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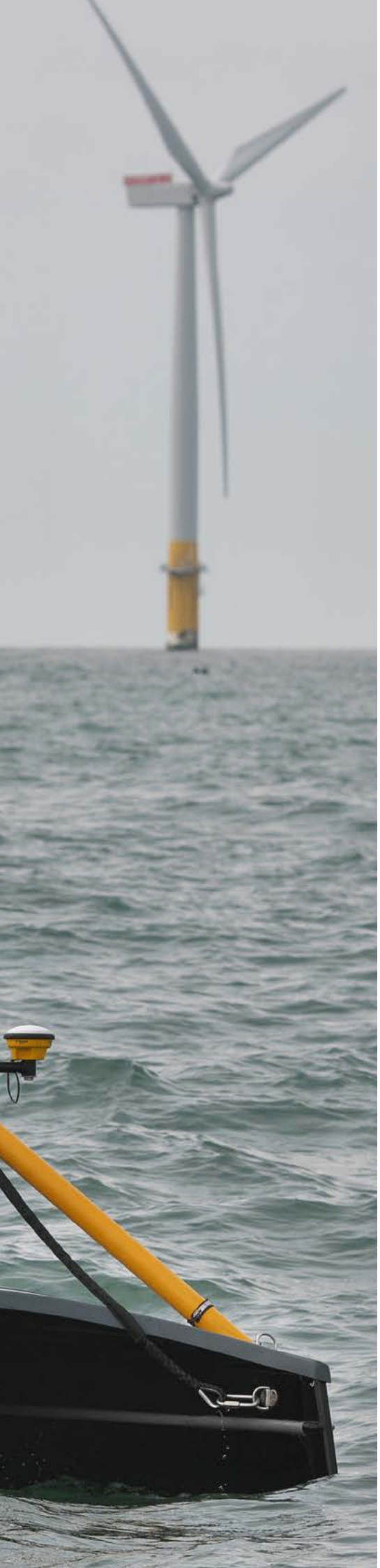
SURVEY
X-03



Harnessing the wind

The Greater Gabbard Offshore Wind Farm, managed by SSE Renewables, stands as an epitome of innovation in the offshore wind energy sector. Since its initiation, the 504 MW facility has been powering over 400,000 UK homes, marking its significance in the UK's renewable energy landscape. In 2020, SSE collaborated with XOCEAN, leading to an ongoing multi-year partnership to provide cutting-edge Operations and Maintenance (O&M) survey support. Through this collaboration, XOCEAN's state-of-the-art Uncrewed Survey Vessels (USVs) have so far accumulated nearly 2,000 operational hours on the Wind Farm across 13 distinct data acquisition campaigns.

The Greater Gabbard Offshore Wind Farm is a collaborative venture between SSE Renewables and RWE Renewables. The wind farm consists of 140 Siemens SWT3.6-107 turbines, two Offshore Substation Platforms (OSP) and one permanent meteorological monitoring mast, across two arrays of turbines, a northern array and a southern array. Each turbine array is connected to one of the OSPs and these are linked by inter-array cable loops and in turn connect to an onshore substation at Leiston, Suffolk, via three 132 kilovolt (kV) cables. Lowestoft acts as the Operations and Maintenance base.

Challenges and objectives

The sustainability and longevity of the Greater Gabbard Offshore Wind Farm depends critically on the quality and reliability of data for its operations and maintenance programs.

An operational wind farm such as Greater Gabbard requires a number of different data needs. These include pre jack-up surveys to prepare for maintenance and servicing; foundation base surveys to ensure the structural integrity of the turbines; cable surveys to ascertain the health and stability of inter-array cables; and seabed morphology assessments to understand seabed movements and maintain turbine stability.

The identification of obstructions or potential hazards is also crucial.

In addition, the data collected needs to be comprehensive enough to evaluate scour levels around the turbine foundations, the condition of existing cables, and the health of cable mattresses.

The strategic positioning of the wind farm in the North Sea, approximately 23km offshore, presents logistical challenges. The water depths of 25 to 35m and the farm's proximity to busy shipping routes compounds the difficulty, requiring advanced logistics planning for every survey.

Beyond the static challenges, the dynamic nature of the seabed results in the need for

Figure 1: Location of Greater Gabbard Offshore Wind Farm

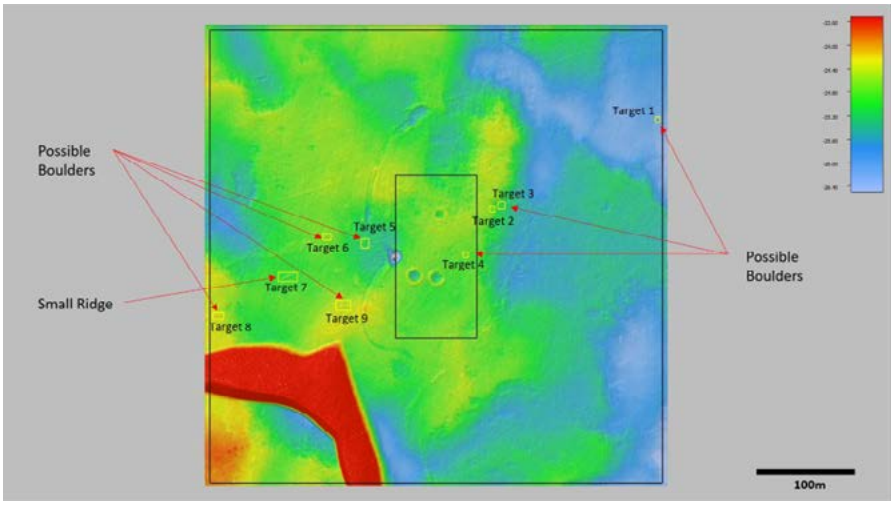


Figure 2: Target identification around GAD03

data that can monitor and understand seabed movements and morphological changes.

XOCEAN's role is to provide high-resolution, accurate, and timely survey data that meets all the outlined challenges, ensuring the continuous and safe operation of the Greater Gabbard Offshore Wind Farm.

Solution

The company deploys an array of advanced solutions to address the intricate challenges. These include advanced uncrewed survey vessels, by leveraging cutting-edge XO-450 Uncrewed Survey Vessels (USVs) for both offshore and nearshore surveys.

State-of-the-art sonar systems are also used, with XOCEAN operating the most advanced Norbit B51 winghead MBES ensuring premium survey data quality, even in challenging sea conditions. Enhanced satellite communication is another feature: The integration of the Starlink Maritime satellite hardware and its network has substantially amplified the efficiency of the USV surveys. This link facilitates online data quality checks (QC) and permits real-time data processing, speeding up post-survey data delivery.

Recognising the importance of sound velocity data across the water column, the XO-450 is fitted with a winch capable of deploying a Valeport Swift SVP while underway.

For assessing the depth of burial across export and inter-array cables, XOCEAN incorporates an Innomar medium parametric sub-bottom profile system ensuring high-resolution sub-seafloor data with outstanding penetration. And to streamline operations, its cyberdeck provides the remote survey team real-time QC capabilities, allowing instantaneous system checks and real-time adjustments to system settings.

In summary, the company's solution strategy centres around leveraging the latest in maritime technology, complemented by consistent procedural improvements and a culture of continuous learning.

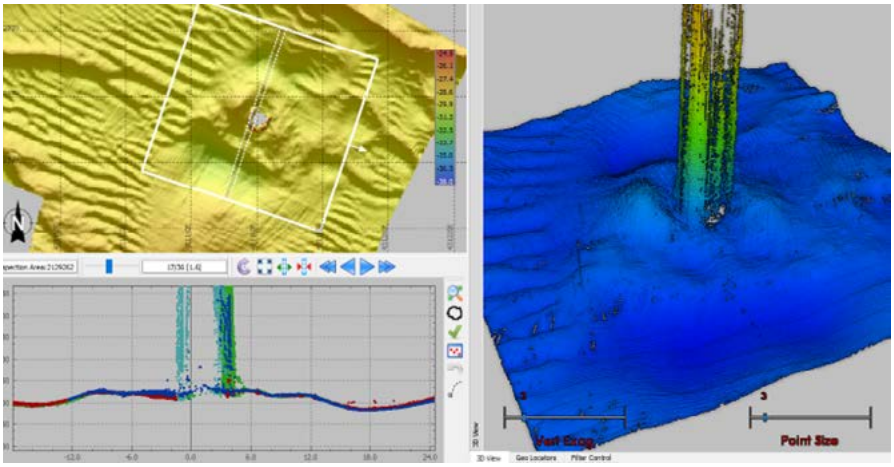


Figure 3. Example freespan and scour imaging

Implementation

For projects at Greater Gabbard, a strong emphasis is placed on meticulous planning, strategic deployment, and local engagement, all underpinned by technological advancements.

Risk management approach

For every deployment at Greater Gabbard, the company develops a detailed Project Risk Assessment and an Emergency Response Plan. By identifying potential hazards and evaluating risk in advance, the company ensures that there are strategies in place to either eliminate or significantly mitigate these risks.

Localized strategy

Understanding the logistical importance of proximity, the USVs are launched and recovered by crane at Southampton Marine Services in Lowestoft. XOCEAN recognizes the value of integrating local resources and uses berths at the Royal Norfolk & Suffolk Yacht Club when necessary. This local approach was further intensified when the firm, acknowledging the benefits of being closer to operations, invested in a dedicated maintenance hub in the region.

Technological integration

XOCEAN's innovative cyberdeck facilitates real-time Quality Control (QC) capabilities for the remote survey team. However, it is a case of continuous process refinement. The lessons learned throughout the ongoing engagement at Greater Gabbard serve as a catalyst for improvements. XOCEAN have introduced measures including Optimized Logistical Planning; Enhanced Training Modules; Structured Weather Reviews; Collaborative Planning; and Efficient Operational Tools.

Adaptability

The drive to constantly evolve means that XOCEAN remains open to refining procedures, adapting to challenges,

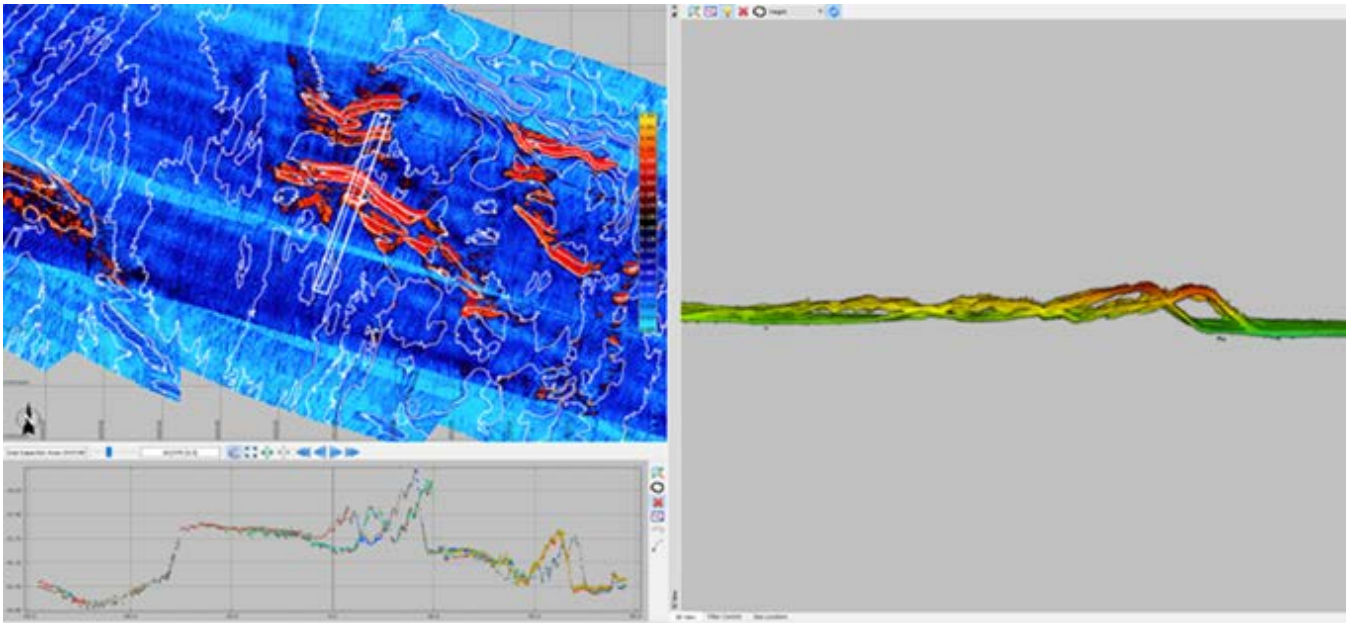


Figure 4: Example of sediment movement across a one week period at Greater Gabbard

and employing innovative ways to enhance the quality and utility of the data provided.

In essence, the implementation strategy adopted by the company at Greater Gabbard is a dynamic blend of risk management, local engagement, technological utilisation, and continuous process optimization, all aiming for operational excellence.

Results

Throughout the multi annual engagement with SSE's Greater Gabbard team, XOCEAN's performance consistently stands out in terms of data quality and timeliness. This is evident through the following achievements.

Comprehensive survey coverage

To date, exhaustive data sets have been delivered. These include conducting advanced jack-up deployments surveys; surveys of inter array cable sections, providing insights into cable mattresses, cable scour, and precise identification of free spanning extents; and evaluation of monopile locations, offering critical data on scour levels and sediment mobility patterns.

Enhanced technology deployment

The application of more advanced sonar technology, complemented by upgraded onboard processing computations and algorithms, leads to the acquisition of superior data. In particular, significant advancements in backscatter acquisition and subsequent processing have equipped the Greater Gabbard team with refined tools that optimize seabed characterization and feature identification accuracy.

Data visualization and utility

Refined to enhance its utility, XOCEAN collaborates closely with the SSE team to tailor data presentation formats, ensuring the data provided is actionable, insightful, and directly addresses the project's specific challenges. It also continuously innovates in how data is displayed, ensuring it not only

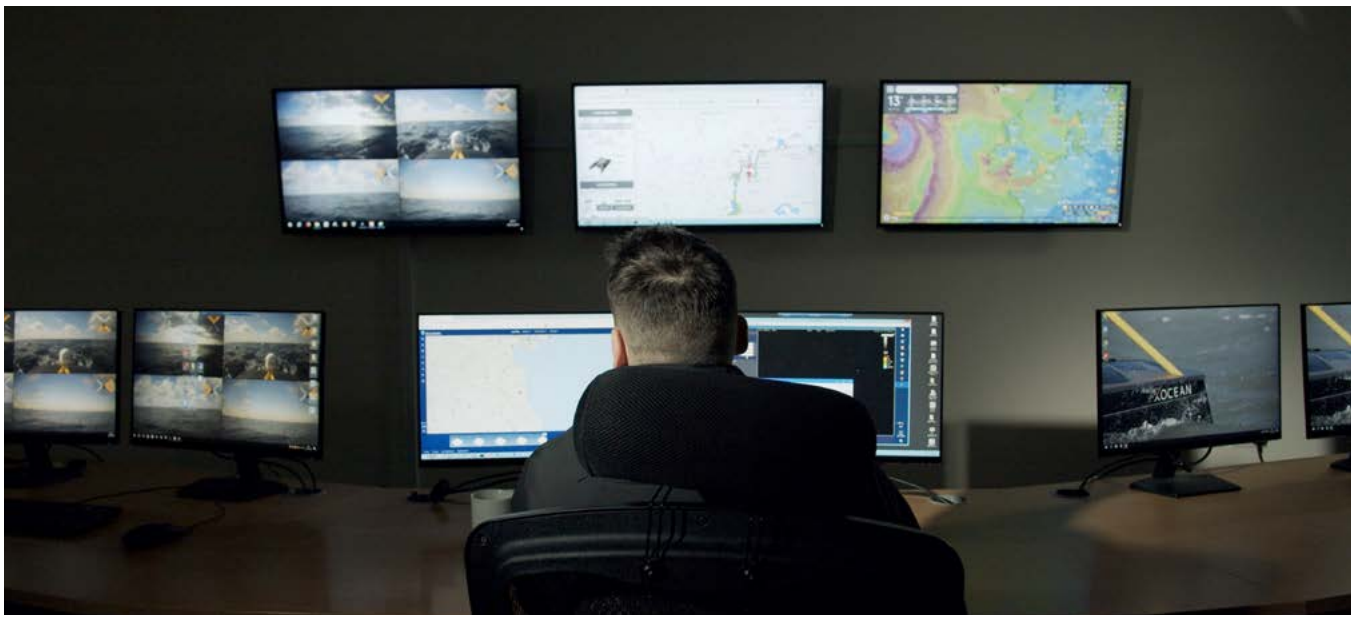


Figure 5: USV operating 'over-the-horizon' and monitored by a USV Pilot remotely via satellite

Figure 6: USVs departing for site

answers existing queries but also provides a proactive perspective, aiding future decision-making processes.

Safety and responsiveness

The proactive approach to safety, through Project Risk Assessments and Emergency Response plans, culminates in a strong safety record throughout the Greater Gabbard survey operations. This demonstrates unparalleled operational agility by rapidly and safely responding to short-notice survey requests, ensuring the data delivered is both timely and meets the exacting standards of the Greater Gabbard Operations team.

Feedback and continuous improvement

The iterative feedback process and lessons learned are not just theoretical exercises. Every improvement, whether technological or procedural, is actively incorporated into subsequent operations. This commitment to refinement ensures that the challenges faced in the dynamic marine environment are not just met but actively anticipated, always keeping the Greater Gabbard project team a step ahead in its operational strategy.

Conclusion

The Greater Gabbard Offshore Wind Farm, managed by SSE Renewables, represents

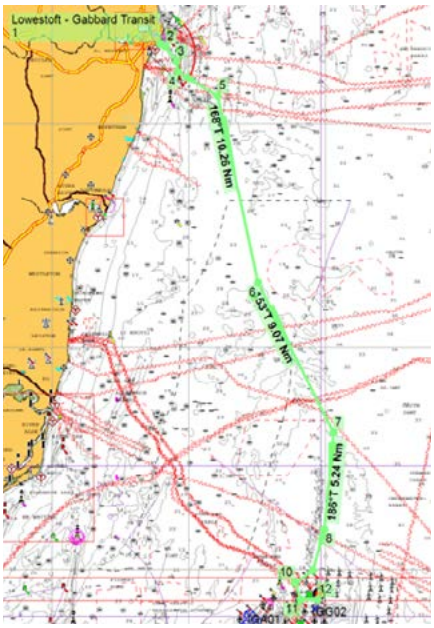


Figure 7: Passage plan from Lowestoft to Greater Gabbard

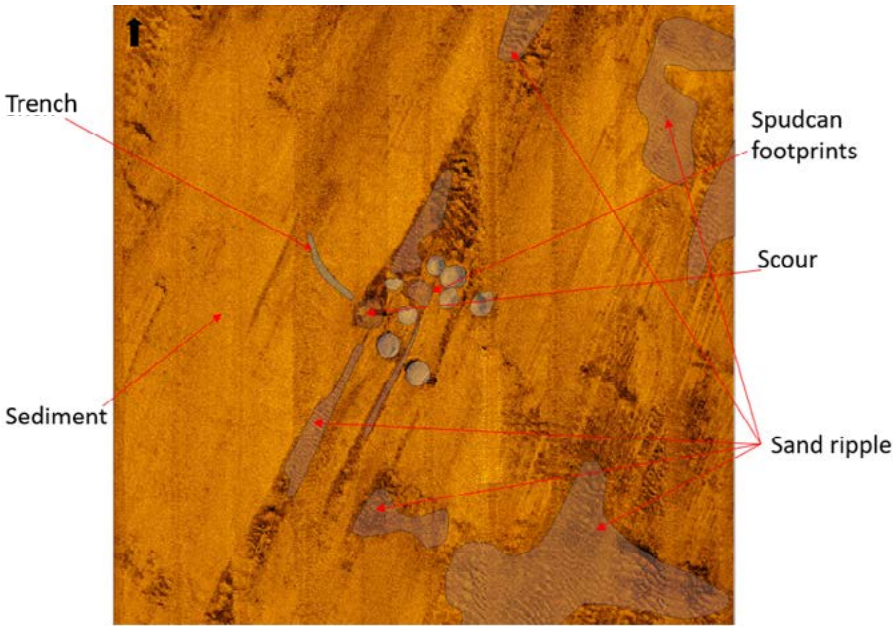


Figure 8: Backscatter mosaic overlaid with interpretation from IGJ01

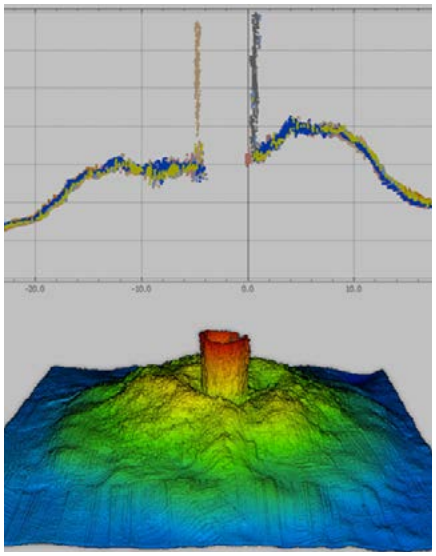


Figure 9: Point cloud and profile of a turbine base with scour protection

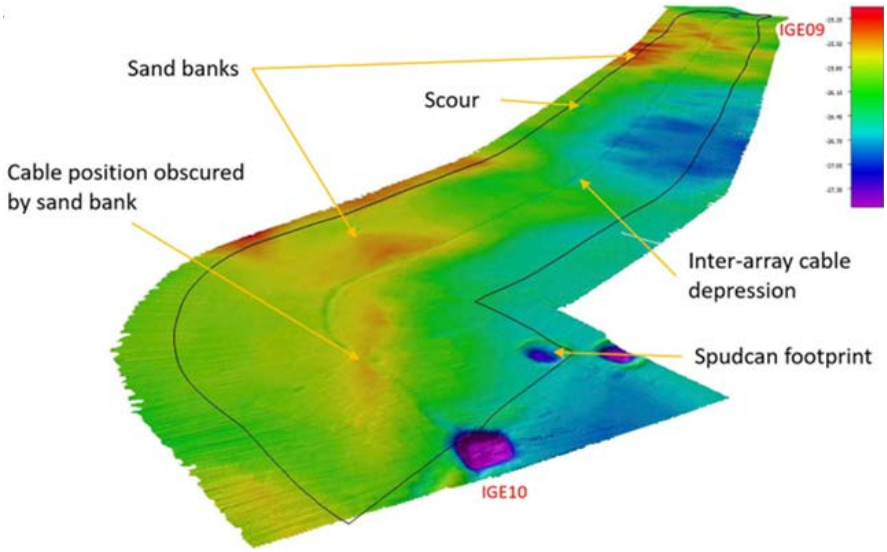


Figure 10: Digital terrain model of the sea bed between IGE09 and IGE10 showing feature identification

a hallmark of innovation, collaboration, and meticulous planning in the offshore wind energy sector. With the formidable challenge of ensuring the ongoing operational integrity of this massive infrastructure, the services rendered by XOCEAN play a key role.

Through deploying state-of-the-art Uncrewed Survey Vessels (USVs) equipped with advanced marine technology, XOCEAN demonstrates an effective and efficient method to monitor, evaluate, and ensure the safety and functionality of the critical elements of the wind farm, from turbine foundations to undersea cables. The systems, capitalizing on cutting-edge technology and advanced sonar equipment, showcase the capabilities of remote, uncrewed operations in challenging maritime environments. This is further enhanced by the rigorous risk management strategies, streamlined operational procedures, and emphasis on continuous learning and improvement.

The consistent high-quality data, real-time quality checks, improved data acquisition, and enhanced data visualization not only satisfy the stringent requirements of the SSE's Greater Gabbard team but also expand the horizons for potential applicability in other similar contexts.

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