

Advances in Subsurface Imaging for Offshore Wind Projects

Authors:

Tony LaPierre, Tetra Tech

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The primary zone of interest for offshore wind farm development lies within the upper 50–100 metres below the seafloor (BSF). Traditional site surveys rely on 2D Ultra-High Resolution Seismic (UHRS) data acquired on a grid with line spacing tailored to anticipated subsurface complexity. However, this approach often requires repeated surveys with denser line spacing, resulting in fragmented datasets with limited spatial continuity and vertical resolution. Although 2D seismic surveys have lower initial costs compared to 3D acquisition, they often incur higher cumulative costs due to data redundancy and misinterpretation risks. Limited spatial coverage can lead to significant uncertainty in subsurface characterization and structural misinterpretation. Interpolation between 2D lines is frequently used to link seismic and geotechnical data, but this introduces uncertainty—especially when site-specific hazards require rapid re-siting decisions under constrained conditions. In contrast, 3D UHRS surveys acquired in a single campaign offer continuous, high-resolution subsurface imaging. This facilitates the development of more accurate ground models and robust hazard assessments. When geophysical and geotechnical data are spatially aligned, calibration is improved, supporting quantitative interpretation and more reliable estimation of subsurface properties. 3D UHRS is particularly valuable in geologically complex or glaciated terrains, where it captures small-scale heterogeneities missed by 2D data. Its high frequency content and fine spatial resolution enhance detection of critical features such as buried boulders, improving engineering confidence and supporting informed design decisions. As offshore wind development expands into increasingly challenging environments with tighter budgets and schedules, the use of 3D UHRS will become essential. It enables precise turbine siting, reduces geotechnical risk, and supports advanced processing such as seismic inversion and diffraction imaging. Ongoing research aims to refine workflows and integrate AI and machine learning for enhanced automation and accuracy in boulder detection and soil property assessment.