De-risking Scour and Anchor Installation for Floating Offshore Wind through Numerical and Experimental Modelling (SCALE)

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Challenge

Under the Climate Action Plan, Ireland has ambitious targets for the development of offshore renewable energy. A common challenge in exploiting such resources is the variable geological structure and dynamics of the seabed. This variability creates a number of geotechnical challenges that can introduce significant risks to the siting and installation of engineering structures, such as foundations, anchors and cables. Identifying, understanding and predicting the nature and implications of these geotechnical challenges requires a firm understanding of the seabed through site surveying and monitoring, as well as laboratory testing. These techniques can be costly and time consuming. However, when combined with numerical and experimental modelling, they can form powerful tools and techniques to assess the seabed and so optimise engineering design.

The aim of the SCALE project is two-fold: (i) to enhance Ireland's experimental modelling capacity in understanding geotechnical and hydrodynamic challenges, and (ii) develop state-of-the-art numerical modelling approaches to assess and mitigate geotechnical and physical processes that impact engineering infrastructure in Irish offshore conditions.

Study Approach

Atlantic Marine Test Site (AMETS):

- Developed by Sustainable Energy Authority of Ireland (SEAI)
- Full-scale Floating Offshore Wind (FLOW) infrastructure testing in an open ocean environment
- Ideal site to understand and mitigate geotechnical challenges that will be widely experienced in the Irish offshore sector related to FLOW installation
- SCALE will use real-world data and conditions at the AMETS to achieve project aims and so further de-risk the site for future technology deployment.

1. Design decision-making tool for FLOW anchor system selection

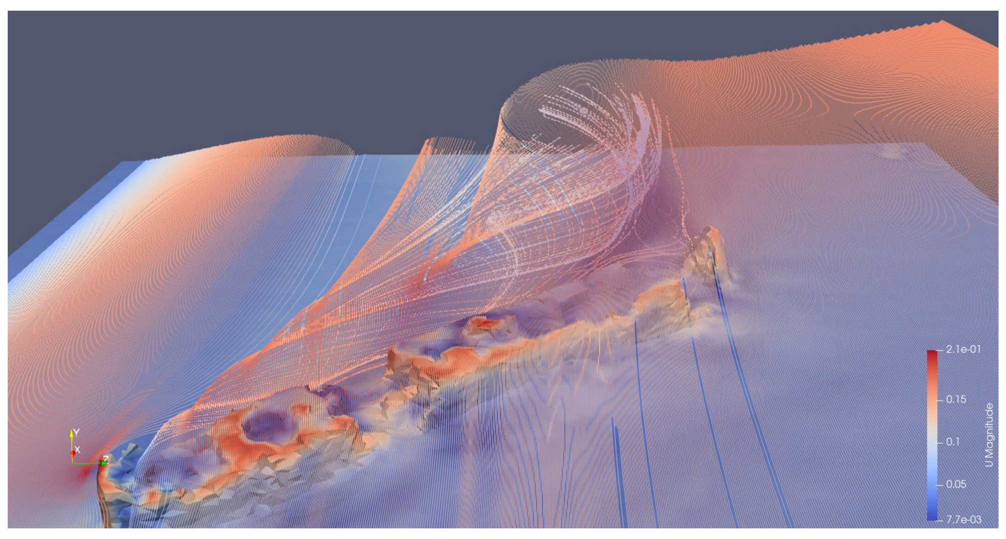
Site Characterisation
- *Environmental Conditions/Loads*
- *Geotechnical Conditions*
- *Seabed Conditions*

Technology screening
- *Technology review*
- *Past projects*
- *Market Research*
- *Stakeholder Engagement*

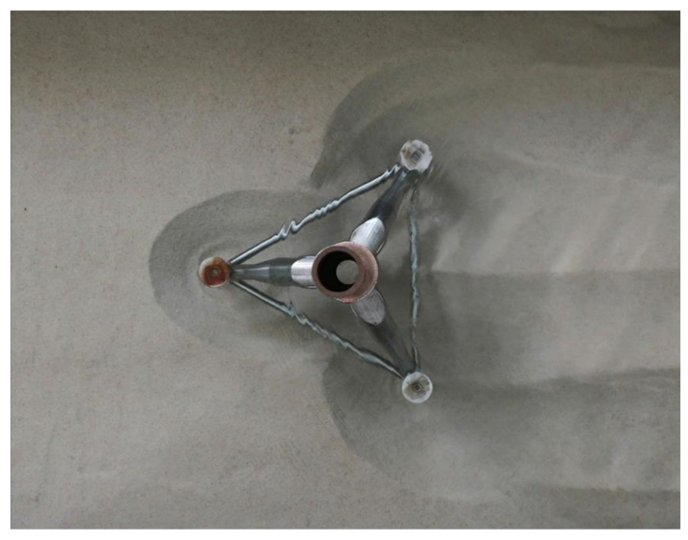
2. Address Offshore Geotechnical Problems in FLOW Mooring Techniques

- *Optimise Key Techniques and Analytical Models during Anchor Installation*
- *Elucidate Complex Kinematic Mechanism and Behavior of Anchors in the Seabed*
- *Assess Tension Transmitting and Profile Properties of Embedded Mooring/Installation Line*
- *Determine Ultimate and Long-Term Cyclic Pullout Capacities of the Anchor*

Finite Element Modelling (FEM) | **Computational Fluid Dynamics (CFD)** | **Flume tank testing** | **Centrifuge testing**



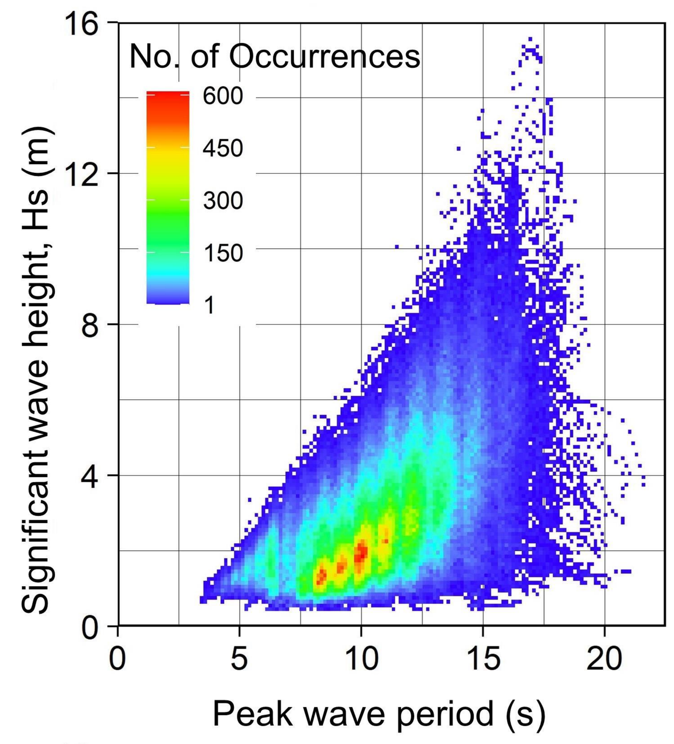
CFD model of fluid flow around shipwreck on the seabed

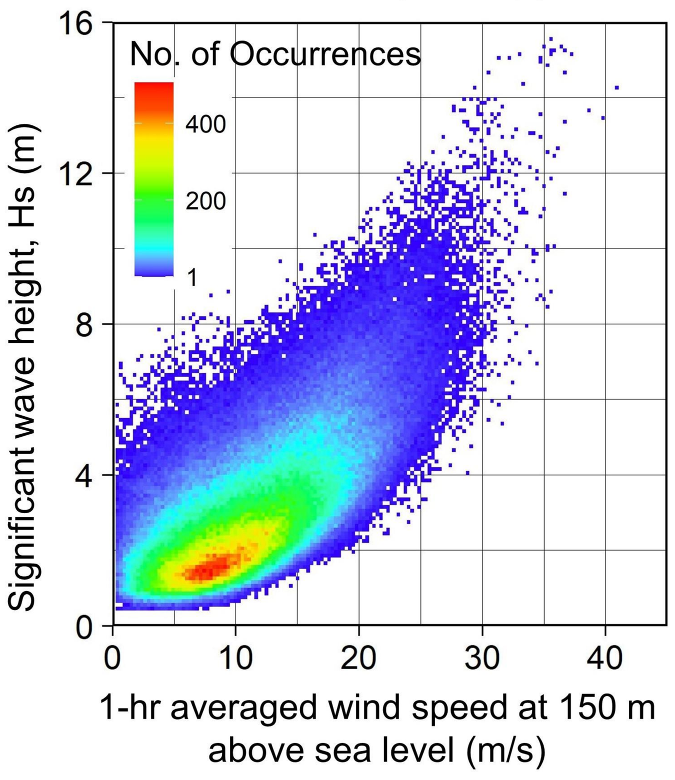


Experimental modelling of scour around offshore wind foundations [1]

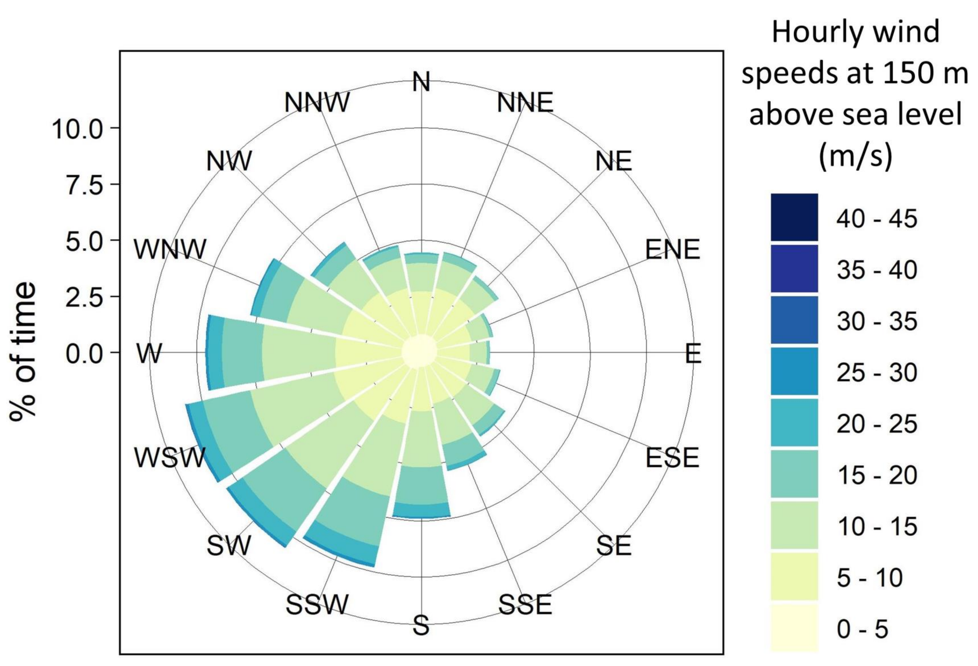
Preliminary Site Characterisation Results

Environmental Conditions Assessment and Geotechnical Ground Model development of AMETS to support Technology screening and ultimately FEM, CFD, Flume tank testing and Centrifuge testing





Environmental Conditions



Preliminary analysis based on ERA5 hindcast data [2]
- Wind: - 10.25°, 54.25°
- Wave: -10.5°, 54°

Extreme Conditions

Parameter	50-year return value
H_s (m)	15.5
T_p (s)	15.5 < 20.0
H_{max} (m)	28.9
T_{ass} (s)	14.0 < 18.0
V_{hub} (m/s) *	45

*10-min wind speeds; V_{hub} = 150 m

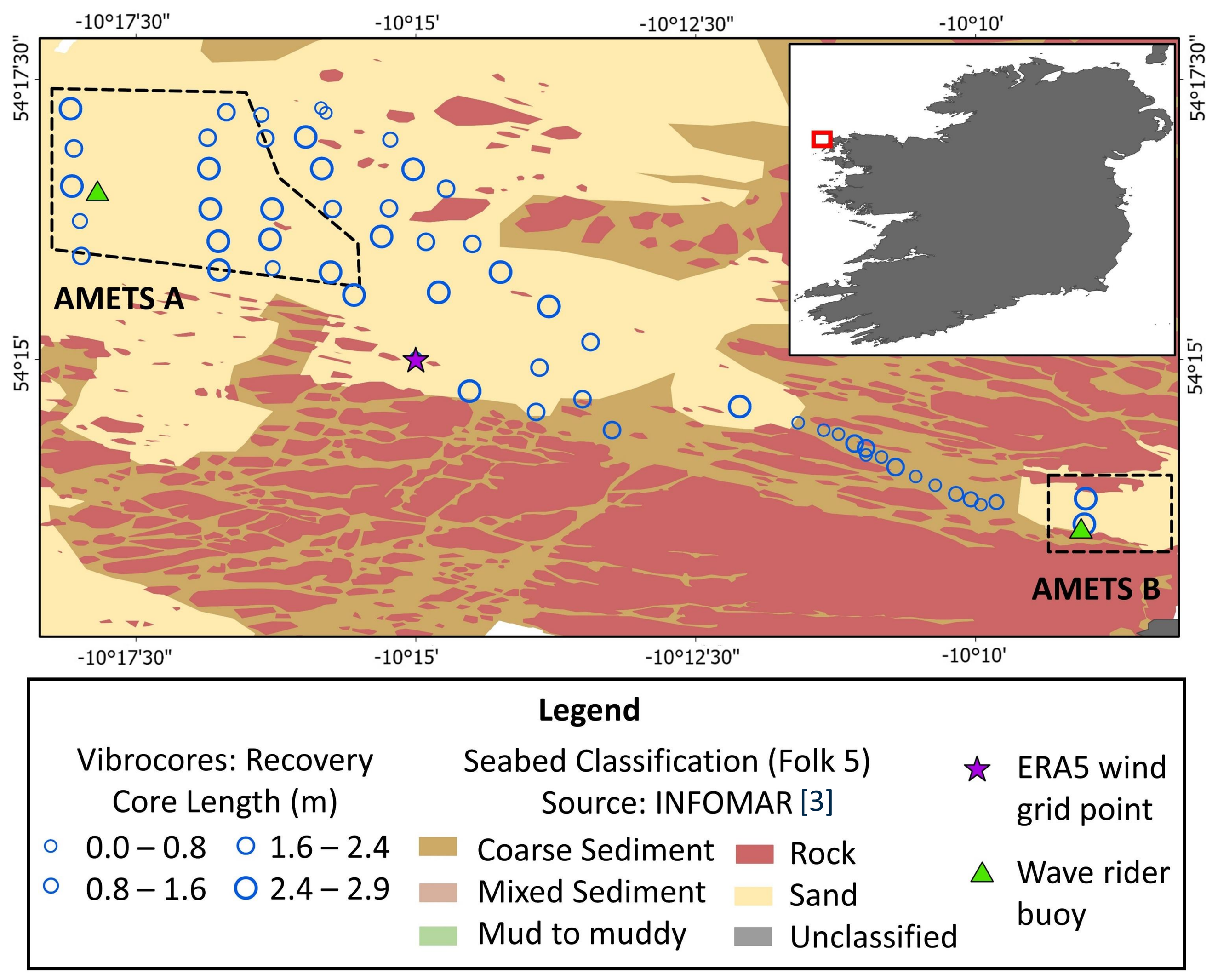
Normal Sea State Conditions

$V_{hub}/H_s/T_p$ Lumped scatter diagram

V_{hub} (m/s)	H_s (m)	T_p (s)	Wave dir (°)	Wind dir (°)	Freq. of Occ. (%)
2	1.5	10.0	281.3	326.3	0.215
4	1.5	10.0	281.3	281.3	0.385
6	1.5	9.0	281.3	247.5	0.523
8	1.5	8.5	281.3	247.5	0.602
10	2.0	10.0	270.0	247.5	0.549
12	2.0	10.0	270.0	247.5	0.394
14	3.0	10.0	270.0	247.5	0.253
16	3.0	10.0	270.0	225.0	0.180
18	4.0	12.0	258.8	213.8	0.131
20	3.5	8.5	258.8	213.8	0.081

V_{hub} (m/s)	H_s (m)	T_p (s)	Wave dir (°)	Wind dir (°)	Freq. of Occ. (%)
22	5.5	11.0	247.5	213.8	0.051
24	5.8	11.5	247.5	202.5	0.054
26	7.0	12.0	236.3	202.5	0.015
28	10.1	14.5	258.8	258.8	0.006
30	7.6	11.5	258.8	247.5	0.004
32	11.8	15.0	258.8	247.5	0.003
34	12.7	15.2	247.5	236.3	0.003
36	15.3	16.9	270.0	236.3	0.001
38	14.4	15.9	258.8	270.0	0.001
40	13.9	15.5	247.5	236.3	0.001

Geotechnical/Seabed Conditions



Technology Screening

Ongoing research, please take this survey

Conclusions

- AMETS A is most suitable for FLOW at an average water depth of 100 m.
- Characterised by severe open-ocean wind and wave conditions.
- Seabed is composed of sand, glacial till or hard bedrock outcrop.
- Where bedrock is close to or at the seabed the facies is a gravel, with sandier facies being found further from the bedrock.
- Technology screening is ongoing.
- Open to discussion with anchor designers about potentially modelling their design, if applicable.

References

1. *Ni, X.; Xue, L. Experimental Investigation of Scour Prediction Methods for Offshore Tripod and Hexapod Foundations. J. Mar. Sci. Eng.* ***2020****, 8, 856. https://doi.org/10.3390/jmse8110856*
2. *Copernicus Climate Data Store https://cds.climate.copernicus.eu/cdsapp#!/dataset/reanalysis-era5-single-levels?tab=overview*
3. *INFOMAR https://www.infomar.ie/*

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