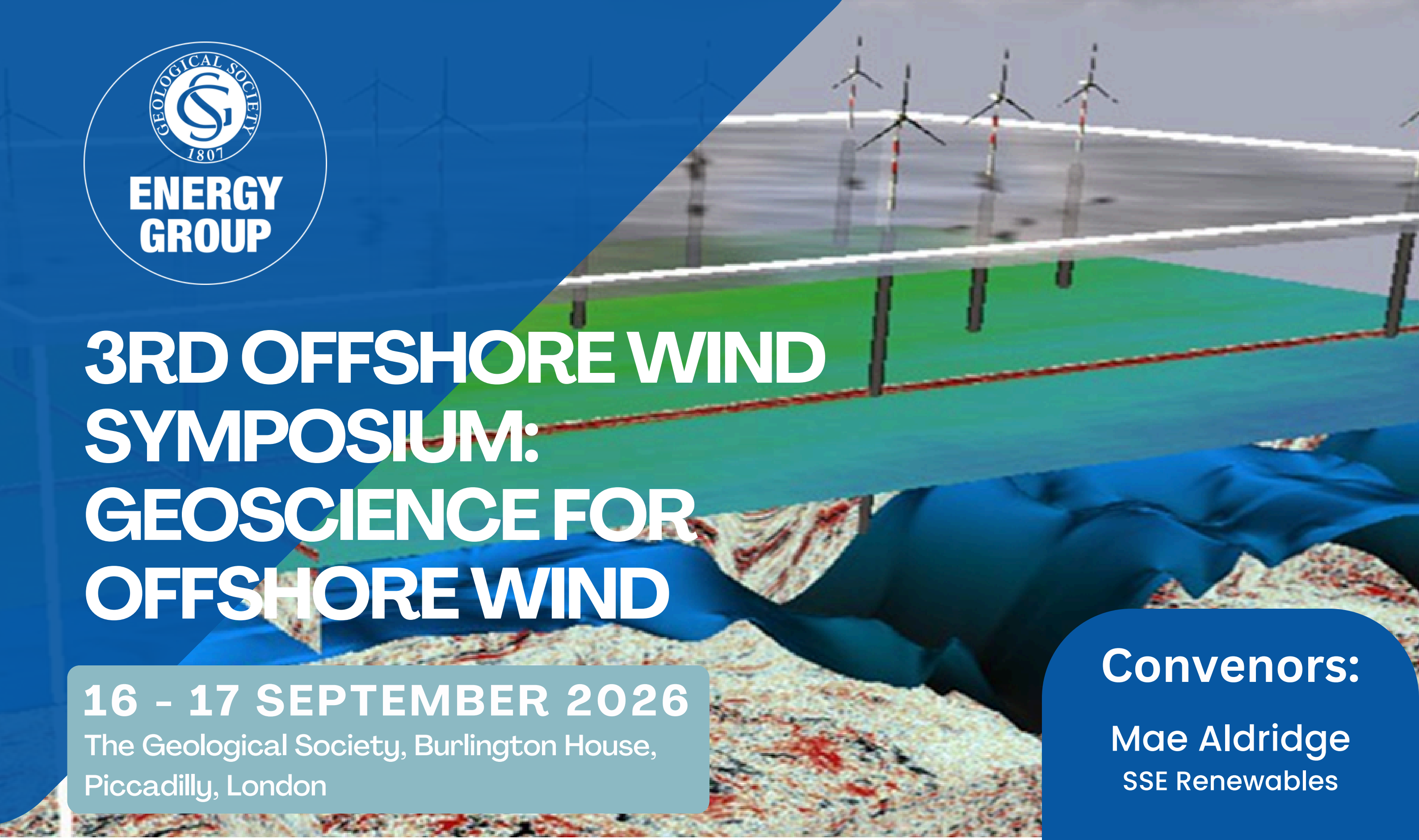

ENERGY GROUP

3RD OFFSHORE WIND SYMPOSIUM: GEOSCIENCE FOR OFFSHORE WIND

16 - 17 SEPTEMBER 2026

The Geological Society, Burlington House, Piccadilly, London

Geoscience remains essential to enabling safe, cost-effective design, installation and operation of offshore wind foundations and subsea cables. As the industry moves toward larger turbines, deeper waters and more complex sites, the need for integrated geological, geophysical and geotechnical insight continues to grow. The 2026 Symposium expands its scope to cover the full geoscience lifecycle for offshore wind—from regional ground models to near-surface characterisation, and from nearshore challenges to emerging survey technologies.

- **Geoscience for Foundations and Support Structures:** Ground models, geohazards, sediment mobility, glacial and shallow gas features, engineering properties and constraints for fixed and floating solutions.
- **Geoscience for Cable Routing, Burial and Protection:** Very shallow soils (<10 mbsf), morphological and sedimentary processes, UXO/obstacles, burial assessment, installation constraints, landfall engineering and trenching/dredging considerations.
- **Nearshore and Landfall Complexity:** Dynamic environments, coastal change, sediment transport, constructability, consenting constraints, ground risk, and engineering mitigation strategies.
- **Digitalisation and Data Integration:** Digital ground models, cloud-native geoscience workflows, machine learning, automation in interpretation, and uncertainty quantification.
- **Autonomous and Next-Generation Survey Technologies:** AUVs, USVs, remote acquisition, high-resolution sensors, rapid processing pipelines and their implications for project efficiency and model reliability.

We encourage case studies, methodological advancements, and lessons learned from real offshore wind projects. Contributions that highlight integrated or cross-disciplinary approaches—geology, geophysics, geotechnics, oceanography, metocean, and engineering—are especially welcome.

This symposium aims to bring together geoscientists, engineers, developers, students, academics and survey practitioners involved in characterising, modelling and interpreting the seafloor and subsurface for offshore wind.

For further information please contact
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Global Maritime

James Todd
ARUP

3rd Offshore Wind Symposium: Geoscience for Offshore Wind

16-17 September 2026

The Geological Society, Burlington House, London and Virtual

Final Programme

Day One	
08.30	**Registration**
08.50	**Welcome**
	Session One: Geoscience for Cable Routing, Burial and Protection
09.05	**KEYNOTE: How effective are our Ground models? Can conditional monitoring data from existing assets improve future modelling approaches?** **Professor Justin Dix**
09.30	**Integrated Geological Insights for the Lir Interconnector: Hazards, Constraints and Ground Model Development** David Harrison, *Geo-4D Ltd*
09.50	**Late-stage rerouting in a target rich environment: lessons from Unexpected Cultural Heritage Discoveries** Alexander Cattrysse, *IMDC*
10.10	**BREAK**
	Session Two: Nearshore and Landfall Complexity
10.55	**Integrating consent and engineering objectives at offshore cable landfalls along the Holderness Coast, UK.** Claire Mellett, *Haskoning*
11.15	**Nearshore sediment dynamics: how to plan for export cable routes** Aggeliki Georgiopoulou, *Ternan Energy*
11.35	**Derisking Cable Landfalls: Integrated Geoscience Approaches for Early-Stage Risk Reduction** Onder Yonlu, *Fugro GB Limited*
11.55	**When Ground Conditions Change the Plan: A Case Study from Eastern Green Link 1** Jack Poleykett, *Xodus Group*
12.15	**LUNCH**
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13.40	**Quantifying Shallow Subsurface Lithological Variability using Geotechnical Logs: a similarity-based framework for the North Sea** Duncan Eliott Stevens, *British Geological Survey*
14.00	**Characterising Palaeovalley Fill Sequences: An Integrated Ground Modelling Approach** Millie Haffenden, *Global Maritime*
14.20	**Mapping of Sub-Seabed Soil Mechanical Properties Whilst Installing a 3-Pile Anchor in Seismically Heterogeneous Marine Soils** Jacques Yves Guigne, *Subsea Micropiles*
14.40	**BREAK - Poster session**

15.25	**Cracks in our foundations: The nature and origin of fractures in Ypresian clays** Loic Piret, *Ghent University*
15.45	**National Scale Ground Model Driving Spatial Characterisation of Seabed for UK Offshore Wind** Helen Povey & Simon Libby,*WSP*
16.05	**De-risking Ground Investigation: Site-wide Geotechnical Parameters and Uncertainty from Pre-stack Inversion of 3D UHRS Data at Green Volt OWF** Esben Dalgaard, *SolidGround*
16.25	**Shallow Geology Prediction with Ice Sheet Models: Dogger Bank, Scotian Shelf, & Grandbanks** Matthew Drew, *Memorial University of Newfoundland*
16.45	**Regional geological synthesis across offshore wind developments in the Central North Sea** Margaret Stewart, *British Geological Survey*
17.05	**End of day one**
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Day Two	
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09.25	**Uncertainty in Machine Learning-Based Vs Predictions from CPTu and Its Impact on Monopile Design** Yuting Zhang, *University of Southampton*
	Session Five: Surveys and Data
09.45	**Acquisition and deblending of an (ultra-) high resolution simultaneous source technique** Peter Cox, *RockWave*
10.05	**When More Is Not Enough: Unlocking the Potential of High-Resolution SAS Data for Automated Object Detection** Andrijana Horvat, *Hidrocibalae*
10.25	**BREAK**
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11.10	**KEYNOTE: Core insights: what the seabed is telling us?** **Chelsea Bradbury, *The Crown Estate***
11.35	**Beyond Mechanical Classification: Uncovering Hidden Installation Constraints through Integrated Ground Modelling – A Bay of Seine Case Study** Arthur Blouin, *Geosciences Department, GEOxyz*
11.55	**Building a Petabyte-Scale Digital Ecosystem for Offshore Wind: Roadmaps, Challenges, and Geoscience Lessons** Darren Biggs, *ET Works Ltd*

12.15	**Assessing uncertainties in quantitative ground modeling workflows for offshore windfarm areas** Lennart Siemann, *Fraunhofer IWES*
12.35	**LUNCH**
13.35	**Enhanced Boulder Detection in Seismic Through Wavefield-Based Diffraction Imaging** Sandeep Bhamber, *RockWave*
13.55	**Towards a regional chronostratigraphic framework for the southern North Sea: Integrating multisource subsurface data** Nicola Dakin, *British Geological Survey (BGS)*
14.15	**BREAK**
15.00	**A Fully Automated Workflow for the Application of UDCAM-S in the Design of Offshore Monopile Foundations** Miquel Lahoz, *Seequent, The Bentley Subsurface Company*
15.20	**A depth-oriented future: advancing offshore wind seismic with tomographic velocity model building** Tas Burn, *RockWave*
15.40	**Satellite-Derived Bathymetry as an Operational Monitoring Layer for Offshore Infrastructure** Damir Matić, *Hidrocibalae d.o.o.*
16.00	**Green Volt Part 2: A Journey from Brownfield to Site-Wide 3D Data** Jordan Geear, *Global Maritime*
16.20	**KEYNOTE: The cultural and heritage values of offshore geology** **Hanna Steyne, *Wessex Archeology***
16.45	**Closing remarks**
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Posters – Day One
Early-phase sediment mobility assessments for subsea cables Holly Cairns, *Global Maritime*
Calculation of stable seabed level surface, for use in offshore cable route engineering and sediment mobility studies Paul Slater, *Global Maritime*
Understanding palaeo versus present day sediment mobility: a case study from a North Sea cable route survey. Susan Rice, *Fugro*
Optimisation of offshore wind export cable routing using GIS-based suitability analysis Jovana Maksimovic, *Gavin & Doherty Geosolutions Ltd, Venterra Group*
Dr. N. Buket Yenigul Buket Yenigul, *Seaway7*
Multidisciplinary Landfall Characterisation - How best to Characterise Challenging Coastal Sites David Harrison, *Geo-4D Ltd*
NOMAD: A Dual-Propulsion AUV Architecture for Vessel-Independent Geophysical Survey of Offshore Wind Sites Aryan Shah, *InX Tech*

Advanced sub-bottom sonar technology in offshore UXO target identification – a state-of-the-art review using case studies from Northern Europe Lee Gooderham, *Dolomite*
Investigating Late Quaternary palaeoenvironments in the Southern North Sea: Ultra-High Resolution Seismic analysis and Implications for offshore wind Development Karam Sarieddine, *Department of Earth Science and Engineering, Imperial College London*
Don't forget the Jack-up David Edwards, *DNV*
The importance of inherited glacial landforms on predicting ground conditions Lydia Kathleen Brown, *University of Leeds*
Offshore Engineering Geomorphology and Terrain Interpretation: A Critical Ground Model Element for Offshore Wind Projects Melanie Froude, *OWC*
An updated stratigraphic framework for the Inner Moray Firth: Supporting safer Offshore Wind Development Simon Blet, *Fugro*
Geology of the North Channel - insights from Historic Geophysical and Geotechnical Surveys Charles Bloore, *Fugro GB Marine*
A regional stratigraphic framework for the Dutch sector of the North Sea derived from offshore wind farm site investigations Harry Eady, *Fugro*
Optimising ground investigations using mooring design parameters for floating offshore wind farms. Alex Nurdin, *University of Aberdeen*
From Soil to Shallow Bedrock: Implications for Site Investigation and Foundation Design in Offshore Wind Vanessa Monteleone, *DNV*
Geohazard assessment for IODP Exp 507 - the first borehole to core the 1.2 km North Sea Quaternary depocentre Jane Huuse, *Seismic Geoscience*

Posters – Day Two
Assessment of Subsurface Hazard Prediction and Uncertainty Between Sparse SBP Lines Using 2D and 3D UHRS Comparison Cai Xinwei, *Imperial College London*
Subseabed Targets: When Too Many Targets Become Too Much? Manuela Jaklić Grbić, *Hidrocibalae*
Pushing Beyond Drilling Chris Ruoso, *Next Geosolutions*
Assessing seabed conditions in support of offshore wind development on the Scotian Shelf, Canada Pierre-Arnaud Desiage, *Geological Survey of Canada – Atlantic, Dartmouth, Canada*
Multi-Modal Geospatial Deep Learning for Shallow Marine Geohazard Segmentation and Risk Mapping Haonan Zhang, *InX Tech / Imperial College London*

Zonal Site Investigation for Offshore Wind: Geophysical–Geotechnical Fusion for Smarter Ground Models, Lower Risk and Better Bankability Jacques Guigne, *Subsea Micropiles/University of Bath*
From Sparse Interpretations to Survey-Scale Seismic Classification: An Interpreter-Guided Deep-Learning Workflow for Offshore Wind Site Characterisation Miaozhou Tang, *Department of Earth Science & Engineering, Imperial College London*
Satellite-Derived Bathymetry as an Operational Monitoring Layer for Offshore Infrastructure Damir Matić, *Hidrocibalae d.o.o.*
From maps to volumes: example of a 3D geohazard assessment for offshore wind Guillaume Michel, *National Oceanography Centre (NOC), Southampton, UK*
Evaluating "A New Reliability-Based Design Method for Offshore Wind Turbine Foundations Using Monte Carlo Simulation": A Systematic and Critical Review Oluwatobi Odubela, *Kingston University*
From Data Management to Engineering Insight: An Integrated Workflow Along Offshore Routes Alessio Saccon, *Next Geosolutions and Seequent*
Exploring the integration of multiple complimentary geophysical datasets to improve potential UXO discrimination in distinct geological settings Tom Larby & Frederic McEwen-Read, *Ordtek Limited, Venterra Group*
Machine-Learning Surrogate Optimisation for Floating Offshore Wind Mooring and Anchoring Systems Zohreh Moradinia, *Daryad*
Society of Underwater Technology's (SUT) Guidance Notes For Risk Identification And Common Mitigations Related To Unexploded Ordnance (UXO) For Offshore Renewable Energy Developments Annelies Vanstraelen, *Independent consultant*
Synthetic seismic data for training automated detection of buried channels in offshore wind site surveys Fatemeh Bozorgi, *Imperial College London*
Spotting boulders before they stop turbines - part 1: using forward modelling to optimise 3D EHRS acquisition and processing Nick Woodburn, *RockWave*
Quantitative Integrated Ground Modelling - An enhanced ability to optimise OWF site characterisation James Faroppa, *Fugro*
An Integrated Conceptual Geological Model of Offshore Galway Bay for Offshore Wind Site Characterisation Onome Omas Okobiebi, *Ulster University*

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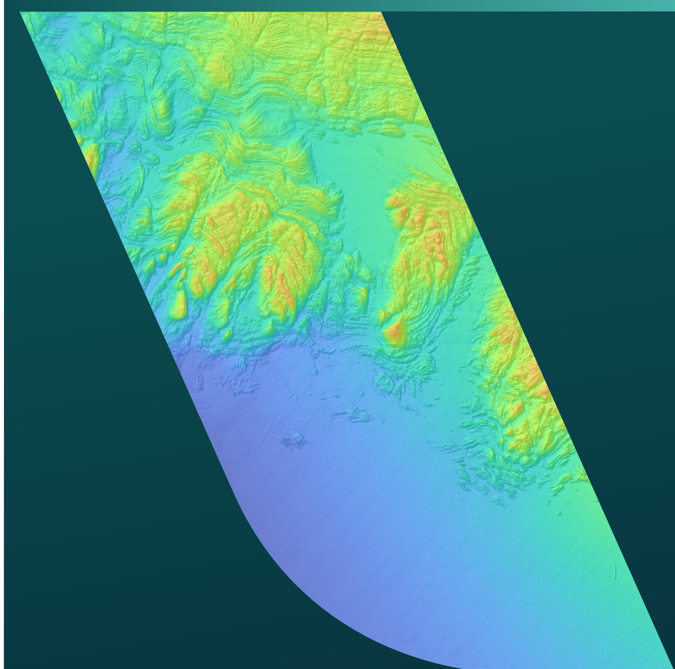

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KEYNOTE: How effective are our Ground models? Can conditional monitoring data from existing assets improve future modelling approaches?

Professor Justin Dix

Pending

Multidisciplinary Landfall Characterisation - How best to Characterise Challenging Coastal Sites

Authors: David Harrison

Organisation(s): Geo-4D Ltd

Abstract
Landfalls are among the most dynamic and technically challenging sections of many cable or pipeline projects, presenting unique complexities for site characterisation and hazard assessment. This presentation details the advantages, limitations, practical considerations, and case study results of a range of survey techniques, including photogrammetry, topographic LiDAR, bathymetric LiDAR, magnetometry, seismics and geotechnical investigation methods. It will also consider different deployment approaches, from traditional ground-based surveys to drone and uncrewed surface vehicle platforms.

The presentation is designed to provide attendees with a clearer understanding of the available survey technologies and their application in the landfall environment. By highlighting the strengths and constraints of each method, it will help develop more targeted, efficient, and cost-effective survey scopes that address site-specific challenges and provide the required inputs to robust, integrated engineering geological ground models.

Late-stage rerouting in a target rich environment: lessons from Unexpected Cultural Heritage Discoveries

Authors: Alexander Cattrysse

Organisation(s): IMDC

Abstract
Following a pre-engineering survey for inter-array cable installation, a marine archaeological authority identified several targets for further investigation. During these investigations, a wooden wreck, including cannon, was discovered.
Due to the potential cultural significance of this find, the project, working in close cooperation with the relevant authorities, developed a strategy to reroute the inter-array cable and further characterise the extent of the site, with the aim of:

- Maintaining the original cable length;
- Limiting potential delays to the cable installation campaign; and
- Ensuring preservation of the cultural heritage.

This presentation will describe a case study of an unexpected cultural heritage discovery. It will outline the actions taken to mitigate the impact of the find on the project, as well as measures implemented to avoid damage to the wreck. Finally, it will highlight lessons learned and propose measures to reduce the risk of late-stage surprises in future projects.

Session Two: Nearshore and Landfall Complexity

Integrating consent and engineering objectives at offshore cable landfalls along the Holderness Coast, UK.

Authors: Claire Mellett

Organisation(s): Haskoning

Abstract
The Holderness coast has become a major focus for offshore cable landfalls associated with southern North Sea energy developments. Its rapidly eroding coastal environment presents a unique combination of engineering and consenting challenges, yet these are often assessed independently despite being driven by the same processes.

Shallow bedrock in the nearshore frequently constrains trenching opportunities, creating a potential requirement for cable protection. While this may be an engineering necessity, it can present significant consenting challenges due to concerns that protection measures may alter sediment transport pathways, contribute to sediment starvation downdrift, and potentially exacerbate cliff erosion. Predicting coastal change is therefore critical, but considerable uncertainty remains regarding the most appropriate methods for design and long-term risk assessment. Additional complexity is introduced through vertical platform lowering, which can reduce cable burial depth over time and promote scour around cable protection structures deployed on cohesive shore platforms.

Landfalls must also navigate a complex environmental setting, including protected sites onshore and offshore, as well as buried geological and archaeological assets. While designated sites may be avoided spatially, their subsurface extent can be less certain and may only be identified through robust ground investigations and integrated geological models. Similarly, undesignated offshore features may represent important palaeolandscape heritage assets requiring mitigation.

We propose that marine physical processes, climate change, geology and archaeology assessments should not be viewed solely as consenting requirements. Instead, by integrating these disciplines with the project design, geoscientists can help align consenting and engineering objectives. Such an approach not only improves project efficiency but also reduces uncertainty, strengthens consent applications, and delivers more resilient cable landfall designs.

Nearshore sediment dynamics: how to plan for export cable routes

Authors: Aggeliki Georgiopoulou

Organisation(s): Ternan Energy

Abstract
It is common practice to conduct sediment mobility studies to feed into route engineering and route optimisation. These studies ideally collate several years-worth of seabed mapping data (high resolution MBES) and by comparing them identify areas of sediment loss and sediment accumulation. These are then modelled to predict/forecast where sediment will be moving towards in the years to come and in the lifetime of a project, usually 35-40 years.

However, in reality the basis of these studies is flawed as consecutive years of MBES data are rarely available and often the resolution differs, especially when lower resolution publicly available data need to be included to make up the dataset. This is particularly problematic in the case of nearshore areas as part of the export cable route where sediment dynamics are highly complex and include along-shore dynamics, tidal dynamics, storm-induced dynamics, not to mention the unknown impact of the climate crisis and how it will impact sediment supply budgets and wave activity in the coming decades. The direction of sediment propagation is not linear, nor is the rate and these are not easy to capture in sediment mobility studies.

One way of “dealing” with this problem is to extend the Horizontal Directional Drilling (HDD) to deeper water and thus avoid the area most severely impacted. On the other hand, HDD is an expensive approach and therefore a balance needs to be found on the cost of yearly mitigating plans post installation. Alternatively, a developer may consider the risk minimal as it would be highly unlikely to have anchor strikes or fishing bottom trawling activities in such shallow water depths and the risk to the cable is potentially only fatigue due to the sediment dynamics.

Derisking Cable Landfalls: Integrated Geoscience Approaches for Early-Stage Risk Reduction

Authors: Onder Yonlu; Markus Chan; Kimberly-Verwijs Taylor

Organisation(s): Fugro GB Limited; Fugro

Abstract

Cable landfalls represent a disproportionately high-risk component of offshore wind developments, where short infrastructure corridors must accommodate rapid transitions between terrestrial, intertidal, nearshore, and offshore environments. Across this narrow zone, geological heterogeneity, active coastal processes, environmental constraints, and installation requirements combine to create significant challenges for site selection, constructability, programme, and project cost.

This presentation argues that effective ground risk management begins during site selection and concept design, before intrusive investigation is undertaken. An iterative workflow is presented in which legacy information, geological mapping, site walkovers, and preliminary constraint mapping are integrated to develop initial ground models and identify the principal hazards, uncertainties, and data gaps that control landfall feasibility.

Particular emphasis is placed on the intertidal and nearshore transition, where fragmented datasets and mismatched survey approaches commonly leave critical uncertainties unresolved. The methodology combines non-intrusive geophysics, remote sensing, and targeted geotechnical investigation to improve cross-environment data continuity, refine conceptual ground models, and support the selection and design of trenchless landfall solutions, including horizontal directional drilling and microtunnelling.

Examples from cable landfall projects in the United Kingdom and Europe demonstrate how treating the ground model and risk register as live project tools can shift site investigation from a reactive data-gathering exercise to a proactive design and risk management process. The presentation shows how early, integrated geoscience can focus data acquisition, test design assumptions, and reduce uncertainty where project sensitivity is greatest and the consequences of poor ground understanding are highest.

When Ground Conditions Change the Plan: A Case Study from Eastern Green Link 1

Authors: Jack Poleykett

Organisation(s): Xodus Group

Abstract
What happens when the interrogation and interpretation of geotechnical and geophysical site investigation data necessitates a fundamental change in design?

Eastern Green Link 1 (EGL1) is a 2 GW high-voltage direct current (HVDC) interconnector linking Torness in East Lothian, Scotland, with Hawthorn Pit in County Durham, England. Recently acquired ground investigation data identified complex ground conditions at the Horizontal Directional Drilling (HDD) breakout, necessitating evaluation of potential HDD breakout closer to shore.

This change potentially introduces new considerations regarding both environmental impacts and engineering risk. In particular, breakout in a shallower, more wave-dominated nearshore environment raises potential challenges associated with seabed mobility, shoreline morphological response, potential impacts to local designated sites and the risk of cable exposure (or over burial) over the operational life of the interconnector.
To address these challenges and support the consenting process, a robust, multi-lines of evidence approach was developed. This integrated methodology combined numerical modelling with data-led analysis and established scientific understanding. The modelling framework comprised (i) high-resolution hydrodynamic and wave modelling to characterise the metocean regime nearshore; (ii) XBeach simulations to assess storm-driven shoreline and seabed response under realistic worst-case scenarios; and (iii) Computational Fluid Dynamics (CFD) modelling to evaluate localised flow–structure interactions and associated sediment transport processes.

Outputs from these analyses were synthesised within a conceptual site model, providing a coherent framework for interpreting results and assessing potential impacts. This integrated approach enabled a robust assessment of both potential environmental effects and cable exposure risk associated with the revised landfall design. The study demonstrates the value of combining multiple lines of evidence to enhance understanding of complex nearshore systems to support regulatory engagement and enable informed engineering and environmental decision-making at landfall locations.

Session Three: Geoscience for Foundations and Support Structures

From Sand to Clay via Silt: Geological Controls on Transitional Soils

Authors: Vicky Catterall; Aggeliki Georgiopoulou; Pooyan Ghasemi

Organisation(s): RWE; Ternan Energy

Abstract
Transitional soils represent sediments whose properties range between sand dominated and clay dominated materials through variations in silt content. From a geological perspective, these materials reflect and record changes within depositional processes resulting in graded sequences. Their heterogeneous nature arises from variability in grain size distribution, sorting, and fabric.

The geological complexity of transitional soils is often under represented when they are identified solely from geotechnical classification charts, where they frequently occur at the boundaries between behavioural zones. Interpreting these materials within a stratigraphic framework provides additional context for understanding their spatial distribution and internal variability.

In offshore wind developments, accurate characterisation of transitional soils relies on mapping their vertical and lateral extent within the stratigraphic succession. This enables geotechnical investigations to be better targeted and aligned with the underlying sedimentological architecture. Transitional soils are commonly associated with specific stratigraphic settings, such as interbedded shallow marine sequences, or glaciomarine and glaciolacustrine sediments, where specific sedimentological processes lead to graded or interbedded units.

This paper presents case studies of transitional soils deposited in different depositional environments. Sedimentological characteristics, including bedding architecture, grain size distributions, sorting, and sediment fabric, are examined to highlight the geological controls governing their formation. Integration of geotechnical indicators (such as particle size distributions and soil behaviour trends) with geological interpretation methods, including sequence stratigraphy and seismic facies analysis, has enabled improved mapping and correlation of these sediments across offshore sites.

Based on these case studies, a geology led framework is proposed in which depositional environment, stratigraphic position, and seismic character are used to inform material interpretation and site investigation planning.

Quantifying Shallow Subsurface Lithological Variability using Geotechnical Logs: a similarity-based framework for the North Sea

Authors: Duncan Eliott Stevens; Matthew Arran; Catriona Macdonald; Michael Brown; William Coombs; Robert Bird

Organisation(s): British Geological Survey; University of Dundee; Durham University

Abstract

Characterising spatial variability in shallow subsurface conditions is critical for offshore engineering and marine spatial planning, yet remains difficult to represent at regional scales using existing seabed mapping approaches. These approaches typically rely on surface proxies derived from multibeam bathymetry, backscatter, sidescan sonar, and geomorphological mapping. While providing valuable constraints on seabed morphology and sediment distribution, they do not directly resolve subsurface lithological variability relevant to ground conditions. This study presents a data-driven framework for quantifying shallow surface geological variability across the UK North Sea continental shelf using lithological interpretations derived from a large regional compilation of geotechnical logs, including cone penetration tests, boreholes, and shallow cores. Site-level metrics are introduced to capture vertical heterogeneity and application-focused material difficulty, and a similarity-based clustering approach is applied to identify groups of sites with comparable lithological sequences. The resulting framework captures subsurface variability not expressed in seabed sediment maps or geomorphological classifications, and provides a consistent means of comparing lithological structure between locations. The principal outcome is a demonstration that complex and spatially heterogeneous geological information can be reduced to quantitative, interpretable metrics that retain geological meaning while remaining accessible for applied use. These findings highlight the potential for translating subsurface complexity into decision-relevant information, supporting improved representation of ground conditions for offshore engineering, marine spatial planning, and related applications.

Characterising Palaeovalley Fill Sequences: An Integrated Ground Modelling Approach

Authors: Millie Haffenden

Organisation(s): Global Maritime

Abstract
Fluvial paleovalley and estuarine systems represent some of the most geologically complex environments encountered in shallow continental shelf settings, where a rapid lateral and vertical variability in ground conditions can be encountered. This complexity poses significant challenges for offshore infrastructure development, particularly for export cable installation where reliable prediction of burial conditions is required over tens to hundreds of kilometres.

Development of an Integrated Ground Model on the inner shelf of the Bay of Biscay, France, using high-resolution geophysical Sub-Bottom Profiler data with geotechnical information from multiple campaigns provides unique insight into the geological complexity, and to specific geo-constraints arising from this that may be critical for cable installation planning. A structured workflow was applied, combining engineering geological unitisation, seismic facies interpretation and statistical derivation of geotechnical parameters.

The subsurface is characterised by palaeovalleys incised into heterogeneous Paleozoic to Eocene bedrock. The paleovalleys are infilled with Holocene sediments deposited in estuarine, tidal and marine environments. The infill sequence comprises sands with varying gravel content as well as localised silts and clays. A gravel lag deposit is also noted, interpreted as a tidal ravinement surface. A total of six Engineering Geological Units were identified, reflecting varying depositional processes associated with tidal flats, estuarine channels, sand bars and open marine environments.

The integrated geological interpretation highlights spatial and vertical variability in unit thickness, lithology and strength, with localised shallow bedrock, lag deposits and low-strength cohesive sediments presenting key engineering geo-constraints and geohazards. These features have direct implications for trenching performance, burial depth achievement and cable protection.

This study emphasises the importance applying geological understanding to characterise the depositional variability associated with tidal and estuarine processes, that can have significant influence on cable installation feasibility, burial performance and long-term asset stability.

Mapping of Sub-Seabed Soil Mechanical Properties Whilst Installing a 3-Pile Anchor in Seismically Heterogeneous Marine Soils

Authors: Jacques Yves Guigne; J. Smith Subsea Micropiles; R. Varghese Subsea Micropiles; J. Machin Subsea Micropiles

Organisation(s): Subsea Micropiles; UK

Abstract

In situ volumetric acoustic monitoring of a 3-pile anchor installation in Scapa Flow (Orkney) was conducted to demonstrate a practical operational capability for capturing drilling interactions within a complex seabed before, during, and after seabed entry. Large-diameter seismic shear-wave imaging of the subseabed area surrounding the anchor's position and installation depth provided an unprecedented delineation of the complex layered sedimentary environment offshore. Based on the resulting shear-wave velocities, the findings indicated that the pile-hammer drilling penetrated a layered, fragmented seabed and that natural material displacements occurred during drilling. As grouting occurred, acoustic shear-wave data and microseismic responses highlighted the fractured conditions of the subseabed and the paths taken by the grouting flow, enabling data collection at all stages of the drilling process. Overall geotechnical observations of subseabed ground stiffness were made using the captured volumetric shear-wave velocity (Vs), which is an elastic constant closely related to Young's and shear moduli. The estimated Vs can serve as an indicator of low-strain stiffness and an identifier of the character of the soil layers. The acoustic record during drilling showed strong, unmistakable events with distinct shear-wave arrivals throughout the surrounding spatial footprint. Alternating weakly consolidated and more coherent soil layers, both holding vertical and horizontal faults, were observed. Distinctive seismic images correlate well with in situ sedimentary conditions, as evidenced by legacy single-borehole data from the Scapa Flow region. The resulting distribution of soil mechanical properties, combined with penetration test data, can lead to safe, cost-effective, and practical subsea anchor design. As a standalone ground investigation tool, this acoustic approach can be integrated with numerical models, offering both soil model calibration and the ability to capture 3D spatial variation in strata. It also enables estimation of a site-specific 3D failure envelope for the anchor, yielding realistic safety factors in any direction or inclination.

Cracks in our foundations: The nature and origin of fractures in Ypresian clays

Authors: Loic Piret; Maarten Van Daele; Bruno Stuyts; Marc De Batist; Stijn Dewaele; Anis Kheffache; Meghdad Payan

Organisation(s): Ghent University

Abstract

The stiff Ypresian clays of the Kortrijk Formation (BE) and London Clay (UK) occur extensively throughout the subsurface of the Princess Elizabeth Zone (PEZ) in the North Sea, a key area for offshore wind energy development. The formation is pervasively deformed with a large-scale layer-bound fault system (Clay Tectonic Features) and drill core samples from the PEZ show a heavily fractured internal structure at the centimeter scale. These faults and fractures have strong geotechnical implications which may pose challenges for offshore wind farm foundations. Here, we establish the origin of fractures in the Ypresian clay core samples to help inform geotechnical analyses and foundation design.

To do so, we investigate 20m-long drill cores from Rumbeke and Moeskroen, onshore stratigraphical equivalents to the offshore PEZ geology. Cores were X-ray CT (computed tomography) scanned and the data was processed through an AI-driven workflow including a denoising algorithm which preserved thin low-contrast features, after which a U-net neural network with 2.5D architecture (trained on ~40 manually annotated slices) segmented the fractures and bioturbation. Grain-size and geochemical analyses were performed to provide geological context to the CT data.

Fractures in the Ypresian core samples are coring-induced as evidenced by their axisymmetric presence therein, and their absence in undrilled sediment blocks from the same site. Indeed, with a moisture content close to its plastic limit, the Kortrijk Formation and London Clays are prone to brittle failure upon disturbance. Consequently, geotechnical parameters derived from tests on heavily disturbed samples, particularly strength and stiffness, must be interpreted with caution.

These findings raise two key questions we aim to address in the future: what controls the degree of coring-induced disturbance, and how far beyond the borehole wall does deformation extend? Resolving these is essential for obtaining reliable geotechnical data to support offshore wind foundation design in the PEZ.

National Scale Ground Model Driving Spatial Characterisation of Seabed for UK Offshore Wind

Authors: Helen Povey; Simon Libby; -; Gayle Plenderleith; Beth Irish; Sinead Birks; Rifky Wijanarko; Chris Jackson; Hassan Moharram; Michael Blair

Organisation(s): WSP; The Crown Estate

Abstract
Complex ground conditions significantly increase project development and capital costs, sometimes leading to offshore wind site relinquishment, yet they are often only identified after significant investment in reconnaissance and detailed design surveys. To address this, WSP and The Crown Estate have developed a national-scale 3D ground model and related geohazard assessment to directly inform site selection and underpin The Crown Estate's cost and technical risk evaluation processes.

The ground model is thought to be the most spatially extensive of its kind in its comprehensive integration of data for offshore wind across the UK seabed. It combines geological, geophysical, geotechnical, and geomorphological datasets in 3D space. Inputs are drawn from a combination of British Geological Survey (BGS) data, The Crown Estate's Marine Data Exchange, other publicly available sources, and contributions from developers and academia. The model and associated geohazard framework have undergone independent peer review by the BGS and are designed to evolve as new data become available.

A novel modelling workflow has been established within Leapfrog™, enabling efficient integration with other modelling software products and workflows. The approach generates geologically plausible sedimentary architectures, capturing complex interbedding while honouring local data constraints and preserving regional trends across offshore UK areas, exceeding 160,000 km². This provides a consistent, reproducible framework for regional ground modelling that can be progressively refined to project-scale applications.

To evaluate engineering implications, drivability assessments incorporating weathering profiles have been undertaken at regular spatial intervals across all model regions for a range of foundation types. In parallel, geohazards have been assessed at a national scale, with their spatial distribution, likelihood, and potential impact directly informing The Crown Estate's risk-based decision-making.

This integrated approach demonstrates how geoscience can play a pivotal role in reducing project risk, supporting more informed leasing strategies, and improving the long-term viability of offshore wind developments.

De-risking Ground Investigation: Site-wide Geotechnical Parameters and Uncertainty from Pre-stack Inversion of 3D UHRS Data at Green Volt OWF

Authors: Esben Dalgaard; Helen Sinclair; Jordan Geear; Bedanta Goswami; Matt Owen; Raisya Noor Pertiwi; Jack Turner; Frederik Horn; Bruno Stuyts

Organisation(s): SolidGround; Vårgrønn; Global Maritime

Abstract
Reducing uncertainty in ground conditions is a key challenge for floating offshore wind developments, where foundation design, anchoring solutions, and installation strategies are highly sensitive to spatial variability in near-surface sediments. At the Green Volt site, an Ultra-High-Resolution 3D seismic (3D UHRS) dataset has been leveraged beyond conventional interpretation through the application of pre-stack inversion to derive quantitative, site-wide geotechnical parameters.

This paper presents a workflow for transforming seismic amplitudes into elastic property volumes and geotechnical properties. These outputs are integrated with available geotechnical data to inform a spatially continuous ground model across the development area.

A key focus of the study is the estimation and propagation of uncertainty associated with the inversion process and its impact on derived geotechnical parameters. Sources of uncertainty, including seismic data quality, geotechnical data quality, and inversion parameterisation, are assessed and quantified to provide confidence bounds on the resulting property volumes. These uncertainty measures are incorporated into the ground modelling workflow to better constrain subsurface variability.

Results demonstrate how quantitative interpretation of 3D UHRS data can enhance site understanding by bridging the gap between sparse geotechnical measurements and continuous geophysical coverage. The integration of uncertainty estimation into this workflow provides a more robust basis for early-stage design and risk assessment, ultimately contributing to reduced ground investigation risks and more efficient development of floating offshore wind projects.

Shallow Geology Prediction with Ice Sheet Models: Dogger Bank, Scotian Shelf, & Grandbanks

Authors: Matthew Drew; Lev Tarasov

Organisation(s): Memorial University of Newfoundland

Abstract
Determining sea-floor geotechnical conditions is a costly but necessary step for offshore development. On mid to high latitude continental shelves, these conditions are determined by past glaciation when ~km thick ice sheets advanced, yielding a potentially hazardous seafloor: 1. prone to submarine landslides were rapidly deposited sediments are unstable, 2. over-consolidated or boulder rich and difficult to pile-drive or drill, or 3. with insufficient sediment cover for specific foundation types. Models of glacial sedimentary processes can be compared against available geomorphologic, geologic and geotechnical data to predict geohazards and seafloor properties in areas without data coverage, enabling regional assessment for site optimization and cable routing and more targeted surveying campaigns.

Using a numerical ice sheet model, we simulate glacial histories for three regions: 1. Dogger Bank, UK, 2. Scotian Shelf, Canada, and 3. Grand banks, Canada. This model, the Glacial Systems Model, is a fully coupled hydro-thermo-mechanical, sedimentary system which simulates a full suite of glacial geologic processes from past climate records. The sedimentary
components simulate deposition rates, transport history, erosion via quarrying & abrasion, melt water pressure and isostatic adjustment. The glacial ice in each of these regions is fed or interacts with a larger continental ice sheet. As such, we simulate continental scale glaciation and drive high resolution simulations of regional glaciation with nested boundary conditions. With this approach we compare glaciation across the three regions and assess the predictive power of the model against an array of geologic data. We suggest that this workflow may be used in regional characterization for offshore infrastructure planning.

Regional geological synthesis across offshore wind developments in the Central North Sea

Authors: Margaret Stewart; Catriona Macdonald; Roger Birchall

Organisation(s): British Geological Survey; SSE Renewables

Abstract
The Central North Sea (CNS) region is a key area for offshore wind development due to its shallow water depths, proximity to energy markets, and existing offshore infrastructure. The subsurface geology of the region varies markedly from the nearshore to offshore, influenced by both bedrock and younger Quaternary sediments. SSE Renewables is developing three offshore wind farm (OWF) projects within the CNS: Seagreen, Berwick Bank and Ossian, which provide a representative variety of the subsurface geology important to windfarm siting across the wider CNS. This study presents the results of a regional geological synthesis undertaken through a collaboration between SSE and the British Geological Survey (BGS). Drawing on commercial geophysical and geotechnical data, legacy BGS data, published literature, and regional interpretations, this work evaluates the similarities and differences in the Quaternary and pre-Quaternary stratigraphy of the Central North Sea (CNS) shelf and its application to windfarm siting. Regionally extensive Quaternary stratigraphic units, including the Aberdeen Ground, Marr Bank, and Forth formations, are present across all sites. However, they show distinct variations in seismic facies, geomorphology, structural complexity and geotechnical behaviour. The study also identifies differences between existing geological interpretations, reflecting the inherent complexity of glacially influenced units, and the challenges of applying regional stratigraphic classifications across multiple offshore wind projects. Finally, the influence of Pre-Quaternary bedrock has been relatively understudied, and may exert an important control on the distribution and preservation of the overlying Quaternary succession. The study demonstrates the value of integrating regional and project-scale datasets, and highlights opportunities for improved consistency in geological interpretation across offshore wind developments.

Session Four: Geoscience for Foundations and Support Structures

KEYNOTE: Navigating Risk on Europe's Glaciated Margin: From Marine Geohazards to Geo-Engineering Solutions

Benjamin Bellwald, NGI

Pending

Uncertainty in Machine Learning-Based Vs Predictions from CPTu and Its Impact on Monopile Design

Authors: Yuting Zhang; Héctor Marín-Moreno; & Susan Gourvenec

Organisation(s): University of Southampton; AtkinsRéalis

Abstract
Shear wave velocity (Vs) is a key parameter for offshore site characterisation because it enables estimation of the small-strain shear modulus, which underpins many geotechnical design analyses. Direct measurements of Vs are often limited by time and cost constraints, while empirical correlations based on piezocone penetration test (CPTu) data can produce substantial prediction errors. Machine learning techniques, particularly deep neural networks (DNNs), have emerged as powerful alternatives owing to their ability to capture complex, nonlinear relationships. However, conventional DNNs provide only deterministic point predictions and do not quantify predictive uncertainty, limiting confidence in their application to geotechnical design. Furthermore, the propagation of prediction uncertainty into foundation performance and design remains poorly understood. This study presents an integrated framework that quantifies the uncertainty associated with machine learning-based Vs predictions and evaluates its influence on offshore foundation design. A global seismic CPTu (SCPTu) database, comprising both onshore and offshore sites, is used to train and validate a DNN-based prediction model, with uncertainty quantified using a deep ensemble approach. The resulting probabilistic Vs predictions are subsequently incorporated into a reliability-based analysis of pile response under design loading conditions to assess the impact of prediction uncertainty on the reliability and design of offshore monopile foundations. The proposed framework provides a practical pathway for integrating uncertainty-aware machine learning into offshore site characterisation and reliability-informed foundation design.

Acquisition and deblending of an (ultra-) high resolution simultaneous source technique

Authors: Peter Cox; Nik Gribb

Organisation(s): RockWave; Oceaneering

Abstract
Site characterisation at offshore windfarm (OWF) sites requires detailed knowledge of the seabed and subsurface geology for ground model development. While depths of interest for engineering design are usually relatively shallow (less than 100 m), knowledge of the deeper subsurface can be invaluable in providing broader geological context and derisking potential geohazards. While ultra-high resolution seismic (UHRS) sources have proven to be highly effective in providing decimetre resolution images of the subsurface down to ~100 m, the ultra-high frequency signal from these sources is attenuated rapidly - both temporally and spatially - resulting in the requirement of a lower frequency wavefield for extended penetration. This lower frequency wavefield is commonly generated through the deployment of mini-airgun sources which typically emit a signal in the 50-500 Hz bandwidth range. Historically the acquisition of sparker and mini-airgun data for OWF sites has been achieved in two acquisition passes, undesirably increasing both the time and cost of marine operations. In this abstract we introduce a novel acquisition solution which enables the recording of both data types, simultaneously, in a single sail-line pass, followed by source separation in processing to isolate the discrete (mini-airgun and sparker) seismic signals. To test the methodology, seismic field trials were conducted which included simultaneous source acquisition in a single pass, accompanied by standard, multi-pass acquisition of both source types to provide baseline comparison datasets. Here, we share the results of these field trials and explore the opportunities that such a method presents to improve both the efficiency, and quality, of shallow site investigations for OWF.

When More Is Not Enough: Unlocking the Potential of High-Resolution SAS Data for Automated Object Detection

Authors: Andrijana Horvat

Organisation(s): Hidrocibalae

Abstract
The recent introduction of Synthetic Aperture Sonar (SAS) into geophysical surveys for the planning, development and monitoring of offshore infrastructure has enabled significantly higher spatial resolution and more detailed seabed imagery than conventional Side-Scan Sonar (SSS). This improvement was considered a key prerequisite for advancing automated object detection solutions - existing workflows developed for SSS datasets were built on the assumption that higher sonar resolution would directly yield higher automated detection accuracy during offshore geophysical investigations. Initial testing on SAS data challenged this assumption fundamentally: automated detection accuracy fell significantly below expectations, indicating that resolution alone does not determine automated workflow performance. Through systematic testing and detailed analysis of SAS-specific acoustic characteristics - including higher data volumes, increased acoustic texture complexity, reduced shadow contrast, and less clearly defined object boundaries - the primary factors limiting automated detection reliability were identified. Iterative workflow adaptation produced targeted modifications that drove automated detection performance beyond the accuracy levels previously achieved on SSS data - not only recovering but surpassing them, with significantly more boulders identified per survey area. A direct comparison of SAS and SSS datasets further quantifies the practical differences between the two sensors - in terms of data quality, achievable detail, and automated detection potential. Real project examples illustrate where high-resolution SAS provides a decisive operational advantage and where conventional SSS remains a technically sufficient, economically practical choice - giving survey planners actionable, evidence-based guidance for informed decision-making in the planning of offshore geophysical surveys.

Session Six: Digitalisation and Data Integration

KEYNOTE: Core insights: what the seabed is telling us?
Chelsea Bradbury, The Crown Estate

Pending

Beyond Mechanical Classification: Uncovering Hidden Installation Constraints through Integrated Ground Modelling – A Bay of Seine Case Study

Authors: Arthur Blouin; Lucile Goswami; Ruth Martinez Lamas; Emmanuelle Gautier; Laura Teresa Pinero Feliciangeli; Panagiotis Foutrakis

Organisation(s): Geosciences Department, GEOxyz

Abstract

Standard offshore infrastructure design often relies on geotechnical unitization driven strictly by mechanical properties. However, this precise and focused approach can ignore subtle but wider stratigraphic complexities, leading to unforeseen installation risks. This study presents how a shift from purely geotechnical based unitization toward a more robust, integrated ground modelling workflow, as recommended by SUT OSIG and CFMS standards, led to the identification of an unanticipated installation constraint.

We demonstrate the efficacy of this iterative framework through a case study of an export cable route in the Bay of Seine, English Channel—a complex environment where Quaternary sediments cover underlying Mesozoic and Paleogene deposits. Our methodology moved beyond traditional CPTu-led unitization by conducting successive interpretation cycles. Initial geotechnical data unitization, based on soil types and mechanical behaviour, overlooked the presence of similar soils with different colours. The integration with high-resolution sub-bottom profiler (SBP) data allowed a correlation between these colour-based sediment transition with regional unconformities.

This synthesis revealed that seemingly uniform sediment intervals were distinct, with some representing weathered Paleogene strata rather than typical interbedded Quaternary deposits. Integrating this data allowed us to reclassify higher risk zones that had been previously underestimated by standard geotechnical parameters. By identifying these features, we were able to map potential installation hazards that standard mechanical classification would have overlooked.

Pushing ground modelling further than a static output, our case study confirms the need to work with iterative frameworks. By reconciling geotechnical observations with geological and geophysical evidence, we can efficiently mitigate uncertainty through ground characterization. This comprehensive approach is essential for offshore infrastructure design, ensuring that engineering decisions are supported not only by geotechnical factual observations but also by a full understanding of the stratigraphic environment.

Building a Petabyte-Scale Digital Ecosystem for Offshore Wind: Roadmaps, Challenges, and Geoscience Lessons

Authors: Darren Biggs Biggs

Organisation(s): ET Works Ltd

Abstract
The rapid transition towards sustainable energy systems is driving an exponential increase in the volume and complexity of data acquired for offshore wind developments. While the subsurface engineering community faces growing challenges in managing these massive datasets, the industry must develop holistic solutions that unify data architecture, cloud-native geoscience workflows, and information governance. This integration is vital to increase data trust, improve data quality, completeness, readiness, and 'findability'—thereby reducing project risk and accelerating regional site characterisation.

Using real-world case studies, this presentation outlines the strategic roadmap for overcoming legacy data barriers and breaking down operational silos. We will discuss establishing specialised support teams, leveraging data governance frameworks (including DAMA and CMMI), and how to navigate the logistical challenges of migrating petabyte-scale datasets from legacy physical drives and architecture to future-proof cloud environments.

Crucially, we will showcase how to establish a unified enterprise taxonomy to index millions of subsurface, oceanographic, and engineering documents using rules-based applications to align unstructured data to MEDIN and COWRIE type systems. This framework creates a digital ground model ecosystem searchable via a context-rich records management application and a 'single-pane-of-glass' map interface. Attendees will learn how this system drives collaboration across geology and geophysics, ground-modelling, ArcGIS, document control, environmental and MetOcean teams, while streamlining compliance and data sharing with bodies like The Crown Estate and the Marine Data Exchange (MDE).

Ultimately, we demonstrate how to leverage mega-scale data management lessons from the oil and gas sector to manage future growth in offshore wind. As offshore wind matures, providing geoscientists with robust digital infrastructure is vital to unlocking actionable subsurface insights and safely delivering clean energy.

Assessing uncertainties in quantitative ground modeling workflows for offshore windfarm areas

Authors: Lennart Siemann; Ramiro Relanez

Organisation(s): Fraunhofer IWES

Abstract
Shallow subsurface conditions are characterized by integrating geotechnical and geophysical measurements to generate ground models that support wind-farm layout decisions. Conventional ground models are largely qualitative, focusing on soil units and geohazard identification, with limited coverage at unexplored sites.
To achieve more informed planning, this study presents uncertainty-aware quantitative ground models that yield information beyond direct measurements, including at locations without observations. Within the prediction workflow, uncertainties from data acquisition, processing, interpretation, and modeling are propagated to quantify their contributions to the final ground model. By randomly sampling from uncertainty ranges, probabilistic outputs are produced, with attention to spatial uncertainty such as seismic reflector positioning and soil measurement variability (e.g., CPT derived parameters). The results demonstrate that quantitative ground models can deliver specific estimates for location and depth, with associated uncertainties, for sites that lack direct measurements. Explicit quantification of uncertainties enables risk-informed design decisions, and supports adaptive management of residual ground risk across the entire project lifecycle. This potentially supports site survey planning, turbine siting, and foundation design.
Moving from qualitative to quantitative models provides a practical basis for future work and emphasizes the value of multidisciplinary collaboration in offshore wind development. The workflow is applicable to both fixed- and floating-turbine installations.

Enhanced Boulder Detection in Seismic Through Wavefield-Based Diffraction Imaging

Authors: Sandeep Bhamber; Greg Hulks; Nick Woodburn; Peter Cox

Organisation(s): RockWave

Abstract
The accurate identification of boulders is a crucial step in offshore wind site characterisation as they pose high risk for infrastructure installation. However, the pre-migration detection of point diffractors, in extremely-high resolution seismic (EHRS), remains challenging due to their relatively low amplitudes and similarity to other hyperbolic features. This study introduces a data-driven approach, based on illumination gather conditioning within the Kirchhoff pre-stack migration workflow, to isolate point diffraction energy from dominant specular reflections and structural diffractions.

In the illumination gather domain, point diffractions and reflections exhibit fundamentally different signal behaviours. This contrast forms the basis for signal separation. The resulting point diffraction-enhanced datasets provide clearer visualisation of potential hazards, reducing reliance on manual quality control (QC) and interpretation effort. Importantly, the approach also minimises false positives by distinguishing point sources from structural diffractions.

This technique delivers faster, more confident boulder identification and represents a significant improvement over traditional pre-migration methods, supporting safer and more cost-effective offshore wind site characterisation.

Towards a regional chronostratigraphic framework for the southern North Sea: Integrating multisource subsurface data

Authors: Nicola Dakin; Dayton Dove; Jon Lee; Catriona MacDonald

Organisation(s): British Geological Survey (BGS); BGS

Abstract

Offshore wind development across the UK Continental Shelf has accelerated rapidly since the early 2000s, supported by largescale acquisition of high-resolution geological, geophysical and geotechnical datasets. This expansion has contributed to significant national energy output, with offshore wind generating 52.9 TWh of electricity over the past 12 months - enough to power approximately 14.6 million homes (The Crown Estate, 2025). The increasing volume, diversity and spatial coverage of subsurface data now provide an unprecedented opportunity to reassess the shallow geological framework of the southern North Sea (SNS).

The British Geological Survey has undertaken a synthesis of opensource data and reporting from multiple offshore wind farm (OWF) sites to produce the first integrated chronostratigraphic framework for the SNS. This new interpretation aligns existing stratigraphic models with recently acquired marine datasets, incorporating palaeoenvironmental indicators and cross project geological observations. By harmonising datasets from disparate OWF investigations, the framework establishes a consistent regional baseline for Quaternary, Pliocene and underlying bedrock stratigraphy. One major outcome highlights that regional offshore stratigraphy requires a full revision to include findings identified from recent developments.

The project demonstrates the value of digital integration in offshore geoscience, highlighting where data convergence strengthens geological understanding and where data gaps limit model confidence. The study identifies several priorities for future work, including: the harmonisation and unitisation of offshore stratigraphy across OWFs; improved prediction of lithofacies using formation level classification schemes; incorporation of geotechnical parameters conditioned by geological formation into a unified reference database; and development of a regional age dating and biostratigraphic dataset.

Together, these advances will support future digital ground models, enabling more robust geohazard assessment, optimised foundation design and efficient data reuse. This integrated approach will ultimately enhance the geoscientific foundation of offshore development and support ongoing research, sustainable marine management and infrastructure planning.

A Fully Automated Workflow for the Application of UDCAM-S in the Design of Offshore Monopile Foundations

Authors: Miquel Lahoz; Ilaria Del Brocco; Ronald B.J. Brinkgreve; Tuan Bui

Organisation(s): Seequent, The Bentley Subsurface Company; Delft University of Technology

Abstract

The design of offshore monopile foundations requires reliable prediction of their response under lateral cyclic loading. Using the explicit modelling approach proposed by Norwegian Geotechnical Institute (NGI), the effects of cyclic loading can be represented through equivalent monotonic analyses. Within the UDCAM-S (Undrained Cyclic Accumulation Model Simplified) framework, the NGI-ADP constitutive model is calibrated to reproduce the equivalent monotonic stress–strain response derived from stress-controlled cyclic laboratory tests using contour diagrams together with the applied cyclic load history.

Applying UDCAM-S to monopile analyses requires extending the procedure to account for the variation of loading conditions along the pile and the redistribution of stresses during loading. To address these challenges, a fully automated workflow is presented for the calibration and application of UDCAM-S on a multilayer iterative basis.

The proposed methodology includes (i) local load-history calculation based on finite element analysis results, (ii) a modified calculation of the equivalent number of cycles (Neq) that accounts for the actual mobilization of soil strength along the pile rather than assuming full mobilization throughout, (iii) an automated optimization procedure with adaptive parameter ranges, (iv) update of the cyclic soil parameters, and (v) streamlined post-processing for convergence assessment and structural result inspection.

The workflow is demonstrated through an application example and validated against the full UDCAM methodology. The results demonstrate that the proposed workflow provides an efficient, robust, and fully automated framework for applying UDCAM-S to offshore monopile foundation design.

A depth-oriented future: advancing offshore wind seismic with tomographic velocity model building

Authors: Tas Burn; Nick Woodburn; Connor Boylan

Organisation(s): Rockwave

Abstract
Accurate characterisation of shallow subsurface conditions is critical for offshore wind foundation design. This study evaluates the use of seismic depth velocity model building with tomography to improve EHRS-derived ground models, addressing a present gap between hydrocarbon and renewables geophysical practices.
Using multiple case studies from the North Sea and Baltic Sea, a tomography workflow is demonstrated to refine velocity models without reliance on borehole data. Validation against independent P-wave logs demonstrates strong correlation within the foundation zone (down to 100 m below seabed), confirming that reliable models can be generated from seismic data alone.
The updated models improve time-to-depth conversion and reveal key geotechnical features, including low-velocity peat channels and tunnel valleys. These features are critical to site assessment but may be poorly constrained using conventional processing.
The derived velocity models provide a valuable input to quantitative ground modelling and enable improved soil property prediction. This approach supports more efficient site characterisation workflows and has the potential to reduce uncertainty in offshore wind development.

Satellite-Derived Bathymetry as an Operational Monitoring Layer for Offshore Infrastructure

Authors: Damir Matić

Organisation(s): Hidrocibalae d.o.o.

Abstract
For decades, offshore asset management has relied on periodic vessel-based surveys to characterise seabed conditions. These surveys remain the benchmark for accuracy and will continue to play a fundamental role throughout the lifecycle of offshore infrastructure. Yet they are costly, require mobilisation, and capture only a snapshot of a seabed that is constantly evolving. This raises a practical question: does every operational decision require survey-grade data, or information reliable enough to indicate where change has occurred?

This presentation explores how Satellite-Derived Bathymetry (SDB), developed in collaboration with the European Space Agency, can complement conventional hydrographic surveys by providing a repeatable, regional monitoring capability between campaigns. Combining multispectral satellite imagery with physics-based modelling and machine learning, SDB enables observation of large shallow-water areas at far lower cost and higher temporal frequency than vessel-based acquisition. In favourable, optically clear conditions, metre-scale spatial resolution and depth retrieval to roughly 20–30 m are already achievable, with vertical accuracy on the order of 0.5–1.5 m, and rapid gains expected as commercial constellations, revisit frequency and processing techniques mature.

Rather than a static mapping product, SDB is most powerful as a tool for tracking morphodynamic change - migrating bedforms, the onset of scour, post-storm response and the stability of cable landfalls - between surveys. Using examples from ongoing ESA activities, the talk demonstrates how this capability supports monitoring of cable corridors, nearshore sediment dynamics and coastal infrastructure, and informs early-stage route planning by flagging where survey effort is justified before any vessel mobilises.

The future of offshore monitoring is not choosing between satellite observation and hydrographic survey - it is combining them into a smarter, more responsive strategy.

Green Volt Part 2: A Journey from Brownfield to Site-Wide 3D Data

Authors: Jordan Geear; Jack Turner; Matt Owen; Bedanta Goswami; Raisya Noor Pertiwi

Organisation(s): Global Maritime

Abstract

The Green Volt project, located in the UK North Sea, aims to become the world's largest commercial-scale FOW development. As previously presented at this symposium in 2024, the Green Volt OWF project successfully made use of brownfield geoscience data and from legacy Oil and Gas developments to support pre-FEED engineering on the project and realise cost and programme efficiencies.

Following on from the use of brownfield O&G geoscience data, the project has executed a phased approach to the management of ground risk across the site, which has included the reconditioning and acquisition of a series of subsurface geophysical datasets to support the management of ground risk across the site. These datasets have included initial reprocessing of a legacy Pinger dataset to support preliminary ground modelling, through to targeted SBP and 2D EHRS acquisition, culminating the acquisition of a novel site-wide 3D EHRS dataset.

The latest stage of acquisition at the site is a comprehensive 3D Extremely-High-Resolution Seismic (EHRS) survey was undertaken across the Green Volt site, which has delivered an extensive dataset designed to characterise shallow stratigraphy, identify potential geohazards, and provide input to ground modelling and project engineering assessments.

Each dataset acquired by the project played a key part in the management of ground risk and geo-engineering constraints at a range of scales. This presentation will showcase the range of datasets acquired by the project over time and demonstrate how each dataset has played a role in incrementally developing the project's understanding of the ground conditions at the site and in refining the project's integrated ground model. The presentation demonstrates the value of acquiring a level of data appropriate to the development stage of the project, and how the reconditioning of legacy datasets has a role to play in providing timely early insight into project ground conditions.

KEYNOTE: The cultural and heritage values of offshore geology

Hanna Steyne, Wessex Archeology

Pending

POSTER ABSTRACTS

Day One

Early-phase sediment mobility assessments for subsea cables

Authors: Holly Cairns; Siew Fong Chen

Organisation(s): Global Maritime

Abstract

A stable seabed level (SSBL) is a surface that represents the base of mobile seabed sediments and is typically calculated by assessing seabed curvature patterns. Global Maritime's sediment mobility workflow bridges the gap between SSBL calculation and detailed seabed mobility models. The workflow incorporates geotechnical and interpreted geophysical data, which provides an insight into the geological composition of seabed and bedforms to indicate whether the sediment is likely mobile or immobile.

Particle size distribution, relative density, and undrained shear strength data from CPTs and Vibrocores are reviewed to map out the physical properties of the seabed and is compared to open source metocean data to assess potentially mobility.

Areas of immobile seabed are determined from an assessment of geotechnical data and interpreted lithology and are then replaced with bathymetry data in the SSBL surface to ensure that false lowering is removed. For example, areas of outcropping bedrock may be misidentified as a bedform due to their convex shape, and it is crucial to cable burial depth calculations and operations to ensure that seabed lowering is not applied in that area.

Where multiple bathymetric datasets are available, the workflow also includes a peak analysis of bedforms. Bedform peaks are indexed and their horizontal and vertical movement is calculated to provide an approximate migration rate.

The sediment mobility workflow was developed as part of a study for an export cable corridor in the Central North Sea. There was a partial coverage of overlapping bathymetric datasets, however the study was able to conclude from peak analysis and an assessment of geotechnical data that an area of sandwaves may be relict, with additional bathymetry data required for confirmation.

Calculation of stable seabed level surface, for use in offshore cable route engineering and sediment mobility studies

Authors: Paul Slater

Organisation(s): AGI

Abstract

With space becoming tight on the seafloor in many development areas, it is often necessary to build in more challenging locations. Seabed type and gradient is one of the main constraints and challenges to construction in a marine environment. In addition to using typical survey data, further analysis of the seabed is required to detect potentially mobile sediments, steep gradients and potential for risk to assets by exposure, over burial or over trawling.

Global Maritime have for the last 5 years been using a novel technique to determine a stable seabed level (SSBL) for input into route design, cable burial risk assessment and sediment mobility study. This works by taking a single MBES survey, or multiple MBES surveys combined to calculate a level below surveyed seabed which is unlikely to become exposed over time, giving a safer burial depth for assets in high risk areas.

This method is achieved by searching for areas of upward convexity, then re-gridding to create a surface which is free from excessive slopes. The result is a surface which can be used over a large site or corridor spatially. This surface can be used to map out potential risk which can be mitigated using the results to reroute assets or determine whether pre-sweeping is required.

We will discuss the challenges of developing this method, limitations of use, other input data to determine immobile seabed/sub strata, and how this technique can be improved by further study.

Understanding palaeo versus present day sediment mobility: a case study from a North Sea cable route survey.

Authors: Susan Rice

Organisation(s): Fugro

Abstract

Subsea cables are a critical yet vulnerable component of an offshore windfarm and require protection from dynamic geohazards and static engineering constraints both at the seafloor and beneath. Mobile sediments indicate an active seafloor and are hazardous to cables for three reasons a) burial and potential overheating b) abrasion due to sediment transport along bedload and c) exposure in areas where sediments are eroded (Walsh et al. 2026). Identifying areas of mobile sediment on its own is not sufficient to quantify risk. A full mobility study is required to confirm if features are active and ascertain the rate and range of movement. This paper presents a case study from an export cable route survey in the outer Moray Firth, North Sea and shows how geophysical survey data can yield useful information prior to a mobility study. Geophysical site survey data revealed sand dunes on the seafloor at water depths between 55 m to 65 m LAT. They are up to 11 m in height and 680 m in wavelength. Piggy backed on top, sand waves were identified with heights of up to 2.3 m and wavelengths between 15 m to 80 m. Multi-beam echo sounder data acquired a month apart either side of a storm event revealed some surprising results. The sand waves had moved laterally between 1.9 m to 4.7 m in the opposite direction to the dunes, which remained static. Revealing that the dunes were relict features formed earlier in the Holocene when sea level was lower and sediment supply was higher than today. Present day sediment mobility is restricted to the sand waves which are formed by currents, reworking material at the crest of the palaeo-dunes. Understanding the true nature of sediment mobility and delineating palaeo versus present day features is critical for de-risking cable design.

"Optimisation of offshore wind export cable routing using GIS-based suitability analysis"

Authors: Jovana Maksimovic; M. Naisbitt; G. McAleese; R. Stanca; M. Gichura; D. Champness

Organisation(s): Gavin & Doherty Geosolutions Ltd, Venterra Group

Abstract

Among the technologies driving the decarbonization of the energy sector, offshore wind has gained particular prominence due to its large-scale generation potential. As offshore wind farms expand in scale and distance from shore, the planning of export cable routes becomes increasingly critical to project feasibility, cost efficiency, and environmental sustainability. This paper proposes a Geographic Information System (GIS) based suitability analysis methodology for optimising offshore wind export cable routing by integrating spatial, environmental, and engineering constraints.
The methodology combines GIS with multi-criteria decision analysis (MCDA) to identify optimal cable corridors while minimising geohazard, anthropogenic, installation, environmental, and operational risks. The analysis considers a range of spatial factors, including water depth, seabed conditions, shallow geology, marine protected areas, shipping routes, fishing activities, and onshore grid connection points. Each criterion is assigned a relative weighting factor based on technical and environmental considerations, thereby creating a weighted suitability map. A least-cost path algorithm is subsequently employed to identify an optimal cable route connecting an offshore wind farm to onshore transmission infrastructure.
A case study was conducted to assess the framework's performance in a realistic offshore wind development scenario. The aim of this paper is to support systematic and data-driven optimisation of offshore wind export cable routing and provide a procedure for future offshore renewable energy projects worldwide.

Dr. N. Buket Yenigul

Authors: Buket Yenigul; Jur Peerden

Organisation(s): Seaway7; Seaway 7

Abstract

Accurate estimation of seabed preparation quantities is a critical component of subsea cable installation projects, directly influencing project cost, installation methodology, vessel selection, schedule, and overall commercial risk. Seabed preparation activities typically include boulder clearance, seabed slope leveling to ensure trencher trafficability, and dredging of sandwaves and other seabed features prior to cable installation. An incomplete understanding of seabed conditions can result in critical geohazards being overlooked leading to cost overruns, schedule delays, contractual disputes, and reduced project performance during execution.
A particular challenge is encountered in regions characterized by dynamic seabed morphology, where mobile sandwaves, megaripples, and active sediment transport processes continuously alter seabed elevations and geometry. These processes can significantly influence the extent of seabed preparation required to create a suitable installation corridor and achieve the target lowering depth. Failure to adequately account for seabed mobility may result in underestimation of dredging volumes, increased installation complexity, and potential risks to the long-term integrity and stability of the cable system.
The reliability of seabed preparation estimates is fundamentally dependent on the quality, coverage, and resolution of geophysical, bathymetric, and geotechnical site investigation data. High-resolution bathymetric and geophysical surveys improve the identification and characterization of boulders, seabed gradients, bedform morphology, and other constraints affecting constructability. Similarly, geotechnical investigations provide essential information on sediment properties, stratigraphic variability, dredgeability, and trenchability. The integration of these datasets into a robust engineering ground model enables more accurate estimation of required seabed preparation prior to cable burial while allowing associated uncertainties to be quantified.
This paper demonstrates the value of an integrated geophysical and geotechnical approach for comprehensive understanding of seabed and how improved site characterization can reduce uncertainty, enhance risk management, and support more reliable estimates and project execution strategies through selected case studies.

Multidisciplinary Landfall Characterisation - How best to Characterise Challenging Coastal Sites

Authors: David Harrison

Organisation(s): Geo-4D Ltd

Abstract

Landfalls are among the most dynamic and technically challenging sections of many cable or pipeline projects, presenting unique complexities for site characterisation and hazard assessment. This presentation details the advantages, limitations, practical considerations, and case study results of a range of survey techniques, including photogrammetry, topographic LiDAR, bathymetric LiDAR, magnetometry, seismics and geotechnical investigation methods. It will also consider different deployment approaches, from traditional ground-based surveys to drone and uncrewed surface vehicle platforms.

The presentation is designed to provide attendees with a clearer understanding of the available survey technologies and their application in the landfall environment. By highlighting the strengths and constraints of each method, it will help develop more targeted, efficient, and cost-effective survey scopes that address site-specific challenges and provide the required inputs to robust, integrated engineering geological ground models.

Assessment of Subsurface Hazard Prediction and Uncertainty Between Sparse SBP Lines Using 2D and 3D UHRS Comparison

Authors: Cai Xinwei; Aryan Shah; Rebecca Bell

Organisation(s): Imperial College London; InX Tech

Abstract

Offshore wind site investigation often relies on sparse 2D sub-bottom profiler or ultra-high-resolution seismic (UHRS) survey lines to characterise shallow subsurface conditions. However, this data provides direct observations only along acquired profiles, leaving uncertainty between survey lines. This is important where shallow seismic horizons, hard layers, buried channels or other potential geohazards vary laterally and may affect foundation design, cable burial and future survey planning.

This project investigates how co-located 3D UHRS data can be used as a reference framework to assess between-line subsurface prediction from sparse 2D survey coverage. The study focuses on interpreted shallow seismic horizons from the Ten Noorden van de Waddeneilanden (TNW) offshore wind area. Existing horizon interpretations, survey-line geometry and seismic attributes will be used to compare sparse 2D line-based information with denser 3D UHRS-derived reference surfaces. A structured prediction dataset will combine horizon observations with spatial and geological variables, including position, distance from survey lines, local horizon geometry and seismic attributes.

Ordinary Kriging will be used as a geostatistical baseline because it incorporates spatial autocorrelation and provides uncertainty estimates (Oliver and Webster, 2015). However, this reliance means prediction performance will degrade where line spacing increases, subsurface structure changes abruptly, or geological complexity is not captured by distance alone. Co-Kriging will test whether secondary variables, such as distance from survey lines, local horizon geometry and seismic attributes, improve the kriging framework, while XGBoost will test whether spatial, geological and seismic-attribute variables improve between-line prediction (Chen and Guestrin, 2016). Results will be validated against withheld 3D UHRS-derived interpretations, allowing prediction error to be evaluated with distance from 2D observations and line spacing.

The expected outcome is to identify line-spacing thresholds where kriging remains useful, where it breaks down, and where machine-learning approaches or additional acquisition may be required.

Investigating Late Quaternary palaeoenvironments in the Southern North Sea: Ultra-High Resolution Seismic analysis and Implications for offshore wind Development

Authors: Karam Sarieddine; Alexander Whittaker; Rebecca Bell; Gary Hampson; Mark Vardy; Margaret Stewart; Abdulqadir Cader; Callum Fry; Fatemeh Bozorgi

Organisation(s): Department of Earth Science and Engineering, Imperial College London; Imperial College London; SAND Geophysics; British Geological Survey; GeoTeric

Abstract

The southern North Sea has experienced multiple glacial and interglacial cycles during the past 500 kyr. Recent 3D ultra-high resolution seismic (UHRS) reflection surveys acquired by the offshore wind industry open a new opportunity to investigate at high temporal resolution how depositional environments in the region have evolved from the Elsterian glacial cycle (500,000-300,000 years ago), through the Saalian glacial cycle (300,000-120,000 years ago), to the present day. We share results from our analysis of sinuous, channelised morphological features observed in the late Quaternary succession of the offshore Netherlands, southern North Sea Basin, using seismic attributes, spectral decomposition, and advanced colour blending techniques. The improved resolution of the data helped us to understand the genesis and infill architecture of these channelised features, and interpret glacial landforms, glacio-tectonised sediments, and post-glacial deformation at smaller scales than were visible in traditional air-gun seismic datasets. The correlation of these seismic stratigraphic and structural interpretations with available borehole geotechnical data provides valuable insights into paleoenvironmental conditions, enabling the development of a high-resolution geological model. The study critically examines a well-preserved late Saalian channel that represents one of multiple superimposed channel generations formed during the Saalian Complex Stage. Our findings show that this large (>50 m deep, >0.5 km wide) channel has considerable variability in its thalweg profiles (i.e., elevation changes of up to ~30m), suggesting that its formation was controlled by glacial processes. The channel infill is composed of coarse-grained sediments at the base, overlain by clayey deposits and then dense sand and gravels. The immediate change from coarse grains to clay implies that, after ice retreat, the valley was drowned under rapid Eemian sea-level rise. These observations can have direct implications for reassessing the extent of late Saalian ice sheet and enhancing the 3D ground models used for wind-farm development.

Don't forget the Jack-up

Authors: David Edwards

Organisation(s): DNV

Abstract

This presentation describes the importance of careful consideration of the needs and constraints associated with wind turbine installation vessel (WTIV) operations at offshore wind turbine locations. It draws on a series of real-world case studies in which foreseeable geological and geotechnical challenges have led to complex installation conditions, and potentially introduced challenges for the future maintenance and decommissioning of the turbines.

The importance of inherited glacial landforms on predicting ground conditions

Authors: Lydia Kathleen Brown; David Hodgson; Mark Thomas; Natasha Barlow

Organisation(s): University of Leeds; Haskoning

Abstract

Submerged landscapes of the North Sea record multiple cycles of Pleistocene glacial advance and retreat that drove abrupt changes in depositional environment which resulted in complicated stratigraphic successions and substantial heterogeneity in subsurface physical properties. However, the role of earlier glacitectonic landforms on conditioning later landscape evolution has not been widely investigated.

We use ultra-high resolution 2D seismic sections across a 45km^2 study area and 13 geotechnical boreholes from the Ten noorden van de Waddeneilanden (TNW) wind farm in the Southern North Sea to interpret a <60m thick NE-SW trending tunnel-valley fill (~10Km^2) that hosts an erosional feature. The tunnel valley-fill comprises stacked nearshore sediments deposited during an interglacial period. Cone penetration test data confirms that the valley fill is softer than adjacent sedimentary successions. The erosional feature (<44m thick, spanning ~8Km^2), has steep lateral margins, a shallow limb extending from its western flank, and intensely deformed interglacial sediments along its northern flank. Sediment infill consists of glacial till transitioning southward from clay-to sand-rich, which is interpreted to reflect downcutting and removal of interglacial sediments by glacial erosion. This produces a laterally heterogeneous fill contrasting to the more uniform infill of the underlying tunnel valley. Regional context supports the underlying tunnel-valley to be Elsterian, and the younger erosional feature to be Saalian.

This complicated stratigraphy of heterogeneous, over consolidated sediments increases the risk of pile damage or refusal during foundation emplacement and decreases reliability in geotechnical characterisation. A ground model has been built to improve understanding of how geomorphic inheritance can control the resulting distribution of physical properties and establish geotechnical implications regarding ground investigation and foundation design. To further contextualise this complexity of subsurface sediment distribution within glaciated regions, we integrate examples of onshore analogues that exhibit similar glacitectonic and heterogeneous sediment styles.

Offshore Engineering Geomorphology and Terrain Interpretation: A Critical Ground Model Element for Offshore Wind Projects

Authors: Melanie Froude; Sean Pearce; Andrew Mills

Organisation(s): OWC

Abstract

The expansion of offshore wind into deeper water and more complex geological and geomorphological settings, with longer export cables and shallower foundations, demands a more integrated understanding of seabed and shallow subsurface conditions than for more traditional fixed structure foundations in shallower water settings. While geological, geophysical and geotechnical datasets form the foundation of offshore ground models, engineering geomorphology and terrain interpretation are often underutilised.

This presentation demonstrates how the principles of engineering geomorphology and terrain evaluation can be applied offshore to provide valuable insight into seafloor conditions and processes. It also links observable terrain characteristics to subsurface geology and geotechnical properties. Examples from offshore wind developments are used to illustrate how bathymetric datasets at regional and site-specific scales can be integrated with contextual information and other site survey data to identify features from sandwaves to glacial landforms, and scour shadows to mass movement. These features provide important indicators of ground conditions, geological history and ongoing seabed processes that may influence foundation design, cable routing, burial assessment and long-term asset performance.

The presentation explores how terrain interpretation contributes to the development of robust geological and integrated ground models by reducing uncertainty, improving spatial understanding of geological variability and highlighting potential geohazards at both site and regional scales. Particular emphasis is placed on the role of geomorphological mapping and terrain unitisation during early-stage site characterisation, where limited ground-truth data often necessitate greater reliance on regional seabed interpretation and geological reasoning.

The integration of engineering geomorphology within the ground modelling workflow also allows a more process-based understanding of offshore environments and supports more effective risk identification and management. The approach provides a valuable bridge between geological interpretation and engineering decision-making, ultimately contributing to safer, more efficient and more cost-effective offshore wind developments in deeper water environments.

An updated stratigraphic framework for the Inner Moray Firth: Supporting safer Offshore Wind Development

Authors: Simon Blet

Organisation(s): Fugro

Abstract

The Inner Moray Firth, located along the north-east coast of Scotland, represents a geologically complex region and is significantly relevant for offshore wind farm development. The Moray Firth is recognized as an area of great economic interest and is widely known as an advantageous location for offshore renewable energy thanks to its wind regime and relative shallow water depths. The Moray Firth currently several offshore wind farm and associated infrastructure such as export cable routes. Several more offshore wind farms are currently in development. The area comprises a heterogeneous sequence of Pre-Quaternary bedrock to Quaternary deposits, influenced by tectonic phases, eustatic sea level changes, glacial and interglacial stages and subsequent marine reworking.

While the Inner Moray Firth is of great economic interest, its geology within infrastructure foundation depths of interest still contains several uncertainties that influence engineering and geohazard risk. Due to the limited coverage and availability of high-resolution geophysical, geotechnical and publicly available data there is currently insufficient information to develop a robust understanding of the geological evolution, stratigraphic framework and their associated geotechnical properties.

Over the past few years, Fugro has conducted both geophysical and geotechnical site investigations in the Moray Firth area. This paper presents an updated geological model for the Moray Firth area providing constraint and refinement to the geotechnical properties which are playing a key role in reducing uncertainties for optimising turbine foundation design, cable routing and ensuring safe development of the installation.

Geology of the North Channel - insights from Historic Geophysical and Geotechnical Surveys

Authors: Charles Bloore

Organisation(s): Fugro GB Marine

Abstract

Fugro assisted National Grid Electricity Transmission (NGET) and Scottish Power Transmission (SPT) in development and planning of future power transmission in the Irish Sea by reviewing and reinterpreting existing data from previously installed transmission assets. Historical data was used to establish a geological model and a framework for interpretation of future route-specific data.

During this data review, geotechnical and geological data from the North Channel were re-appraised through integration with the geophysical data. The data review highlighted the value of the historic data, and particularly how relooking at the source data can provide new insights on the geology.

Identifying the boundary between the Quaternary and pre-Quaternary sediments is a key constraint for cable installation within the North Channel. This boundary is challenging to interpret on sub-bottom profiler data with bedrock occurring close to or at seafloor. However, cone penetration test (CPT) and vibrocore (VC) data showed soils consistent with Quaternary sediments at seafloor. Sample photographs were a vital input to the interpretation of this critical boundary at the top of the bedrock. British Geological Survey maps showed bedrock at seafloor, the interpretation of the geophysical data indicated bedrock was outcropping; however, the CPT and VC data told a different story, with sand and clay layers present overlying the bedrock units. These sand and clay sediments were previously interpreted to be glacial in origin but when sample photographs were re-appraised the interpretation was updated to weathered bedrock units.

This presentation focusses on an area of complex geology and provides examples of where historic data has been re-appraised to provide insights which can be used to improve the understanding on new developments at the earliest stage.

A regional stratigraphic framework for the Dutch sector of the North Sea derived from offshore wind farm site investigations

Authors: Harry Eady; Charles Bloore

Organisation(s): Fugro; c.bloore@fugro.com

Abstract

(intended to be a poster, would happily give a talk on this as well)

The Dutch sector of the North Sea exhibits a highly variable depositional history, stratigraphy and structural framework resulting from complex interactions between glacial cycles, fluvial processes and sea-level changes from the Late Pleistocene to the present day. Whilst numerous offshore wind farm sites have been investigated in detail, these studies are typically undertaken in isolation, limiting the development of a unified regional geological framework.

This poster presents a representative cross section and regional guide to the subsurface conditions of the Dutch sector through the development of a regional scale geological framework, guided by the integration of seismostratigraphy, regional formation correlation and geochronology from nine offshore wind farm zones with published academic data.

Results highlight regional spatial variability of subsurface formations driven by palaeo-environmental changes, particularly in relation to shoreline positions during glacial advance and retreat phases. Key variations in depositional characteristics and associated geotechnical properties are observed. In the shallow subsurface, the present-day bathymetry provides key insights into the soils identified across the Dutch sector.

The presented framework provides a fresh synthesis of regional geology, enabling improved understanding of subsurface variability and offering a predictive basis for geological conditions in previously uncharacterised areas of the Dutch sector. This work bridges the gap between site-specific investigations and basin-scale geological understanding.

Optimising ground investigations using mooring design parameters for floating offshore wind farms.

Authors: Alex Nurdin; Dr Bartosz Kurjanski; Prof Clare Bond; Dr David Cornwell

Organisation(s): University of Aberdeen

Abstract

Floating offshore windfarms (FOW) use mooring lines and anchors as station-keeping systems which will inevitably interact with the seabed and shallow subsurface. During the planning and design phase of FOW, geotechnical and geophysical ground investigations are necessary to characterise the seabed and ground conditions, most crucially, around locations where contact between the mooring system and the seafloor/shallow subsurface is expected by design. Gathered data are then used to develop ground models and to identify potential geohazards and geoengineering constraints, microsite chains and anchors and plan installation and maintenance operations. However, planned FOW sites often span hundreds of square kilometres in size, which means that both ground investigations and ground modelling will need to negotiate insurmountable volumes of data should the same approach to site investigations be used as for fixed-foundation windfarm sites. Here, we evaluate alternative approaches and differences in data requirements for each element of the FOW mooring and investigate how site surveys can be optimised to address ground characterisation requirements using mooring design parameters as a baseline. The aim is to achieve a sufficient level of ground characterisation while strategically minimising the cost of site surveys. We demonstrate that by understanding mooring design parameters, we can better understand geotechnical and geophysical data coverage requirements which, in turn, helps to optimally plan site investigations. From our findings, optimising how ground surveys are planned has the potential to reduce both the amount of time spent gathering what might be considered unnecessary data and the overall cost of development.

From Soil to Shallow Bedrock: Implications for Site Investigation and Foundation Design in Offshore Wind

Authors: Vanessa Monteleone

Organisation(s): DNV

Abstract

Offshore wind developments are increasingly encountering shallow, heterogeneous bedrock that must be addressed rather than avoided in foundation design. In these environments, variability in rockhead depth, weathering, fracturing, and anisotropy introduces significant uncertainty in the geotechnical parameters controlling pile drivability, bearing capacity, and anchor performance for moored (floating) systems, ultimately influencing installation risk and design reliability.

Characterising these conditions remains challenging. Cone Penetration Testing (CPT) typically reaches premature refusal at shallow rockhead, limiting its ability to constrain engineering properties. Boreholes provide higher-confidence data but are costly and inherently one-dimensional, making it difficult to capture the strong lateral variability that often governs foundation and anchor behaviour. Yet, it is precisely this three-dimensional variability - ranging from intact to highly weathered rock, and from massive to intensely fractured states - that must be understood for robust design.

Geophysical methods offer a means to bridge this gap; however, imaging and interpreting shallow, irregular bedrock remains complex due to signal attenuation, heterogeneity, and anisotropy. Recent offshore wind developments highlight the combined geotechnical and geophysical challenges in reliably defining such ground conditions.

This paper presents a case study of volcanic bedrock shoaling and locally outcropping within an offshore wind farm. It examines implications for layout optimisation and foundation design, and outlines integrated workflows aimed at better constraining uncertainty. These approaches support both fixed-bottom and floating developments by improving confidence in subsurface models where bedrock cannot be simplified or avoided.

Geohazard assessment for IODP Exp 507 - the first borehole to core the 1.2 km North Sea Quaternary depocentre

Authors: Jane Huuse; Mads Huuse; Andrew Newton; Katrine Andresen; Georgina Heldreich; Freek BUsschers

Organisation(s): Seismic Geoscience; University of Manchester; University of Belfast; University of Aarhus; TNO

Abstract

The North Sea Quaternary reaches 1.2 km thickness in a central depocentre extending from south of Dogger Bank to the Outer Moray Firth. IODP3 Expedition 507, planned for 2027, will drill the first full-thickness core through this succession to investigate NW Europe's climatic and environmental evolution and provide a reference dataset for offshore wind, shallow gas and CCS projects. Site selection combined existing 3D seismic and borehole data with new multi-resolution seismic and multibeam surveys to identify stratigraphically complete, mud-prone 'sweet spots' and screen them for geohazards. In the Dogger Bank area, the target succession comprises a 0.9 km early Pleistocene progradational clinoform package overlain unconformably by c. 0.3 km of complex Middle Pleistocene to Recent glaciogenic strata. Key hazards and geological features include gas-bearing iceberg scours, tunnel valleys, glacial tectonics, ice-moulded surfaces, anomalous soft and hard bodies, and shallow gas or peat associated with Holocene channels. The assessment adapted workflows from the oil and gas site survey industry to define drilling sites with substantial stand-off from hazardous features, while demonstrating that conventional industry 3D seismic data inadequately image the upper 50 m of the seabed in shallow water. The multi-resolution dataset therefore provides both a drilling-risk assessment and a template for interpreting near-surface geohazards relevant to offshore wind and other seabed-penetrating infrastructure.

References
Newton et al. 2026. IODP3 Expedition GLACE-NS: Expedition Outline Late Cenozoic Glaciers, Landscapes, Climates, and Ecosystems of the North Sea. https://iodp3.org/documents/expedition-glace-ns-expedition-outline/

Day Two

Assessment of Subsurface Hazard Prediction and Uncertainty Between Sparse SBP Lines Using 2D and 3D UHRS Comparison

Authors: Cai Xinwei; Aryan Shah; Rebecca Bell

Organisation(s): Imperial College London; InX Tech

Abstract

Offshore wind site investigation often relies on sparse 2D sub-bottom profiler or ultra-high-resolution seismic (UHRS) survey lines to characterise shallow subsurface conditions. However, this data provides direct observations only along acquired profiles, leaving uncertainty between survey lines. This is important where shallow seismic horizons, hard layers, buried channels or other potential geohazards vary laterally and may affect foundation design, cable burial and future survey planning.

This project investigates how co-located 3D UHRS data can be used as a reference framework to assess between-line subsurface prediction from sparse 2D survey coverage. The study focuses on interpreted shallow seismic horizons from the Ten Noorden van de Waddeneilanden (TNW) offshore wind area. Existing horizon interpretations, survey-line geometry and seismic attributes will be used to compare sparse 2D line-based information with denser 3D UHRS-derived reference surfaces. A structured prediction dataset will combine horizon observations with spatial and geological variables, including position, distance from survey lines, local horizon geometry and seismic attributes.

Ordinary Kriging will be used as a geostatistical baseline because it incorporates spatial autocorrelation and provides uncertainty estimates (Oliver and Webster, 2015). However, this reliance means prediction performance will degrade where line spacing increases, subsurface structure changes abruptly, or geological complexity is not captured by distance alone. Co-Kriging will test whether secondary variables, such as distance from survey lines, local horizon geometry and seismic attributes, improve the kriging framework, while XGBoost will test whether spatial, geological and seismic-attribute variables improve between-line prediction (Chen and Guestrin, 2016). Results will be validated against withheld 3D UHRS-derived interpretations, allowing prediction error to be evaluated with distance from 2D observations and line spacing.

The expected outcome is to identify line-spacing thresholds where kriging remains useful, where it breaks down, and where machine-learning approaches or additional acquisition may be required.

Subseabed Targets: When Too Many Targets Become Too Much?

Authors: Manuela Jaklić Grbić

Organisation(s): Hidrocibalae

Abstract

Target picking is a near-universal requirement in the interpretation of subseabed geophysical data for offshore geophysical surveys. Within sub-bottom profiler (SBP) datasets, point diffractions (hyperbolas) must be identified and classified. Where infrastructure data is available, hyperbolas can be cross-referenced against known pipeline or cable routes; where magnetometer data is co-acquired, metallic anomalies, potentially associated with unexploded ordnance (UXO) or other obstacles, can be flagged accordingly. In most remaining cases, these diffractions are classified as possible boulders.

The challenge intensifies on long cable routes with wide survey corridors, where the volume of candidate targets increases substantially. In most workflows, each hyperbola must still be picked, classified, and catalogued manually. In sandy or low-clutter environments, this remains manageable. In areas dominated by glacial sediments, particularly till, boulder density can become a significant bottleneck, affecting interpretation time and project cost. Automated boulder detection on shallow seismic data, including SBP, continues to develop, though the high noise-to-signal ratio of these datasets means human review remains necessary to validate results.

This raises the question of whether picking workflows can be made more targeted and efficient without compromising deliverable quality. One approach that would save time is constraining target picking to a defined depth window relevant to burial assessment, given that only the uppermost few metres typically govern cable burial feasibility. A second option is to limit detailed picking to the route position line (RPL). The two could then be combined: detailed picking along the RPL combined with the depth distribution of boulder-rich units, to build a predictive, interpreted density representation of likely target distribution in area where precision is less critical. Ultimately, this raises a further question: how should cost and turnaround time be balanced against the accuracy of the final result?

Pushing Beyond Drilling

Authors: Chris Ruoso

Organisation(s): Next Geosolutions

Abstract

Cone Penetration Testing (CPT) remains a fundamental tool in offshore wind geotechnical investigations; however, increasingly complex stratigraphic conditions continue to challenge the operational limits of conventional seabed systems. In particular, profiles characterised by weak surficial sediments overlying dense or over consolidated strata present significant difficulties, as insufficient initial reaction force and poor seabed coupling often limit penetration capability, leading to premature refusal and compromised data continuity. These constraints frequently necessitate the supplementary adoption of downhole CPT techniques, with associated impacts on productivity and cost.

In response to growing client demand for more efficient, lower risk site investigation strategies, this study presents the development and field validation of an ultra high thrust seabed CPT system designed to extend penetration capability while reducing reliance on time intensive borehole campaigns.

The seabed CPT system, developed by NextGeoSolutions, is capable of delivering up to 380 kN thrust and features a modular configuration ranging from 5 to 48 tonnes. Key engineering innovations include a casing assisted penetration mechanism to enhance load transfer through weak overburden, fluid assisted friction reduction, and an extended skirt to improve seabed coupling and stability. Combined with an integrated seismic module enabling shear wave velocity profiling, the system has been specifically designed to maximise data continuity, quality, and operational reliability in challenging ground conditions.

Field data acquired during offshore campaigns demonstrate a step change in performance, with penetration rate increases of up to three to four times in dense strata and reductions in non productive time exceeding 30%, directly lowering vessel exposure and programme related risks. Furthermore, the significantly higher execution efficiency compared to downhole CPT techniques, particularly in favourable ground conditions, enables substantial reductions in vessel time and overall survey duration. In such scenarios, the combined effect of accelerated CPT acquisition, minimised downtime, and reduced reliance on borehole and downhole methods can result in overall ground investigation cost reductions of up to approximately 40%.

These results demonstrate that high capacity seabed CPT systems can significantly shift site investigation strategies from reactive, sampling led approaches to more efficient CPT led workflows, reducing vessel time, schedule, and cost while lowering overall project delivery risk in offshore wind developments.

Assessing seabed conditions in support of offshore wind development on the Scotian Shelf, Canada

Authors: Pierre-Arnaud Desiage; Jordan B.R. Eamer; Calvin D. Campbell; Alexandre Normandeau; Genevieve Philibert; Jean-Carlos Montero-Serrano; Université du Québec à Rimouski; Louis-Marin Bodiguel-Dupuis; Université du Québec à Rimouski

Organisation(s): Geological Survey of Canada – Atlantic, Dartmouth, Canada; Institut des sciences de la mer (ISMER; UQAR

Abstract

In response to growing interest from the Nova Scotia provincial government and the Government of Canada, the Scotian Shelf has been identified as a priority area for offshore wind energy development and is expected to host Canada's first offshore wind farms during the 2030s. Future developments are likely to be concentrated on shallow offshore banks designated as Wind Energy Areas (WEAs), where the seabed consists of glacigenic deposits overlain by post-glacial sediments. Mandated to develop a comprehensive surficial geology dataset to support decision-making for offshore wind energy developments, the Geological Survey of Canada (GSC) initiated data acquisition efforts on the Eastern Scotian Shelf in 2023. By June 2026, 13 marine surveys had been completed, acquiring a wide range of geoscientific data, including surface and subsurface sediment samples, seabed imagery, near-bottom current and suspended sediment concentration, high-resolution bathymetry, and high-resolution seismic reflection profiles. Grain-size, mineralogical composition, and elemental geochemistry of surface and subsurface sediments, integrated with seabed photography and geophysical data collected over the WEAs were used to characterize depositional environments, identify regional hydrodynamic patterns, and assess potential geoconstraints relevant to offshore wind development. Grain-size analyses of the first 200 surface sediment samples highlight a complex morphosedimentological distribution, with sediments ranging from sandy mud to sandy gravel and exhibiting pronounced spatial variability across the banks. In localized sectors, these heterogeneous mixtures of mud, sand, and pebbles are associated with large cobbles and small boulders, indicating the persistence of coarse glacigenic deposits at the seabed. Characterization of seabed conditions and assessment of geoconstraints over the WEAs on the Scotian Shelf, still preliminary, will be further refined through ongoing analyses and data acquisition.

Multi-Modal Geospatial Deep Learning for Shallow Marine Geohazard Segmentation and Risk Mapping

Authors: Haonan Zhang; Aryan Shah

Organisation(s): InX Tech / Imperial College London; InX Tech

Abstract

This project examines whether deep learning can deliver a faster first-pass seabed risk assessment for offshore wind site investigation. Data from multibeam echosounder, side-scan sonar and magnetometer surveys remain largely hand-interpreted. This slow and labour-intensive process can require several weeks of specialist time per development area or cable corridor, adding cost and delay to downstream engineering decisions. Using data from the Ten noorden van de Waddeneilanden wind farm zone in the Dutch North Sea, the method draws on multibeam bathymetry, high-frequency side-scan sonar and magnetometer measurements that have been co-registered to a common coordinate system and resolution.

A five-level reference geohazard risk map, constructed from geophysical interpretation and available geophysical contacts, will be used to supervise training. The survey area is tiled into 512 × 512-pixel patches, each covering 256 × 256 m. Separate geographical regions are assigned to training, validation and testing, enabling performance to be assessed in previously unseen areas. A U-Net semantic segmentation model will be trained to predict a risk level for each valid pixel.

The workflow is not designed to replace geophysicists or project-specific engineering assessment. Instead, it is intended to provide a screening layer that highlights higher-risk areas, supports early cable-route comparison and flags locations where further interpretation or survey may be required. By automating part of an interpretation process that currently takes weeks, the approach could shorten the survey-to-engineering loop and reduce repetitive manual work. Applied across projects, a reproducible screening layer could improve consistency, reduce the cost of initial risk assessment and free specialist time for complex features that genuinely require expert judgement.

Zonal Site Investigation for Offshore Wind: Geophysical–Geotechnical Fusion for Smarter Ground Models, Lower Risk and Better Bankability

Authors: Jacques Guigne; Sherif Gebaly; Jon Machin

Organisation(s): Subsea Micropiles Ltd /University of Bath; Arcadis Ltd; Subsea Micropiles Ltd

Abstract

Offshore wind site investigations still rely heavily on dense point-sampling boreholes and CPTs, even though the engineering decisions they inform are inherently spatial and three-dimensional. As turbines become larger, projects move into more variable seabed conditions, and development schedules tighten, this mismatch can leave teams with locally precise but field-scale incomplete ground models, driving conservative design assumptions, avoidable contingency, installation inefficiency, and financing uncertainty. The industry has experienced these upsets in multiple projects in recent years.

We propose a zonal, risk-based site investigation philosophy in which large-area geophysical imaging is fused with targeted geotechnical data to define, calibrate and validate engineering ground zones, rather than treating each intrusive point as an isolated truth. In this framework, the seismic technique Acoustic Zoom, which provides volumetric geophysical coverage, is used to map continuity, interfaces and lateral variability, while selected CPTs, boreholes and laboratory data anchor the interpretation and assign representative engineering properties and confidence levels at the zone scale. The method does not replace geotechnics; it makes each CPT and borehole work harder by extending its value into a spatially informed ground model.

The expected outcome is a smarter, potentially leaner investigation strategy: efficient intrusive locations where geology is laterally consistent, more focused sampling where uncertainty or geohazard potential is highest, and a larger effective footprint for design, constructability assessment and installation planning. For developers and engineers, the benefit is improved foundation selection, earlier visibility into difficult ground conditions and reduced risk of unforeseen installation behaviour. For investors and lenders, improved subsurface confidence should support more credible contingencies, stronger technical diligence and better bankability.

At gigawatt scale, where small ground-model errors can compound across dozens of assets, geophysical–geotechnical fusion offers a timely shift from dense point sampling to calibrated, spatially informed zoning—provocative, practical and overdue.

From Sparse Interpretations to Survey-Scale Seismic Classification: An Interpreter-Guided Deep-Learning Workflow for Offshore Wind Site Characterisation

Authors: Miaozhou Tang; Yueyu Jiang; Xiao Zhang; Langming Liang; Xindi Jiang; Simon Warder; Rebecca Bell

Organisation(s): Department of Earth Science & Engineering, Imperial College London

Abstract

Offshore wind site characterisation relies on shallow seismic interpretation to identify stratigraphic variability and support early ground-model development. However, manual interpretation of densely sampled surveys is time-consuming and subject to interpreter variability. Conventional horizon propagation tools can support interpretation of continuous reflectors, but may be less reliable in heterogeneous, discontinuous, or channelized settings. This study presents a supervised deep-learning workflow that uses sparse manual interpretations to predict facies and horizons across a larger 3D seismic volume. The aim is to accelerate interpretation while maintaining stratigraphic consistency and quality control. The workflow used manually labelled two-dimensional seismic sections derived from the publicly available Ten noorden van de Waddeneilanden Wind Farm Zone dataset provided by the Netherlands Enterprise Agency (RVO). These sections were divided into overlapping amplitude patches to train a U-Net-based segmentation model with class-weighted loss. Patch-wise predictions were recombined into complete sections and lightly post-processed to remove isolated artefacts and improve boundary continuity. Performance was evaluated using accuracy, macro F1 and mean intersection over union (mIoU), supported by checks against seismic reflectors and manual interpretations. Predicted facies maps and extracted horizons showed broad agreement with the manual interpretation and good lateral continuity. When applied to the 3D seismic volume, predictions were spatially coherent, followed the main seismic geometry and captured major stratigraphic and channel-like features. The workflow also supports iterative refinement, using interpreter feedback or targeted labelling to improve subsequent predictions. These results suggest that the workflow could support survey-scale facies and horizon mapping by reducing manual effort and providing rapid first-pass seismic interpretation for offshore wind site characterisation. Further work will validate against ground data and test additional offshore wind case studies.

Satellite-Derived Bathymetry as an Operational Monitoring Layer for Offshore Infrastructure

Authors: Damir Matić

Organisation(s): Hidrocibalae d.o.o.

Abstract

For decades, offshore asset management has relied on periodic vessel-based surveys to characterise seabed conditions. These surveys remain the benchmark for accuracy and will continue to play a fundamental role throughout the lifecycle of offshore infrastructure. Yet they are costly, require mobilisation, and capture only a snapshot of a seabed that is constantly evolving. This raises a practical question: does every operational decision require survey-grade data, or information reliable enough to indicate where change has occurred?

This presentation explores how Satellite-Derived Bathymetry (SDB), developed in collaboration with the European Space Agency, can complement conventional hydrographic surveys by providing a repeatable, regional monitoring capability between campaigns. Combining multispectral satellite imagery with physics-based modelling and machine learning, SDB enables observation of large shallow-water areas at far lower cost and higher temporal frequency than vessel-based acquisition. In favourable, optically clear conditions, metre-scale spatial resolution and depth retrieval to roughly 20–30 m are already achievable, with vertical accuracy on the order of 0.5–1.5 m, and rapid gains expected as commercial constellations, revisit frequency and processing techniques mature.

Rather than a static mapping product, SDB is most powerful as a tool for tracking morphodynamic change - migrating bedforms, the onset of scour, post-storm response and the stability of cable landfalls - between surveys. Using examples from ongoing ESA activities, the talk demonstrates how this capability supports monitoring of cable corridors, nearshore sediment dynamics and coastal infrastructure, and informs early-stage route planning by flagging where survey effort is justified before any vessel mobilises.

The future of offshore monitoring is not choosing between satellite observation and hydrographic survey - it is combining them into a smarter, more responsive strategy.

From maps to volumes: example of a 3D geohazard assessment for offshore wind

Authors: Guillaume Michel; Roxana Stanca; Pawel Narozny

Organisation(s): National Oceanography Centre (NOC), Southampton, UK; Gavin & Doherty Geosolutions (GDG

Abstract

With the rapid development of offshore wind renewable projects, carbon capture storage and densification of cable networks, the pressure on the maritime domain is increasing significantly. To accommodate these developments, new projects are being developed in areas with increasingly complex challenging soil and geological conditions. At the seabed and beneath the seabed, unseen variations in sediment or rock properties, as well as geological features can pose major risks to foundation design, cable installation, and long-term asset stability.

To reduce these risks, geohazard assessments are routinely undertaken and typically summarised in risk registers used as live documents, updated as new data are incorporated into ground models. As datasets from multiple sources and resolutions are integrated, these ground models naturally evolve towards 3D representations (Narozny et al., 2025). Despite this, geohazard outcomes are most often communicated through 2D risk maps, which support site zonation but provide limited insight into with regards to depth variability. This disconnect can lead to the underestimation of geohazards, with potential impacts on safety and asset performance, or conversely to overestimation, resulting in unnecessary over-engineering and increased project costs.

To improve geohazard representation, this study presents the elevation of conventional 2D risk maps into a 3D geohazard assessment model for the Tonn Nua offshore windfarm site in the South DMAP area, Ireland. Publicly available datasets and industry interpretation results are used to demonstrate the proposed workflow. A standard 2D risk map is first developed from the available information, which then forms the basis for constructing a 3D geohazard assessment model. The methodology is described, and the benefits and limitations of the 3D approach are discussed in comparison with traditional 2D assessments.

Narożny, P., Maksimovic, J., Michel, G., Stanca, R., & Trindade, L. (2025). Enhancing Offshore Wind Farm Development Through Advanced 3D Ground Modelling.

Evaluating “A New Reliability-Based Design Method for Offshore Wind Turbine Foundations Using Monte Carlo Simulation”: A Systematic and Critical Review

Authors: OLUWATOBI ODUBELA; Dr Joshua R Omer

Organisation(s): Kingston University; Kingston University Faculty of Engineering, Computing and the Environment, LONDON, United Kingdom.

Abstract

Abstract: This paper introduces a reliability-based design approach for offshore wind turbine (OWT) foundations utilising Monte Carlo Simulation (MCS). It responds to the growing demand for renewable energy and to the challenges in designing OWT foundations, including environmental uncertainties and complex soil conditions. The study reviews both traditional and modern structural reliability analysis methods, favouring probabilistic over deterministic strategies. MCS is emphasised for its capability to manage complex, nonlinear systems and to quantify uncertainties related to environmental loads, soil properties, and material characteristics. The proposed framework combines high-fidelity numerical models with MCS to evaluate structural performance regarding serviceability and ultimate limit states. Variance-reduction methods like Latin Hypercube Sampling improve simulation efficiency. Applied to monopile foundations, the method shows strengths in dealing with large diameters and multihazard scenarios. The review underscores the need for accurate geotechnical modelling and soil-structure interaction. This research promotes the move toward probabilistic design to enhance the reliability of OWT foundations and lower the levelised cost of energy (LCOE). Future research should focus on refining MCS techniques and incorporating data-driven monitoring for better cost-effectiveness.

From Data Management to Engineering Insight: An Integrated Workflow Along Offshore Routes

Authors: Alessio Saccon

Organisation(s): Next Geosolutions and Seequent

Abstract

The increasing demand for reliable offshore cable design requires robust integration of geotechnical, geological, and geophysical datasets into consistent engineering frameworks. However, conventional approaches to data management and modelling often result in fragmented datasets, limited traceability, and challenges in developing continuous ground models along linear infrastructure such as export cable routes. This paper presents a technically auditable workflow integrating geotechnical data sets managed cloud based and following integration on 3D geological modelling, enabling a seamless transition from data acquisition to engineering interpretation. The workflow incorporates Cone Penetration Tests (CPT), vibrocore logs, laboratory testing, and high resolution geophysical data into a unified and fully traceable database structure, ensuring data governance, quality control, and auditability throughout the project lifecycle.

The processed datasets are then used to generate numerical 3D models, specifically adapted to address the challenges of long, linear offshore developments. The interpretation framework extends beyond stratigraphic modelling to derive engineering parameters relevant to cable design thermal resistivity. Soil units are classified and parameterised using laboratory measurements and empirical correlations, enabling spatially consistent distributions to be incorporated into cable burial and rating assessments.

The methodology is demonstrated through a field based case study, where integrated data handling and modelling resulted in improved model continuity, reduced interpretative uncertainty, and enhanced parameter consistency along the route. The approach supports more reliable burial and engineering assessments, reduces the risk of over conservative design assumptions, and enables optimised cable installation strategies.

The results highlight how a structured digital workflow can bridge the gap between data acquisition and engineering decision making, delivering measurable improvements in efficiency, traceability, and risk reduction in offshore cable projects.

Exploring the integration of multiple complimentary geophysical datasets to improve potential UXO discrimination in distinct geological settings

Authors: Tom Larby

Organisation(s): Ordtek Limited

Abstract

The EdgeTech Buried Object Sonar System (eBOSS) is an advanced sub-bottom imaging technology designed to detect and characterise buried seabed objects, including both ferrous and non-ferrous targets. As offshore development expands into increasingly complex environments, the ability to identify and discriminate potential unexploded ordnance (pUXO) buried beneath the seabed has become a critical component of geophysical site investigations.

This presentation presents the application of eBOSS data acquired during two offshore UXO surveys undertaken in different geological settings: one in Baltic Sea and the other in North Sea, providing an opportunity to assess the performance across varying geological condition. This presentation evaluates the effectiveness of eBOSS in detecting buried anomalies and assessing their characteristics for the purpose of potential UXO discrimination. Particular attention is given to the influence of local geology on data quality, target visibility, and confidence in interpretation. Through a comparative analysis of the two case studies, the presentation highlights the strengths and limitations of the eBOSS data across different seabed conditions and demonstrates the importance of considering geological context when integrating buried object sonar data into UXO risk management workflows.

The findings provide practical insights for offshore developers, survey contractors, and UXO specialists seeking to optimise the application of sub-bottom imaging technologies in offshore survey.

Machine-Learning Surrogate Optimisation for Floating Offshore Wind Mooring and Anchoring Systems

Authors: Zohreh Moradinia; Joshua Murphy

Organisation(s): Daryad

Abstract

Mooring and anchor systems are critical, cost-driving subsystems for floating offshore wind, and their design is tightly coupled to seabed geotechnical conditions, environmental loading and site-specific ground risk. Conventional design relies on high-fidelity time-domain simulation (e.g. OrcaFlex), where each run can take hours to days and ground parameters such as soil stiffness, shear strength and anchor holding capacity are treated as fixed inputs. Exhaustive exploration of the combined geotechnical-environmental design space is therefore impractical, and engineers adopt conservative safety margins that inflate material use and cost.
This contribution presents a validated machine-learning surrogate framework for accelerating mooring line design under variable ground conditions. Regressor-based surrogates are trained on simulation data spanning a range of seabed stiffness and anchor-soil interaction parameters, and integrated with a multi-objective genetic algorithm (NSGA-II) to navigate the design space without repeated simulation [1].

Applied to a mooring line design case study, the framework minimised manufacturing cost while controlling platform offset and line tension across varying ground conditions, yielding a Pareto front of optimal configurations. It reduced design time from months to minutes and cut construction cost by roughly 40%, with surrogate accuracy exceeding $R^2 = 0.95$.
Ongoing work extends this toward digital ground-model-integrated optimisation for deepwater (>50 m) floating installations, combining physics-informed neural networks—embedding governing structural, hydrodynamic and geotechnical equations to improve generalisation in novel ground regimes while reducing data needs—with Bayesian optimisation to select the most informative simulation points. Together, these enable joint optimisation of floater, moorings, anchors and dynamic cables against site-specific ground models, with explicit uncertainty quantification on geotechnical inputs.
This demonstrates how digital, data-driven workflows convert geoscience complexity into actionable, optimised anchoring design across the UK floating wind pipeline.

Reference: [1] Moradinia, Z., Vandierendonck, H. and Murphy, A., 2024, June. Efficiency and Innovation in Offshore Renewable Energy: A Surrogate Modeling Approach to Mooring System Optimization. In International Conference on Offshore Mechanics and Arctic Engineering (Vol. 87783, p. V001T01A007). American Society of Mechanical Engineers.

Society of Underwater Technology's (SUT) Guidance Notes For Risk Identification And Common Mitigations Related To Unexploded Ordnance (UXO) For Offshore Renewable Energy Developments

Authors: Annelies Vanstraelen; Dorthe Erbs-Hansen; Tobias Kulgemeyer; Robert Mills; Daniel Morgan; Aline Rabain; Joris Siermann; Daniel Sumner; Eric Swanson

Organisation(s): Independent consultant; Ceridwen; Vattenfall; RWE; Sulmara; EDF; N-Sea; OWC; Maritime Discovery

Abstract

The Society for Underwater Technology's (SUT) UXO Special Interest Group (SIG) has developed a comprehensive guidance document to address the risks posed by Unexploded Ordnance (UXO) in offshore renewable energy projects. Aimed at developers, operators, service providers, and government agencies, this framework standardises a phased approach to UXO risk management, integrating industry best practice and emerging knowledge.

UXO—military munitions that failed to detonate—could pose a significant safety hazard during offshore construction and operations. The guidance ensures cost-effective, risk-based mitigation, safeguarding personnel across project lifecycles. Structured in seven phases, it begins with a Desktop Study (Phase 1) for historical research, followed by Geophysical Investigation (Phase 2) for detection, Target Discrimination (Phase 3) for analysis, and Inspection & Mitigation (Phase 4) for direct action. ALARP Sign-off (Phase 5) documents risk reduction, while Risk Management (Phase 6) addresses unexpected discoveries. A final section explores future innovations in UXO risk mitigation.

By adopting this adaptable framework, stakeholders can systematically identify, assess, and mitigate UXO risks in line with best practice, ensuring safety and operational efficiency in offshore renewable energy developments.

Spotting boulders before they stop turbines - part 1: using forward modelling to optimise 3D EHRS acquisition and processing

Authors: Nick Woodburn; Ed Henden; Marc Richards

Organisation(s): RockWave; AtkinsRéalis; Ocean Winds

Abstract

Synthetic forward modelling was applied to optimise 3D extremely high-resolution seismic (EHRS) acquisition for detecting subsurface glacial boulders at a Baltic Sea offshore windfarm. Two representative geological scenarios – undeformed glaciolacustrine sediments and complex glaciogenic deposits – were constructed using velocity and density models derived from seismic and geotechnical data. Boulders ranging from 0.2–2.0 m in diameter were embedded at multiple depths. Acoustic forward modelling simulated realistic acquisition conditions, including environmental effects, for alternative survey geometries. The resulting datasets were processed through a full 3D pre-stack time migration workflow and assessed for detectability.

The study demonstrates that a single-azimuth “race-track” acquisition, when processed on a refined 0.25 × 0.25 m grid, is sufficient to resolve boulders down to 0.5 m diameter within both geological settings. Dual-azimuth acquisition provided limited additional benefit relative to cost.

These findings confirm that forward modelling is an effective tool for de-risking acquisition design, enabling cost-efficient survey planning while meeting stringent detection requirements for offshore wind turbine foundation design.

Quantitative Integrated Ground Modelling - An enhanced ability to optimise OWF site characterisation

Authors: James Faroppa; Madhuri Murali; Joek Peuchen

Organisation(s): Fugro

Abstract

Quantitative Integrated Ground Modelling (QIGM) represents a step-change in offshore geotechnical site characterisation by combining geophysical, geotechnical, and geological data, within a unified, objective, data-driven workflow. Traditional ground models often rely on sparse, one-dimensional observations such as boreholes, whereas QIGM integrates these with spatially continuous ultra ultra high resolution 2D/3D seismic data to generate accurate models of sub-surface spatial variability. This integration enables the prediction of key soil parameters, at almost the resolution of a CPT profile, across entire development areas, rather than only at discrete investigation points, improving spatial understanding and reducing uncertainty in design inputs.

A core feature of the QIGM workflow is its ability to quantitatively estimate and propagate uncertainty. By incorporating probabilistic methods uncertainties associated with data quality, interpretation, modelling workflows, and model assumptions can be explicitly captured and carried through to design parameters. Advanced methods such as elastic seismic inversion, bayesian geostatistics, machine learning, and geostatistical co-kriging further enhance the prediction of engineering properties, allowing more efficient and targeted site investigations to calibrate and refine the model.

By providing a consistent and comprehensive subsurface model, a QIGM optimises SI campaigns, reduces uncertainty in foundation and infrastructure design, and improves decision-making across a project lifecycle. Its use is increasing, as uncertainty within the model is better understood and its reliability for offshore wind foundation ground models is better described

An Integrated Conceptual Geological Model of Offshore Galway Bay for Offshore Wind Site Characterisation

Authors: Onome Omas Okobiebi; Prof Sara Benetti; Prof Andrew Cooper; Prof Mark Coughlan; and Dr Aggeliki Georgiopoulou

Organisation(s): Ulster University; Ulster University Coleraine; University College Dublin; Ternan Energy

Abstract

Conceptual geological models that integrate geological, geophysical, geomorphological, and geotechnical information are essential for reducing uncertainty and supporting offshore renewable energy development. The western Irish continental shelf (WICS) is a complex glaciated margin shaped by repeated advances and retreats of the British Irish Ice Sheet, resulting in a heterogeneous seabed and complex shallow subsurface deposits. This study aims to develop an integrated geological conceptual model that captures these complex scenarios offshore and within the Galway Bay area on the WICS by combining regional geological information, bathymetric, 2D seismic reflection, sub-bottom profiler, borehole, and well data, to interpret the distribution and architecture of Quaternary sediments, glacial landforms, and associated seabed geohazards, such as pockmarks and boulders, and how these features may affect offshore wind development planning. Preliminary interpretation has identified two grounding-zone systems, glacial ridges, moraines, exposed bedrock, in the highly faulted southeastern sector of the study area. Geotechnical analysis of shallow core JC106_183VC from this area identified horizontally laminated sandy, shelly, fragmented mud. P-wave velocity and gamma density measurements indicate constrained modulus (M modulus) values ranging from 5.2 to 8.1 GPa, increasing with depth, suggesting progressive sediment compaction and increasing stiffness. These preliminary findings demonstrate the value of integrating geophysical and geotechnical datasets to improve understanding of the shallow subsurface and provide critical information for site characterisation, geohazard assessment, and foundation design for future offshore wind developments.

Geological Society
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