = 8.54 ; k = 2.15
Wind speed (150 m above sea level) – Weibull parameters	A = 12.03 ; k = 2.10
Extreme 10-min wind speed (150 m above sea level) (m/s) (1-year)	25.13
Extreme 10-min wind speed (150 m above sea level) (m/s) (50-year)	47.44
Extreme 10-min wind speed (150 m above sea level) (m/s) (100-year)	48.88
Normal Sea State (NSS)	See relevant report section
Extreme Sea State (ESS) – Significant wave height (1-year) (m)	7.74
ESS – Peak wave period (1-year) (s)	$10.96 \leq 14.11$
ESS – Individual maximum wave height (1-year) (m)	14.40
ESS – Period of maximum wave height (1-year) (s)	$9.86 \leq 12.70$
ESS – Significant wave height (50-year) (m)	15.15
ESS – Peak wave period (50-year) (s)	$15.33 \leq 19.74$

ESS – Individual maximum wave height (50-year) (m)	28.18
ESS – Period of maximum wave height (50-year) (s)	13.80 ≤ 17.77
Severe Sea State	See relevant report section

5.4 Ulsan Floating Wind farm

Reference site 4 was chosen as a global site for consideration and development of the global offshore wind research. It utilises the location of the proposed Ulsan Floating Offshore Wind Farm, which is approximately 60 km east of the Ulsan Port in South Korea. The site is in development by a consortium of companies under a joint venture of offshore wind company Corio Generation, TotalEnergies, and SK ecoplant. It is expected to reach a capacity of 1.5 GW at full capacity.

To conduct a preliminary site characterisation study in the proximity of this site, a 45-year timeseries was utilised from the ERA5 reanalysis dataset for both wind and wave conditions, whereas a 20-year modelled timeseries was extracted for water levels and currents from the three-dimensional Hybrid Coordinate Ocean Model (HYCOM) global reanalysis model.

Normal, extreme and severe metocean statistics and parameters were generated from these datasets. Operability statistics, such as wind-wave persistence, were also generated. A summary of parameters most relevant to design are presented in Table 5-4. More detail can be found in Appendix D, IDEA-IRL WP1 D1D, and [7].

Table 5-4: Summary of metocean conditions at Ulsan Floating Wind Farm

Variable	Value
High Still Water Level (50-year) (mMSL)	1.25
High Still Water Level (1-year) (mMSL)	0.28
Highest Astronomical Tide (HAT) (mMSL)	0.13
Lowest Astronomical Tide (LAT) (mMSL)	-0.17
Low Still Water Level (1-year) (mMSL)	-0.32
Low Still Water Level (50-year) (mMSL)	0.60
Bottom current speed (m/s) (Normal Conditions)	Mean: 0.12 Max: 0.32 P25: 0.08 P50: 0.12 P75: 0.15
Bottom current speed (m/s) (1-year)	0.24

Bottom current speed (m/s) (50-year)	0.35
Mid current speed (m/s) (Normal Conditions)	Mean: 0.12 Max: 0.56 P25: 0.06 P50: 0.11 P75: 0.17
Mid current speed (m/s) (1-year)	0.27
Mid current speed (m/s) (50-year)	0.56
Surface current speed (m/s) (Normal Conditions)	Mean: 0.24 Max: 1.71 P25: 0.13 P50: 0.21 P75: 0.32
Surface current speed (m/s) (1-year)	0.74
Surface current speed (m/s) (50-year)	1.66
Wind speed (150 m above sea level) (m/s) mean	9.2
Wind speed (150 m above sea level) (m/s) max	39.3
Wind speed (150 m above sea level) (m/s) P95	16.7
Wind direction (150 m above sea level) (°) mean	313.3
Wind speed (10 m above sea level) – Weibull parameters	A = 8.60; k = 2.20
Wind speed (150 m above sea level) – Weibull parameters	A = 11.06; k = 2.38
Extreme 10-min wind speed (150 m above sea level) (m/s) (1-year)	19.82
Extreme 10-min wind speed (150 m above sea level) (m/s) (50-year)	41.73
Extreme 10-min wind speed (150 m above sea level) (m/s) (100-year)	45.50
Normal Sea State (NSS)	See relevant report section
Extreme Sea State (ESS) – Significant wave height (1-year) (m)	2.5

ESS – Peak wave period (1-year) (s)	$6.2 \leq 8.0$
ESS – Individual maximum wave height (1-year) (m)	4.7
ESS – Period of maximum wave height (1-year) (s)	$5.6 \leq 7.2$
ESS – Significant wave height (50-year) (m)	9.4
ESS – Peak wave period (50-year) (s)	$12.1 \leq 15.6$
ESS – Individual maximum wave height (50-year) (m)	17.4
ESS – Period of maximum wave height (50-year) (s)	$10.9 \leq 14.0$
Severe Sea State	See relevant report section

5.5 Sørlige Nordsjø II - phase 2 and Utsira Nord

The Sørlige Nordsjø II - phase 2 and Utsira Nord sites (reference sites 5 and 6) (Figure 5-1) were assessed by IDEA, with metocean analyses presented in Section 4.4.7 of [7], and Appendix G (for Utsird Nord) and Appendix K (for Sørlige Nordsjø II) of the same report.

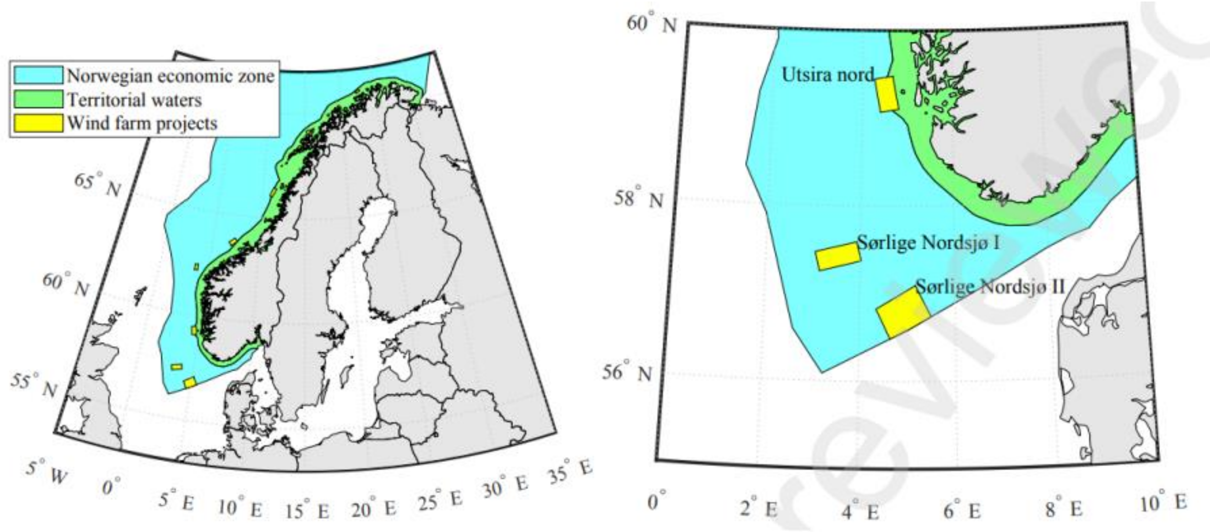


Figure 5-1: (Left) Areas opened for wind farm deployment in the Norwegian economic zone. (Right) Close-up of Utsira Nord and Sørlige Nordsjø II [7]

Extreme Value Analysis for the sites presented in the report, based on [17], are shown in Table 5-5 and Table 5-6.

Table 5-5: Extreme Value Analysis at Utsira Nord. The values in brackets represent the minimum and maximum values from all grid points [7]

Return Period (year)	Significant Wave Height (m)	Wind Speed at 150-m Hub Height (m/s)
1	9.6 [9.3, 9.8]	31.0 [30.4, 31.2]
10	12.8 [12.7, 13.0]	34.7 [34.4, 35.3]
50	14.4 [14.3, 14.5]	37.5 [37.0, 38.5]
100	14.9 [14.9, 15.1]	38.7 [38.0, 39.8]

Table 5-6: Extreme Value Analysis at Sørlige Nordsjø II. The values in brackets represent the minimum and maximum values from all grid points [7]

Return Period (year)	Significant Wave Height (m)	Wind Speed at 150-m Hub Height (m/s)
1	8.7 [8.4, 8.9]	30.5 [30.3, 30.9]
10	11.3 [10.8, 11.7]	37.6 [37.5, 39.6]
50	12.7 [12.1, 13.2]	43.0 [42.6, 46.2]
100	13.2 [12.6, 13.8]	45.3 [44.8, 48.9]

Design of the Sørlige Nordsjø II site reference FOWA will be led by IDEA.

5.6 Humboldt SW

A preliminary metocean study for the Humboldt site (reference site 7) is presented in Appendix B of [7], with summary details provided in Section 4.4.2 of the same report. The Humboldt reference site is based on conditions representative of the Humboldt Bay lease areas awarded by the Bureau of Ocean Energy Management (BOEM) in 2023. The water depths of the leased areas range from 550 m to 1,300 m. The target location (40.928, -124.708) is the centroid of the western lease area because it is located further offshore (25 nautical miles [nm] to shore) and in deeper waters (800 m) than the adjacent lease area.

Data for the reference site conditions come from the 2023 National Offshore Wind dataset (NOW-23), measurement data from metocean buoys operated by the National Data Buoy Center (NDBC) and the National Oceanic and Atmospheric Administration (NOAA), and high-frequency radar national network (HFRNet) current measurements from SCRIPPS Institution of Oceanography. Extreme wind, wave, and current parameters for return periods ranging from 1 year to 500 years are presented in [7], and shown below in Table 5-7.

Table 5-7: Extreme Metocean Parameters for Humboldt Bay [7]

Return Period (years)	Wind Speed (m/s)	Significant Wave Height (m)	Peak Wave Period (s)	Current Speed (m/s)
1	31.0	8.5	16.8	0.92
5	34.9	9.8	18.1	1.09
10	36.4	10.4	18.6	1.15
50	39.4	11.8	19.8	1.28
100	40.6	12.4	20.3	1.33
500	43.0	13.7	21.4	1.44

Design of the reference FOWA for the Humboldt site will be led by IDEA.

6 Port Infrastructure Requirements

Ports will play a key role in all development phases involved in a floating offshore wind farm, being the link between land-based activities and marine operations.

To inform understanding on this, GDG prepared a Technical Note to provide general information about the main requirements that a port should comply with to provide a satisfactory service during a floating offshore wind farm construction and operation. This Technical Note is included as Appendix E (IDEA-IRL WP1 D1E) to this report, with summary details included here. This note was prepared originally for the IDEA project, and has also been included in [7].

Port site requirements are dependent on the floating foundation/substructure typology, which will determine the necessities in relation to manufacturer, assembly and staging port facilities. The main floater typologies considered for the ports assessment are shown in Figure 6-1.

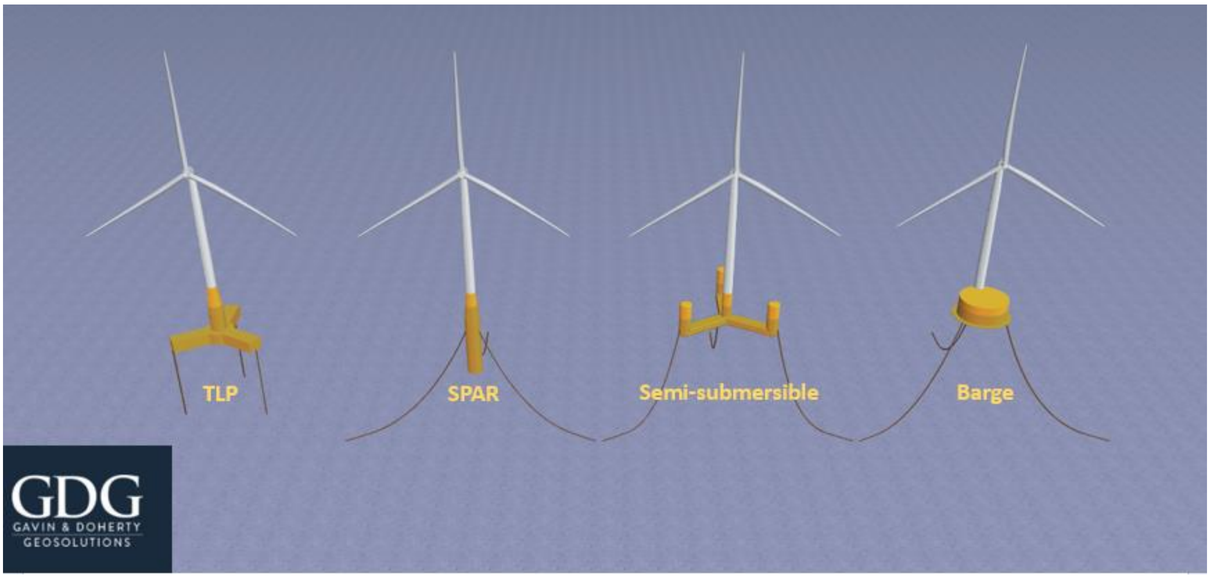


Figure 6-1: Typical Floating Foundation Types

Floating foundations are usually manufactured and assembled onshore, to be later towed to the integration port for the installation of the wind turbines.

The typical vessel categories used in the construction of a typical FOWA are presented in Table 6-1.

The main port requirements defined for the integration port, the floater fabrication port and for the O&M port, are shown in Table 6-2, Table 6-3, Table 6-4. The port requirements presented are based on the existing available information and shall be reviewed as more floating offshore projects are developed in a commercial scale and more detailed information become available. The assessment mainly focused on the distance from the OWF, navigation requirements, quay length, storage areas and port services in general.

A port site screening shall be performed in early stages of a floating offshore wind project based on project-specific parameters such as project location, wind turbine generator (WTG) size, floater typology, transport and installation (T&I) philosophy, etc.

Table 6-1: Typical Vessels Used in FOWA Construction

Vessel Category	Activities	Vessel Type	Vessel Particulars
Component Transfer Vessel(1)(2)	Import of WTG components to the staging port and transport of mooring equipment to installation site or to an intermediate staging port. These vessels can be equipped with Heavy Lift Cranes that can be used for offloading operations, however; in some occasions they consist of open deck cargo ships that require cranes on deck or the use of Self-propelled modular transporter (SPMT) modules ("ro-ro operations").	Heavy-lift vessels (HLVs), general cargo vessels, barges or coasters.	Length overall (LOA): [100 – 204] m Beam: [15 – 43] m Draft: [5.25 – 13] m *E.g.: Star Lysefjord, Zhi Xian Zhi Xing, SAL 171, etc.*
Floaters Transport(1)	Transport of modular substructure elements or fully assembled substructures to either assembly or staging ports. Given the significant submerged draft, fully assembled substructures may need to be floated-off in deep water and towed either into the staging port or to wet storage facilities.	Semi-sub HLVs	LOA: [134 – 275] m Beam: [36 – 68] m Draft: [9 – 11] m *E.g.: BOKA Vanguard, COSCO 68 - Xin Guang Huz, SAL MV Sun Rise, etc.*
Anchor Handling Tug Supply Vessel (AHTS)	Used for towing fully assembled units from deeper water into staging ports, and for towing fully assembled units from the staging port to the installation site. Vessels also used for the installation of mooring equipment for floaters.	Specialist anchor handling tug	Beam = 18.50m Length Overall = 77.0m Draft = 7.00m *E.g.: AHTS Bourbon Orca*
Tug Vessels(3)	Used alongside AHTS in towing of fully assembled units to ensure motions are limited during transit, as well as during approaching and departure manoeuvre of the component transfer vessels to guarantee complete control of the vessel. *Note that tug requirements are generally required by Port Authorities depending on vessel type and size.*	Tug Vessel	Beam = 27.00m Length Overall = 140.00m Draft = 6.85m *E.g.: Boskalis Boka Ocean*
Cable Installation Vessels (CIV)	Floating wind turbines will require dynamic cables to support export in addition to the typical buried cables associated with fixed-bottom installations. It is anticipated that cables will be transferred directly to the installation site, and as such there is no requirement for the staging port to accommodate these types of vessels.	Specialist cable installation vessels	Beam = 32.00m Length Overall = 138.00m Draft = 7.30m *E.g.: Jan de Nul Isaac Newton*

Notes:

1) Main vessel parameters are defined by a range of values due the variability of vessel sizes within this vessel typology.
2) As a conservative approach, only general cargo vessels and HLVs have been considered for the definition of vessels main particulars as they are associated with larger dimensions in general.
3) Tug vessels parameters are dependent on tug availability in the Port site/s considered during the construction of the FOWA.

Table 6-2: Port Requirements for the Integration Port

Parameter	Min	Max
Distance to OWF	-	150
Channel Width (m)	160	310
Channel Depth (m)	11.25	16.25
Air Draft (m)	Unrestricted	Unrestricted
Turning Basin Diameter (m)	270	550
Water Depth at Berth (m)	10	14.3
Quay Wall Length (m)	≈430	≈600
Laydown Area (Ha)	6	25
Wet Storage Area in Sheltered Waters (Ha)	4	70
Bearing Capacity at Quayside (t/m^2)	20	50
Bearing Capacity at Laydown Area (t/m^2)	10	20

Table 6-3: Port Requirements for the Floater Manufacturing Port

Parameter	Min	Max
Distance to OWF	Unlimited	Unlimited
Channel Width (m)	160	310
Channel Depth (m)	11.25	13.75
Air Draft (m)	50	-
Turning Basin Diameter (m)	270	550
Water Depth at Berth (m)	10	12.1
Quay Wall Length (m)	≈310	≈485
Laydown Area (Ha)	20	40
Wet Storage Area in Sheltered Waters (Ha)	4	70
Bearing Capacity at Quayside (t/m^2)	20	50
Bearing Capacity at Laydown Area (t/m^2)	10	20

Table 6-4: Port Requirements for O&M Port

Parameter	Min	Max
Distance to OWF	-	40
Laydown Area (Ha)	1	4

7 Ground Conditions

The development of Floating Offshore Wind Farms is influenced by various factors, with ground conditions being among the most critical. Ground conditions determine the most appropriate anchoring techniques. To inform understanding on this, GDG prepared a technical note to provide general information about the geotechnical parameters and to establish a baseline for the geotechnical parameters and stratigraphy that may be encountered at the selected reference sites for the IDEA-IRL project. This note is included as Appendix F to the report, with summary details provided here. The site conditions identified will be used by WP2 as inputs to inform the reference wind farm designs and preliminary anchor sizing.

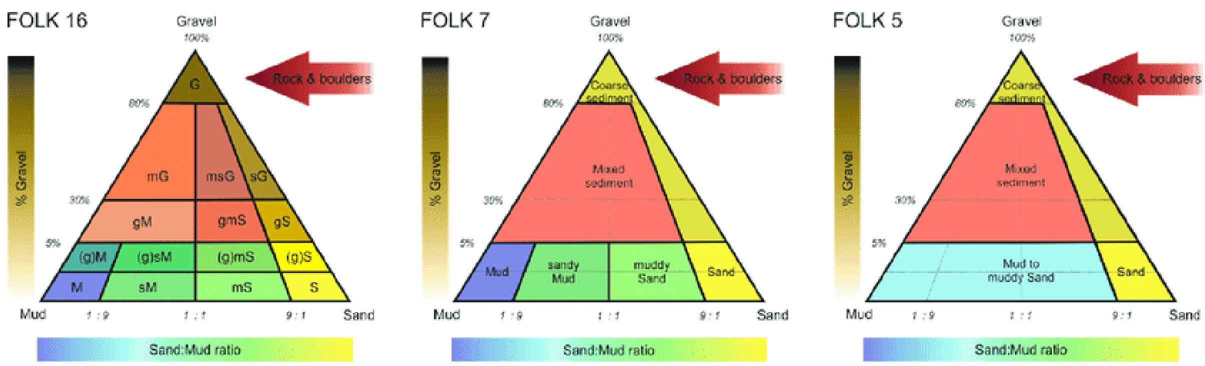
The requirements and parameters presented are indicative only and detailed and site-specific studies would be required during the early stages of a project to develop a comprehensive design. The analysis presented is based on scenario-based case studies using a simplified methodology. A soil investigation program should be undertaken in the early stages of floating offshore wind projects.

- The data provided for each scenario has been extracted from several sources, including literature, the public domain data from NOAA, European Marine Observation and Data Network (EMODnet), Integrated Mapping for the Sustainable Development of Ireland's Marine Resource (INFOMAR), and GDG experience on nearby sites. Due to the nature of these publicly accessible sources, the availability of parameters varies across locations.

- For certain selected sites, direct data at the desired location is unavailable. Consequently, the data is generally derived from broader regional geology, geophysics, and geotechnical information. For these sites, several assumptions will be made during the design stage.

- To best observe the changes in seabed morphology, hillshade rasters were derived from the multibeam echosounder (MBES) data and applied as a semi-transparent layer for the visualization. This allows the identification of more subtle changes in seabed morphology.

- The seabed substrate classification presented are mainly based on Folk 7 in the EMODnet Folk sediment triangles and the hierarchy of Folk classification (Figure 7-1).



FOLK, 16 classes	FOLK, 7 classes	FOLK, 5 classes
Rock & Boulders	Rock & Boulders	Rock & Boulders
Gravel - G sandy Gravel - sG gravelly Sand - gS	Coarse sediment	Coarse sediment *(Gravel >= 80% or (Gravel >= 5% and Sand >=90%)*
muddy Gravel - mG muddy sandy Gravel - msG gravelly Mud - gM gravelly muddy Sand - gmS	Mixed sediment	Mixed sediment *(Mud 95-10%; Sand < 90%; Gravel >= 5%)*
(gravelly) Mud - (g)M Mud - M	Mud *(Mud >= 90%; Sand < 10%; Gravel < 5%)*	Mud to muddy Sand *(Mud 100-10%; Sand < 90%; Gravel < 5%)*
(gravelly) sandy Mud – (g)sM sandy Mud - sM	sandy Mud *(Mud 50-90%; Sand 10-50%; Gravel < 5%)*	
(gravelly) muddy Sand – (g)mS muddy Sand - mS	muddy Sand *(Mud 10-50%; Sand 50-90%; Gravel <5%)*	
(gravelly) Sand – (g)S Sand	Sand *(Mud < 10%; Sand >= 90%; Gravel < 5%)*	Sand

Figure 7-1 The Folk sediment triangle and the hierarchy of Folk classification (EMODnet Geology project).

7.1 Moneypoint Offshore One

The seabed substrate classification map shows that the majority of the seabed within the site boundary is composed of mud to muddy sand, with a significant amount of coarse sediment covering the site also. There are some indications of rock or other hard substrate to the south and southeast of the site. A summary of the interpreted units is provided in Table 7-1.

Table 7-1: Summary of each interpreted unit.

Unit	Interpreted description	Seismic characteristics	Depth to base/top of Unit (mBSF)	Thickness (m)	Shear Stress (kPa)	Density (g/cm^3)
Unit 1	Marine sediments composed of sand	The unit is acoustically transparent, with occasional internal reflections	0 – 8.2 (Base)	0 – 8.2	2-10	2.1
Unit 2	Reworked sand and possible gravel	Acoustically transparent, occasionally displaying sub-parallel internal reflections	0 – 8.1 (Base)	0 – 8.1	10-25	2.2
Unit 3	Comprise sands, silts and clays	Acoustically transparent with a similar background amplitude to Unit 2	-	0 – 17.8	15-35	2.25
Unit 4	Potential till	Internally acoustically transparent	0 – 13.1 (Top)	0 – 14.2	15-50	2.35
Unit 5	Bedrock	Chaotic or acoustically transparent internally	0 – 21.9 (Top)	-	60-250	2.30

7.2 M5 wave buoy

The seabed substrate classification map shows that the seabed of the wind energy area (WEA) could be characterised into three sections. In the north, the seabed is primarily coarse substrate with patches of well-sorted sand which decrease in occurrence towards the centre of the site. The centre of the site is characterised mostly by rock outcrop with some sandy areas. The southern part of the site is chiefly coarse substrate with patches of sand and mud to muddy sand becoming predominantly sand with patches of coarse substrate towards the southernmost boundary.

A summary of the interpreted lithological units and geotechnical parameters is provided in Table 7-2.

Table 7-2: Summary of each interpreted unit at the M5 Wave Buoy area.

Unit	Interpreted Description	ϕ' (degrees)	s_u (kPa)	UCS (MPa)
Unit 1	Soft, muddy SAND/GRAVEL to SAND/GRAVEL (Holocene)	-	-	0.2 – 74
Unit 2	Sandy GRAVEL and gravelly SAND	25 – 42	130-2800	-
Unit 3	Fine SILT and CLAY	21 – 22	20 + 20z	-
Unit 4	TILL deposits	20 – 32	0 – 80	-
Unit 5	BEDROCK	-	-	-

7.3 Kinsale Gas Field - Alpha Platform

According to the modified seafloor sediment maps, most of the seabed within the WEA is composed of muddy sand. The seabed across the north of the proposed site, as well as a few smaller areas in the west and southwest, is dominated by exposed rocks and boulders. Other smaller areas of sandy mud, coarse and mixed sediment have also been identified. A summary of the interpreted units and representative geotechnical parameters is provided in Table 7-3.

Table 7-3: Summary of each interpreted unit at the Kinsale Alpha Platform Area.

Unit	Interpreted Description	Depth to base/top of Unit (mBSF)	Thickness (m)	Effective Unit Weight, γ'	Undrained Shear Strength, su	Small Strain Shear Modulus, G0	Sand Relative Density, Dr
Unit 1	Soft muddy SAND/GRAVEL to SAND/GRAVEL (Holocene)	0 - 3.7 (Base)	0 – 3.7	19	-	20	50
Unit 2	Sandy GRAVEL and gravelly SAND	0.5 – 6.3 (Base)	0-5.8	-	-	-	-
Unit 3	Fine SILT and CLAY	-	0-19.5	19	50	25	-

Unit 4	TILL deposits	2.2 – 12.0 (Top)	0 – 9.8	19	500	250	-
Unit 5	BEDROCK	0 – 25.5 (Top)	Not possible to determine	-	-	-	-

7.4 Ulsan Floating Wind farm

Due to a lack of publicly available data, the Noto Hantō site in the Japanese Sea site was chosen as representative of the geological conditions at the Ulsan Floating Offshore wind farm site. Seabed sediments encountered the study area range from coarse sand to fine silt. There is also rock exposed at the seabed close to the shore. Generally, the south to southeast of the WEA is dominated by medium to very coarse sand, whereas the southwest corner is dominated by fine and coarse silt and very fine sand. A review of seismic data and knowledge of marine deposits have also been used to provide a preliminary interpretation of expected lithologies (Table 7-4). Cores from multiple surveys have been used to inform an interpretation of lithologies in the WEA. Grab samples consist of silts and sand layers and are most likely representative of Unit A in the WEA. Geotechnical data is absence in the northern part of the WEA, so there is limited confidence in the expected lithologies outlined in Table 7-4.

Table 7-4: Summary of each interpreted unit at the Noto Hantō Area (chosen proxy for Ulsan conditions)

Unit	Interpreted Description	Indicative Depths (mBSF)	Shear Strengths (KPa)	Average Shear Strengths (KPa)
Unit 1	Terrigenous sediments. It is possible that this unit comprises mainly silts, very fine sands, clays and fine sands with granules.	Min: Very thin, approximately 1.5 metres Max: ~100 mBSF	17-93	45
Unit 2	Shallow marine sediments. Mainly sands with some clay, and gravels.	Min: Thin approximately <5 metres Max: ~ 200 mBSF	-	-
Unit 3	Glacial-interglacial cyclicity. Composed of layers of sands, silts, and clays.	Min: Thin approximately <5 metres Max: ~400 mBSF	-	-
Unit 4	It is possible that this unit comprises mainly consolidated clays, sands with layers of volcanic clastics and bedrock granites.	Min: Thin approximately <10 metres in the north of the site Max: Unknown	-	-

Unit 5	Early Miocene and older igneous rocks.	Min: Bottom of unit is difficult to refine. Max: Unknown	-	-

7.5 Utsira Nord

A summary of the expected lithologies in the WEA is provided in Table 7-5. The geological sequence at the WEA is interpreted to consist of veneer Holocene deposits over the Fladen Member of the Witch Ground Formation, underlain by the Swatchway Formation and followed by the Coal Pit Formation. The base of the Fladen Member is observed as gently undulating across the width of the WEA, reaching its mean maximum depth of 4.4 mBSF towards the centre of the site and decreases in depth at both the southwest and north east corners to a mean minimum depth of 1.2 mBSF. CPT data at the site shows an expected top of low strength clay where the Base of the Fladen Member is seen, marking the top of the Swatchway Formation.

Table 7-5: Summary of each interpreted unit at the Utsira Nord site area.

Seismic Unit	**Interpreted Description**	**Depth to base of Unit along centre line (mBSF)**	
		Minimum	Maximum
Forth Formation	very soft to firm sandy MUD	2.8	22.8
Witch Member	Very soft to firm sandy silty CLAY	0.8	3.8
Fladen Member	Very soft sandy silty CLAY	1.0	17.3
Swatchway Formation	Muddy SAND	5.2	44.0
Alternative Base of Swatchway Formation/Coal Pit Internal	-	27.1	44.0
Coal Pit Formation	Sandy silty CLAY	N/A	N/A

7.6 Humboldt SW

For the majority of the site, the seabed is composed of mud (Clay to clayey silt). Areas of exposed bedrock, running in a north-south trend, are present across the centre-west of the WEA. Preliminary interpretation of lithologies at the site is mainly based on regional geology and is presented in Table 7-6. No geotechnical or other data is available at this time to inform lithologies and geotechnical soil properties within the WEA, therefore this information has been extracted from neighbouring boreholes within the Cascadia Basin to the north. Quaternary shear strengths appear to consistently increase with depth. Pliocene shear strengths do not appear to show any consistent depth trend.

Table 7-6: Summary of each interpreted unit at the Humboldt area. .

Unit	Interpreted Description	Indicative Unit Depths (m BSF)	Shear Strengths (KPa)	Average Shear Strengths (KPa)
Unit 1	Clay to clayey silt with occasional thin fine to medium sands	Min: Thin to absent at Outcropping Pliocene anticlines Max: ~177 m BSF	5-79	35
Unit 2	Clayey silt to silty clay	Min: Outcropping or shallow sub-cropping at anticlines Max: ~688 m BSF	61-220	130
Unit 3	Unknown, possibly crystalline basement	Outcrops at seabed, but rapidly deepens either side below interpretable depth	-	-

8 Conclusion

This report has been prepared by the IDEA-IRL team as part of WP 1 – Reference Sites.

This report has presented:

- An Outline of key conditions to inform FOWA design
- An Overview of 'the Building Block Concept' to reference site conditions definition
- Detail on the reference site selection process and the chosen reference sites, including an update on Irish offshore wind policy as it relates to site selection
- Summary of MO conditions at the reference sites
- Summary of Port infrastructure requirements for floating offshore wind
- Summary of ground conditions at the chosen reference sites

This report is a summary report to draw together the different appendix reports which together make up WP1-D1: Reference site technical report. For more detail on any particular condition class or site, the appendices to this report listed below should be consulted.

- **Appendix A:** IDEA-IRL_WP1_D1A: Reference site technical report A: Reference site 1 preliminary metocean site conditions assessment (Moneypoint) [1]
- **Appendix B:** IDEA-IRL_WP1_D1B: Reference site technical report B: Reference site 2 preliminary metocean site conditions assessment (M5 Buoy) [2]
- **Appendix C:** IDEA-IRL_WP1_D1C: Reference site technical report C: Reference site 3 preliminary metocean site conditions assessment (Kinsale Alpha) [3]
- **Appendix D:** IDEA-IRL_WP1_D1D: Reference site technical report D: Reference site 4 preliminary metocean site conditions assessment (Ulsan) [4]
- **Appendix E:** IDEA-IRL_WP1_D1E: Port Infrastructure Requirements [5]
- **Appendix F:** IDEA-IRL_WP1_D1F: Reference Site Ground Conditions [6]

This work was also completed in close collaboration with the IEA Wind TCP Task 49 IDEA project, and further detail can be found in [7].

The relevant site information will now be shared with WP2 to inform reference floating wind array designs, which will be delivered in 2025.

9 References

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Appendix A: IDEA-IRL_WP1_D1A: Reference site technical report A: Reference site 1 preliminary metocean site conditions assessment (Moneypoint)

See [1].

Appendix B: IDEA-IRL_WP1_D1B: Reference site technical report B: Reference site 2 preliminary metocean site conditions assessment (M5 Buoy)

See [2].

Appendix C: IDEA-IRL_WP1_D1C: Reference site technical report C: Reference site 3 preliminary metocean site conditions assessment (Kinsale Alpha)

See [3].

Appendix D: IDEA-IRL_WP1_D1D: Reference site technical report D: Reference site 4 preliminary metocean site conditions assessment (Ulsan)

See [4].

Appendix E: IDEA-IRL_WP1_D1E: Port Infrastructure Requirements

See [5].

Appendix F: IDEA-IRL_WP1_D1F: Reference Site Ground Conditions

See [6].