# Spiorad na Mara Offshore Wind Farm

## Offshore Project

## Environmental Impact Assessment Report

## Appendix 11.1: Subtidal Environmental Baseline Survey Technical Report, Volume 2c

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OCEAN ECOLOGY

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# Spiorad na Mara OWF Subtidal Environmental Baseline Survey: Technical Report

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## Abbreviations

| | |
|---|---|
| **AL** | Action Level |
| **BAC** | Background Assessment Concentration |
| **BIIGLE** | Bio-Image Indexing and Graphical Labelling Environment |
| **BRUV** | Baited Remote Underwater Video |
| **BSH** | Broadscale Habitat |
| **CAA** | Civil Aviation Authority |
| **CEFAS** | Centre for Environment, Fisheries and Aquaculture Science |
| **CLOC** | Clear Liquid Optical Chamber |
| **CRS** | Coordinate Reference System |
| **CSQG** | Canadian Sediment Quality Guideline |
| **DBT** | Dibutyltin |
| **DDC** | Drop-Down Camera |
| **DEM** | Digital Elevation Model |
| **DMARES** | Drone and Model Aircraft Registration and Education Services |
| **DWE** | DeepWater Exploration |
| **DVL** | Doppler Velocity Log |
| **EC** | European Commission |
| **eDNA** | Environmental DNA |
| **EIA** | Environmental Impact Assessment |
| **EPA** | Environmental Protection Agency |
| **ERL** | Effect Range Low |
| **EUNIS** | European Nature Information System |
| **GBIF** | Global Biodiversity Information Facility |
| **GeMS** | Geodatabase of Marine features adjacent to Scotland |
| **GPS** | Global Positioning System |
| **HD** | High Definition |
| **HDD** | Hard Disk Drive |
| **IDA** | Industrial Denatured Alcohol |
| **INNS** | Invasive Non-Native Species |
| **ISQG** | International Sediment Quality Guideline |
| **IUCN** | International Union for Conservation of Nature |
| **JNCC** | Joint Nature Conservation Committee |
| **LAT** | Lowest Astronomical Tide |
| **LED** | Light-Emitting Diode |
| **LOD** | Limit of Detection |
| **MBES** | Multibeam Echosounder |
| **MD-SEDD** | Marine Directorate Science Evidence Data Digital |
| **MMMR** | Marine Mammal Mitigation Report |
| **MMO** | Marine Mammal Observer |
| **MMO** | Marine Management Organisation |
| **MP** | Megapixel |
| **MPA** | Marine Protected Area |
| **MSFD** | Marine Strategy Framework Directive |
| **MW** | Megawatts |
| **NLP** | Northland Power Inc |
| **NMBAQC** | NE Atlantic Marine Biological Analytical Quality Control |

| | |
|---|---|
| **nMDS** | Non-Metric Multidimensional Scaling |
| **OCAS** | Offshore Cable Area of Search |
| **OCP** | Organochlorine Pesticides |
| **OEL** | Ocean Ecology Ltd |
| **OWF** | Offshore Wind Farm |
| **PAH** | Polycyclic Aromatic Hydrocarbons |
| **PCB** | Polychlorinated Biphenyls |
| **PEL** | Probable Effect Level |
| **PMF** | Priority Marine Feature |
| **PSD** | Particle Size Distribution |
| **QAF** | Quality Assurance Framework |
| **ROV** | Remotely Operated Vehicle |
| **SAC** | Special Area of Conservation |
| **SBAS** | Satellite-Based Augmentation System |
| **SBL** | Short Baseline |
| **SOP** | Standard Operating Procedure |
| **SPA** | Special Protected Area |
| **SSS** | Side-Scan Sonar |
| **SSSI** | Site of Special Scientific Interest |
| **SVP** | Sound Velocity Profiler |
| **TBT** | Tributyltin |
| **TEL** | Threshold Effect Level |
| **THC** | Total Hydrocarbon Content |
| **TOC** | Total Organic Carbon |
| **UAV** | Unmanned Aerial Vehicle |
| **UN** | United Nations |
| **UPS** | Uninterruptable Power Supply |
| **USBL** | Ultra-Short Baseline |
| **WoRMS** | World Register of Marine Species |

# Non-Technical Summary

### Introduction

Ocean Ecology Limited (OEL) were commissioned by Spiorad na Mara Limited (The Project) to undertake a subtidal environmental characterisation survey of the Spiorad na Mara Offshore Wind Farm (OWF) Project Area. The Spiorad na Mara OWF is a proposed fixed bottom OWF located in the North Atlantic Ocean between 5 km – 13 km off the west coast of the Isle of Lewis in the Outer Hebrides. The Project Area is located within the vicinity of but does not intersect any sites designated for the protection of marine features (e.g. Marine Protected Areas (MPA), Special Area of Conservation (SAC)). A desk-based study of the Project Area and its surroundings indicated the potential presence of features of conservation importance. These included Priority Marine Features (PMF) such as kelp beds, seagrass beds and basking sharks, as well as potential Annex I bedrock and stony reef.

### Survey Strategy

A sampling plan was developed prior to the survey being undertaken which included 38 co-located Drop-Down Camera (DDC) and grab stations for macrobenthic, sediment particle size distribution (PSD) and chemical contaminant analysis. A further 12 DDC transects were selected to target potential sensitive habitats that were identified during the review of geophysical data that was made available by The Project (e.g. Potential Annex I reef habitats). Ten baited remote underwater video (BRUV) stations were also included to help describe mobile epifauna and demersal fish species across the Project Area.

During the environmental characterisation survey, the Priority Marine Feature (PMF) habitat 'Kelp beds' was noted within the Offshore Cable Area of Search (OCAS). A comprehensive PMF survey was therefore conducted by OEL utilising Unmanned Aerial Vehicle (UAV) and Remotely Operated Vehicle (ROV) to capture more seabed imagery of the area to better characterise the seabed and map the extent of kelp beds within the OCAS.

Two UAV flights and ROV sampling along 15 target transects resulted in the acquisition of UAV orthomosaic outputs and 730 high-resolution images for subsequent analysis and mapping. ROV video footage also underwent photometric methods to produce an orthomosaic of the seabed along each transect.

### Survey Results

Of the 38 original scope DDC/grab stations, 31 failed DDC pre-screening due to the presence of hard substrate and thus grab sampling was not attempted. This meant only 7 of the original stations were grabbed. An additional 17 DDC/grab stations were proposed to increase coverage of the Project Area, of which 11 failed DDC pre-screening and grabbing was therefore not attempted. Of the remaining 6 stations where grabbing was deemed suitable, four were successful whilst two failed due to the presence of cobbles in the jaws of the grab which prevented sample collection. In total 11 stations were successfully grabbed and of these, it was only possible to collect chemical contaminant samples at 7 stations. The result of this was 55 DDC stations, 11 grab samples for macrobenthic and PSD analysis, and 7 samples for full analysis (macrobenthic, PSD and chemical contaminants). The 12 original scope DDC transects were successfully sampled, and BRUV frames were deployed at 7 stations yielding 7 hours of baited video footage. It was not possible to sample the remaining three BRUV stations due to poor weather.

**Geophysical Analysis**

The geophysical data covering the Project Area collected prior to the environmental survey in spring and summer 2023 was interpreted as predominantly heterogeneous displaying high reflectivity, indicative of hard seabed features.

**Seabed Imagery Analysis**

Across the Project Area as a whole, a total of six European Nature Information System (EUNIS) Broad-Scale Habitats (BSH), five EUNIS Level 4 habitat complexes, five EUNIS Level 5 biotope complexes and four EUNIS Level 6 biotopes were identified in the DDC seabed imagery. The most commonly occurring of these was A4.214 'Faunal and algal crusts on exposed to moderately wave-exposed circalittoral rock' identified in 360 of the 550 total images analysed. Annex I reef was present in approximately 74 % of the DDC images analysed during the environmental characterisation survey with regions of low stony reef and bedrock reef identified in the north and northeast of the site, respectively. Areas of coarse sediments and sands identified as the habitat complexes A5.14 'Circalittoral coarse sediment' and A5.26 'Circalittoral muddy sand' respectively, were also identified in the southernmost region of the Project Area. An area interpreted as biotope complex A3.214 '*Laminaria hyperborea* and foliose red seaweeds on moderately exposed infralittoral rock' was identified towards the northeastern corner of the OCAS based on DDC imagery. This biotope complex was located on an expanse of seabed assigned as Annex I bedrock reef. A3.214 which is a component biotope of the 'Kelp beds' PMF. Kelp was observed in a localised nearshore area situated towards the southeast of the OCAS. The locations of the kelp, which could be considered as a potential 'Kelp Bed' PMF, identified during the environmental characterisation survey loosely corroborated the existing mapping of PMF habitats based on the GeMS geodatabase collated by NatureScot and Joint Nature Conservation Committee (JNCC). This shallow section of the OCAs was further investigated by ROV during the PMF survey and the majority of the seabed was characterised as complex with diverse rock habitats and biotopes typical of tide-swept environments. The PMF habitat 'Kelp beds' was confirmed in the area as component biotope A3.214 '*Laminaria hyperborea* and foliose red seaweeds on moderately exposed infralittoral rock'. Conversely, deeper areas of the OCAS investigated by ROV during the PMF survey were identified as A4.214 'Faunal and algal crusts on exposed to moderately wave-exposed circalittoral rock'. Many of the images obtained nearer the shore contained mosaic habitats such as areas of infralittoral rock surrounded by cobbles and pebbles supporting red seaweeds or areas of rock surrounded by barren sediments with sparse fauna.

Based on the taxa present where Annex I reef was observed in the DDC seabed imagery, an additional assessment was undertaken to understand the functionality of the reef ecosystem and infer its ecological value (EV). Taxa richness (S) and taxonomic distinctness (Δ+) were calculated based on the taxa recorded in the seabed imagery and used to map diversity hotspots indicative of the complexity of the reef system present. Most of the Project Area included reef of good EVs with only a few discrete patches of barren or sparsely colonised reef which resulted in a low and/or poor reef EV. Additionally, predictive mapping of reef EV was attempted based on taxonomic distinctness (Δ+) and the physical environmental characteristics of the Project Area, however, model performance was very low and had high variability indicating that predictions of taxonomic distinctness (and therefore reef EV) were inconsistent and most likely due to chance.

Annex I reef was present or predicted to be present in 97 % of the ROV images collected along the 15 transects investigated during the PMF survey. The majority of the reef observed across this area was bedrock with low stony and medium stony reef also present. Imagery analysis found the PMF habitat ‘Kelp beds’ to be present in 68 % of all images with all but transects T01 and T02 containing kelp. These two transects were located in the southwestern corner of the nearshore OCAS. The absence of kelp at these two transects may be due to either waters being too deep or energy too strong to support kelp.

**BRUV analysis**

A diverse range of taxa were identified in the BRUV footage collected from across the Project Area with six major morphological groups observed: Bony fish, Cartilaginous fish, Crustacea, Echinoderms, Molluscs and Marine Mammals. A total of 21 different species were recorded across the survey area. Station B007 had the highest total abundance with 106 individuals recorded. This was due to the high number of sand lances (*Ammodytes* sp.) at this station. Station B007 also recorded the lowest species richness with just two species present. Seventeen of the taxa observed were of economic and/or conservation importance including PMF and Annex V species as well as species listed under the UK List of Priority Habitats and Species, the IUCN Red List of Threatened Species (2010) and the OSPAR List of Threatened and/or Declining Species and Habitats (2008).

**Sediment PSD**

Sediments across the Project Area were relatively homogenous with high sand content across all but station STAD002. Gravel content at station STAD002 was significantly higher than all other stations. This station was located away from the majority of other stations and may represent an area of transition between soft and hard substrate. The soft sediments encountered during grab sampling across the Project Area are representative of the PMF habitat ‘Offshore Subtidal Sands and Gravels’.

### Sediment Chemistry

Except for Nickel (Ni), all metals analysed were recorded below all national and international reference levels. Ni concentrations exceeded CEFAS Action Level (AL) 1 at stations ST023 and STAD008 and OSPAR Background Assessment Concentrations (BAC) at STAD008. Both stations were located in the southwestern region of the Project Area, however, none of the surrounding stations demonstrated elevated concentrations. Ni along with other heavy metal contaminants are often associated with waste produced by industrial activity; however, given the nature of the surrounding land use, the exact cause of this is not obvious. All other chemical contaminants including Polycyclic Aromatic Hydrocarbons (PAH), Polychlorinated biphenyls (PCB), Organochlorine Pesticides (OCP) and organotins were recorded below the Limit of Detection (LOD). Where contaminants occurred below the LOD or below AL1, BAC and the Threshold Effect Level (TEL), then they were considered to be of no concern.

### Macrobenthos

Within the 11 macrobenthic samples collected across the Project Area, a total of 957 individuals and 95 taxa were recorded. Nematoda (roundworms) were the most abundant taxa closely followed by the bivalve *Goodallia triangularis* and the polychaete *Pisione remota*. Annelida taxa were the highest contributors to overall abundance and diversity. Abundance and diversity were relatively homogenous across the Project Area as grab samples were only collected in areas of soft sediments with similar characteristics therefore supporting a similar macrobenthic community. The multivariate analysis of the macrobenthic data identified just one macrobenthic group which did not include any biotope defining key taxa of any EUNIS classifications, with most of these taxa commonly found in UK waters. The Invasive Non-Native Species (INNS) polychaete *Goniadella gracilis* was identified in macrobenthic samples at two stations.

### Habitat Mapping

All habitats and biotopes were digitally mapped utilising the geophysical data and results of the seabed imagery analysis as well as grab samples where available. The key broadscale habitats included A4.2 'Moderate energy circalittoral rock', A5.2 'Subtidal sand', and A5.1 'Subtidal coarse sediment'. The biotope A4.214 'Faunal and algal crusts on exposed to moderately wave-exposed circalittoral rock' dominated both the array and OCAS.

Annex I reef covered an approximate area of 266 $km^2$, accounting for ~ 95 % of the total survey area. Over 95 % of total reef cover was mapped with high confidence.

The PMF habitat 'Kelp beds' was mapped across a 10 $km^2$ area within the shallow section of the OCAS. This habitat is of high ecological importance and is commonly found around the Scottish mainland and islands, especially off the west coast, including the Hebrides and Northern Isles. ROV imagery was utilised alongside acoustic data and UAV outputs to define boundaries and map the extent of this PMF habitat. Kelp beds were found to be almost continuously present along the entire length of the nearshore region of the PMF survey area, mapped with high confidence in the north and central regions and low confidence to the south due to sparser ground-truthing data. No kelp occurred in waters deeper than 20 m. Interpretation of the acoustic data identified some potential gaps in the extent of kelp, the most prominent of which was located within the area of search of cable route option 2B.

The soft sediments encountered across the Project Area represent the PMF habitat 'Offshore Subtidal Sands and Gravels'. This is one of the most common habitat types found around the British Isles, often home to diverse infaunal communities dominated by polychaetes and small bivalves.

# 1. Introduction

## 1.1. Project Overview

The Spiorad na Mara Offshore Wind Farm (OWF) is a proposed fixed bottom OWF located in the North Atlantic Ocean between 5 km – 13 km off the west coast of the Isle of Lewis in the Outer Hebrides. The Spiorad na Mara OWF site, 'The Project Area', has an expected nominal capacity of 900 megawatts (MW) and is owned by Northland Power Inc (NLP) (75.5%) and ESB (24.5%) with NLP leading the development, operation, and construction of the project (Figure 1).

Spiorad na Mara Limited (The Project) contracted Ocean Ecology Limited (OEL) to undertake a subtidal environmental characterisation of the Project Area in October 2023. This was aimed to provide a description of the biological and physico-chemical nature of the marine environment across the proposed Project Area by collecting seabed imagery and sediment samples. This work will form a baseline for future monitoring. Additionally, the subtidal environmental characterisation survey was also aimed at providing accurate ground-truthing of geophysical data collected during a previous survey campaign conducted by The Project in summer and autumn 2023. Following the comprehensive environmental characterisation survey conducted in Autumn 2023, areas of the Priority Marine Feature (PMF) habitat 'Kelp beds' were noted within the Offshore Cable Area of Search (OCAS) and initially mapped based on DDC imagery and acoustic data. To better define the 'Kelp beds' PMF, a dedicated survey was carried out in September 2024 targeting kelp beds and their boundaries/extent within the OCAS. This survey also aimed to further define the extent of Annex I reef and update previous habitat mapping within the OCAS and is referred to throughout as the 'PMF survey'..

This report provides a summary of the survey methodologies employed during the surveys, presents mapping of the habitats / biotopes encountered, and sets out a detailed description of the biological and physico-chemical status of the substrates encountered across the Project Area. This was achieved through detailed interpretation of Drop-Down Camera (DDC) and Remotely Operated Vehicle (ROV) imagery combined with information on the macrobenthic and physico-chemical characteristics of sediments sampled via grab sampling. This information was considered alongside high-resolution Multibeam Echosounder (MBES), and Side-Scan Sonar (SSS) data collected by The Project to allow for the creation of full coverage habitat and biotope mapping across the Project Area including the delineation of important and environmentally sensitive features (e.g., Annex I habitats and PMFs).

## 1.2. Aims and Objectives

The primary aim of the surveys was to provide a comprehensive characterisation of the benthic environment across the Project Area to inform the subsequent Environmental Impact Assessment (EIA).

The key objectives of the technical report are to:

- Provide an initial description of the seabed habitats within the Spiorad na Mara OWF Project Area. This was achieved using DDC and sediment grab sampling followed by subsequent laboratory analysis to provide accurate ground–truthing of geophysical data collected by The Project.
- Describe the benthic communities present within the Project Area, including biotopes, abundance, species richness, representativeness, rarity and sensitivity. This covered the range of water depths across the site and included both infaunal and epifaunal communities.
- Identify and assess the status of species and habitats of conservation importance, including PMFs, Annex I protected species and habitats, and Annex V species[1] of the Habitats Regulations, species listed under Schedule 5 of the Wildlife & Countryside Act[2], OSPAR species and habitats[3] and designated features of the Marine Protected Area (MPA) network (e.g., Special Area of Conservation (SAC)).
- Confirm the presence / absence of any invasive non-native species (INNS), and species non-native to the local habitat types (e.g., hard substrate specialists in a wider sedimentary habitat).

  Identify mobile, pelagic species present within the Spiorad na Mara OWF Project Area using baited remote underwater video (BRUV).

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[1] https://jncc.gov.uk/our-work/article-17-habitats-directive-report-2019-species/
[2] https://www.legislation.gov.uk/ukpga/1981/69/schedule/5
[3] https://www.ospar.org/work-areas/bdc/species-habitats/list-of-threatened-declining-species-habitats

## 2. Current Understanding

The following section is based on the findings of a desk-based study of the Project Area with data sourced from EMODnet, NatureScot and JNCC websites as well as from available literature (JNCC, Tyler-Walters et al. 2016, EMODnet 2021, NatureScot 2021).

### 2.1. Site Information

The Spiorad na Mara OWF site consists of an array area and an OCAS collectively referred to as the 'Project Area' located in the Outer Hebrides (North Atlantic) to a distance of 13 km off the west coast of the Isle of Lewis.

Bathymetry data from EMODnet suggested the seabed within the array area to be gently sloping (< 2°) with water depth ranging from approximately 40 to 60 m Lowest Astronomical Tide (LAT). Outcrops or near-surface rock were believed to be present in the south and southwest of the site. Steeper slopes were indicated within the OCAS, particularly closer to the coast. Water depths within the OCAS range from approx. 20 – 40 m LAT, with shallow water (< 10 m) a few hundred meters from the coastline (EMODnet 2021).

### 2.2. Existing Habitat Mapping

The 2021 EUSeaMap broad-scale predictive model classifies and maps intertidal and subtidal habitats according to the European Nature Information Systems (EUNIS) classification criteria. The system is able to identify keystone species that have been evidenced to inhabit areas with certain environmental conditions and can therefore act as an indicator, allowing inferences of overall community composition.

Based on EUSeaMap 2021 data, the seabed across the site was thought to be characterised by a range of substrata, including boulders and cobbles, pebbles and shingle, coarse sands, sands, fine sands, muds, and mixed sediments (EMODnet 2021). It was also interpreted from preliminary geophysical data provided by the project, that large areas of exposed, outcropping or very shallow rock would be present at the site. However, due to the paucity and sparse nature of ground-truthing data this type of predictive habitat mapping heavily relies on high-degree interpolation and therefore is not expected to be representative of highly variable substrates or patchy/mosaiced habitats and it is best used in a broad-scale context.

EUSeaMap mapping for the Project Area predicts the majority of the array area as A5.14 'Circalittoral coarse sediments' with the southeastern boundary and within the OCAS the EUNIS Broad-Scale Habitat (BSH) A4.1 'Atlantic and Mediterranean high energy circalittoral rock'. The nearshore region of the OCAS is predicted to comprise of the EUNIS BSH A3.1 'Atlantic and Mediterranean high energy infralittoral rock' (EMODnet 2021) (Figure 1).

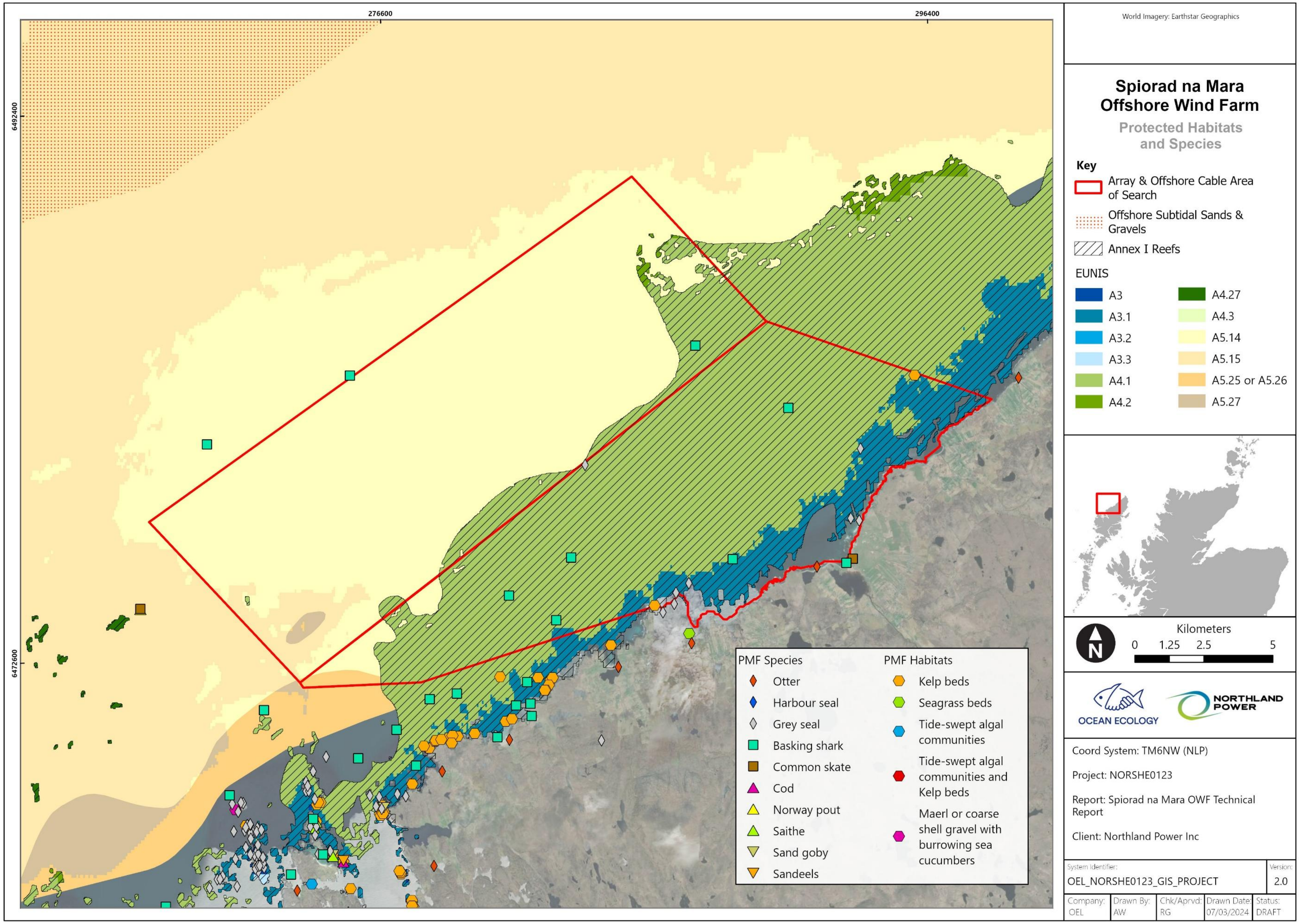


**Figure** 1 Protected habitats and species within the vicinity of the Project Area (SpatialData.gov.scot; JNCC Resource Hub).

## 2.3. Relevant Conservation Legislation

European Commission (EC) Council Directive 92/43/EEC on the Conservation of Natural Habitats and of Wild Fauna and Flora, commonly known as the 'Habitats Directive', ensures the conservation of a wide range of rare, threatened endemic animal and plant species as well as habitats. The EU Habitats Directive (1992) was transposed into UK law by The Conservation of Habitats and Species Regulations 2017 within 12 nautical miles (nm), and The Conservation of Offshore Marine Habitats and Species Regulations 2017 between 12 nm out to 200 nm or the UK Continental Shelf. Under these regulations, a network of Special Protected Areas (SPA) and SACs have been established to grant protection and conservation to rare and threatened habitats and species. The Project Area lies within the 12 nm.

The Marine (Scotland) Act 2010 provides the legal mechanism to assist in the conservation and enable the recovery of protected wildlife and habitats within nature conservation MPAs. This together with the UK Marine and Costal Access Act 2009 allowed NatureScot to lead on nature conservation matters in the waters adjacent to Scotland including the development of a list of PMFs.

### 2.3.1. Designated Sites

The Project Area is located within the vicinity but does not overlap any site of conservation interest or designation (JNCC Resource Hub; NatureScot SiteLink; Ramsar.org). Figure 2 provides an overview of all the designated sites within the vicinity of the Project Area. Further information on each site is also provided in the following paragraphs.

**North-East Lewis MPA**

The North-East Lewis MPA is situated approximately 30 km northeast of the Project Area and covers an area of 907 $km^{2.}$ This MPA is designated for the protection of the Risso's dolphin (*Grampus griseus*) and sand lances (*Amomodytes marinus* and *Ammodytes tobianus*). The Risso's dolphin, which typically prefer deeper waters, gather closer to the shore around the Isle of Lewis, particularly during the summer months (Figure 2).

**Inner Hebrides and the Minches SAC**

The project site is approximately 20 km to the west of the Inner Hebrides and Minches SAC, which covers an area of 13,813.9 $km^2$ off the east coast of Lewis. This SAC is designated for the protection of the harbour porpoise (*Phocoena phocoena*) (Figure 2).

**Loch Roag Lagoons SAC**

Loch Roag SAC is a complex of silted lagoons located approximately 4 km south of the project area at its closest point and is designated due to the presence of the PMF and Annex I habitat 'coastal lagoons.' Tob Valasay, one of the lagoons, contain a diverse range of subtidal habitats, including rocky outcrops, boulders, and muddy sand, with softer mud in the eastern basin, and boulders, cobbles and shell-gravel in the narrow inlet linking the lagoon towards the east of Loch Roag. A range of communities are present including beds of eelgrass (*Zostera spp*). and tasselweed *Ruppia spp*., turfs of marine algae and stands of large brown algae. Loch Shader is a smaller, mainly brackish lagoon with soft, sheltered mud and sand sediments, with some boulders supporting a range of species including kelp, anemones and sponges. (Figure 2).

**Tràigh na Berie SAC**

The Tràigh na Berie SAC is located approximately 12 km southwest of the Project Area and is one of four sites in the Western Isles selected for the conservation of machair, a distinctive sand dune formation typically vegetated and supporting a diverse floral and faunal community (Figure 2).

**Loch Stiapavat Site of Special Scientific Interest (SSSI)**

The Loch Stiapavat Site of Special Scientific Interest (SSSI) is located approximately 14 km northeast of the Project Area, on the northernmost point of the Isle of Lewis. It covers an area of 0.35 $km^2$ and is designated for the protection of machair (Figure 2).

**Loch na Cartach SSSI**

The Loch na Cartach SSSI is located approximately 16 km from the Project Area on the eastern coast of Lewis. The SSSI is 0.25 $km^2$ and is designated for the protection of maritime cliffs (Figure 2).

**Tong Saltings SSSI**

The Tong Saltings SSSI is located on the eastern coast of the Isle of Lewis covering an area of 4.4 $km^2$. The marine element of this site is designated for the protection of mudflats, saltmarsh and sand dunes (Figure 2).

**Lewis Peatlands RAMSAR**

The Lewis Peatlands RAMSAR site is a SPA located approximately 5 km inland (at its nearest point) from the Project Area. It is made up of a near-continuous mantle of blanket bog interspersed by a large number of small pools and locahans. The site qualifies by supporting one of the largest and most intact known areas of blanket bog in the world. The vast expanse of this relatively undisturbed peatland supports a diverse range of associated flora and fauna, including 31% of the world population of dunlin (*Calidris alpina schinzii*).

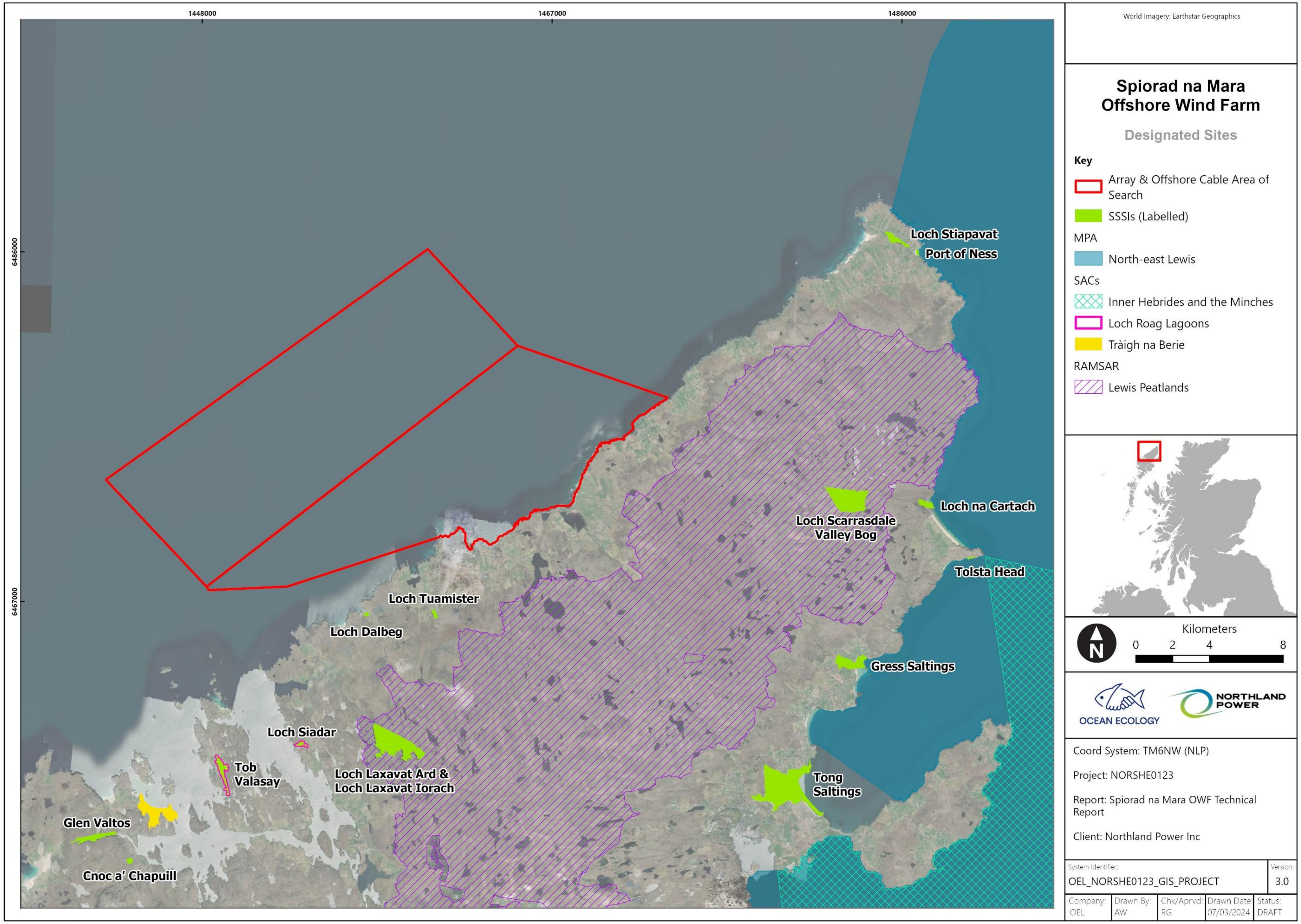


**Figure 2** Designated sites within the vicinity of the Project Area (JNCC Resource Hub).

### 2.3.2. Potential PMFs

PMFs are habitats and species that are marine nature conservation priorities in Scottish waters (Tyler-Walters et al. 2016). The following PMF habitats and species described below have been recorded within or near to the Project Area. These PMF habitats are mapped in Figure 1 (SpatialData.gov.scot).

**Kelp Beds**

The kelp *Laminaria hyperborea* is commonly found around the coast of Scotland and its islands in shallow waters (to a maximum of 20 – 30 m) and it can form forests and parks in rocky coastal areas, under a variety of wave and tidal conditions. The kelp provides a canopy under which a wide range of animals and other seaweeds can thrive. The rocks below the kelp are often encrusted with coralline algae or support cushion forming fauna, such as sea anemones, sponges and sea squirts. Small crustaceans and worms live among the kelp, while sea urchins and sea snails graze on the seaweeds, and fish find shelter from predators among the fronds. Scotland holds a significant proportion of the UK records of kelp beds and therefore the habitat is considered to be nationally important. Threats to this habitat include activities that alter wave exposure or tidal flow. Observations of this habitat within the Project Area were obtained from the GeMS geodatabase collated by NatureScot and JNCC and have been reported as EUNIS biotope A3.2131 '*Laminaria hyperborea* forest and foliose red seaweeds on tide-swept upper infralittoral mixed substrata' and EUNIS classification A5.52 'Kelp and seaweed communities on sublittoral sediment'. Records of this habitat type appear in high densities along the coastal areas to the south, just outside the boundary of the Project Area as well as a single record to the northeast within the OCAS boundaries (Tyler-Walters et al. 2016) (Figure 1).

**Offshore Subtidal Sands and Gravels**

Sand and gravel sediments are the most commonly occurring subtidal habitat around the British Isles. They often support diverse infaunal communities including polychaetes, burrowing brittlestars and bivalves as well as mobile predators such as flatfish, starfish, crabs and hermit crabs. Offshore sand and gravel habitats also support a variety of internationally important commercial fisheries. These habitats are found from sheltered to highly wave exposed conditions with sediment type and bedforms highly dependent on the physical environmental conditions present. In certain instances, these features may qualify as Annex I Sandbanks that are slightly covered by seawater all the time (Tyler-Walters et al. 2016). This habitat is present offshore and to the northwest of the project area (Figure 1).

**Maerl Beds**

Maerl beds are formed by red seaweeds with a hard chalky skeleton that grows to form small nodules or short branched shapes. Three maerl species exist across the UK and the relative composition of these within a bed and the proportion of living / dead maerl varies with factors such as salinity and wave exposure. Maerl needs light to grow, so living maerl is restricted to the surface of the beds overlying the chalky skeletons of dead maerl. Maerl is typically found in coarse clean sands and gravels either on the open coast or in tide-swept channels to a depth of about 20 m. In high abundance, maerl can form loosely interlocking beds and support a diverse community of plants and animals including other PMFs. Scotland has approximately 30 % of the maerl beds in north-west Europe and most of the beds in the UK. They are sensitive to physical disturbance, smothering, increased suspended sediment and changes in water flow. Pressures are known to include mobile demersal fishing activity, aquaculture, pollution, and extraction. No observations of this habitat exist within the Project Area, however observations in proximity of the Project Area (to the Southwest of the project boundary) have been reported as EUNIS classification A5.51 'Maerl beds' (Tyler-Walters et al. 2016) (Figure 1).

**_Zostera_ (Seagrass) Beds**

Seagrass (or eelgrass) beds are biogenic habitats formed by angiosperms adapted to saline conditions. In the UK, two species of seagrass are known to form beds: *Zostera marina* and *Zostera noltii*. The first species is found in fully marine conditions in the intertidal to sublittoral zone, the second species occurs higher on the shore being tolerant to desiccation. *Zostera* sp. beds are representative of EUNIS subtidal biotope A2.6111 and EUNIS intertidal biotope A5.5331 (Tyler-Walters et al. 2016).

Seagrass beds are identified as a habitat which provides many important ecosystem services (e.g., carbon sequestration, flood/storm defence), and support diverse communities of algae and fauna, including species of conservation concern (e.g., seahorses) and serve as nursery grounds for numerous commercial species. They are classed as vulnerable habitats, sensitive to multiple stressors (e.g., pollution, climate warming, increased sediment turbidity). In recognition of their ecological and economic importance, *Zostera* beds are also afforded protection under the Habitats Directive as they are encompassed by Annex I habitats (Tyler-Walters et al. 2016):

- Sandbanks,
- Estuaries,
- Mudflats and sandflats not covered by seawater at low tide,
- Large shallow inlets and bays.

Specifically, *Zostera* beds have been recorded in the shallow coastal waters just outside the boundary of the Project Area (Figure 1).

**Basking Shark (_Cetorhinus maximus_)**

The basking shark (*Cetorhinus maximus*) is the largest fish in Britain and the second largest on earth, reaching up to 12 m in length. They are filter feeders, feeding on zooplankton from the water which passes in through the mouth and out through the comb-like rakers on the gills. They are mainly found in open waters but can occasionally be spotted in the inshore waters around

Scotland, particularly in the summer months. Their slow growth rate, late maturation and small litter sizes mean that they are unable to recover quickly from population declines. In the past targeted fisheries caused a decline of this species in European waters but now it is banned. Boat collisions and disturbance continue to be potential threats to populations in British waters. A number of records of this species exist within the array and OCAS areas as well as further south along the coast within the vicinity of the Project Area (Tyler-Walters et al. 2016) (Figure 1).

**Grey Seal (*Halichoerus grypus*)**

Grey seals (*Halichoerus grypus*) are the largest of the two seal species found in Scotland with adult males reaching up to 2 m in length. Over 90 % of the UK's grey seal population breed in Scotland with significant populations found around the Hebrides. Around Scotland, Grey seal pup production is stable or slowly increasing, however, they are sensitive to a number of anthropogenic pressures including anti-predator shooting at fish farms and fisheries, bioaccumulation of toxic compounds and underwater noise disturbance. A number of records of this species exist from the coastal areas of the OCAS (Tyler-Walters et al. 2016) (Figure 1).

**Other PMF Species**

Other PMF species recorded in the vicinity of the Project Areas include Cod (*Gadus morhua*), Common skate (*Dipturus batis*), Harbour seal (*Phoca vitulina*), Norway pout (*Trisopterus esmarkii*), Otter (*Lutra lutra*), Saithe (*Pollachius virens*), Sand lance (*Ammodytes marinus* and *Ammodytes tobianus*) and Sand goby (*Pomatoschistus minutus*) (Tyler-Walters et al. 2016) (Figure 1).

## 2.4. Annex I Habitats within the Project Area and its Surroundings

**Reefs**

For the purposes of the EC Habitats Directive, the Interpretation Manual of European Union Habitats – EUR25 (CEC 2013) defines Annex I 'Reefs' as:

*'Reef can be either biogenic concretions or of geogenic origin. They are hard compact substrata on solid and soft bottoms, which arise from the sea floor in the sublittoral and littoral zone. Reefs may support a zonation of benthic communities of algae and animal species as well as concretions and corallogenic concretions.*

Following this definition, Annex I reef habitats can be classified into the following subtypes discussed in detail below:

- Bedrock - encompassing "hard compact substrata", specifically, "rocks (including soft rock, e.g. chalk)" of "geogenic origin";
- Stony - encompassing "hard compact substrata", specifically, "boulders and cobbles (generally > 64 mm in diameter" of "geogenic origin";
- Biogenic (encompassing "biogenic concretions").

All habitats meeting the criteria set out in the EC Habitats Directive will qualify as Annex I reef; however, Annex I reef habitats are afforded protection only when occurring as a designated feature within the boundaries of a SAC. The following Annex I reef habitats have been recorded within or near to the Project Area and are mapped in Figure 1.

***Bedrock Reef***

Annex I bedrock reef habitat occurs where soft (e.g., clay) or hard bedrock arises from the surrounding seabed, providing a stable habitat for attachment for a diverse range of epibiota. Bedrock reefs and associated biological communities can be highly variable due to the diverse nature of these habitats in terms of topography, structural complexity and exposure to tidal streams. In the photic zone communities associated with bedrock reefs are often dominated by attached algae, and often support various invertebrate species such as corals, sponges and sea squirts.

These epibiotic communities further increase structural complexity and represent key prey items that in turn attract more mobile and commercially valuable species such as fish and crustaceans.

***Stony Reef***

Stony reef habitats occur when stable hard substrata, namely cobbles and boulders > 64 mm in diameter arise from the surrounding habitat, creating a habitat colonised by a variety of species (Irving 2009, Golding et al. 2020). Numerous SAC sites have been designated in European waters to protect stony reef habitats and associated communities. Reefs are in many cases hot spots for the biodiversity supporting assemblages of various coral, sponges, ascidians, fish and crustaceans. These associated communities vary dramatically according to environmental variables and may incorporate species that occupy a range of trophic levels. The complexity of habitat created by stony reefs often supports a higher abundance of mobile fauna such as echinoderms and various crabs, hermit crabs, and squat lobsters, as well as fish species for which these species represent key prey items.

# 3. Survey Design (Environmental Characterisation Survey)

## 3.1. Rationale

The environmental characterisation sampling plan was developed to provide maximum spatial coverage of the proposed Project Area, whilst also ensuring that all key habitats and communities likely to be encountered across the Project Area were adequately targeted across a range of depths. This environmental characterisation sampling plan was presented to and approved by NatureScot ahead of the survey mobilising.

Prior to commencement of the survey, The Project collected near-full coverage geophysical datasets including SSS, MBES and magnetometer data. The environmental characterisation sampling plan was based on a stratified sampling approach following a detailed review and interpretation of the geophysical datasets and in consideration of the recommendations of best practice guidance where relevant (Scottish Natural Heritage 2011; Natural England 2021). All surface, subsurface, and subsea hazards, and their respective exclusion/ buffer zones were also accounted for.

The geophysical datasets were reviewed manually to identify areas of differing substrate type and seabed elevation. Substrate type was inferred primarily from SSS based on the reflectivity (coarser sediments providing greater reflectivity) and seabed elevation was determined by review of the MBES bathymetry dataset.

The full catalogue of information that was assessed in the development of the sampling plan includes:

- Preliminary geophysical data including MBES bathymetry, SSS, and magnetometer data in mosaiced geotiff format collected during a geophysical campaign carried out in spring and summer 2023.
- All previous mapping of key features from historic data (sources include: EUSeaMap 2021, EMODnet Bathymetry data).
- All available GIS shapefiles and rasters in ESRI format including: the array and OCAS areas, planned and existing infrastructure to include all oil and gas surface and subsurface infrastructure within the project boundary or within close proximity to it; the latest relevant MPA boundaries, admiralty charts for the Project Area (if available) (sources include: Project shapefiles, EMODnet, NatureScot Open Data).

## 3.2. Sampling Approach

To fully characterise the subtidal environment across the Project Area, a suite of sampling approaches was employed. This included grab sampling, DDC and BRUV.

The environmental characterisation sampling plan included 38 co-located DDC and grab stations and a further 12 DDC transects, selected to target potential sensitive habitats that were identified during the review of the geophysical data (e.g. Annex I reef habitats). Grab sample locations were selected based on a stratified approach providing broad coverage of the Project Area whilst targeting all interpreted sediment types and depths (using both geophysical data and EUSeaMap 2021 data).

Due to safety risks relating to the heterogeneity of the seabed and the coarse and rocky nature of the substrate across the Project Area, BRUV sampling was proposed as a non-destructive alternative to scientific beam trawling. These deployments allowed for the collection of supplementary data on the mobile epibiota and demersal fish species across the Project Area. This, alongside data collected during the DDC deployments, enabled the characterisation of a greater breadth of the epibenthic communities associated with the bedrock and coarse sediment habitats expected across much of the Project Area than with DDC imagery alone. This data also provides a valuable insight into the potential presence and prevalence of several mobile PMF species across Project Area. Ten BRUV sampling stations were positioned across the Project Area. BRUV data was interpreted in conjunction with findings of a desk-based study into taxa of conservation and economic importance.

## 3.3. Timing

The sampling was undertaken aboard the *MV Situla* during periods of favourable weather between the 17$^{th}$ and the 27$^{th}$ of October 2023.

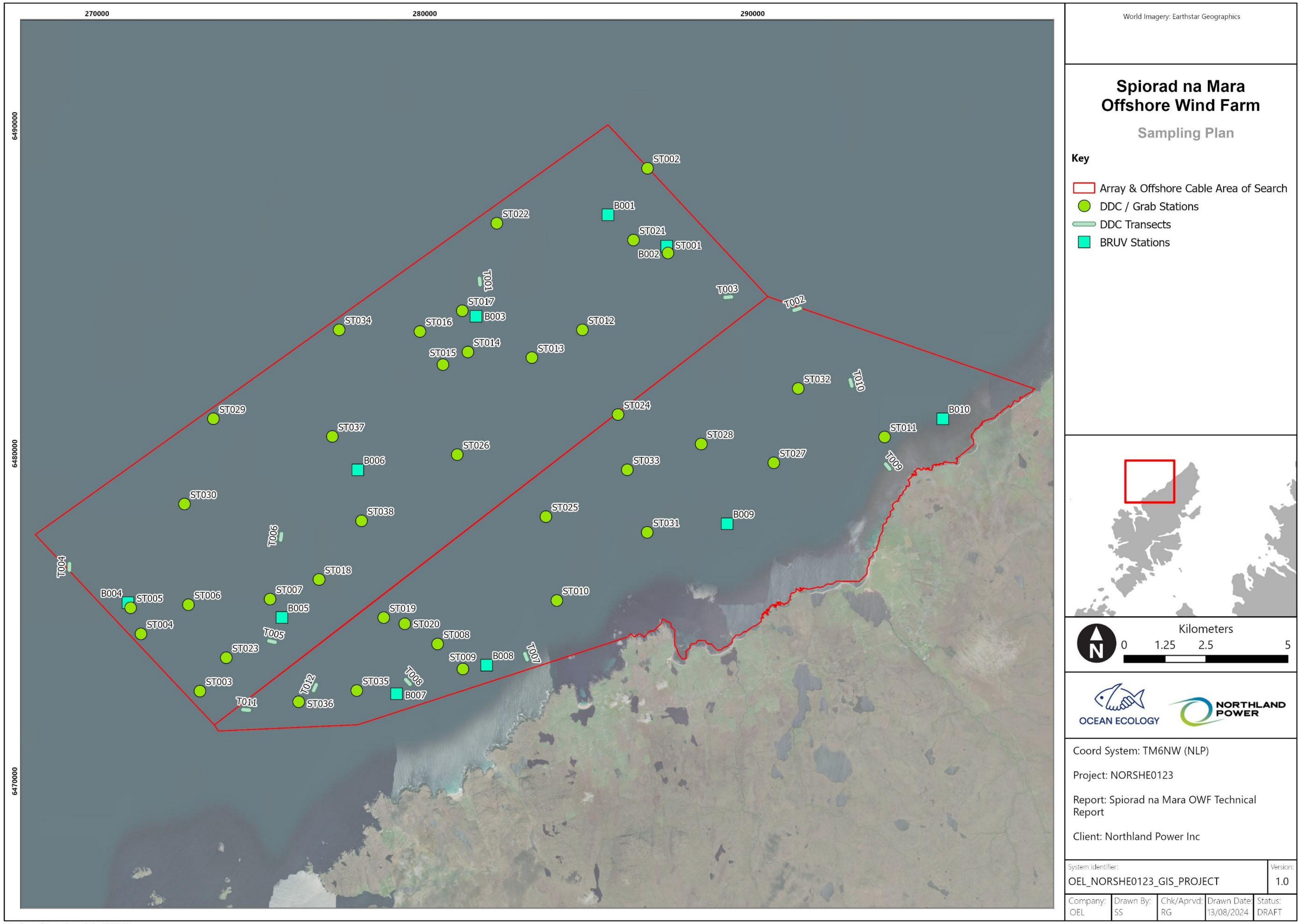


**Figure 3** Overview of the proposed DDC/grab sampling and BRUV sampling stations across the Project Area.

# 4. Survey Design (PMF Survey)

## 4.1. Overview

During the environmental characterisation survey conducted in Autumn 2023, areas of the PMF 'Kelp beds' were noted within the OCAS. Subsequently, a dedicated PMF survey was undertaken in September 2024 targeting kelp beds and their boundaries/extent and to further define the extent of Annex I reef and update previous habitat mapping within the OCAS. Where appropriate, the results of the environmental characterisation survey and PMF survey have been combined.

The PMF survey sampling plan was structured around the use of Unmanned Aerial Vehicle (UAV) and ROV survey methods to capture aerial and subsea imagery of kelp bed habitats. As no clear boundaries in kelp beds could be identified in the available geophysical data, no pre-defined sampling plan was designed or presented ahead of the survey. The location and extent of UAV flights and ROV transects were instead determined in the field to target visible or predicted boundaries in kelp beds (Figure 4).

## 4.2. Sampling Approach

UAV flights were initially planned to be undertaken from a survey vessel over appropriate water depths (i.e., shallower areas where kelp is visible in UAV imagery), however, the sea state encountered during the survey did not allow for the deployment of the UAV. Instead, UAV flights were conducted from the shore in locations where landowner access had been agreed prior to the survey (Figure 4).

ROV transects were used to ground-truth the available acoustic data within kelp beds and, most importantly, target the boundaries between kelp beds and any other habitat types. The number and total length of transects was to be determined *in situ* and extended as needed to delineate the boundaries of the habitats identified in the field. Three operational days were allocated to gather as much data as possible from the survey area.

Based on the interpreted seabed type and water depths, it was thought that kelp beds could be present along the entire length of the nearshore area within the export OCAS. Spiorad na Mara Ltd provided OEL with updated route planning shapefiles prior to the survey mobilising for areas of search relating to three potential cable landfall options. As these are the three primary areas of focus for cable route planning, the PMF survey was constrained to within these areas and extend from approximately the 30 m depth contour into the shallow sublittoral. Refined survey areas are presented in Figure 4.

## 4.3. Timing

The PMF survey was undertaken onboard the *MV Lochlann* between the 5$^{th}$ and 7$^{th}$ of September 2024. A series of short UAV flights were opportunistically undertaken from the shore on the 4$^{th}$ and 8$^{th}$ September 2024 before / after mobilising the vessel for ROV works.

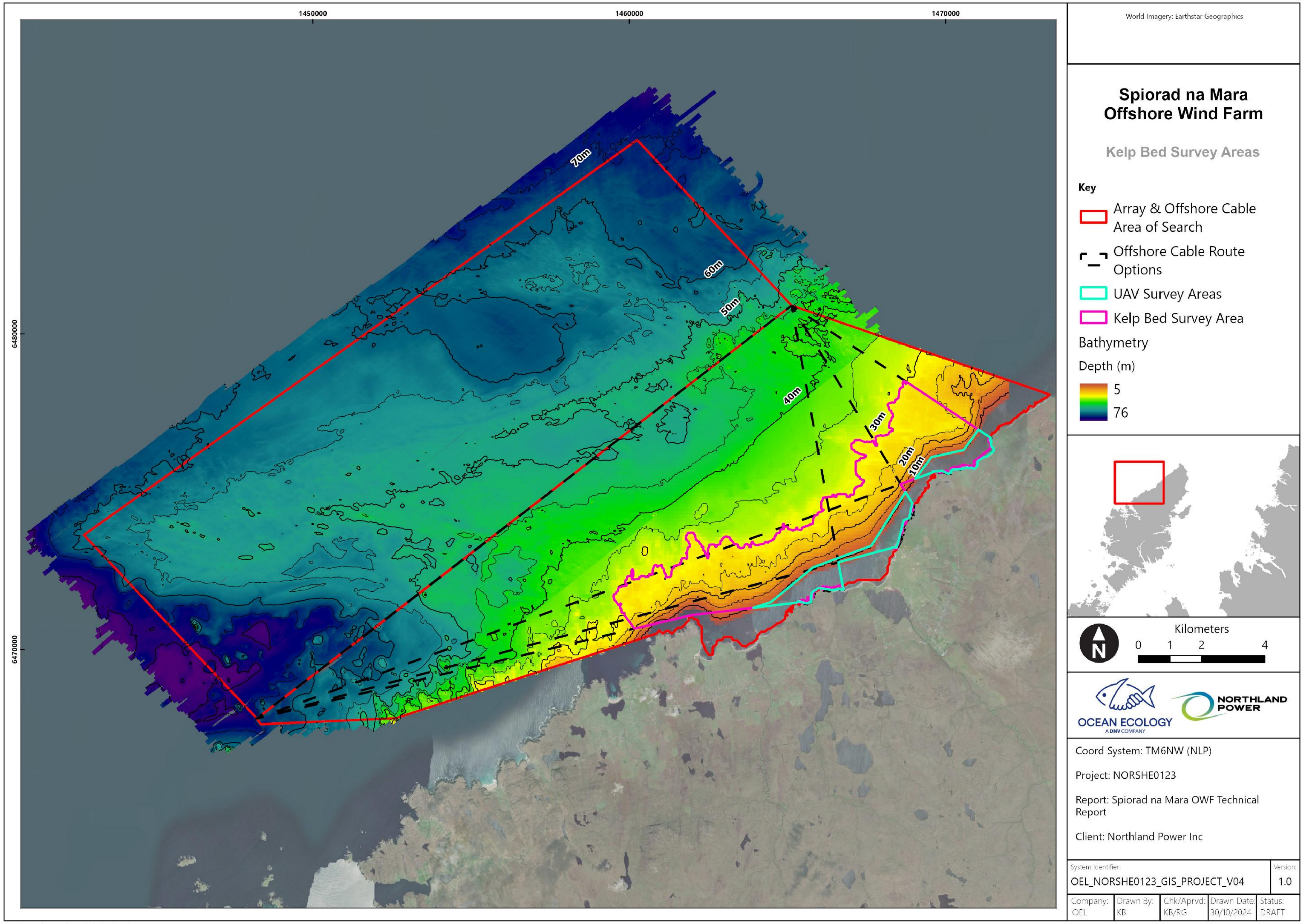


**Figure 4** PMF survey area with smaller UAV survey areas. All survey areas confined to within the offshore cable route options.

# 5. Field Methods (Environmental Characterisation Survey)

## 5.1. Survey Vessel

Sampling was conducted between the 17th and 27th of October 2023 aboard the 38.1 m vessel *MV Situla* (Plate 1). The vessel was mobilised from Galway, Ireland, and used Ullapool as a port of opportunity during periods of poor weather. Operations were performed on a 24-hour basis.

**Table 1** Vessel details.

| | |
|---|---|
| **Vessel Name** | *MV Situla* |
| **Area of operation** | Offshore |
| **Call Sign** | HO8727 |
| **IMO Number** | 9246188 |
| **Mobilisation Port** | Galway |
| **Length** | 38.1 m |
| **Beam** | 9.5 m |
| **Draft** | 2.9 m |


**Plate 1** Survey vessel *MV Situla*.

## 5.2. Geodetic Parameters

The following geodetic parameters, as provided by The Project, were used throughout the survey.

### 5.2.1. Horizontal Datum

**Table 2** Geodetic parameters

| Parameter | Details |
|---|---|
| Name | World Geodetic System 1984 (WGS84) |
| Ellipsoid | WGS 84 |
| Semi-Major Axis (a) | 6378137.000 m |
| Semi-Minor Axis (b) | 6356752.314 m |
| Inverse Flattening | 298.257 223 563 |
| Geodetic parameters EPSG Code | 4326 |

**Table 3** Projection parameters.

| Projection | Transverse Mercator 6 NW |
|---|---|
| Name | TM 6 NW |
| Longitude of Natural Origin | 6° West |
| Latitude of Natural Origin | 0° |
| False Easting | 1 500 000.00 m |
| False Northing | 0.00 m |
| Scale Factor at Natural Origin | 1 |
| Units | meters |

### 5.2.2. Datum Transformation Parameters

All data provided in this report is referenced to WGS84, TM 6 NW, with no datum transformation need. No conversion or test coordinate was provided by the Client.

### 5.2.3. Vertical Datum

All altitude and depth data above seabed are referenced to LAT. All depth data below the seabed is referenced to LAT where available, depths are reported as derived from ultra-short baseline (USBL) beacon.

### 5.2.4. Unit Format and Conversions

The following have been used throughout this project and are expressed using the following conventions.

**Table 4** Project unit format and convention details.

| Unit Formats and Conventions | |
|---|---|
| Geographical Coordinates | Latitude N DD˚MM.mmmmmm' to 6 decimal places.<br>Longitude E/W DD˚MM.mmmmmm' to 6 decimal places. |
| Grid Coordinates | Meters in the following format:<br>Easting EEE EEE.eee m to 3 decimal places.<br>Northing NNN NNN.nnn m to 3 decimal places. |
| Linear distances | Meters to 1 decimal places. |
| Offset measurement sign conventions | Meters in the following format:<br>'Y' is positive forward.<br>'X' is positive to starboard.<br>'Z' values are positives upwards from the waterline. |
| Time | UTC (GMT). |

## 5.3. Survey Navigation

### 5.3.1. Surface Positioning

The *MV Situla* was equipped with a Hemisphere V104s Global Positioning System (GPS) compass system. The Hemisphere V104s internal GPS receiver utilises a minimum of 4 GPS satellites, managing the navigation information required to obtain a position within 3 m at 95 % accuracy. The V104s automatically tracks Satellite-Based Augmentation System (SBAS) differential correction to improve position accuracy to > 1 m at 95 % accuracy. The V104s includes an integrated gyro and two tilt sensors to provide an accurate heading for navigation software.

### 5.3.2. Subsea Positioning

The vessel was equipped with an Easytrak Nexus 2 Lite USBL system and 1329A Omni-directional +/- 90 ° Micro Beacons for subsea positioning of the camera and grab. The Easytrak Nexus 2 Lite is an advanced USBL positioning and tracking system that determines the position of dynamic subsea targets through the transmission and reception of acoustic signals between the submerged transceiver and a target beacon. The USBL was fully calibrated prior to survey operations and a Valeport SWiFT Sound Velocity Profiler (SVP) was used for taking sound of speed measurements throughout the survey. Readings were obtained daily from both the up-cast and down-cast.

### 5.3.3. Navigation Software

A vessel-based positioning system was employed utilizing EIVA NaviPac V4.6 software to ensure the accurate positioning of the vessel and subsea positioning of the sampling equipment via the USBL system as well as recording continuous track plots of the sampling equipment and recording sampling fixes. A navigation screen, displaying EIVA Helmsman Display was provided at the helm position of the vessel for the Officer on Watch.

### 5.3.4. Positional Checks & Calibrations

The GPS has an internal precision calculation which outputs a graphical representation of horizontal accuracy, displaying numerical precision as easting and northing. The accuracy of vessel heading, and reference systems was verified during mobilisation using agreed reference points.

A USBL calibration was undertaken using the inbuilt Easytrak Nexus calibration software package to eliminate any alignment errors of the installation. Offsets were measured dynamically between the Easytrak Nexus transceiver head and the external sensors interfaced. This enabled accurate operation of the Easytrak Nexus tracking system when pole-mounted onto a vessel with external VRU and gyro.

## 5.4. Survey Equipment and Sampling

### 5.4.1. DDC System and Seabed Imagery Collection

Seabed imagery (simultaneous video and stills) was acquired at each station using OEL's SubC Rayfin PLE camera system, set up to obtain 1080p High Definition (HD) video and 20 Megapixel (MP) still images. The camera system (Plate 2) consisted of a SubC Imaging Rayfin PLE camera mounted in a Clear Liquid Optical Chamber (CLOC) (otherwise known as a 'freshwater lens') filled with fresh water to ensure imagery of suitable quality is obtained regardless of turbidity. The frame included light emitting diode (LED) strip lamps and a 10 cm point laser scaling array that is projected into the field of view and topside computer. The camera was powered with the use of an Uninterruptable Power Supply (UPS) to ensure no damage would be caused should the vessel have lost power or in the case of a power surge. A full redundancy SubC Rayfin PLE camera system was stored onboard throughout the survey but was not required.

The CLOC was height and angle adjustable providing a variety of options for view, lighting, and focal length to maximise data quality with respect to prevailing conditions (e.g., high turbidity).

**Plate 2** Left: OEL CLOC camera system. Right: The camera system topside setup.

All DDC stations and transects were sampled in line with the Joint Nature Conservation Committee (JNCC) epibiota remote monitoring operational guidelines (Hitchin et al. 2015) For transects, the camera was deployed to the seabed over the target start / end transect location and slowly 'flown' just above the seabed along the transect to obtain both continuous video footage and still images. A live feed was displayed on a monitor and photographs taken continually along the transects. Whenever a photograph was taken a positional fix was taken of the USBL beacon position in the navigation software. For stations, the camera was manoeuvred within a 50 m radius of the target location to provide broad and representative coverage of the sample area.

The camera system was deployed from the hydraulic 'A' frame on the aft deck of the *MV Situla* using coaxial winch. Continuous footage of the seabed was collected along with still images every 5 - 10 m using a 'bed-hopping' approach. During the deployment, all footage underwent a preliminary review *in situ* by OEL's onboard Environmental Scientists. Videos were recorded in a digital format direct to topside hard disk drives (HDDs) and digitally overlaid retrospectively with information including project, date, time, depth, and coordinates. Detailed notes were taken of visible sediment conditions and seabed features, obvious fauna, and habitat-related features whilst in the field.

### 5.4.2. Grab Equipment and Sediment Sampling

Sediment samples were collected from within 50 m of the target sampling location using OEL's 0.1 $m^2$ Day grab sampler (Plate 3).

A single deployment of the Day grab yielded a single sample of approximately 5 - 10 L at each station for macrobenthic and particle size distribution (PSD) analysis. At chemical contaminant sampling stations, an additional deployment of the Day grab was required to collect a second replicate sample for subsequent chemical contaminant analysis.

The grab system was deployed and retrieved from the hydraulic ‘A’ frame on the aft deck of the *MV Situla* using the deck mounted coaxial winch in a similar approach to the DDC system deployment as described above.

To ensure consistency in sampling, grab samples were screened by the lead Environmental Scientist and considered unacceptable if:

- The sample was less than 5 L. i.e., the sample represented less than half the 10 L capacity of the grab used.
- The jaws failed to close completely or were jammed open by an obstruction, allowing fines to pass through (washout or partial washout).
- The sample was taken at an unacceptable distance from the target location (> 50 m).
- There was obvious contamination of the sample from survey equipment, paint chips etc.

At least three attempts were made at each station, with a further single attempt made approximately 50 m from the original sample station before a station was to be abandoned. No pooling of samples took place. If samples of less than 5 L were continually achieved, these samples would be retained and assessed to establish whether the sample volume was acceptable to allow subsequent analysis.

Initial grab sample processing of ‘A’ replicate grabs for PSD and macrobenthos was undertaken onboard the survey vessel in line with the following methodology:

- An initial visual assessment was made of sample size and acceptability.
- A photograph was taken of the sample with station details and scale bar.
- 500 - 750 ml of the sample was removed for PSD analysis and transferred to a labelled tray.
- The remaining sample (retained for faunal sorting and identification) was emptied onto a 1.0 mm sieve net laid over a 4.0 mm sieve table and washed through using gentle rinsing with a seawater hose.
- This remaining sample was backwashed into a suitably sized sample container and diluted 10 % formalin solution was added to fix the sample prior to laboratory analysis.
- Sample containers were clearly labelled internally and externally with date, sample ID and project name.
- Detailed field notes were taken including station number, fix number, number of attempts, sample volume, sediment type, conspicuous fauna, any sign of protected features, and water depth.

Initial grab sample processing of ‘B’ replicate grabs for chemical contaminants was undertaken onboard the survey vessel in line with the following methodology:

- Initial visual assessment of sample size and acceptability made.
- Photograph of the full sample with station details and scale bar taken.
- Inspection cover lifted and general assessment of sample size and acceptability made ensuring sediment surface is undisturbed and no obvious sign of contamination.

- A ‘primary’ sub-sample of sediment decanted into the appropriate sample containers provided by the laboratory and frozen immediately at - 20°C in an onboard freezer. A second ‘back-up’ sub-sample taken from the remaining sediment following the same process and retained in case of requirement for re-analysis or in the event of any primary subsamples becoming compromised during transit / storage prior to analysis.
- The containers were acid cleaned and solvent-rinsed before use, sealed with a foil liner where appropriate and tightened appropriately to avoid potential loss of determinands, contamination of samples, or both. A temperature of 25°C was not exceeded at any stage of storage or transportation.

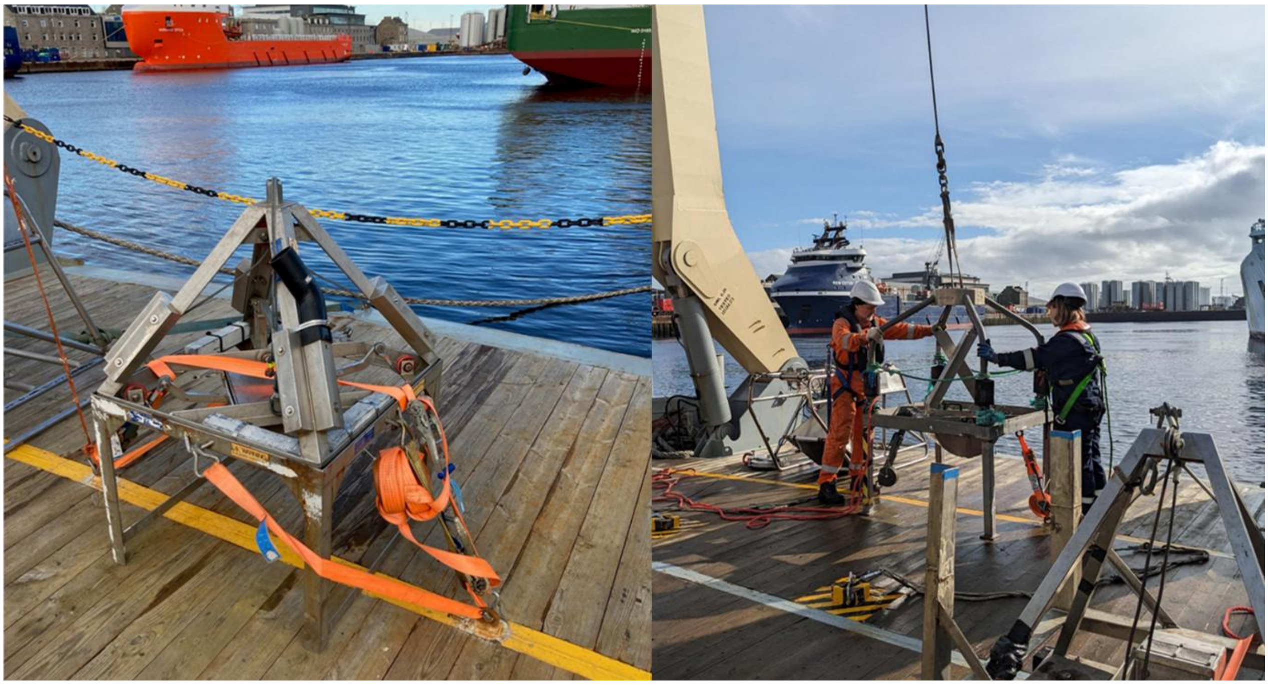

**Plate 3** Left: OEL’s 0.1 $m^2$ Day grab sampler on the deck of the *MV Situla*. Right: OEL’s 0.2 $m^2$ Dual Van Veen grab sampler during a wet test deployment, mobilised as a redundancy sampler.

### 5.4.3. BRUV Sampling

At each BRUV location a minimum of 1 hour of HD video was recorded using OEL’s mono-BRUV systems. Each BRUV seabed frame was equipped with a GoPro Hero 9 Black camera and two battery powered LED Anchor Dive lights. A bait pole was rigged on each frame with a bait bag attached and positioned within the field of view of the camera. A minimum of 100 g of mackerel was used as bait for each deployment and was replenished after each 1-hour soak.

The BRUVs were prepared for deployment, with cameras and lights switched on. The frame was then deployed by hand by one ecologist and one member of the crew following confirmation from the vessel master that the vessel was on position, and it was safe to do so. The second ecologist managed the rigging (rope length and surface marker buoy) to ensure no entanglement during deployment. Following deployment, the vessel remained in the general vicinity of the marker buoy to ensure it had not shifted from location with the tide. BRUV deployments were undertaken during day light hours only including dawn and dusk where operational restrictions dictated.

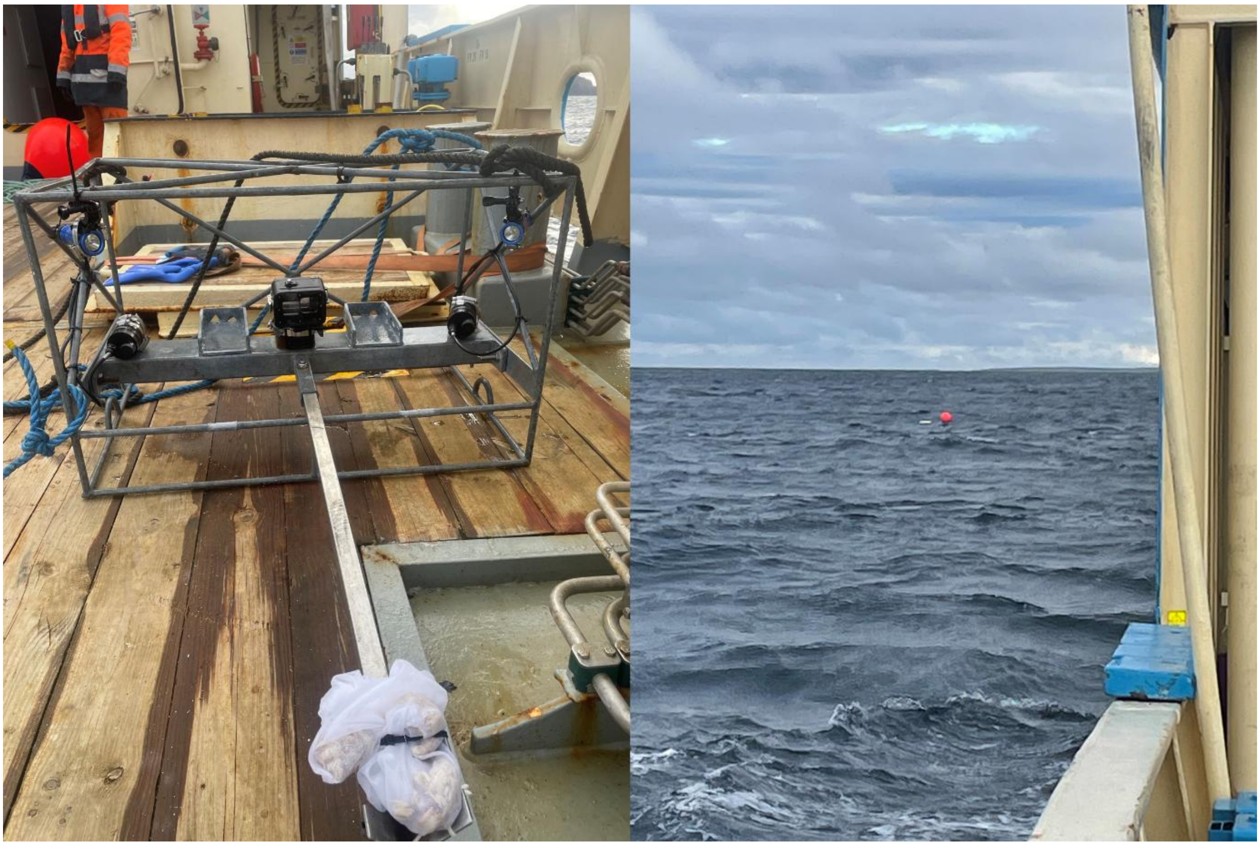

**Plate 4** Left: BRUV frame with bait attached prior to deployment. Right: BRUV marker buoy when deployed.

# 6. Field Methods (PMF Survey)

## 6.1. UAV Imagery Collection

UAV imagery data was collected using a DJI Mavic 2 multi-rotor quadcopter, launched from the shore. All flights were conducted by OEL's Qualified UAV Pilots under the Civil Aviation Authority (CAA) Drone and Model Aircraft Registration and Education Services (DMARES) within the A3 Open Category. Data was collected across pre-planned flights, which will serve to detail the nearshore extents of the export cable areas of search at low water. Pre-planned flights were automated to ensure still images in plan-view were captured with a sufficient accuracy and overlap to ensure full coverage of the UAV survey areas. Still images were automatically 'stitched' together within Drone Deploy software to produce an orthomosaic of the flight survey area.

Automated UAV flights were monitored via the remote control and could be paused and manual control taken when the drone needed to be landed or course diverted. The UAV also had a 'home point' assigned before take-off which the UAV would have automatically returned to if required (for example if connection to the controller is lost or the UAV battery is low).

All survey flight lines, orientation, sampling frequency (number and frequency of still images captured) and minimum resolution limits were planned to achieve a minimum resolution of 5 cm/pixel with an accuracy of 5-10 m. UAV positioning was achieved internally within the UAV via an in-built GPS and GLONASS accurate to 0.5 m.

## 6.2. ROV Survey Vessel

The multipurpose vessel 'MV *Lochlann*' (Plate 5), owned and operated by Seatrek Marine, was used to undertake the survey. Seatrek Marine are a vessel operator based on the Isle of Lewis. *MV Lochlann* was mobilised and operated out of Miavaig on a 12-hour operational basis between the 5$^{th}$ and 7$^{th}$ of September 2024.

## 6.3. Vessel Navigation

All vessel navigation equipment was provided and operated by the vessel. OEL surveyors instructed and advised the vessel on transect placement and navigating along the transects *in situ*. All subsea positioning was achieved through the use of a short baseline (SBL) system to provide accurate positions for seabed sampling locations (detailed further in Section 6.4.1.1).


**Plate 5** Survey vessel *MV Lochlann*.

## 6.4. Subsea Seabed Imagery Collection

Subsea seabed imagery was collected using a BlueROV II ROV (Plate 6), equipped with three 4k GoPro video cameras, one DeepWater Exploration (DWE) HD live feed camera and four 1,500 lumen subsea lights with 10 levels of adjustable brightness. The ROV configuration has four vertical T200 thrusters and four vectored T200 thrusters, giving six degrees of freedom and increased buoyancy for added control. The ROV has the best thrust-to-weight ratio in its class and provides an ideal ROV for operations in shallow to moderate waters, with a standard 100 m depth rating. Forward and down-facing GoPro cameras were attached to the ROV for the capture of HD imagery, whilst the low light Sony navigation camera and downward facing DWE camera provided live HD video.

A data tether was used for both live video feeds to a topside camera unit which was viewed by an experienced marine ecologist for real-time review of video imagery, image capture and assessment of the seabed.

**Plate 6** OEL's BlueROV II ROV.

#### 6.4.1.1. Subsea positioning

Underwater positioning of the ROV was achieved using the Waterlinked SBL GPS G2 system and Waterlinked Doppler Velocity Log (DVL) A50, vessel mounted antenna and subsea digital hydro acoustic A1 Locator device. The G2 topside was connected to the G2 Antenna which was vessel mounted with direct line of sight to the A1 locator mounted onto the topside of the ROV unit. The antenna was equipped with 4 receivers with large dynamic range followed by advanced digital signal processing functionality providing reliable, accurate and robust acoustic positioning of a single locator with omnidirectional 360° operation and a 100 m range. The A50 DVL provided fine scale (cm), positioning and station keeping, to be fused with the coarse scale (1 m+) hydroacoustic positioning provided with the SBL. Slant range inaccuracy was minimized by keeping the surface vessel as close as practical to the ROV.

#### 6.4.1.2. ROV Deployment & Sampling Procedure

The onboard cameras were configured to record continuous video, with the HD video being streamed in real-time. Complementary to the live view video stream provided by the ROV camera, 4K / 5K quality video was captured on a GoPro camera mounted at 45 degrees at the front of the ROV frame. Two downward facing GoPros captured 27-megapixel images at a rate of 2 per second, to allow for photomosaicing and 3D photogrammetry.

The ROV pilot monitored the live video feed to navigate the ROV and monitor survey parameters (e.g., visibility, camera angle, relative position). Vessel personnel assisted the pilot to manage the tether and ensure the vessel skipper was directed accordingly and always kept the vessel within 10 m of the horizontal position of the ROV.

The vessel skipper was provided with live feed from the SBL to maintain situational awareness. The ROV tether was deployed over the bow section of the vessel and the vessel was maneuvered to track the ROV along the transect.

The ROV transect Standard Operating Procedure (SOP) was completed as follows:

- The vessel was positioned ahead of the start point of the transect line and the ROV pilot / ecologist undertook final checks prior to commencing operations.
- The GoPros were switched on, synchronised and set to start recording along with the BlueROV II camera software set to record.
- The vessel crew assisted with the ROV and hand-deployment over the starboard side allowing the pilot to 'Arm' the ROV safely and manoeuvre the ROV away from the vessel prior to commencing the dive. Logging was switched on once the ROV was 'armed'.
- The ROV tether was placed over the port / starboard side, depending on prevailing weather conditions, and sufficient slack paid out by vessel crew.
- The ROV pilot then dived the unit to the seabed and communicated with vessel crew to assist with paying out the tether to ensure there was no tension.
- The ROV pilot then confirmed video recording was on and commenced survey along the transect line.
- The vessel skipper then tracked the ROV with good communication between pilot and skipper for ROV speed and depth (i.e. pay out or take in tether).
- Once at the end of the transect, the ROV position was communicated and ROV ascended to the surface with the vessel propulsion system out of gear. Tether reeled in slowly by vessel crew.
- Once at the surface, all lighting and video recording was disabled, the ROV propulsion was disarmed and then ROV manually towed back to the vessel for recovery by vessel crew and pilot.
- All video and still imagery was saved and checked by the ecologist and confirmed prior to departing for the next transect location.

## 6.5. Marine Mammal Mitigation

Marine mammal mitigation was conducted in line with the previous benthic survey operations detailed within the technical note OEL_HSE_NORSHE0123_NTE_V02 (OEL 2023). A detailed summary of Marine Mammal Observer (MMO) activity and field logs has been presented in a standalone Marine Mammal Mitigation Report (MMMR) (OEL 2024). To summarise, no marine mammals were observed within the 500 m mitigation zone of the vessel, and therefore no operational shutdown procedures were employed during this survey.

# 7. Laboratory and Analytical Methods

## 7.1. Seabed Imagery Analysis

All seabed imagery collected by either DDC or ROV was analysed using the Bio-Image Indexing and Graphical Labelling Environment (BIIGLE[4]) annotation platform (Langenkämper et al. 2017) and in consideration of JNCC epibiota remote monitoring interpretation guidelines (Turner et al. 2016) and the latest NMBAQC/JNCC Epibiota Quality Assurance Framework (QAF) guidance and identification protocols.

A full reef habitat assessment was conducted to determine whether habitats met the definitions of Annex I stony reef habitats as detailed in Table 5. Additionally, bedrock reef was identified as a hard compact substrate of geogenic origin (rock) including soft rock (e.g. chalk and clay). The identification of stony reef habitats was carried out under the Habitats Directive and following JNCC's recommendations (Irving 2009, Golding et al. 2020). The annotation label tree used during analysis had major headings for each of reef type. Under each reef type labels were assigned for each of the categories required to determine whether reef habitat was present.

Analysis of still images was undertaken in two stages. The first stage, "Tier 1", consisted of labels that referred to the whole image being assigned, providing appropriate metadata for the image. These included labels such as image quality, BSH, EUNIS habitat, PMFs and INNS in line with (Parry 2019) Tier 1 analysis is further explained in Section 7.1.1.

The second stage, "Tier 2", was used to assess presence/absence of conspicuous epibiota and to assign percentage cover of 'reef' types by drawing polygons to inform the habitat assessment process and further explained in Section 7.1.2.

**Table 5** Characteristics of stony reef (Irving 2009).

| Characteristic | 'Reefiness' | | | |
|---|---|---|---|---|
| | Not a Reef | Low | Medium | High |
| Composition (proportion of boulders/cobbles (>64 mm)) | <10 % | 10-40 % matrix supported | 40-95 % | >95 % clast-supported |
| Elevation | Flat seabed | <64 mm | 64 mm - 5 m | >5 m |
| Extent | <25 m$^2$ | >25 m$^2$ | | |
| Biota | Dominated by infaunal species | >80 % of species present composed of epibiotal species | | |

[4] https://www.biigle.de/

### 7.1.1. Tier 1 Analysis

The first stage, "Tier 1", consisted of assigning labels that referred to the whole image, providing appropriate metadata for the image. Metadata "Image Labels" include:

- BSH type,
- Substrate type (and percentage cover in 10% intervals),
- Bedforms present,
- The presence of any Annex I habitats, PMF species or habitats, and INNS.
- The presence of any visible impacts or other modifiers (such as discarded fishing gear or marine litter (as per the Marine Strategy Framework Directive (MSFD) categories), visible physical damage to the seabed, evidence of strong currents, non-native species, etc.).
- Image quality categories (including "Not Analysable" category).

The EUNIS habitat classification is a comprehensive pan-European system that covers all types of habitats from natural to artificial, from terrestrial to freshwater and marine. Under the EUNIS classification, all marine habitats are classified under the letter 'A' while the numbers following the letter 'A' indicate whether a habitat is littoral or sublittoral, rock or sediment dominated, its energy or sediment type, and finally the community populating it. For instance, biotope A4.2145 refers to a marine habitat (A), of circalittoral rock (4) and moderate energy (2), populated by echinoderms and crustose communities (1), more specifically by faunal and algal crusts (4), with *Spirobranchus triqueter* and *Alcyonium digitatum* (5).

Depending on the presence of reef, this will also include:

- Extent: As it is not possible to fully determine the extent of reef habitats from a single image alone this label will be used to identify areas that are highly unlikely to constitute reef habitats. An example is an image that shows a large boulder being preceded and succeeded by images of unconsolidated sandy sediments.
- Biota: Labels assigned to determine whether epifauna dominate the biological community observed.
- Elevation: Labels assigned depending on reef type. Laser points will be used to assist in the assignment of categories.

### 7.1.2. Tier 2 Analysis

The second stage, "Tier 2", was used to assess epibiota presence / absence (PA) data as "annotations" within each image for visible flora and fauna. This was undertaken as follows:

- Using the BIIGLE Annotation Platform enumeration of visible taxa will be undertaken using point annotation. A single representation of each taxa present was assigned a point to generate presence/absence data outputs.
- To assist the Tier 1 analysis of reef presence, polygons were drawn at the Tier 2 stage to delineate percentage cover of biogenic and geogenic reef features.

- Identification of any INNS and species non-native to UK waters. Information was also included on species non-native to the local habitat types (e.g., hard-substrate specialists in a wider sedimentary habitat).

The substratum observed in each still image was recorded as a percentage cover using the CATAMI classification scheme for scoring substrata in seabed imagery (Althaus et al. 2015). Determination of sediment type (such as coarse, mixed, sand etc.) was facilitated using the adapted Folk sediment trigon (Long 2006) incorporated into a sediment category correlation table. Percentage cover of the different substrate types was used to determine and assign EUNIS classifications and BSHs.

### 7.1.3. Adapted Subtidal Imagery Analysis Methods for ROV Imagery

Due to the nature of the substrate investigated by ROV with dense cover of kelp and seaweed, it was necessary to adapt the methods for imagery analysis to account for this. Typically, if the substrate is not visible due to anything obscuring it, including epibiotal cover, the 'visual quality' category of an image is marked as 'Not Analysable' and therefore the image is removed from further assessment. Based on this method, most of the images collected by ROV were to be discarded from analysis due to kelp and seaweed masking the seabed. To address this, a 'faunal visual quality' assessment was undertaken to highlight the quality of images where there was inability to see the physical habitat (substrates) due to reasons other than the actual quality of the image.

All images underwent a EUNIS assessment, where a EUNIS code based on the visual quality was assigned, as well as a predicted EUNIS based on the epibiotal community and patches of visible substrate within both the images and video footage.

Reef polygons were assigned to images where appropriate substrate was visible. In addition to the standard reef assessment, a 'potential' and 'predicted' grading was given to any image where there was potential reef found, but the cover did not equate to a reef due to lack of visibility caused by epibiotal obstruction, or where there was no note of reef present, but where there is high potential reef determined based on video footage and acoustic data, respectively.

### 7.1.4. ROV Image Photogrammetry

In addition to the above analysis, ROV imagery was also used in photogrammetry. Short baseline positional data was correlated with the EXIF data of each image to generate sets of georeferenced pictures. These were then processed in line with using the Agisoft Metashape Pro photogrammetry package. Scale was derived from locations (i.e., distance between images). Outputs produced included a 2D orthomosaic and 3D model which was used to inform and aid seabed imagery analysis and habitat mapping.

### 7.1.5. Reef 'Ecological Value' Assessment

To understand the ecological value (EV) of the reef habitats observed across the survey area, all DDC images that qualified as Annex I geogenic reef based on the Tier 1 analysis detailed above were selected for further analyses. Biodiversity indices were then calculated based on the PA epifaunal data obtained from the Tier 2 imagery analysis of these selected stills. Seabed imagery was collected at DDC stations and along DDC transects, and biodiversity indices were calculated for the full set of images to account for all seabed heterogeneities. The biodiversity indices calculated were taxa richness (S), as in the number of taxa present in one image, and taxonomic distinctness ($\Delta^+$), which is a measure of phylogenetic diversity based on the relationship between organisms. The idea of taxonomic distinctness among taxa and within stations can be extended to infer the functionality of a habitat. In an exemplified way, epifauna belonging to the same taxonomic group will have similar functionality within an ecosystem and by looking at the relationship between taxa, an insight into the functional composition of a habitat can be deduced. In other words, $\Delta^+$ accounts for the taxonomic spread of taxa within a station or along a transect providing further insight into the biodiversity of the habitats present such as geogenic reefs.

$\Delta^+$ was calculated using the software PRIMER v7 (Clarke & Gorley 2015) and was compared to 'average' values for the Project Area where reef was confirmed. Average values were obtained from the list of all taxa encountered across the Project Area where reef was confirmed (master list). The WoRMS matching tool was used to obtain taxonomic information for each taxa encountered.

The EV of a DDC station/transect was then inferred based on whether its $\Delta^+$ indicated a "smaller than average" or "greater than average" taxonomic spread by examining whether the observed $\Delta^+$ value lied below or above the average value for the Project Area (Clarke & Warwick 1998). If $\Delta^+$ values fell in line with the average value for the Project Area, then the station would have a ***background***, if $\Delta^+$ values fell below the average value for the Project Area then the station would have a ***low*** EV and if $\Delta^+$ values fell above the average value for the Project Area then the station would have a ***good*** EV. Additionally, if $\Delta^+$ values fell below the confidence limits of the distribution, then the station would have a ***poor*** EV while if $\Delta^+$ values fell above the confidence limits of the distribution then the station would have a ***high*** EV. Considering that only images where Annex I reef was confirmed as present based on DDC imagery analysis were included in this assessment, the EV assigned to each image provided an indication of whether the observed rocky habitats (Annex I geogenic reefs) exhibited a high EV relative to the other areas of Annex I reef habitat assessed.

A reef EV assessment was not performed on imagery obtained by ROV during the PMF Survey. Imagery collected with the ROV often had the seabed and therefore epifauna fully or partially obscured by kelp, or the ROV was flown at an altitude above the kelp which made identification of epifauna difficult. As such an EV assessment on this data would have been difficult and biased towards area of kelp absence where epifauna could more easily be identified.

## 7.2. Heat Mapping

S and Δ+ values calculated as explained above were then used to create heat maps to show 'hot spots' of inferred EV. As heat maps were generated based on data interpolation and do not consider the surrounding physical environment, they provide an indication of the functionality of reef habitats where reef is known to occur. Less confidence is given to the extrapolated data where no data is available on the type of habitat present.

## 7.3. UAV Image Processing

Following initial screening to remove any erroneous images, all images collected during the UAV mapping flights underwent Terrain (2D) processing in the flight planning software Drone Deploy and were 'stitched' together to generate orthomosaic outputs for the UAV survey areas.

This data was interpreted both during the survey to inform potential areas to focus ROV transects, but more importantly post-survey during the mapping of the PMF habitat 'Kelp beds' as detailed further in Section 7.9.

## 7.4. BRUV Video Analysis

The methods used to analyse the BRUV footage recorded were based on Jones et al. (2020). Raw video footage was reviewed for the maximum number of individuals observed in one frame (*MaxN*) (Priede et al. 1994). Taxa were identified to the highest taxonomic level possible depending on the visibility of distinguishable features. However, the data was truncated to only include individuals identified to species level to calculate diversity (species richness) as the total number of different species observed in one frame. This was done to avoid overestimating diversity in instances where taxonomic diversity was noted, namely different levels of the same taxonomic group were encountered (e.g., Gadidae and *Gadus morhua* observed in the same frame). Truncating that data to the lowest taxonomic level would have led to a drastic underestimation of diversity in the BRUV data as some of the individuals recorded were identified to phylum level such as Molluscs.

## 7.5. PSD Analysis

PSD analysis of the sediment samples was undertaken by in-house laboratory technicians at OEL's NE Atlantic Marine Biological Analytical Quality Control (NMBAQC) participating laboratory in line with NMBAQC best practice guidance (Mason 2016).

Frozen sediment samples were first transferred to a drying oven and thawed at 80°C for at least 6 hours before visual assessment of sediment type. Before any further processing (e.g., sieving or sub-sample removal), samples were mixed thoroughly with a spatula and all conspicuous fauna (>1 mm) which appeared to have been alive at the time of sampling were removed from the sample. A representative sub-sample of the whole sample was then removed for laser diffraction analysis before the remaining sample screened over a 1 mm sieve to sort coarse and fine fractions.

The >1 mm fraction was then returned to a drying oven and dried at 80°C for at least 24 hours before dry sieving. Once dry, the sediment sample were run through a series of Endecott BS 410 test sieves (nested at 0.5 φ intervals) using a Retsch AS200 sieve shaker to fractionate the samples into particle size classes. The dry sieve mesh apertures used are given in Table 6.

**Table 6** Sieve series employed for PSD analysis by dry sieving.

| Sieve aperture (mm) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 63 | 45 | 32 | 22.5 | 16 | 11.2 | 8 | 5.6 | 4 | 2.8 | 2 | 1.4 | 1 |

The sample was then transferred onto the coarsest sieve at the top of the sieve stack and shaken for a standardised period of 20 minutes. The sieve stack was checked to ensure the components of the sample had been fractioned as far down the sieve stack as their diameter would allow.

The sub-sample for laser diffraction was first screened over a 1 mm sieve and the fine fraction residue (<1 mm sediments) transferred to a suitable container and allowed to settle for 24 hours before excess water syphoned from above the sediment surface until a paste texture was achieved. The fine fraction was then analysed by laser diffraction using a Beckman Coulter LS13 320.

The dry sieve and laser data was then merged for each sample with the results expressed as a percentage of the whole sample. Once data was merged, PSD statistics and sediment classifications were generated from the percentages of the sediment determined for each sediment fraction using Gradistat v9 software. Gradistat v9 also generated a trigon based on triangle classifications of sediment gravel percentage and the sand-to-mud ratio (Folk 1954) to convert textural groups into BSHs under the EUNIS habitat classification system (adapted from (Long 2006).

Sediment descriptions are defined by their size class based on the Wentworth classification system (Wentworth 1922) (Table 7). Statistics such as mean and median grain size, sorting coefficient, skewness and bulk sediment classes (percentage silt, sand and gravel) were derived following the Folk classification (Folk 1954).

**Table 7** The classification used for defining sediment type based on the Wentworth Classification System (Wentworth 1922).

| Wentworth Scale | Phi Units (φ) | Sediment Types |
|---|---|---|
| >64 mm | <-6 | Cobble and boulders |
| 32 – 64 mm | -5 to -6 | Pebble |
| 16 – 32 mm | -4 to -5 | Pebble |
| 8 – 16 mm | -3 to -4 | Pebble |
| 4 - 8 mm | -3 to -2 | Pebble |
| 2 - 4 mm | -2 to -1 | Granule |
| 1 - 2 mm | -1 to 0 | Very coarse sand |
| 0.5 - 1 mm | 0 – 1 | Coarse sand |
| 250 - 500 µm | 1 – 2 | Medium sand |
| 125 - 250 µm | 2 – 3 | Fine sand |
| 63 - 125 µm | 3 – 4 | Very fine sand |
| 31.25 – 63 µm | 4 – 5 | Very coarse silt |
| 15.63 – 31.25 µm | 5 – 6 | Coarse silt |
| 7.813 – 15.63 µm | 6 – 7 | Medium silt |
| 3.91 – 7.81 µm | 7 – 8 | Fine silt |
| 1.95 – 3.91 µm | 8 – 9 | Very fine silt |
| <1.95 µm | <9 | Clay |

## 7.6. Chemical Contaminants Analysis

All chemical contaminant analyses on sediment samples were undertaken by UKAS accredited and Marine Management Organization (MMO) Validated laboratory SOCOTEC UK Limited. Sediment samples were processed and analysed for Total Hydrocarbon Content (THC), Polycyclic Aromatic Hydrocarbons (PAH), Polychlorinated biphenyls (PCB), Organochlorine Pesticides (OCP), organotins, and Heavy and Trace Metals. A description of the methods used to test for each chemical determinand is provided in Table 8.

**Table 8** Chemical contaminant analysis methods.

| Determinand | Detection Limit | Method/ Instrument |
|---|---|---|
| THC (inc. saturates) | 1 mg $kg^{-1}$ (Total) | Solvent extraction & GC-FID |
| PAHs (Environmental Protection Agency (EPA) 16) | 1µg $kg^{-1}$ | Solvent extraction & GC-MS |
| Metals suite: As(0.5), Cd(0.04), Cr(0.5), Cu(0.5), Pb(0.5), Hg(0.01), Ni(0.5), Zn(2) mg/kg | Detection Limit provided in parentheses in 'Determinand' column, | Aqua Regia extraction and ICPMS |
| Total Organic Caron (TOC) | | Carbonate removal and sulphurous acid/combustion at 1600°C/NDIR. |
| PCB | 0.00008 mg $kg^{-1}$ | Solvent extraction and clean up followed by GC-MS-MS analysis. |
| OCP | 0.0001 mg $kg^{-1}$ | Solvent extraction and clean up followed by GC-MS-MS analysis. |
| Organotins | 0.001 mg $kg^{-1}$ | Solvent extraction and derivatisation followed by GC-MS analysis. |

### 7.6.1. Hydrocarbons

Indices and ratios were calculated to assess source origin of hydrocarbons in the sediment sampled across the Project Area. Generally, there are three sources of hydrocarbons depending on their origin: biogenic, petrogenic and pyrogenic. Hydrocarbons of biogenic origin are the produce of biological processes or early diagenesis in marine sediments (e.g., perylene) (Venkatesan 1988, Junttila et al. 2015). Hydrocarbons of petrogenic origin are the compounds present in oil and some oil products following low to moderate temperature diagenesis of organic matter in sediments resulting in fossil fuels. Hydrocarbons of pyrogenic origin are the product of incomplete combustion of organic material (Fagbote 2013), such as forest fires and incomplete combustion of fossil fuels.

Based on PAH compounds the following ratios were calculated as follows:

Phenanthrene / Anthracene ratio: values lower than 10 indicate a pyrogenic source origin for the hydrocarbons; while values higher than ten account for hydrocarbons of petrogenic origin (Kafilzadeh et al. 2011).

Fluoranthene / Pyrene ratio: for values higher than one, the hydrocarbons are pyrogenic in origin, for values below one, the hydrocarbons are petrogenic in origin (Kafilzadeh et al. 2011).

### 7.6.2. Heavy and Trace Metals

A total of eight main heavy and trace metals were analysed from sediments taken across the Project Area. These were Arsenic (As), Cadmium (Cd), Chromium (Cr), Copper (Cu), Lead (Pb), Mercury (Hg), Nickel (Ni), and Zinc (Zn).

Where available, metal concentrations were compared to the OSPAR Background Assessment Concentration (BAC) (OSPAR et al. 2009), the USA EPA Effect Range Low (ERL) (NJDEP 2009), Centre for Environment, Fisheries and Aquaculture Science (CEFAS) (DEFRA 2003) Action Level (AL) 1 and AL 2, and the Canadian sediment quality guideline (CSQG) Threshold Effect Level (TEL) and Probable Effect Level (PEL) (CCME 2001). To note that ERL, TEL and PEL are based on field research programmes based on North American data that have demonstrated associations between chemicals and biological effects by establishing cause and effect relationships in particular organisms (CCME 2001). This means they provide a measure of environmental toxicity compared to the other reference levels which instead provide information on the degree of contamination of the sediments. At levels above the TEL, adverse effects may occasionally occur, whilst at levels above the PEL, adverse effects may occur frequently; concentrations below the ERL rarely cause adverse effects in marine organisms. Additionally, the TEL has been adopted as the International Sediment Quality Guideline (ISQG) (CCME 2001), while ERL has been adopted by OSPAR to assess the ecological significance of contaminant concentrations in sediments, where concentrations below the ERL rarely cause adverse effects in marine organisms. For these reasons ERL, TEL and PEL are presented here as reference values despite being based on North American data.

BACs were developed to assess the status of contaminant concentrations in sediment within the OSPAR framework with concentrations significantly below the BAC considered to be near background levels for the North-East Atlantic. CEFAS ALs are used as part of a 'weight of evidence' approach to assessing dredged material and its suitability for disposal to sea (DEFRA 2003). Contaminant levels in dredged material which fall below AL1 are of no concern and are unlikely to influence decision-making, while contaminant levels above AL2 are generally considered unsuitable for at-sea disposal.

## 7.7. Macrobenthic Analysis

All elutriation, extraction, identification, and enumeration were undertaken at OEL's NMBAQC scheme participating laboratory in line with the NMBAQC Processing Requirement Protocol (Worsfold & Hall 2010). All processing information and macrobenthic records were recorded using OEL's cloud-based data management application ABACUS that employs MEDIN validated, controlled vocabularies ensuring all sample information, nomenclature, qualifiers, and metadata are recorded in line with international data standards.

For each macrobenthic sample, the excess formalin was drained off into a labelled container over a 1 mm mesh sieve in a well-ventilated area. The samples were then re-sieved over a 1 mm mesh sieve to remove all remaining fine sediment and fixative. The low-density fauna was then separated by elutriation with freshwater, poured over a 1 mm mesh sieve, transferred into a Nalgene and preserved in 70 % Industrial Denatured Alcohol (IDA). The remaining sediment from each sample was subsequently separated into 1 mm, 2 mm and 4 mm fractions and sorted under a stereomicroscope to extract any remaining fauna (e.g., high-density bivalves not 'floated' off during elutriation).

All fauna present was identified to species level, where possible, and enumerated by trained benthic taxonomists using the most up to date taxonomic literature and checks against existing reference collections. Nomenclature utilises the live link within ABACUS to the World Register of Marine Species (WoRMS) web services to ensure the most up to date taxonomic classifications are recorded. Colonial fauna (e.g., hydroids and bryozoans) were identified to species level where possible and recorded as present (P). For subsequent data analysis, taxa recorded as P were given the numerical value of 1. A full reference collection was retained including at least one example specimen of each taxon.

### 7.7.1. Data Truncation and Standardisation

The macrobenthic taxon list was checked using the R package "*worms*" (Holstein 2018)to check against WoRMS taxon lists and standardise species nomenclature. Once the species nomenclature was standardised in accordance with WoRMS-accepted species names, the species list was examined carefully by a senior taxonomist to truncate the data, combining species records where differences in taxonomic resolution were identified.

### 7.7.2. Pre-Analysis Data Treatment

All data were collated in excel spreadsheets and made suitable for statistical analysis. All data processing and statistical analysis was undertaken using R v 1.2 1335 (R Core Team, 2022) and PRIMER v7 (Clarke & Gorley 2015) software packages.

In accordance with the OSPAR Commission guidelines (OSPAR 2004) records of colonial, meiofaunal, parasitic, egg and pelagic taxa (e.g., epitokes and larvae) were recorded, but were excluded when calculating diversity indices and conducting multivariate analysis of community structure.

Newly settled juveniles of macrobenthic species may at times dominate the macrobenthos, however the OSPAR (2004) guidelines suggest they should be considered an ephemeral component due to heavy post-settlement mortality and not therefore representative of prevailing bottom conditions (OSPAR 2004). OSPAR (2004) further states that "Should juveniles appear among the ten most dominant organisms in the data set, then statistical analyses should be conducted both with and without these in order to evaluate their importance". As juveniles of the family *Anomiidae* appeared in the top ten of the most dominant taxa across Project Area, a

2STAGE analysis was conducted to compare the two data sets (with and without juveniles) which revealed a high level of similarity (99 %) between the two and therefore juveniles were retained in the dataset for all further analyses and discussion.

In accordance with NMBAQC PRP (Worsfold & Hall 2010), Nematoda were recorded during the macrobenthic analysis and included in all datasets for all further analyses and discussion.

For some of the data analysis, taxa have been grouped into five major groups (Annelida, Crustacea, Mollusca, Echinodermata, and Miscellaneous taxa) to assess brad patterns in community composition.

### 7.7.3. Multivariate Statistics

Prior to multivariate analyses, data were displayed as a shade plot with linear grey-scale intensity proportional to macrobenthic abundance (Clarke et al. 2014) to determine the most efficient pre-treatment (transformation) method. Macrobenthic abundance data from grab samples were square-root transformed to prevent taxa with intermediate abundances from being discounted from the analysis, whilst allowing the underlying community structure to be assessed.

The PRIMER v7 software package (Clarke & Gorley 2015) was utilised to undertake the multivariate statistical analysis on the biotic macrobenthic dataset. To fully investigate the multivariate patterns in the biotic data, macrobenthic assemblages were characterised based on their community composition, with hierarchical clustering and non-metric multidimensional scaling (nMDS) used to identify groupings of sampling stations that could be grouped together as a habitat type or community. SIMPER (similarities-percentage) analysis was then applied to identify which taxa contributed most to the similarity within that habitat type or community.

## 7.8. Determining Habitat Classifications

Habitats were identified and classified in accordance with the EUNIS habitat classification system (under the 2012 EUNIS classification system), in line with JNCC guidance on assigning benthic biotopes (Parry 2019). Classifications were assigned based on the combined analysis of seabed imagery, geophysical data and sediment and macrobenthos data from garb samples alongside existing habitat maps (EMODnet). Seabed features were assigned the highest level of classification possible. All habitat / biotope determination was undertaken through consideration of the following:

- Existing habitat mapping (derived from EMODnet);
- Review and interpretation of geophysical data;
- Seabed imagery;
- BSH derived from PSD data;
- Macrobenthic assemblage composition for biotope assignment.

## 7.9. Habitat Mapping

All habitat mapping was undertaken in ESRI ArcPro Version 3.3.2 by a habitat mapping specialist and reviewed by a secondary senior environmental scientist. This involved overlaying EUNIS classifications on the mosaiced SSS and MBES data allowing for delineation of areas representative of similar acoustic signatures aligned to those at each DDC / grab station and DDC transects, as well as ROV and UAV imagery. Each sampling location was assigned to a EUNIS habitat / biotope based on the available data (still images, grabs, acoustic data) while existing EMODnet was consulted as supporting information. Following this, an Annex I habitat assessment was carried out at each sampling location where the criteria for Annex I reef were met as per Table 5. Similarly, a PMF assessment was also carried out at locations targeted by DDC, ROV and UAV to delineate any PMF habitats, including 'Kelp beds'. The final step involved overlaying this classification onto the mosaic SSS and MBES data to delineate large-scale habitats and identify noteworthy features.

Confidence scores were assigned to all polygons to give an indication of their accuracy. Values ranged from 1 (single data source) to 2 (multiple data sources) depending on the following:

- Whether ground-truth data (seabed imagery, PSD, macrobenthos) was available within the polygon
- Whether multiple data sources confirmed/suggested the presence of the same habitat/biotope within a polygon
- Whether the boundaries of the habitat/biotope were clearly defined in the acoustic data

Highest scores were given to polygons where all data sources identified the same habitat / biotope, with distinct boundaries. Lower scores were assigned to polygons where the boundaries were not obvious. In these cases, polygons were drawn based upon expert judgement, given the information available.

## 7.10. Predictive Mapping of Reef Ecological Value

Due to initial assessments determining the majority of the site to be dominated by geogenic reef features, a further assessment was recommended to capture the Ecological Value (EV) of reef areas to help inform micrositing of infrastructure. An EV assessment was conducted (Section 7.1.3), with the resultant data suitable for predictive modelling across the project area.

A predictive modelling exercise was undertaken to explore the potential to predict the EV of reef habitats from physical environmental data for this site. The analysis focused on predicting the variable of taxonomic distinctness ($\Delta+$), from which EV may be derived.

Predictive modelling is a widely used, automated process of classifying and mapping benthic habitat (Degraer et al. 2008, McGonigle et al. 2009, Brown et al. 2011, Stephens & Diesing 2014, Calvert et al. 2015, Boswarva et al. 2018). It utilises a variety of high-resolution physical variables identified as proxies for habitat and the composition of species and communities of species associated with particular habitats (Brown et al. 2011). Thus, promoting wide-scale, relatively fast and cost-effective methods of mapping large areas of the seabed to high degrees of accuracy (Andersen et al. 2018). Predictive maps can also act as a baseline in which to develop further comprehensive investigations, further maximising survey time and effort (Wynn et al.).

The model utilised acoustic data (MBES and SSS) as well as hydrodynamic data obtained from Copernicus Marine Data Store (https://data.marine.copernicus.eu/products). This was supplemented by georeferenced ground-truth data derived from DDC imagery. Each point location in the dataset had an associated value for taxon richness (S), taxonomic distinctness ($\Delta^+$) and EV, a classification derived from taxonomic distinctness.

Random Forest models (Breiman L 2001) were used to explore whether combinations of environmental variables and their derivatives could predict taxonomic distinctness. Random Forests is a popular machine learning algorithm that has shown good performance in a range of contexts, including predicting ecological properties of marine benthic habitats from physical environmental variables (Misiuk & Brown 2024). The algorithm is particularly useful for identifying complex, non-linear relationships in several variables. Random Forest is suitable in the context of the present study as it is non-parametric, has few assumptions, and is robust to multi-collinearity in predictor variables.

Variables were generated from the acoustic data to characterise the physical environmental properties of the Project Area across a range of spatial scales, to be used to predict the response variable. As there were no prior expectations about the most influential properties or spatial scales, a standard selection was generated based on recommendations in the literature (Lecours et al. 2017).

Predictor variables were sampled at the locations of the ground-truth data and their individual relationships with the response variable of taxonomic distinctness were assessed by examining scatterplots and Spearman rank correlation coefficients. Random Forest models were built to train and test the model on its ability to predict the test data and the metric $R^2$ was used to describe the proportion of variation in the response variable that is explained by the predictor variables. This same modelling process was repeated after reducing the predictor variables to six principal components using Principal Components Analysis (PCA).

PCA transforms a number of different, but potentially correlated, variables into a smaller number of uncorrelated principal components (Amiri-Simkooei et al. 2011). In doing so, it condenses all information into the first few bands, removing highly correlated information and thus reducing dimensionality without losing data (Costa & Battista 2013). All modelling and modelling processes were conducted in ESRI ArcGIS ESRI ArcPro Version 3.3.1.

# 8. Results

## 8.1. Survey Progress

### 8.1.1. Environmental Characterisation Survey

During the survey, an initial *in situ* review of the 38 original scope DDC and grab stations revealed 31 stations to be unsuitable for grab sampling due to the presence of hard ground (cobbles and boulders) and potential Annex I geogenic reef features in some areas. An *ad hoc* adapted sampling plan was therefore agreed upon during the survey to maximise operational effort and increase visual site characterisation by increasing the number of DDC stations across the Project Area (Figure 5).

Seventeen DDC stations were added to the scope (8 high priority, 5 medium priority and 4 low priority). These stations were identified based on the ground-truthing imagery and existing acoustic data to a) identify additional areas to increase grab sample replication, and b) increase ground-truthing points across the Project Area to increase confidence in habitat mapping outputs, with high priority stations positioned in areas where grab sampling was more likely to be successful.

Of these additional 17 stations, 11 failed DDC pre-screening and grabbing was therefore not attempted. Of the remaining 6 stations where grabbing was deemed suitable, four were successful whilst two failed due to the presence of cobbles in the jaws of the grab which prevented the collection of an acceptable sample (Table 9). In total 11 stations were successfully grabbed and samples for PSD and macrobenthic analyses obtained. However, it was only possible to collect duplicate samples (for chemical contaminant analysis) at 7 of these stations. The result of this was 55 DDC stations and 11 grab samples for macrobenthic and PSD analysis with 7 of these samples undergoing full analysis (macrobenthic, PSD and chemical contaminants). Full DDC imagery and video logs are provided in Appendix I and II respectively, and grab logs in Appendix III.

Twelve DDC transects were also sampled, as designated in the original sampling plan (Table 9). Alongside the 55 sampled DDC stations, this resulted in the collection of 550 still images and 70 videos which were analysed to identify the BSH and biotopes across the Project Area and ground truth geophysical data. Images were further assessed to inform on the distribution and extent of any protected and/or sensitive habitats and species (e.g., Annex I reef features/ PMFs) (Section 8.3).

BRUV frames were deployed at 7 stations, yielding 7 hours of baited video footage. It was not possible to visit the remaining three BRUV stations due to poor weather (Table 9).

**Table 9** Summary of sampling effort.

| Type | Proposed scope | Achieved Sampling | Additional scope | Achieved Sampling | Total Stations |
|---|---|---|---|---|---|
| DDC (Stations) | 38 | 38 | 17 | 17 | 55 |
| DDC (Transects) | 12 | 12 | - | - | 12 |
| Grab | 38 | 7 | 6 | 4 | 11 |
| BRUVs | 10 | 7 | - | - | 7 |

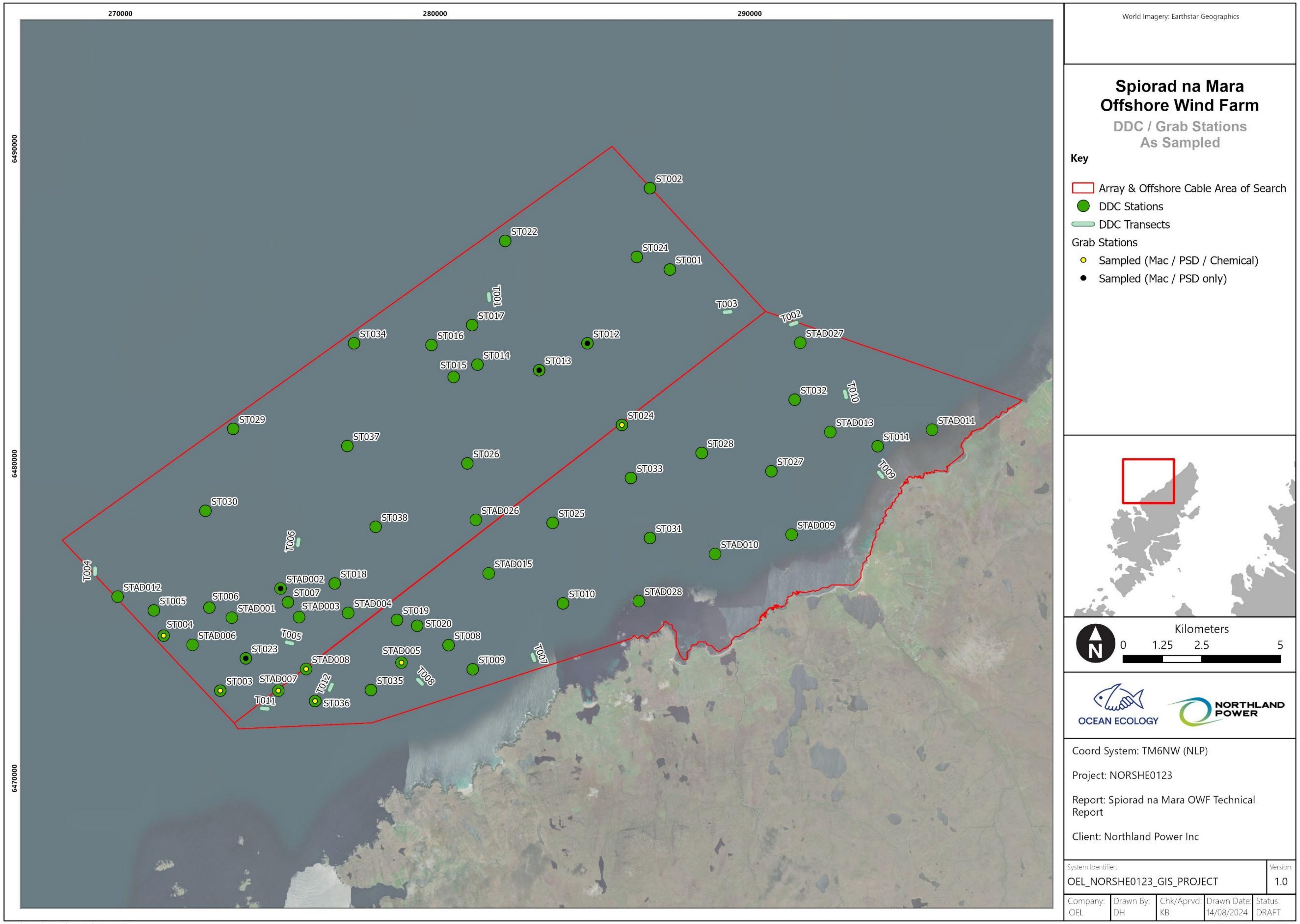


**Figure 5** DDC/grab sampling stations, and DDC transects as sampled (post-survey).

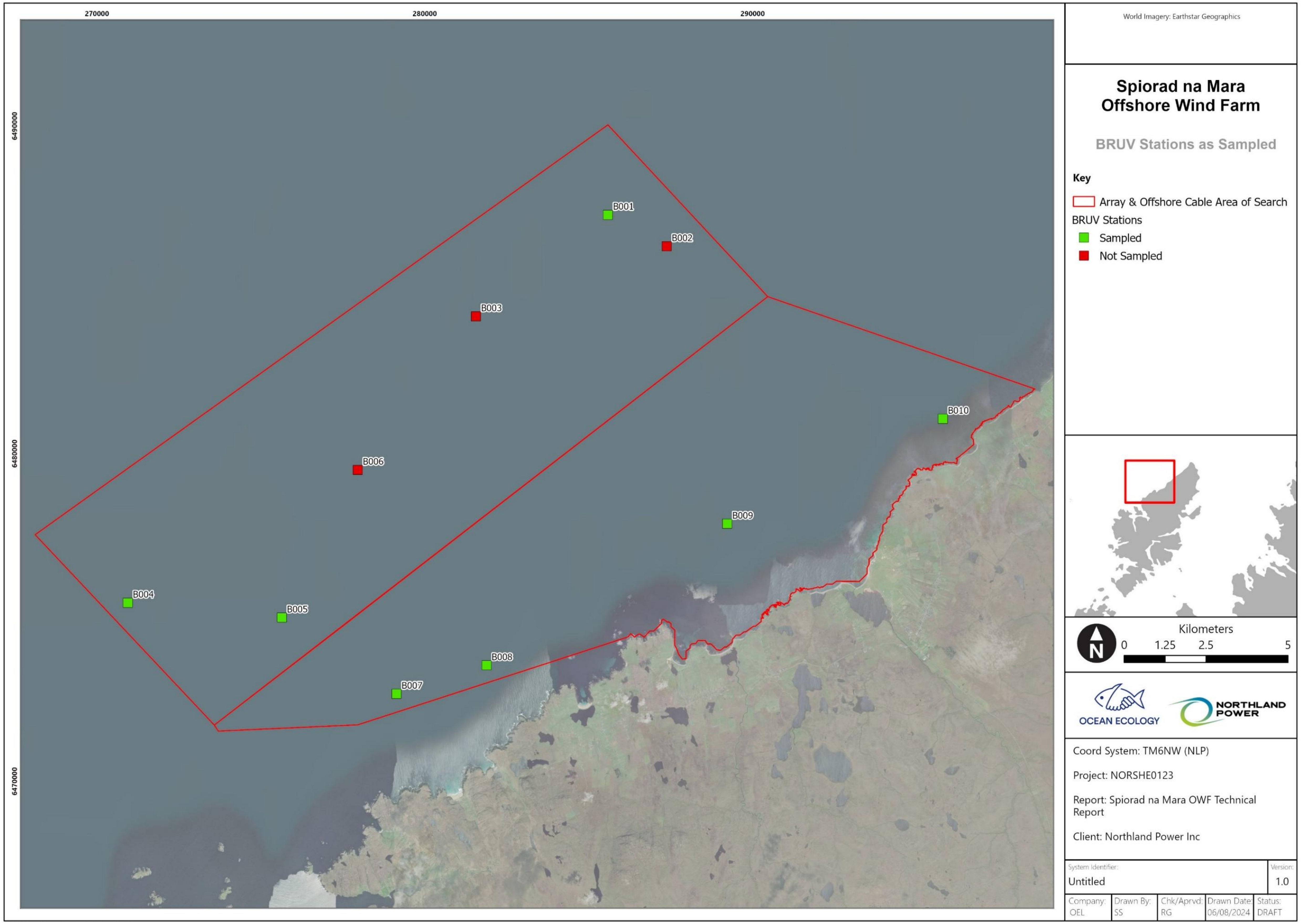


**Figure 6** BRUV sampling stations as sampled (post-survey).

### 8.1.2. PMF Survey

Two UAV flights were successfully undertaken from the shore on the 4th and 8th September resulting in the acquisition of 1,438 high-resolution nadir images across a total coverage area of 0.52 $km^2$ to produce a high resolution orthomosaic model (GSD = 3.28 cm/px). These were undertaken at low tide and, while wind speed and sea state were not optimal for high quality data capture, an initial review of the outputs indicated that nearshore kelp was visible and boundaries could be identified. This data was used to feed into the identification and mapping of kelp habitats within the nearshore OCAS. UAV flight 2, conducted on the 8th September 2024, was outside of the refined landfall areas for the three cable route options. This was due to time restrictions and adhering to landowner access approved rights of way which limited meaningful access further north along the shore to the nearest landfall area. This data still proved valuable in aiding interpretation of acoustic data and in the wider understanding of kelp presence / absence along this area of coastline.

The full orthomosaic output is provided as Appendix XV. UAV orthomosaic outputs are presented in Figure 7 and Figure 8.

The ROV survey was conducted along a total of 15 target ROV transects covering a combined distance of 8 km, as mapped in Figure 9. This resulted in the collection of 730 images and 90 HD video files totalling 1 hour 15 minutes of footage for subsequent analysis. ROV field logs are provided in Appendix XVI and the kelp bed boundaries video log is provided in Appendix XVII.

ROV transect placement was determined *in situ* and adapted based on observations and findings from the ongoing survey operations. An initial ROV survey area defined pre-survey extended to the 30 m depth contour, however after the first two ROV dives it was evident that kelp did not extend deeper than around the 17 - 20 m contour. This finding was immediately applied to focus operational effort closer inshore for the remaining transects. In some areas the deeper water kelp boundary was marginally shallower, in to around the 13 - 15 m contour. Breaks in kelp coverage were identified *in situ* and these boundaries were accurately positioned through subsequent image analysis. Breaks in kelp coverage appeared largely due to a change in seabed type away from a geogenic dominated substrate into either sand with patchy cobble cover or dense cover of smaller cobbles / pebbles.

ROV video footage was divided up into screenshots for still image analysis and also underwent photogrammetric methods to produce orthomosaics of the seabed along each surveyed transect. These orthomosaics were used to aid in image analysis and subsequent mapping of kelp boundaries. Example photogrammetric outputs are presented in Plate 7.

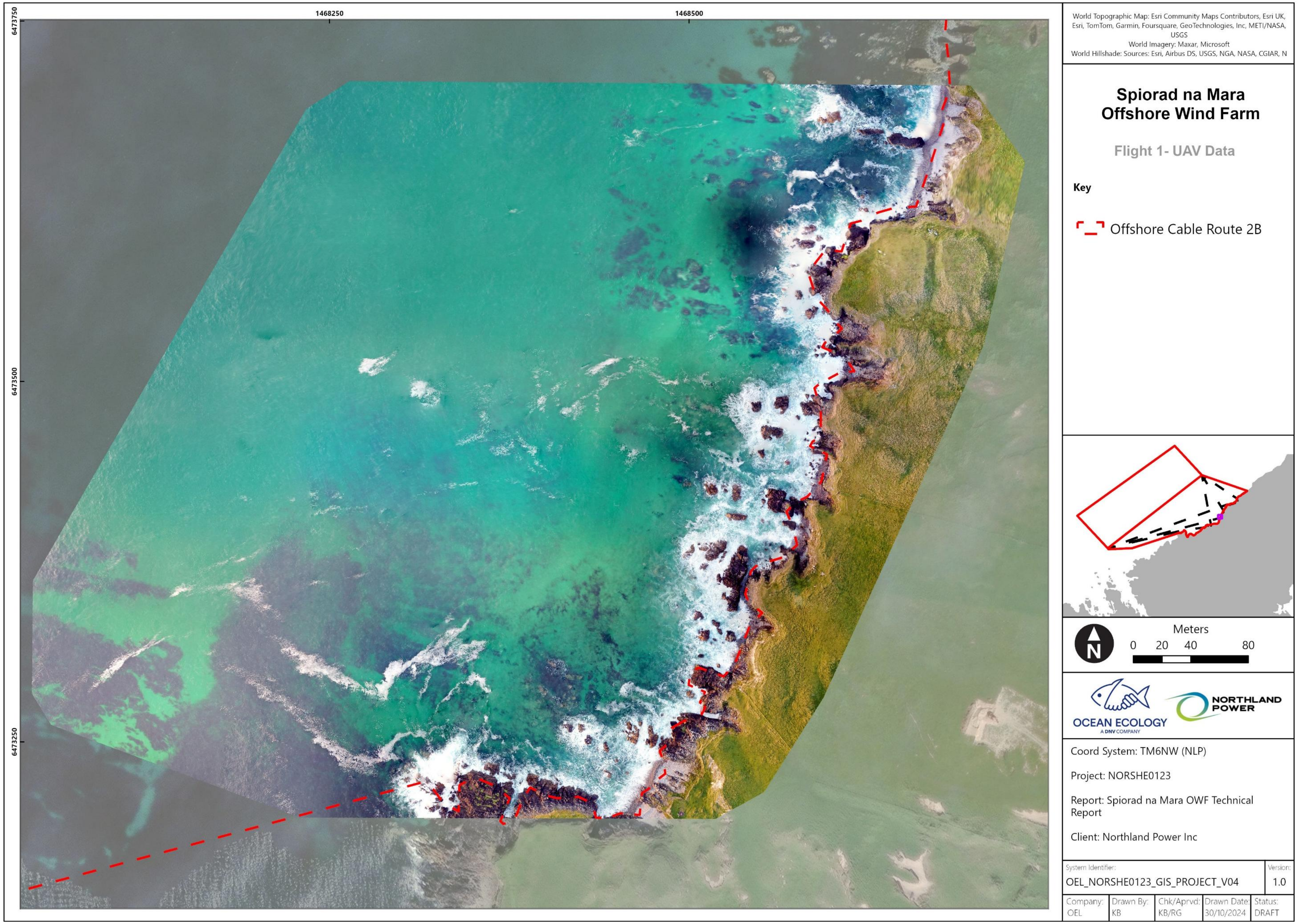


**Figure 7** Flight 1 UAV data captured on 04/09/2024 within the landfall area of cable route option 2B.

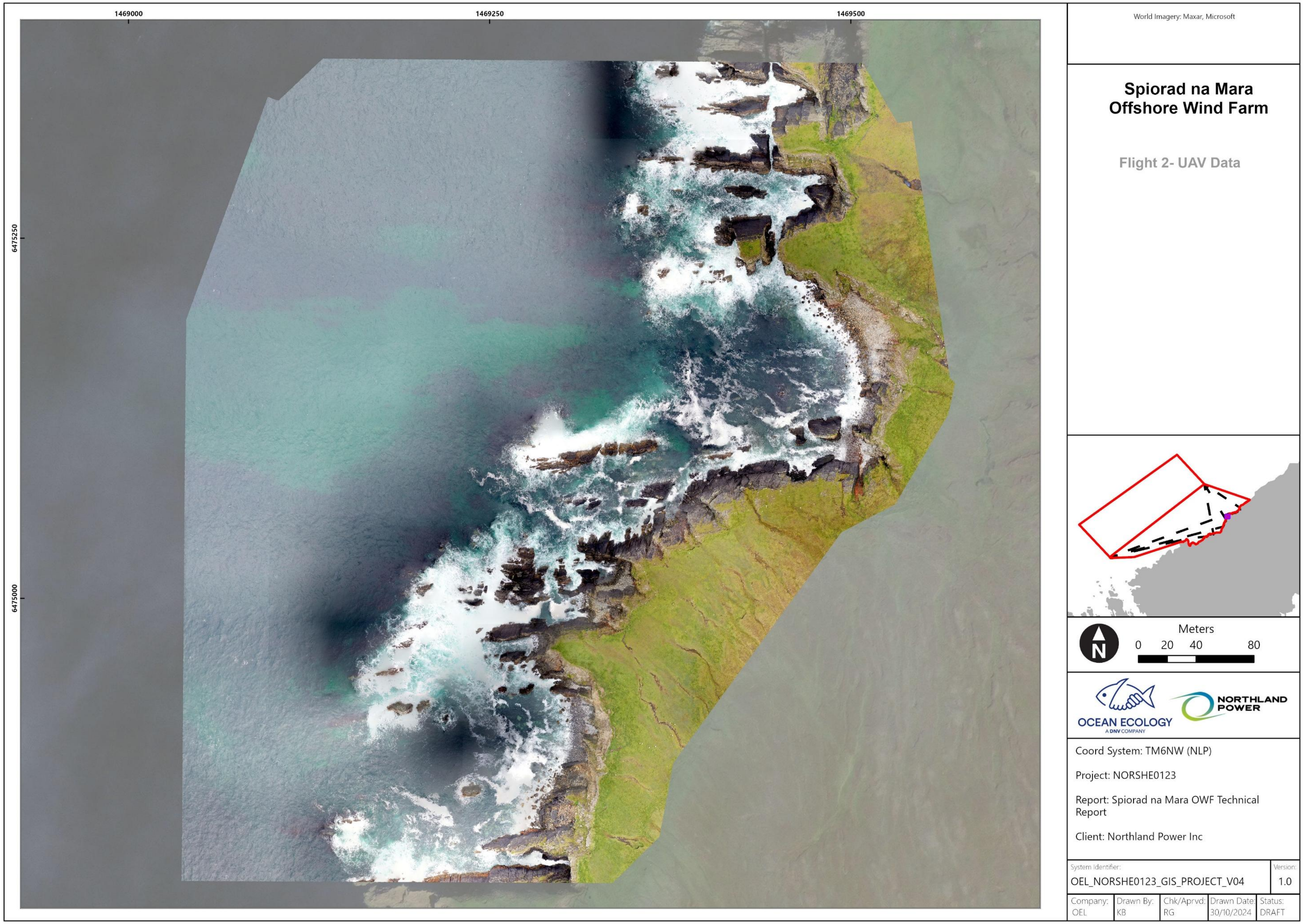


**Figure 8** Flight 2 UAV data captured on 08/09/2024.

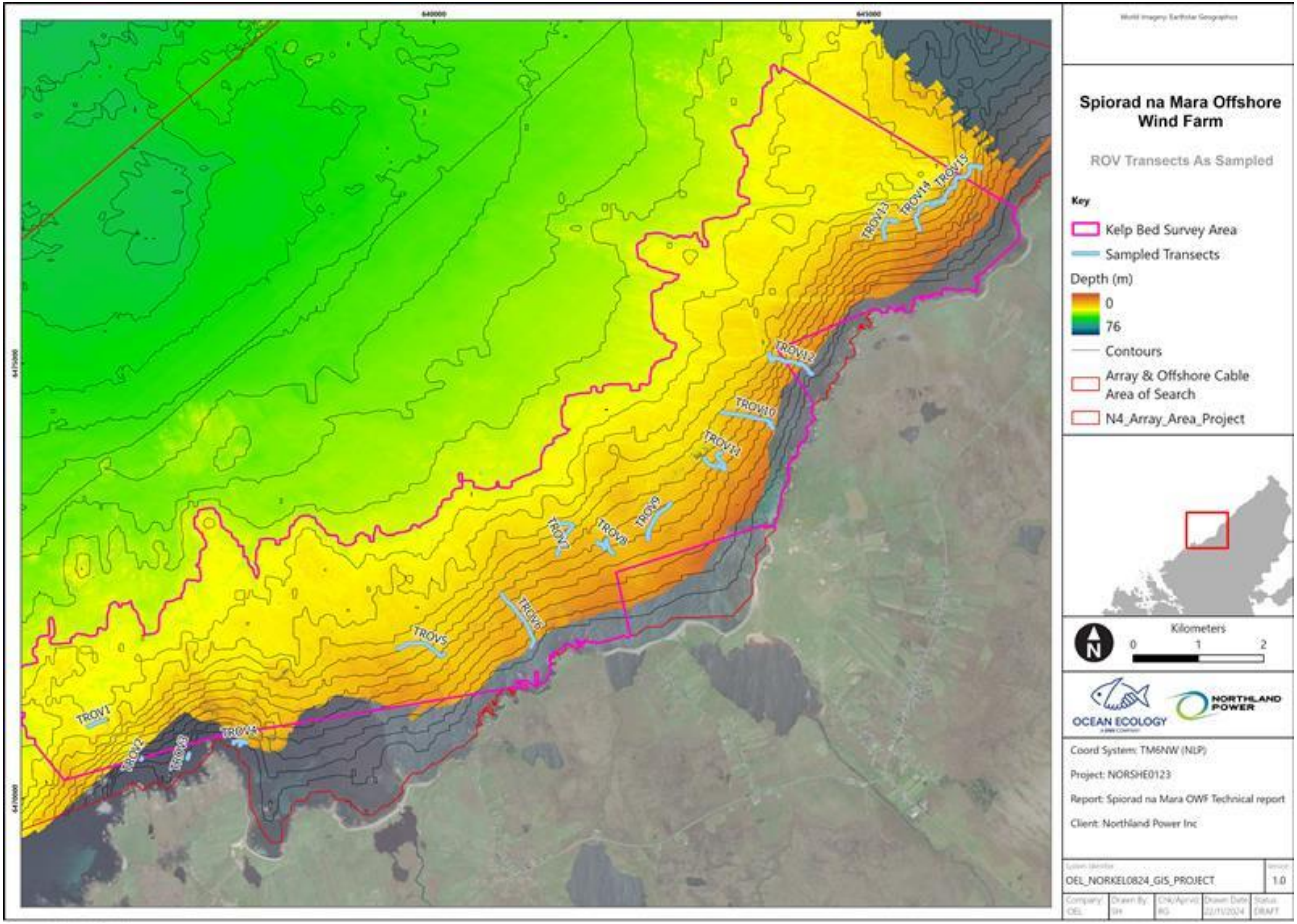


**Figure 9** As sampled ROV transect locations from within the PMF survey area (located within the wider Project Area OCAS). Overlain on 2023 MBES bathymetry data.

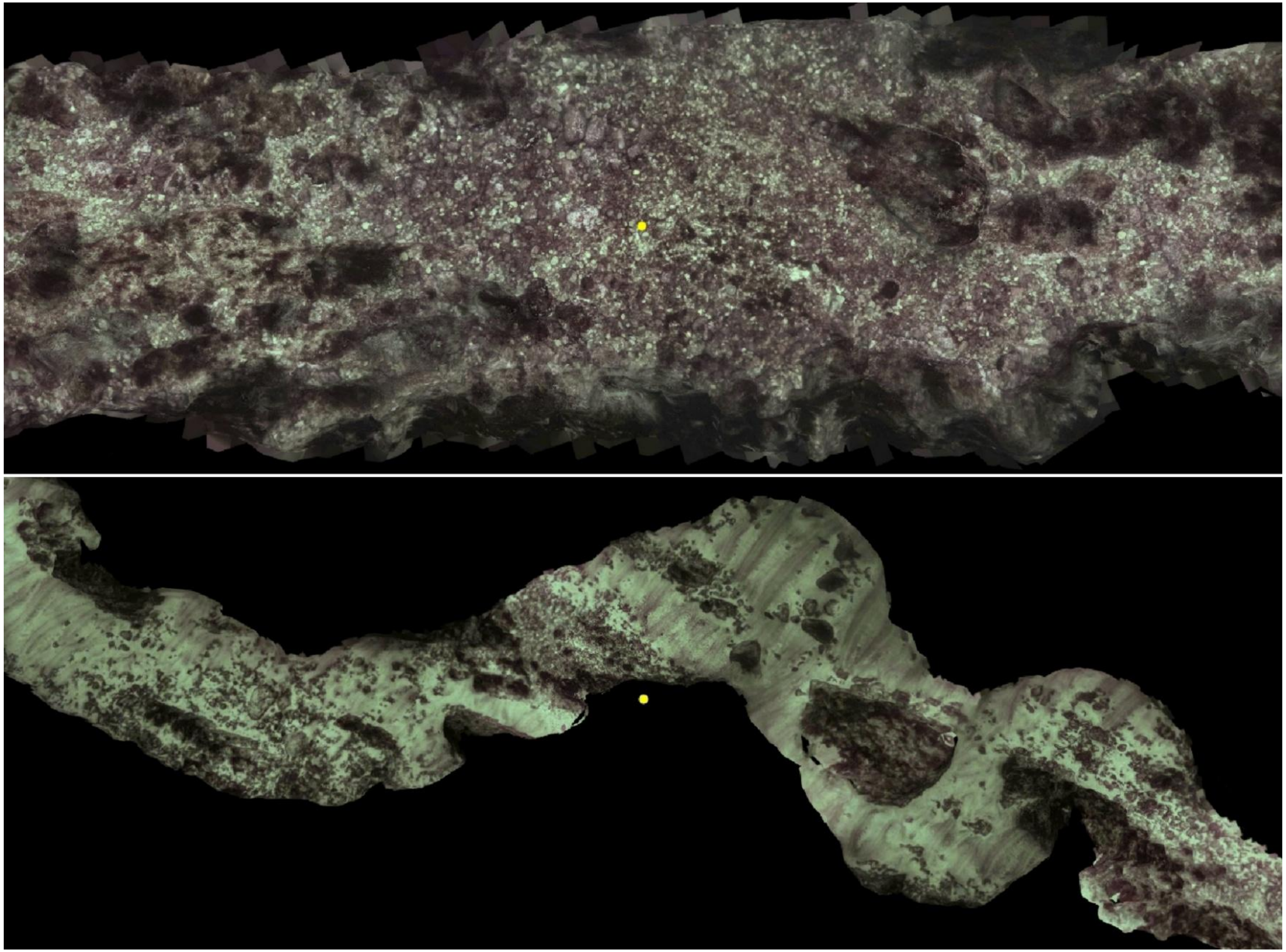

**Plate 7** Example sections of photogrammetry outputs produced using ROV footage. Top: T10. Bottom: T12.

## 8.2. Geophysical Data

The geophysical data (MBES and SSS) collected by The Project during the geophysical survey campaign are presented in Figure 10 and Figure 11, respectively. It provided almost 100 % coverage of the Project Area and was interpreted together with the seabed imagery to inform the seabed habitat assessment and mapping process.

The bathymetry presented as a generally shallow (~5 - 76 m) seabed, predominantly sloping gently to the northwest with a steeper slope and bathymetric low to the southwest. The Project Area was dominated by a topographically complex terrain interpreted as hard seabed features (Figure 10).

The SSS data presented a predominantly heterogenous high reflectivity seabed interpreted as hard seabed features comprising predominantly of a mosaic of mobile coarse sediments and cobbles. Distinct outcrops were interpreted to the northeast and east. Ripples were noted in the SSS data that were interpreted as soft sediments (Figure 11).

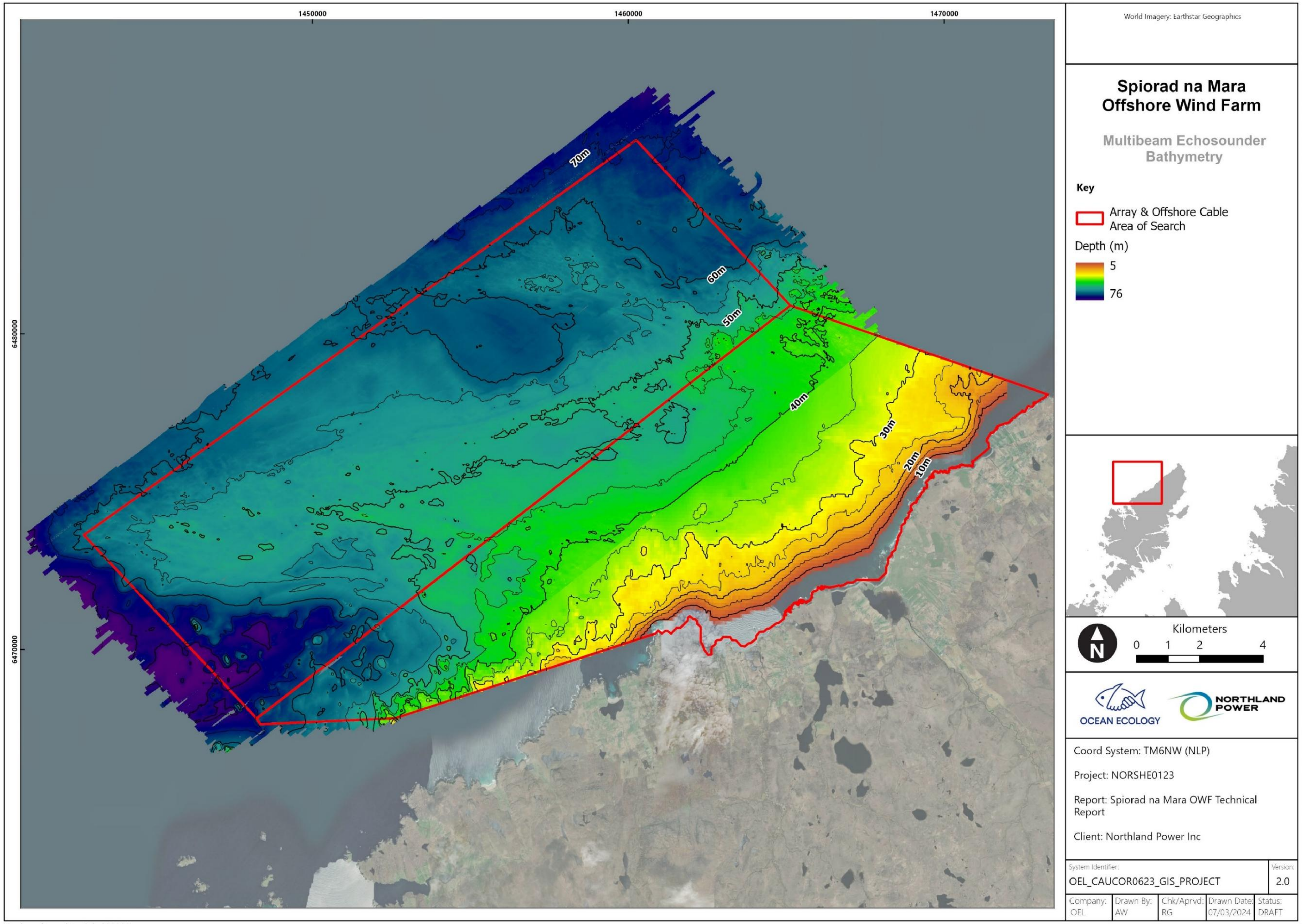


**Figure 10** MBES data collected within the Spiorad na Mara Array Area and OCAS.

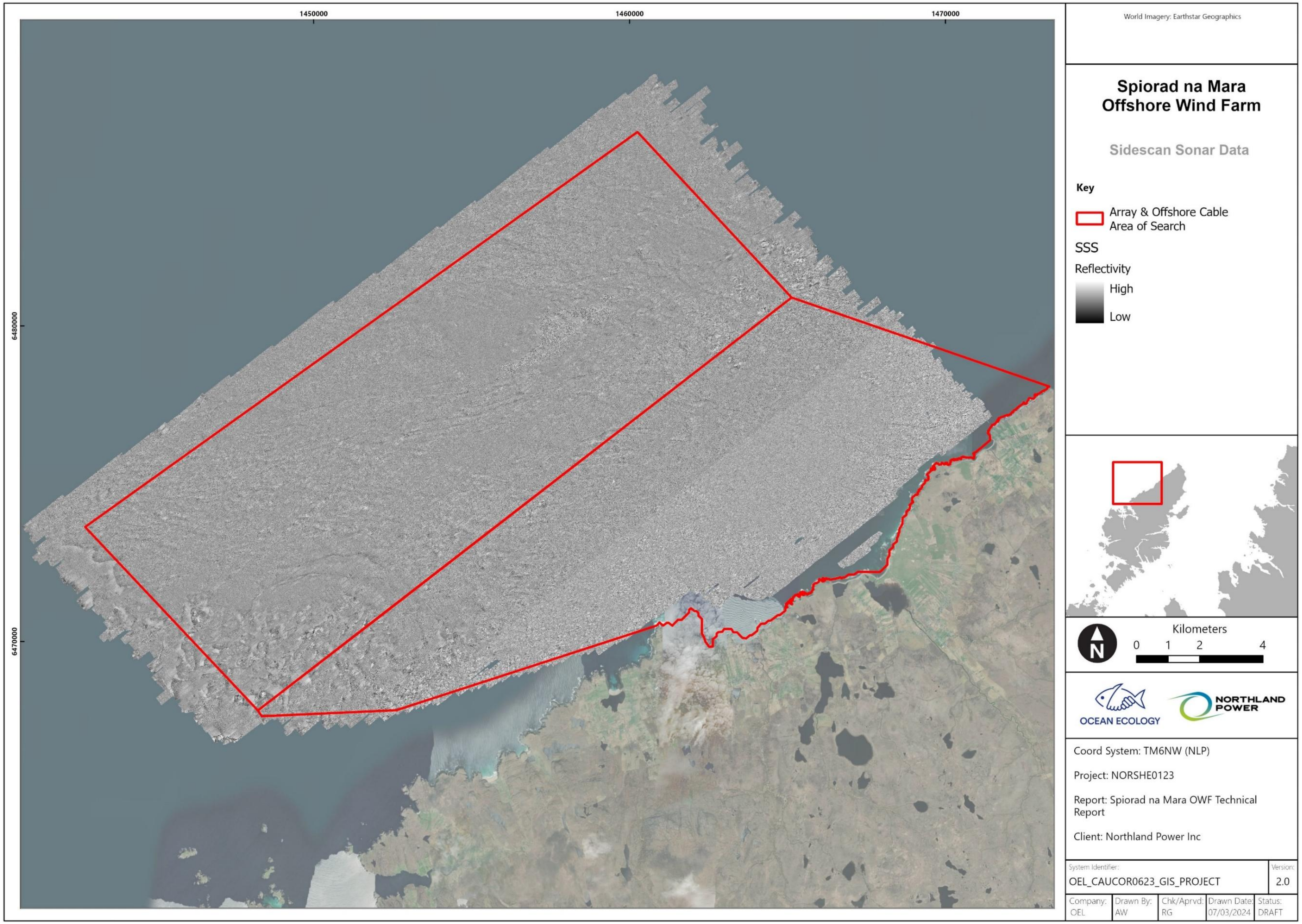


**Figure 11** SSS data collected across the Spiorad na Mara array area and OCAS.

## 8.3. Seabed Imagery Analysis

### 8.3.1. DDC

DDC stills and video logs are presented in Appendix I and II, respectively. Example imagery is presented in Plate 8 to Plate 12. The full DDC imagery proforma is provided in Appendix IV.

Across the Project Area as a whole, a total of six EUNIS Level 3 BSH, five EUNIS Level 4 habitat complexes, five EUNIS Level 5 biotope complexes and four EUNIS Level 6 biotopes were identified in seabed imagery. The most commonly occurring of these was A4.214 'Faunal and algal crusts on exposed to moderately wave-exposed circalittoral rock' identified in 360 of the 550 total images.

**Stations**

*Array*

At DDC stations within the array area, a total of three EUNIS Level 3 BSHs, four EUNIS Level 4 habitat complexes, one EUNIS Level 5 biotope complex and one EUNIS Level 6 biotope were identified in the seabed imagery. The most commonly encountered of these was A4.214 'Faunal and algal crusts on exposed to moderately wave-exposed circalittoral rock' identified in 123 of the 183 images collected across the array area followed by A5.14 'Circalittoral coarse sediment', identified in a further 30 images (Table 10 and Figure 12). A mosaic between the habitats A4.214 'Faunal and algal crusts on exposed to moderately wave-exposed circalittoral rock' and A5.14 'Circalittoral coarse sediment' was identified in all images collected at station ST005.

**Table 10** EUNIS BSH and habitat/biotope complexes identified in seabed imagery collected by DDC within the array area.

| BSH | EUNIS Code | EUNIS Description |
|---|---|---|
| A4.2 | A4.21 | Echinoderms and crustose communities on circalittoral rock |
| | A4.214 | Faunal and algal crusts on exposed to moderately wave-exposed circalittoral rock |
| | A4.2145 | Faunal and algal crusts with *Pomatoceros triqueter* and sparse *Alcyonium digitatum* on exposed to moderately wave-exposed circalittoral rock |
| A5.1 | A5.14 | Circalittoral coarse sediment |
| A5.2 | A5.25 | Circalittoral fine sand |
| | A5.26 | Circalittoral muddy sand |

*OCAS*

At DDC stations within the OCAS, two EUNIS Level 3 BSHs, two EUNIS Level 4 habitat complexes and one EUNIS Level 5 biotope complex were identified during seabed imagery analysis. The most common habitat type was A4.214 'Faunal and algal crusts on exposed to moderately wave-exposed circalittoral rock', identified in 114 of the 145 images collected along the OCAS. Twentynine images were identified as A5.14 'Circalittoral coarse sediment' and the remaining two as A4.21 'Echinoderms and crustose communities on circalittoral rock' (Table 11 and Figure 12). A mosaic between the habitats A4.214 'Faunal and algal crusts on exposed to moderately wave-exposed circalittoral rock' and A5.14 'Circalittoral coarse sediment' was identified in all images collected at station ST008. A mosaic between A4.21 'Echinoderms and crustose communities on circalittoral rock' and A5.14 'Circalittoral coarse sediment' was also observed in two images collected from ST019.

**Table 11** EUNIS BSH and habitat/biotope complexes identified in seabed imagery collected from DDC stations within the OCAS.

| BSH | EUNIS Code | EUNIS Description |
|---|---|---|
| A4.2 | A4.21 | Echinoderms and crustose communities on circalittoral rock |
| | A4.214 | Faunal and algal crusts on exposed to moderately wave-exposed circalittoral rock |
| A5.1 | A5.14 | Circalittoral coarse sediment |

**Transects**

*Array*

Along DDC transects within the array area two EUNIS Level 3 BSHs, three EUNIS Level 4 habitat complexes, two EUNIS Level 5 biotope complexes and two EUNIS Level 6 biotopes were identified. The most commonly occurring of these was EUNIS A4.214 'Faunal and algal crusts on exposed to moderately wave-exposed circalittoral rock' accounting for 52 of the 87 images analysed from transects in this area. The remaining images consisted of a variety of circalittoral rock (A4.2) and circalittoral sand (A5.2) habitats, including the EUNIS Level 6 biotope A4.2146 '*Caryophyllia smithii* with faunal and algal crusts on moderately wave-exposed circalittoral rock' (8 images at T005) (Table 12, Figure 13, Figure 14 and Figure 15).

**Table 12** EUNIS BSH and habitat/biotope complexes identified in seabed imagery collected from DDC transects within the array area.

| BSH | EUNIS Code | EUNIS Description |
|---|---|---|
| A4.2 | A4.2 | Atlantic and Mediterranean moderate energy circalittoral rock |
| | A4.21 | Echinoderms and crustose communities on circalittoral rock |
| | A4.212 | *Caryophyllia smithii*, sponges and crustose communities on wave-exposed circalittoral rock |
| | A4.214 | Faunal and algal crusts on exposed to moderately wave-exposed circalittoral rock |
| | A4.2144 | Brittlestars on faunal and algal encrusted exposed to moderately wave-exposed circalittoral rock |
| | A4.2146 | *Caryophyllia smithii* with faunal and algal crusts on moderately wave-exposed circalittoral rock |
| A5.2 | A5.25 | Circalittoral fine sand |
| | A5.26 | Circalittoral muddy sand |

*OCAS*

Seabed imagery analysis of images collected from DDC transects within the OCAS identified six EUNIS Level 3 BSHs, four EUNIS Level 4 habitat complexes, four EUNIS Level 5 biotope complexes and two EUNIS Level 6 biotopes. A4.214 'Faunal and algal crusts on exposed to moderately wave-exposed circalittoral rock' was again the most commonly occurring habitat, identified in 71 of the 135 images analysed in this region. The remaining images were identified as a wide range of habitats. These included the Atlantic and Mediterranean high (A3.1) and moderate (A3.2) energy infralittoral rock habitats A3.116 'Foliose red seaweeds on exposed lower infralittoral rock' and A3.214 '*Laminaria hyperborea* and foliose red seaweeds on moderately exposed infralittoral rock'. A4.2 biotopes such as A4.2141 '*Flustra foliacea* on slightly scoured silty circalittoral rock' and A4.2142 '*Alcyonium digitatum, Pomatoceros triqueter*, algal and bryozoan crusts on wave-exposed circalittoral rock' were also identified, as well as circalittoral coarse (A5.1) and mixed (A5.4) sediments and circalittoral sands (A5.2) (Table 13, Figure 13, Figure 14 and Figure 15).

**Table 13** EUNIS BSH and habitat/biotope complexes identified in seabed imagery collected from DDC transects within the OCAS.

| BSH | EUNIS Code | EUNIS Description |
|---|---|---|
| A3.1 | A3.116 | Foliose red seaweeds on exposed lower infralittoral rock |
| A3.2 | A3.214 | *Laminaria hyperborea* and foliose red seaweeds on moderately exposed infralittoral rock |
| A4.2 | A4.2 | Atlantic and Mediterranean moderate energy circalittoral rock |
| | A4.21 | Echinoderms and crustose communities on circalittoral rock |
| | A4.214 | Faunal and algal crusts on exposed to moderately wave-exposed circalittoral rock |
| | A4.2141 | *Flustra foliacea* on slightly scoured silty circalittoral rock |
| | A4.2142 | *Alcyonium digitatum*, *Pomatoceros triqueter*, algal and bryozoan crusts on wave-exposed circalittoral rock |
| | A4.215 | *Alcyonium digitatum* and faunal crust communities on vertical circalittoral bedrock |
| A5.1 | A5.14 | Circalittoral coarse sediment |
| A5.2 | A5.26 | Circalittoral muddy sand |
| A5.4 | A5.44 | Circalittoral mixed sediments |

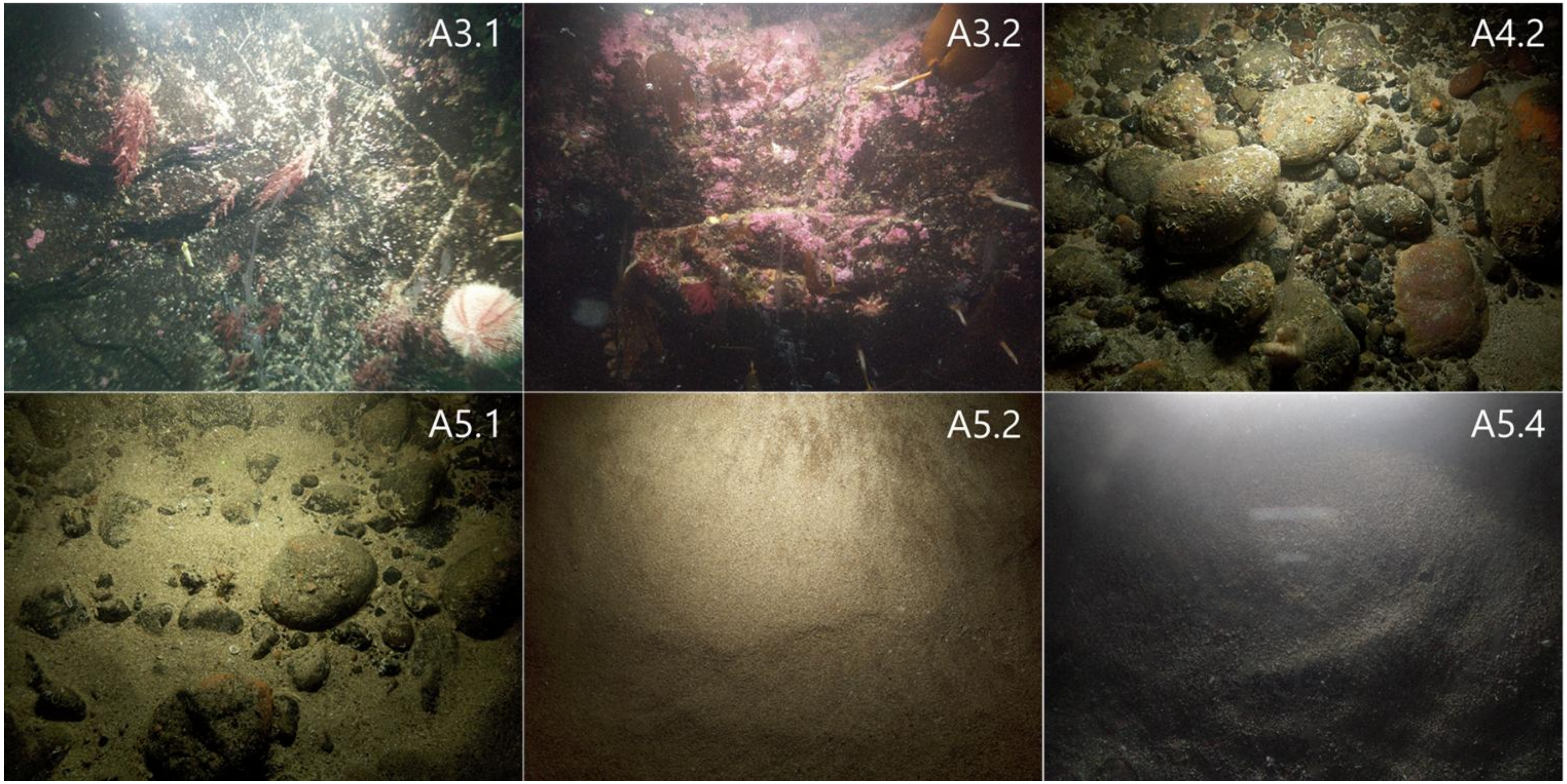


**Plate 8** Example imagery of BSHs[5] identified in DDC imagery across the Project Area. Clockwise from top left: T009, T007, ST001, T008, ST003 and ST005.

[5] A3.1 - Atlantic and Mediterranean high energy infralittoral rock
A3.2 - Atlantic and Mediterranean moderate energy infralittoral rock
A4.2 - Atlantic and Mediterranean moderate energy circalittoral rock
A5.1 - Sublittoral coarse sediment
A5.2 - Sublittoral sand
A5.4 - Sublittoral mixed sediments

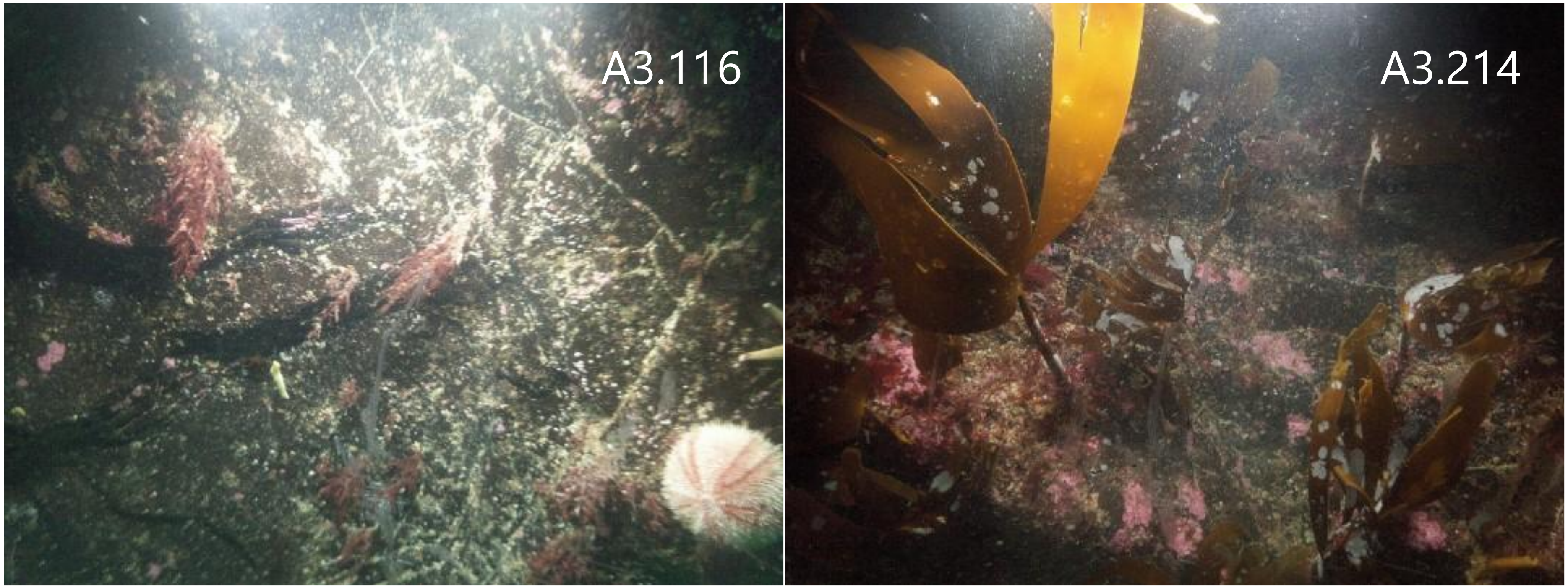


**Plate 9** Examples of biotope[6] complexes captured via DDC identified within the EUNIS BSHs A3.1 and A3.2. Left T009, right T009.

[6] A3.116 - Foliose red seaweeds on exposed lower infralittoral rock
A3.214 - *Laminaria hyperborea* and foliose red seaweeds on moderately exposed infralittoral rock

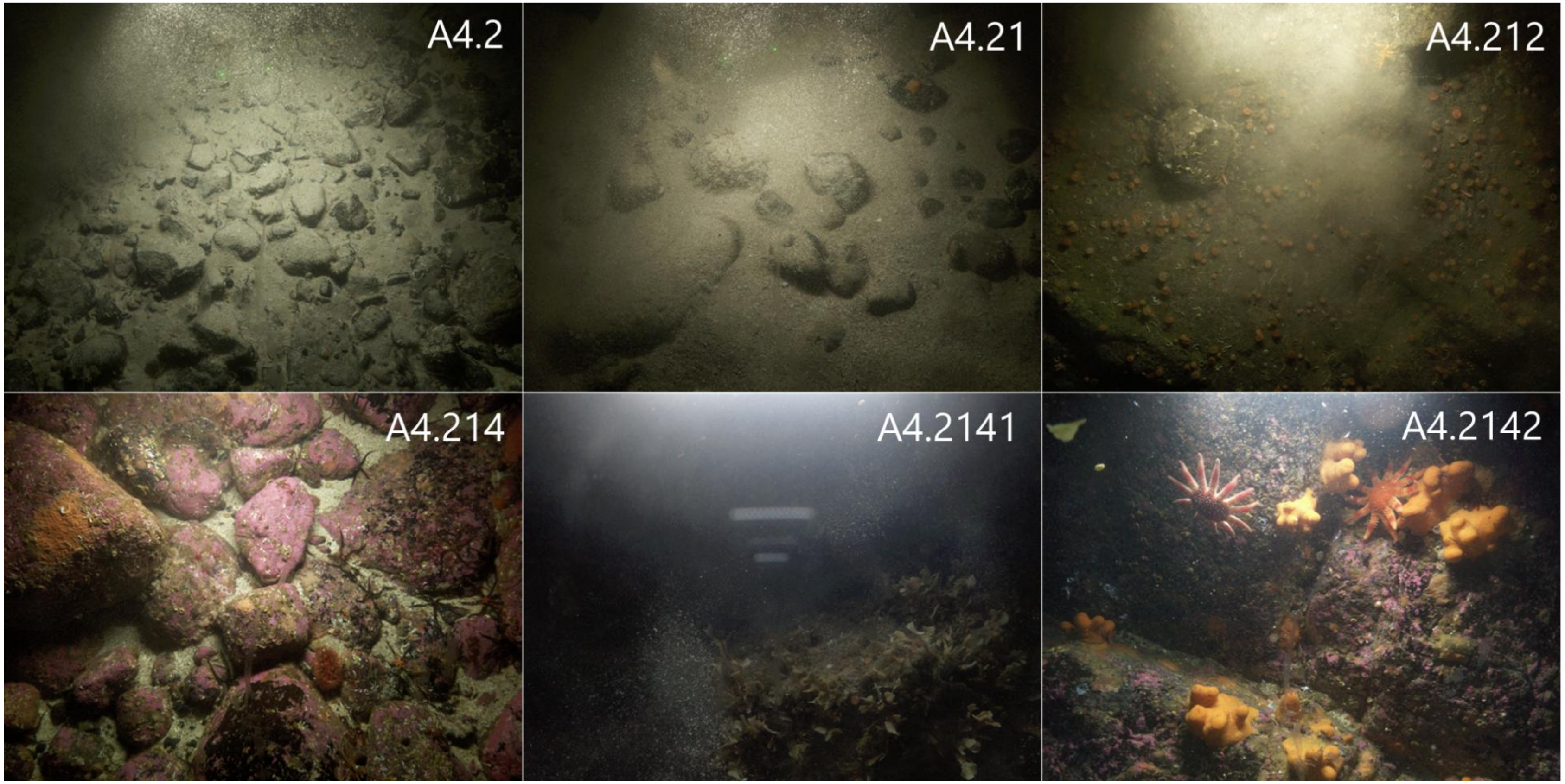


**Plate 10** Examples of habitat and biotope complexes [7]captured via DDC within EUNIS BSH A4.2. Clockwise from top left: T005, STAD001, T005, T002, T008 and ST011.

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[7] A4.2 - Atlantic and Mediterranean moderate energy circalittoral rock
A4.21 - Echinoderms and crustose communities on circalittoral rock
A4.212 - *Caryophyllia smithii*, sponges and crustose communities on wave-exposed circalittoral rock
A4.214 - Faunal and algal crusts on exposed to moderately wave-exposed circalittoral rock
A4.2141 - *Flustra foliacea* on slightly scoured silty circalittoral rock
A4.2142 - *Alcyonium digitatum, Pomatoceros triqueter*, algal and bryozoan crusts on wave-exposed circalittoral rock

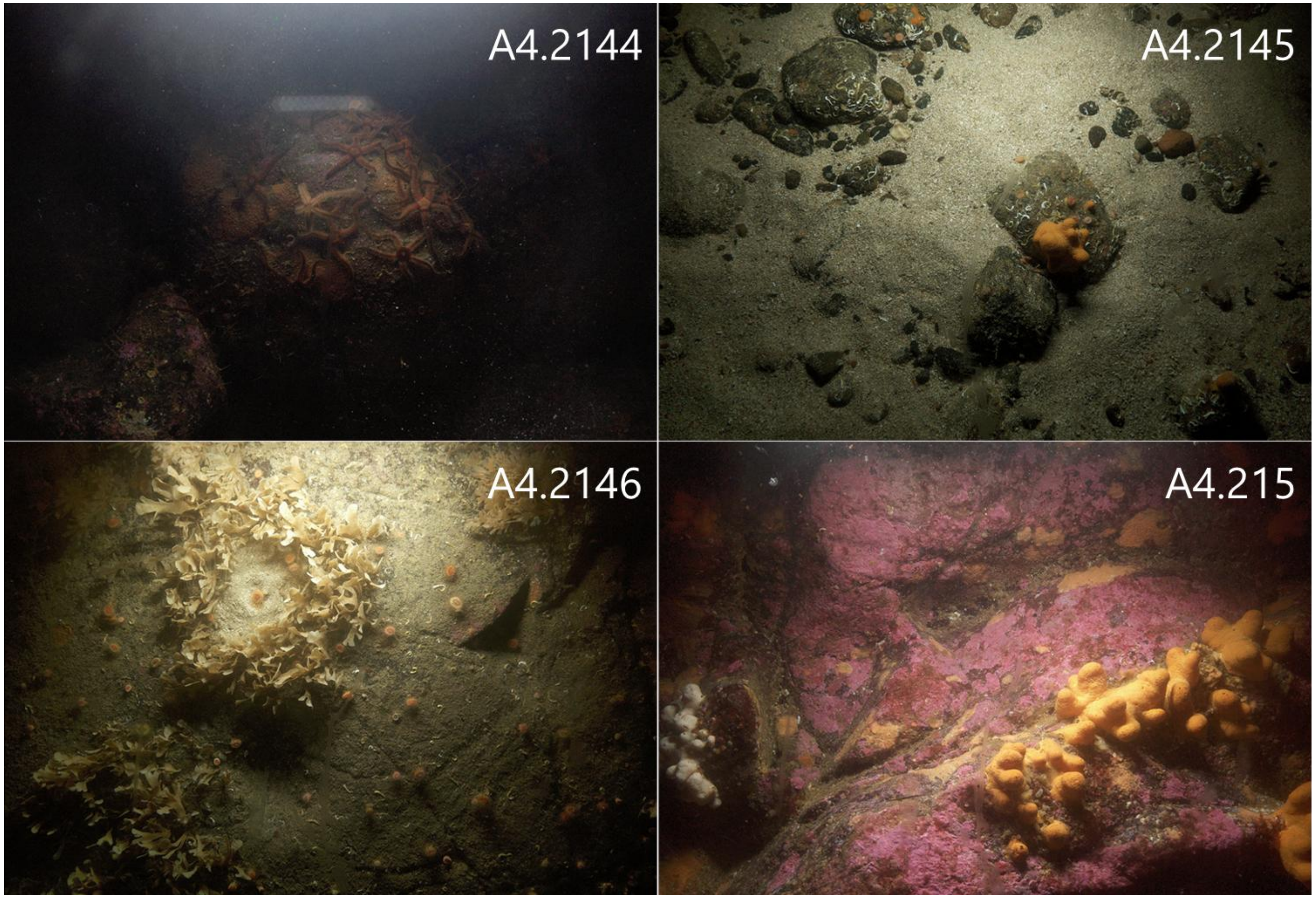


**Plate 11** Further examples of habitat and biotope complexes[8] captured via DDC within EUNIS BSH A4.2. Clockwise from top left: T006, ST001, T007 and T005.

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[8] A4.2144 : Brittlestars on faunal and algal encrusted exposed to moderately wave-exposed circalittoral rock
A4.2145 : Faunal and algal crusts with Pomatoceros triqueter and sparse Alcyonium digitatum on exposed to moderately wave-exposed circalittoral rock
A4.2146 : Caryophyllia smithii with faunal and algal crusts on moderately wave-exposed circalittoral rock
A4.215 : Alcyonium digitatum and faunal crust communities on vertical circalittoral bedrock

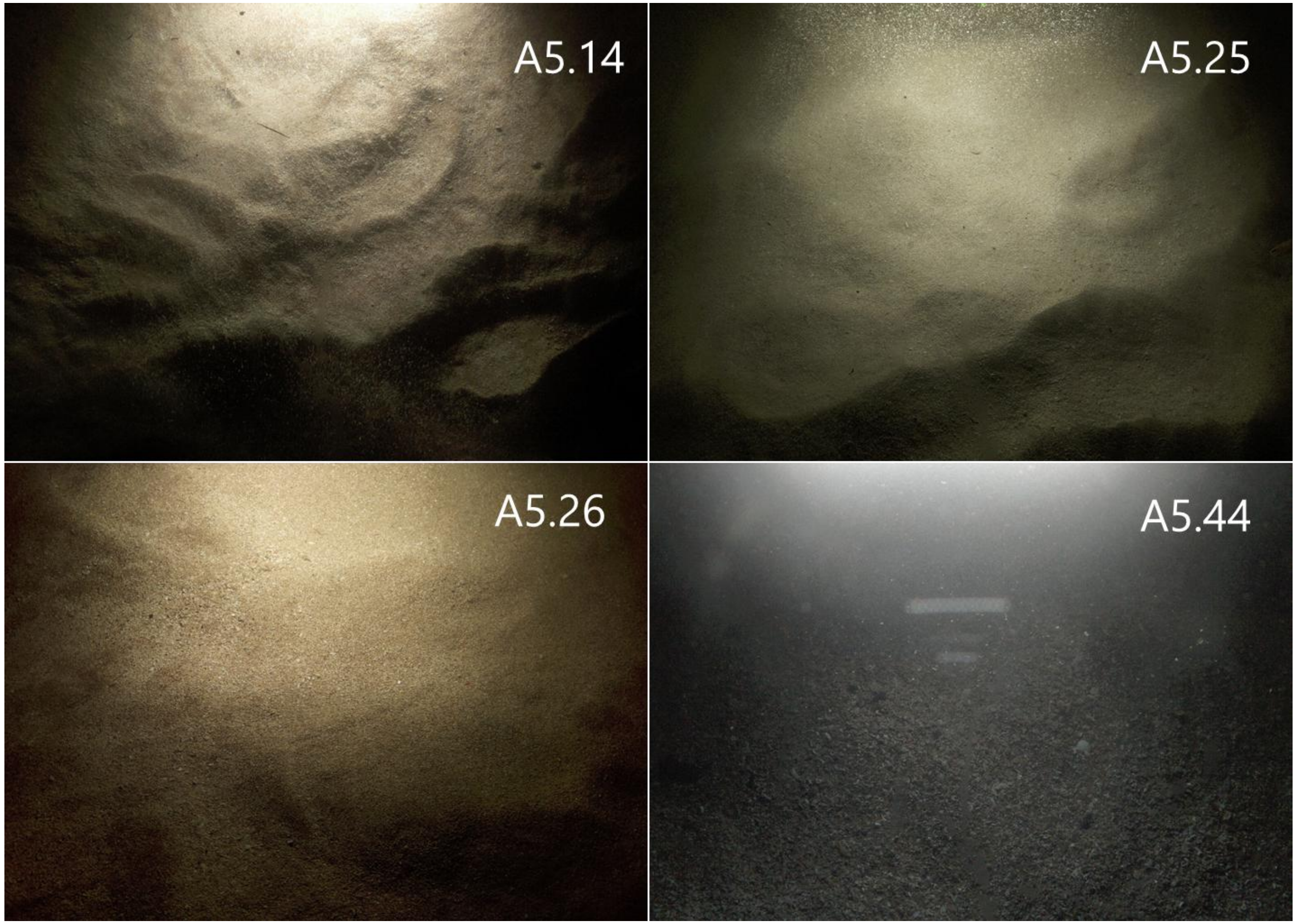


**Plate 12** Examples of habitat and biotope complexes[9] captured via DDC within EUNIS BSHs A5.1, A5.2 and A5.4. Clockwise from top left: ST035, ST013, T008, ST003.

[9] A5.14 - Circalittoral coarse sediment
A5.25 - Circalittoral fine sand
A5.26 - Circalittoral muddy sand
A5.44 - Circalittoral mixed sediments

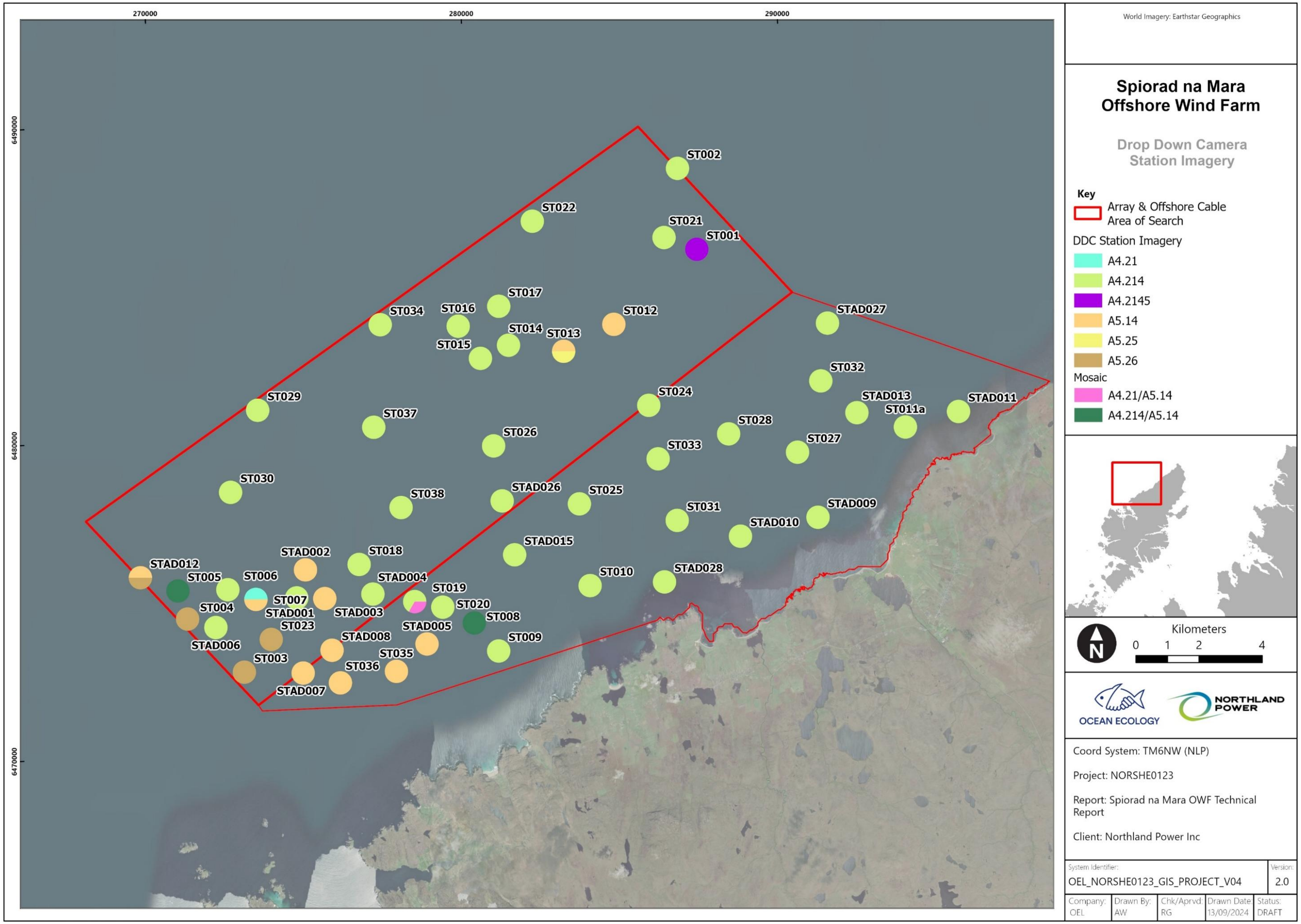


**Figure 12** EUNIS classifications derived from seabed imagery collected at DDC stations across the Project Area.

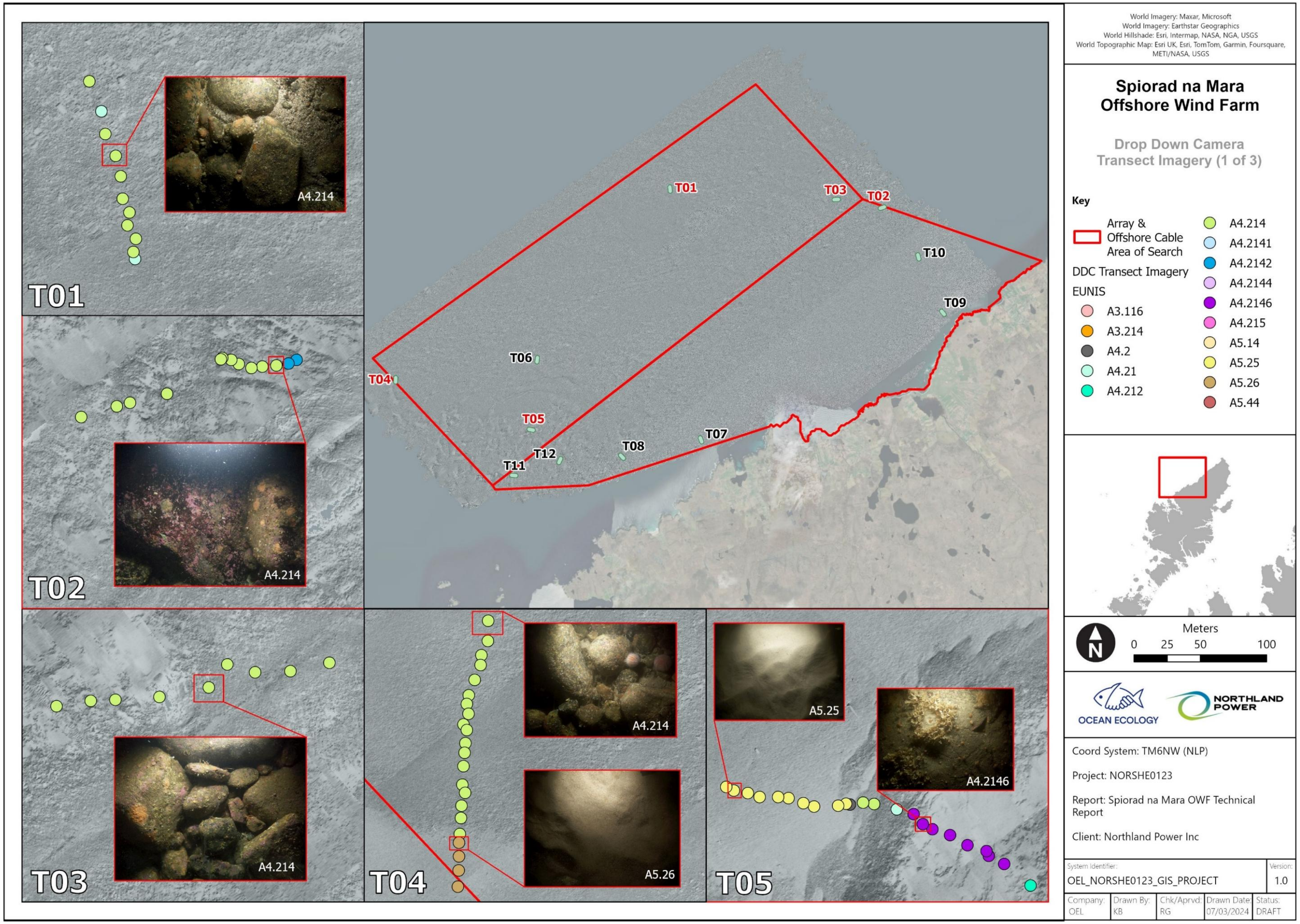


**Figure 13** EUNIS classifications derived from seabed imagery collected along DDC transects across the Project Area (1 of 3).

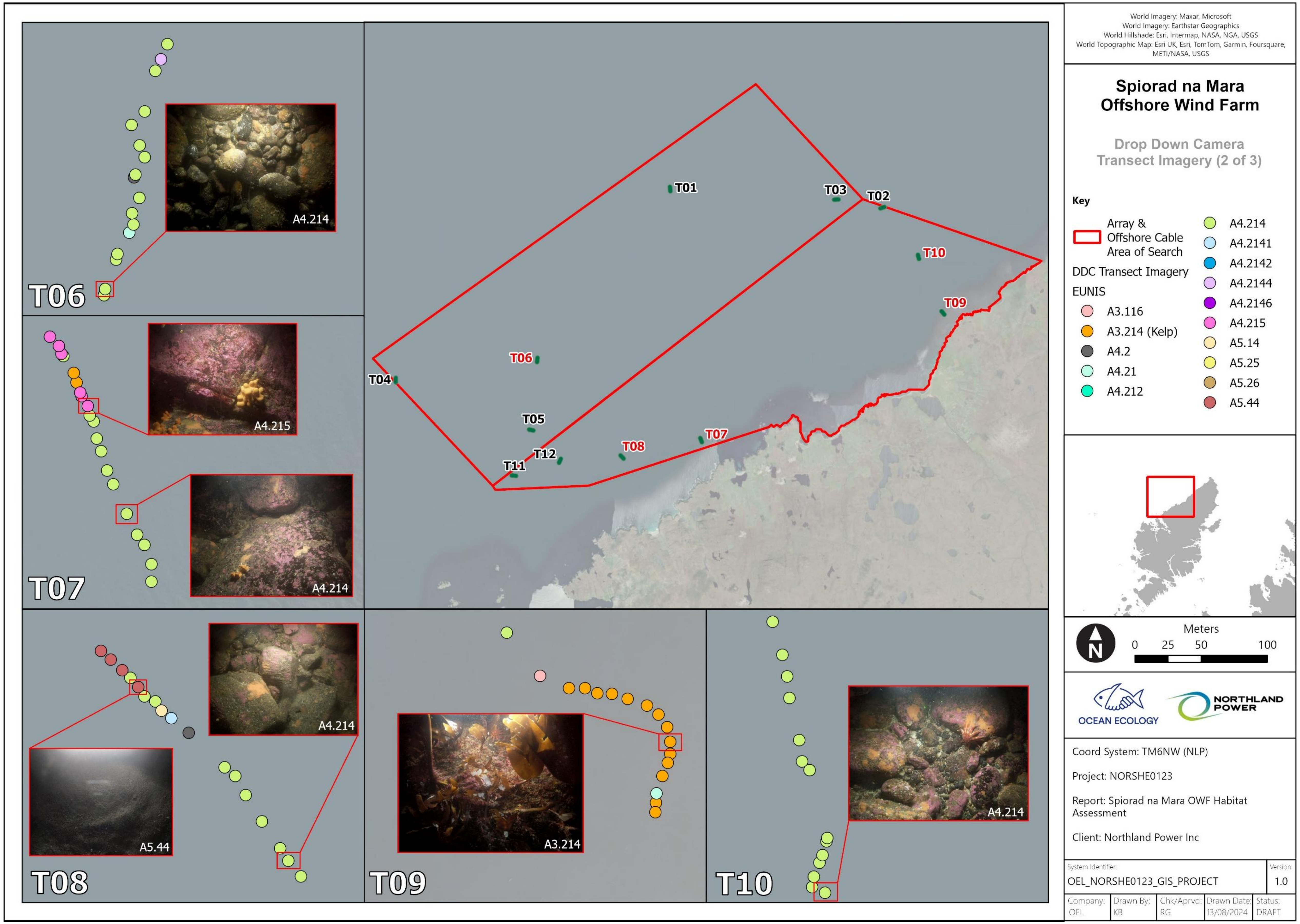


**Figure 14** EUNIS classifications derived from seabed imagery collected along DDC transects across the Project Area (2 of 3), with *Laminaria hyperborea* kelp highlighted.

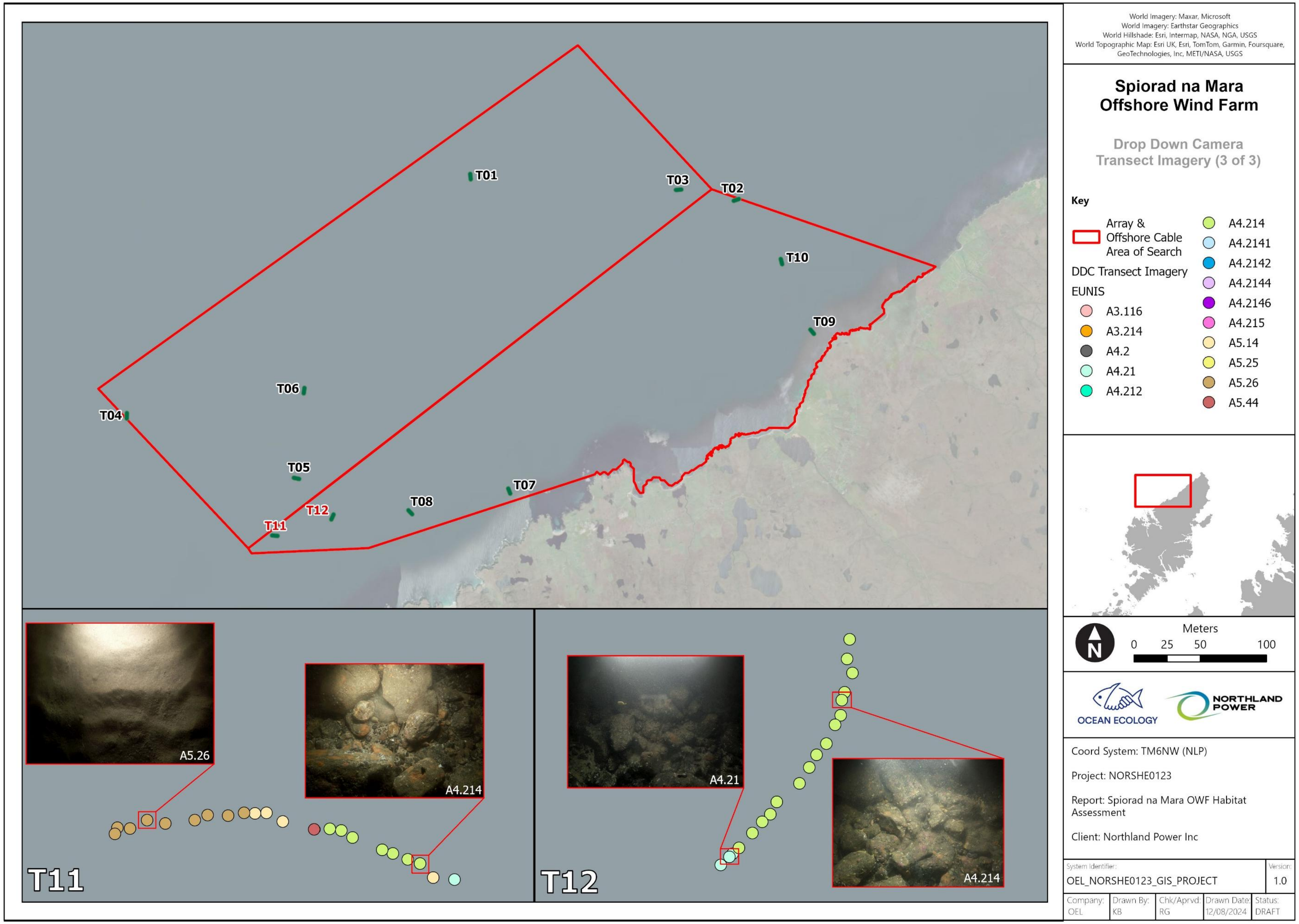


**Figure 15** EUNIS classifications derived from seabed imagery collected along DDC transects across the Project Area (3 of 3).

#### *8.3.1.1. Epifauna*

The most commonly occurring epifauna observed in the DDC seabed imagery obtained across the Project Area were tubeworms of the family Serpulidae, identified in 318 of the 550 images analysed. The encrusting bryozoan *Parasmittina trispinosa* was the second most common species identified in 232 images followed by cup corals (109 images) and the soft coral *Alcyonium digitatum* (103 images). Echinoderms such as the brittlestars *Ophiothrix fragilis* and *Ophiocomina nigra* were also common (Plate 13). The full list of taxa present is provided in Appendix V.

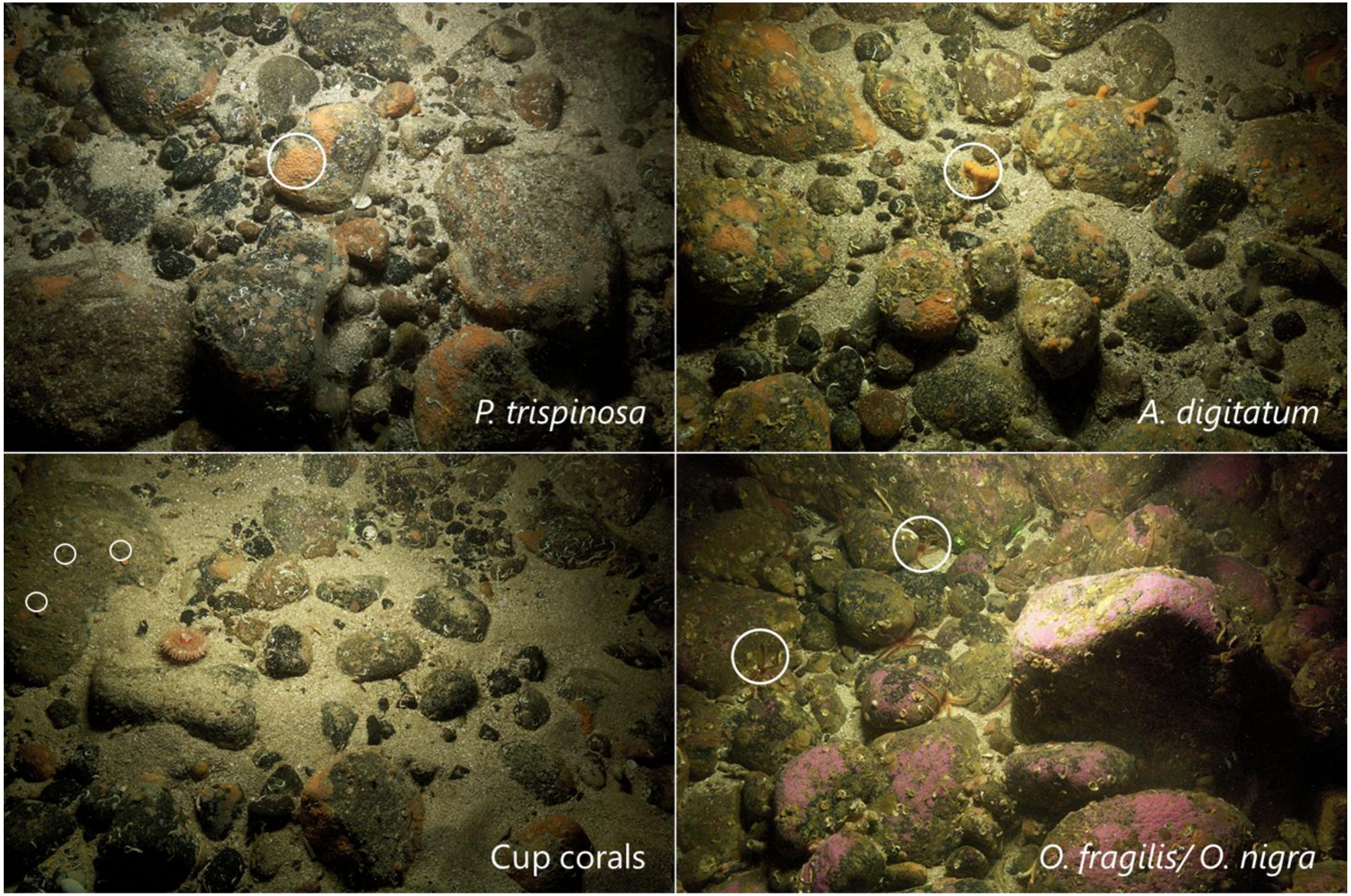


**Plate 13** Examples of common epifaunal taxa identified in DDC imagery across the Project Area. Clockwise from top left: ST002, ST015, ST033 and ST005. The tube worms Serpulidae are also visible in each image (casts). Examples of taxa circled.

### *8.3.1.2. Annex I Reef Assessment*

A comprehensive Annex I reef assessment was conducted on all DDC imagery collected within the array (Table 14) and OCAS (Table 15). Annex I reef was observed within 406 of the 550 images collected throughout the Project Area. Results of the Annex I reef assessment are presented in Figure 16, Figure 17, Figure 18 and in Appendix VI. Example imagery is shown in Plate 14.

**Table 14** Annex I reef assessment results (Array).

| Annex I Reef | Stations | Transects |
|---|---|---|
| Low stony | ST001, ST005, ST021 | T005 |
| Medium stony | ST001, ST002, ST006, ST007, ST014, ST015, ST016, ST017, ST018, ST022, ST026, ST029, ST030, ST034, ST037, ST038, STAD004, STAD006, STAD026 | T001, T003, T004, T006 |
| Bedrock and Bedrock with medium stony | None | T003, T005 |
| High stony | None | T003, T004, T005 |

**Table 15** Annex I reef assessment results (OCAS).

| Annex I Reef | Stations | Transects |
|---|---|---|
| Low stony | ST008, ST009, ST019 | T008, T012 |
| Medium stony | ST010, ST011, ST020, ST024, ST025, ST027, ST028, ST031, ST032, ST033, STAD009, STAD010, STAD011, STAD013, STAD015, STAD027 | T007, T008, T010, T011, T012 |
| Bedrock and Bedrock with medium stony | STAD011, STAD027 | T002, T007. T008, T009, T010, T012 |
| High stony | STAD028 | T007 |

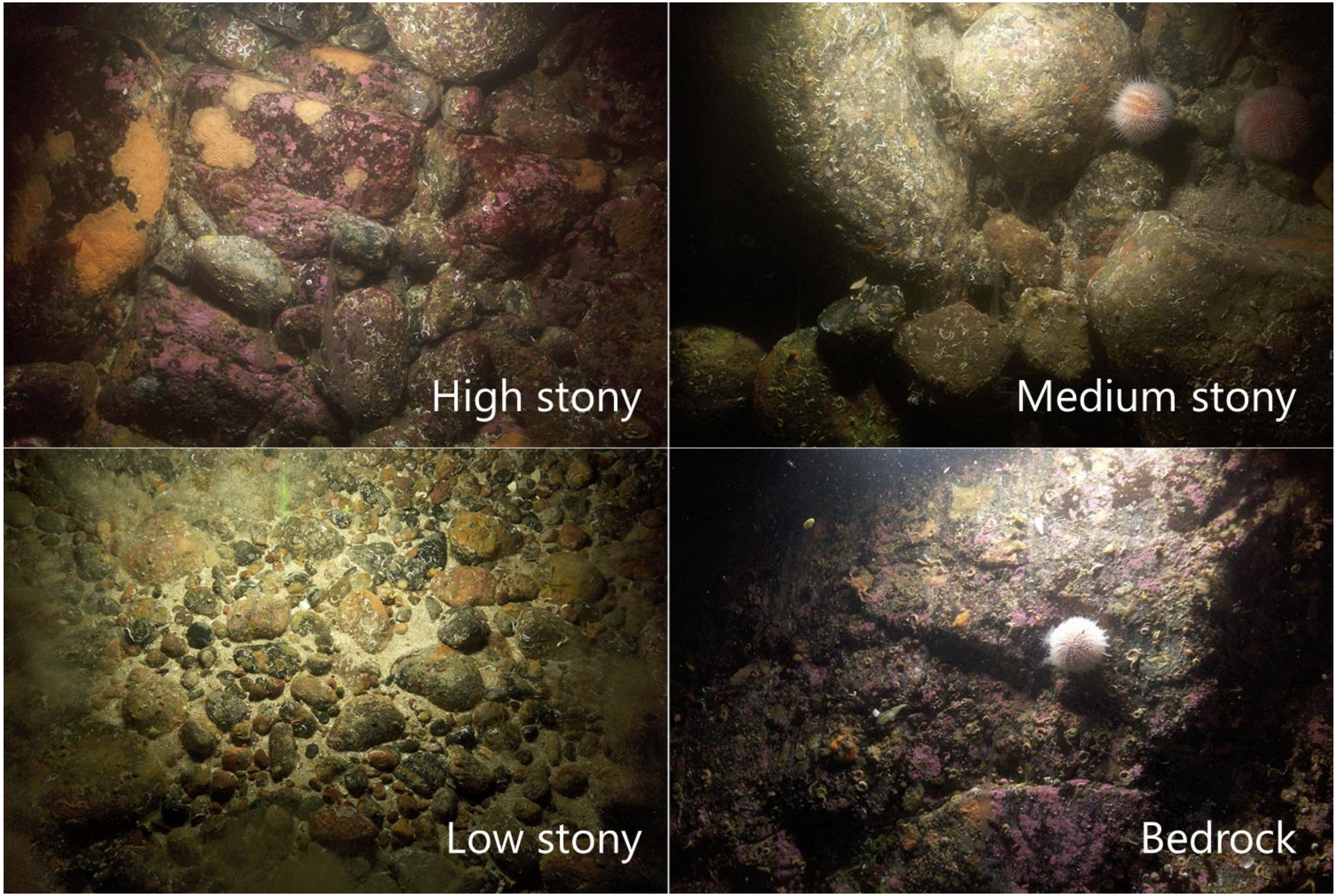


**Plate 14** Examples of Annex I reef habitats identified in DDC imagery across the Project Area. Clockwise from top left: STAD028, T004, T002, ST008

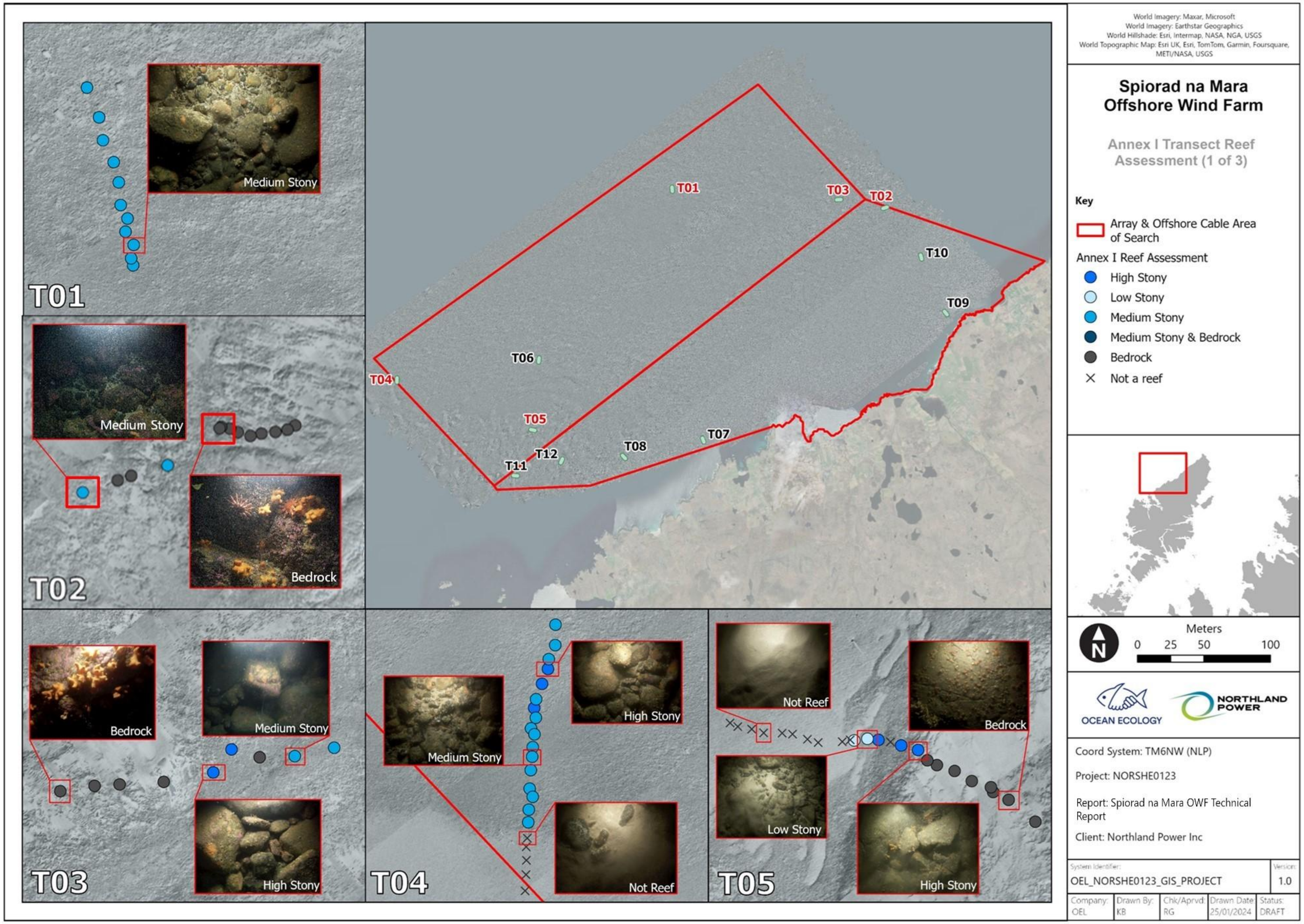


**Figure 16** Annex I reef assessment (DDC transects; map 1 of 3).

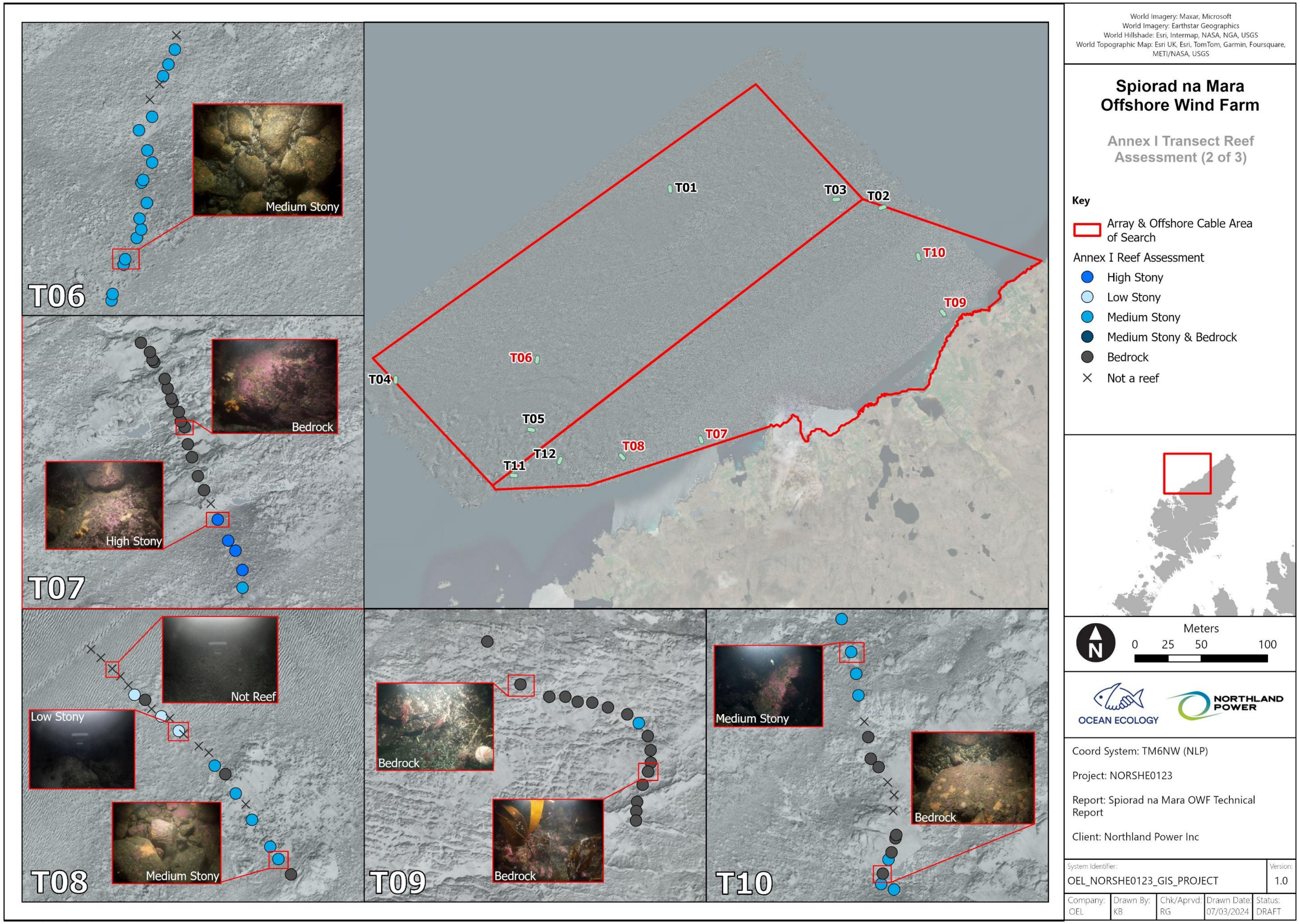


**Figure 17** Annex I reef assessment (DDC transects; map 2 of 3).

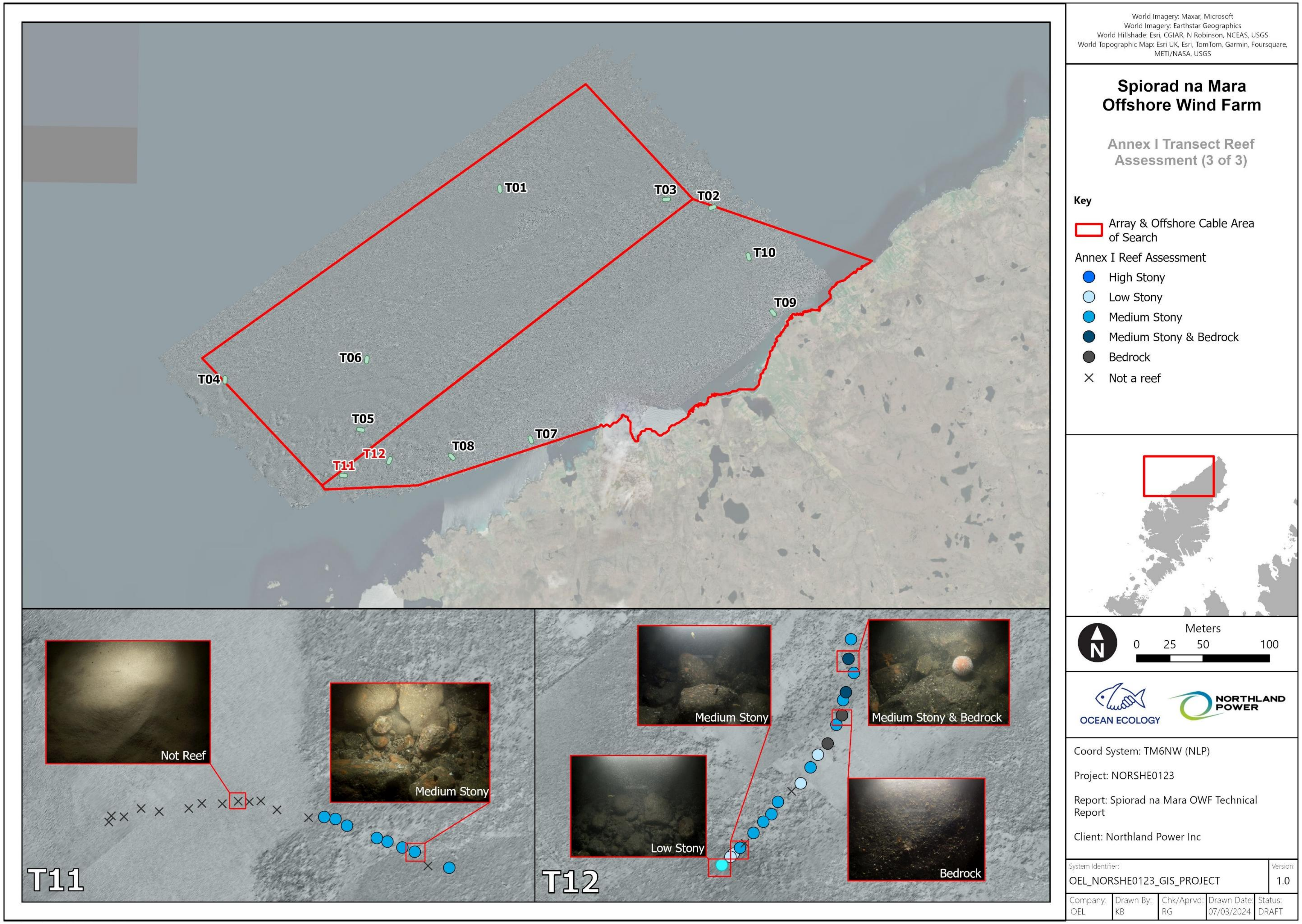


**Figure 18** Annex I reef assessment (DDC transects; map 3 of 3).

*8.3.1.3. Reef 'Ecological Value' Assessment*

Across the Project Area, S ranged from zero at DDC stations/transects where no epifauna was noted to 11 at one of the images captured along transect T006 (Figure 20, Figure 21 and Figure 22). $\Delta^+$ varied between zero at DDC stations/transects where S was lower than two and therefore not calculable and 85.7 along sections of the 12 transects surveyed (Figure 23, Figure 24 and Figure 25). Heat maps based on S and Δ+ values as illustrated in Figure 26 and Figure 27 provide an indication of functionality of the reef ecosystem with 'hot spots' for reefs of good EV. As heat maps are generated based on data interpolation and do not consider the surrounding physical environment, they provide an indication of the functionality of reef habitats where reef is known to occur (i.e. in correspondence or proximity of ground truthing data supporting the presence of reef). Less confidence is given to the extrapolated data where no or little ground truthing data is available on the type of habitat present.

The EV of each image that captured reef was derived based on the funnel plot where $\Delta^+$ was plotted against the observed number of taxa S in each of the 404 images analysed (Figure 19). No averaging of data by station was performed in the funnel plot and all images at which Annex I reef was recorded have been included. The dashed line in Figure 19 indicates the mean of 1,000 simulated $\Delta^+$ for each S ranging from 2 to 11, which corresponds to the background EV of the reef present in DDC imagery across the Project Area. Background values corresponded to $\Delta^+$ varying between 82.2 and 82.35 for the range of S found across the Project Area. Continuous lines denote the 95 % probability limits for $\Delta^+$ for a single S value from the master list of 91 taxa (see section 7.1.3 for more details on the master list). Of the 404 images at which Annex I reef was observed, 50 were assigned a poor EV as 49 were either barren or with only one taxon present ($\Delta^+ = 0$) while one image from station ST006 plotted below the 95 % probability limits (Figure 19). Fifty-one images plotted below the average value for the Project Area and were therefore assigned a low EV, while 301 images were assigned a good EV as they plotted above the average value for the Project Area (Figure 19). Only two images, one from station ST020 and one from ST032, plotted on the dashed line and were therefore considered representative of background EVs (Figure 19). No image plotted above the 95 % probability limit meaning that no image qualified as of high ecological status. Figure 28 to Figure 30 illustrate spatial patterns in reef EV.

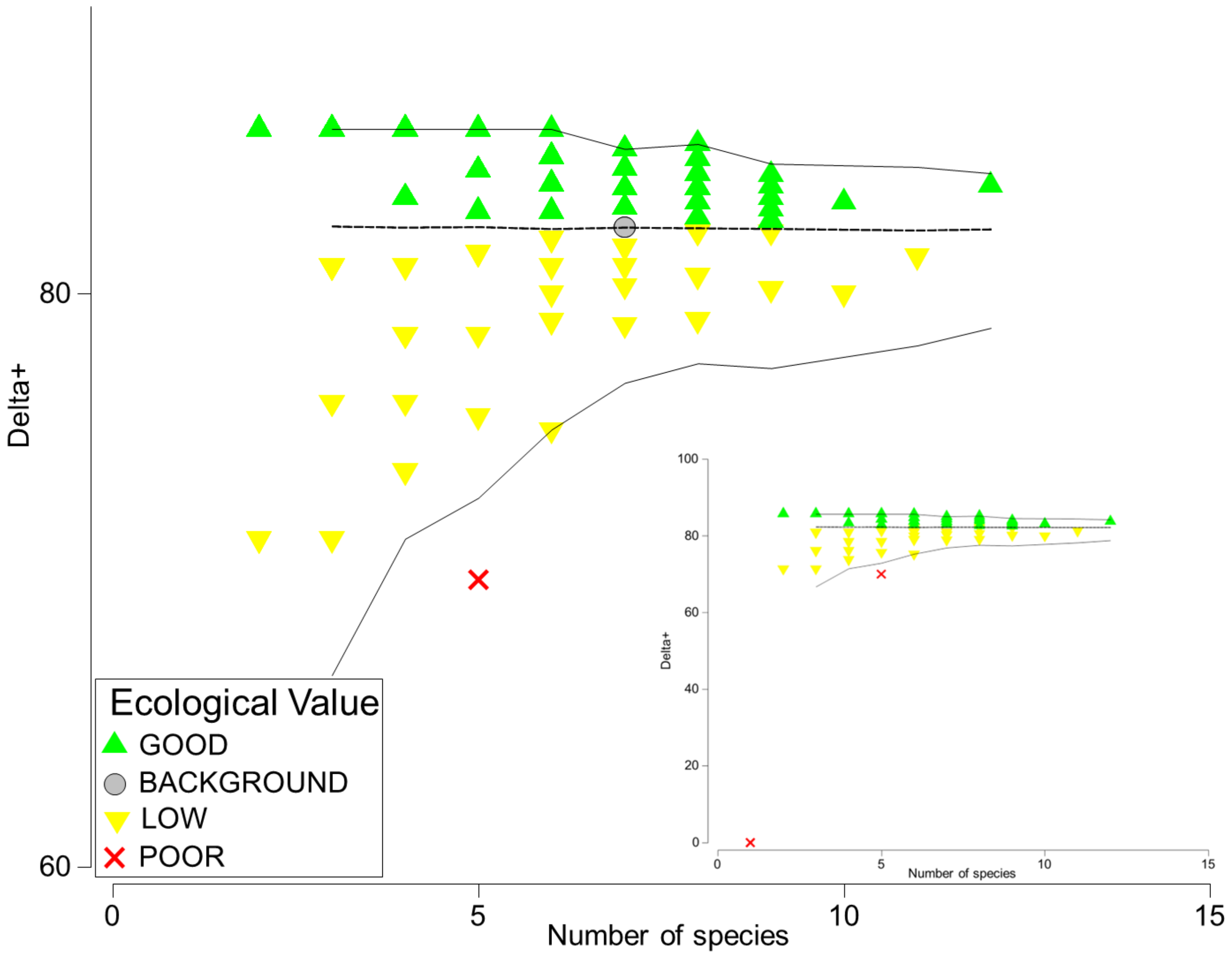


**Figure 19** Funnel plot to show Δ⁺ at all stations/transects at which reef was observed. Dashed line shows average Δ⁺ values for the Project Area based on a master list of 91 taxa derived from all images captured across the Project Area that included reef features. Inset graph shows full range of values including Δ⁺=0.

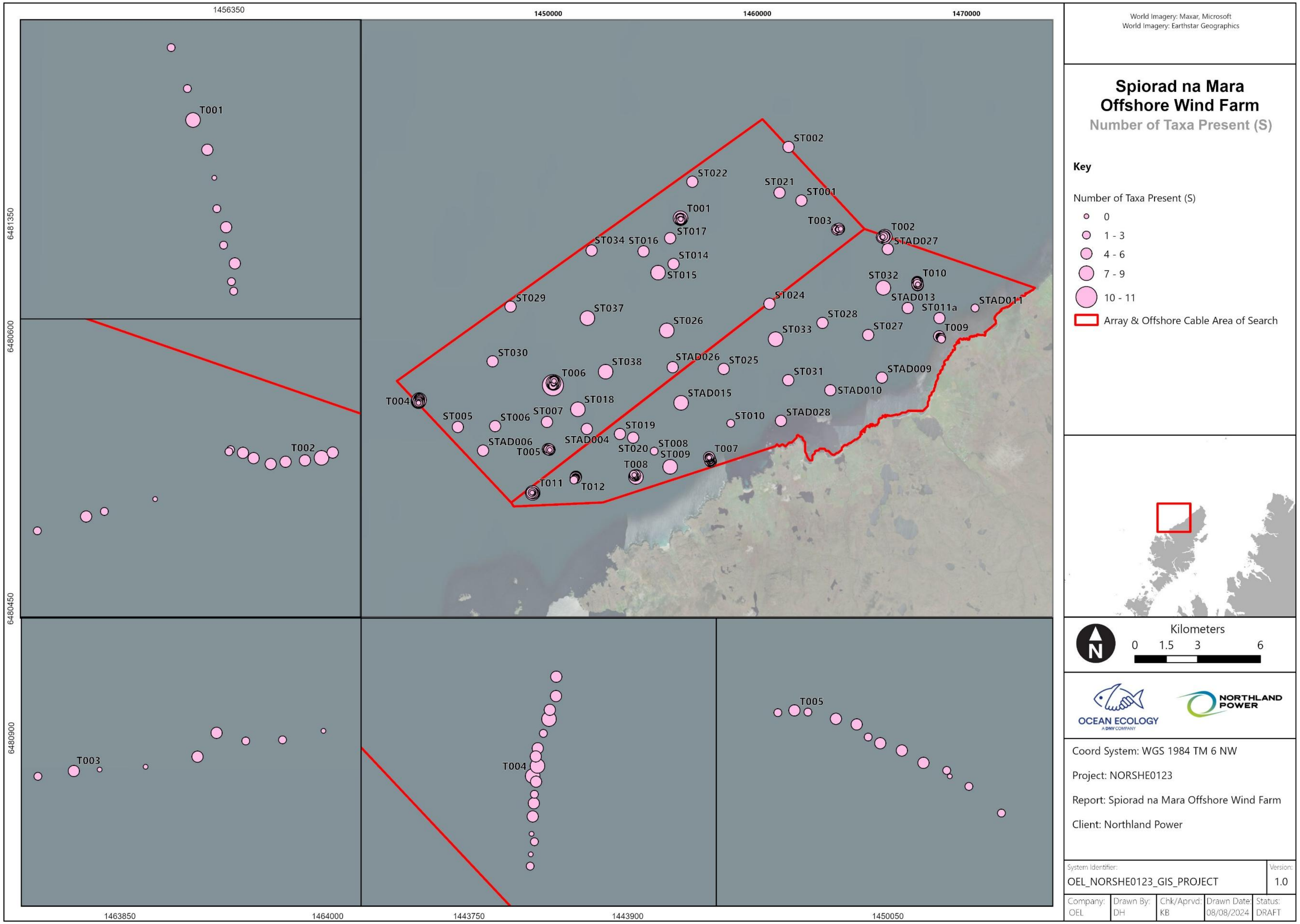


**Figure 20** Spatial distribution of the number of taxa (S) observed in imagery representing Annex I geogenic reef across the Project Area.

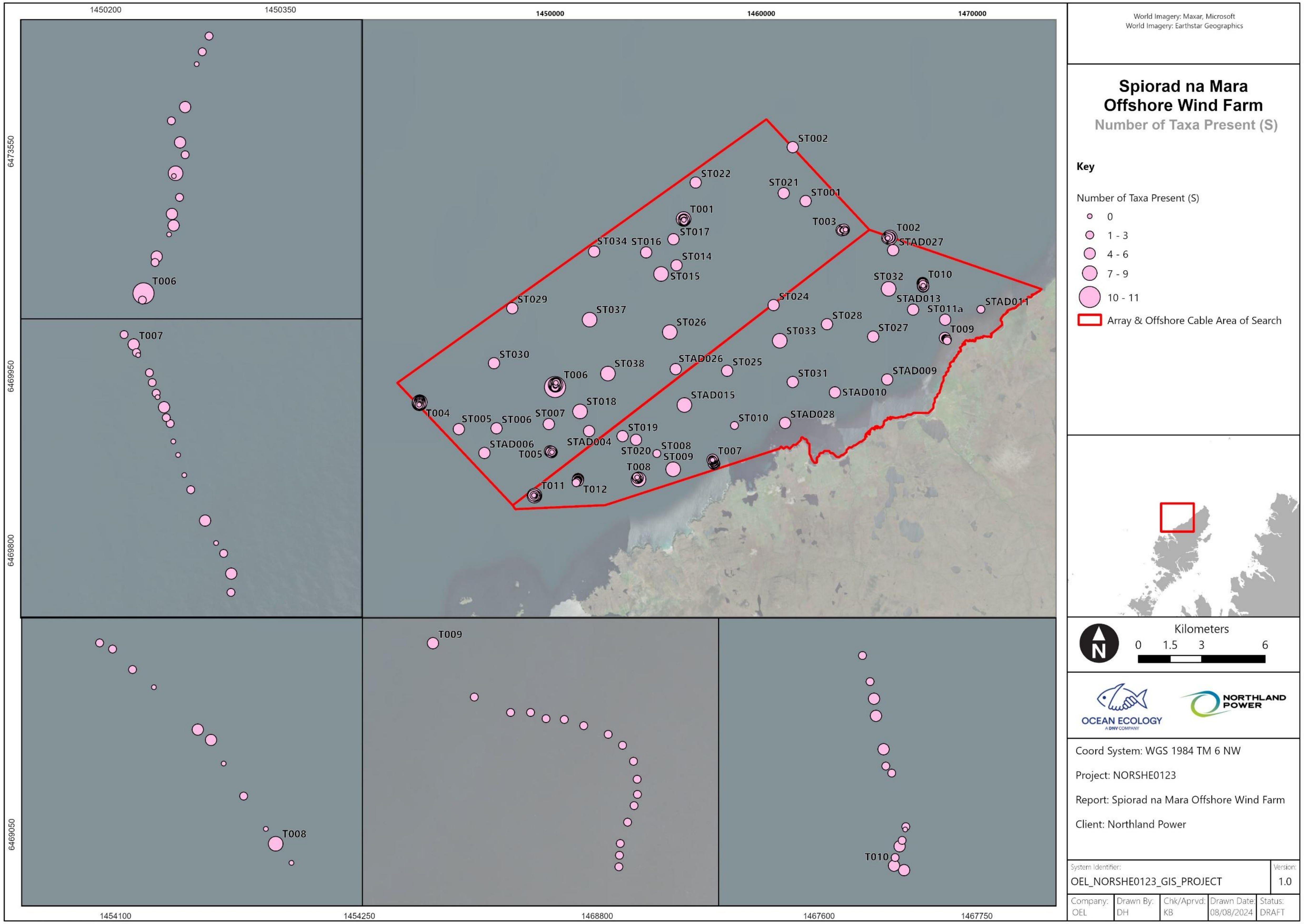


**Figure 21** Spatial distribution of the number of taxa (S) observed in imagery representing Annex I geogenic reef across the Project Area.

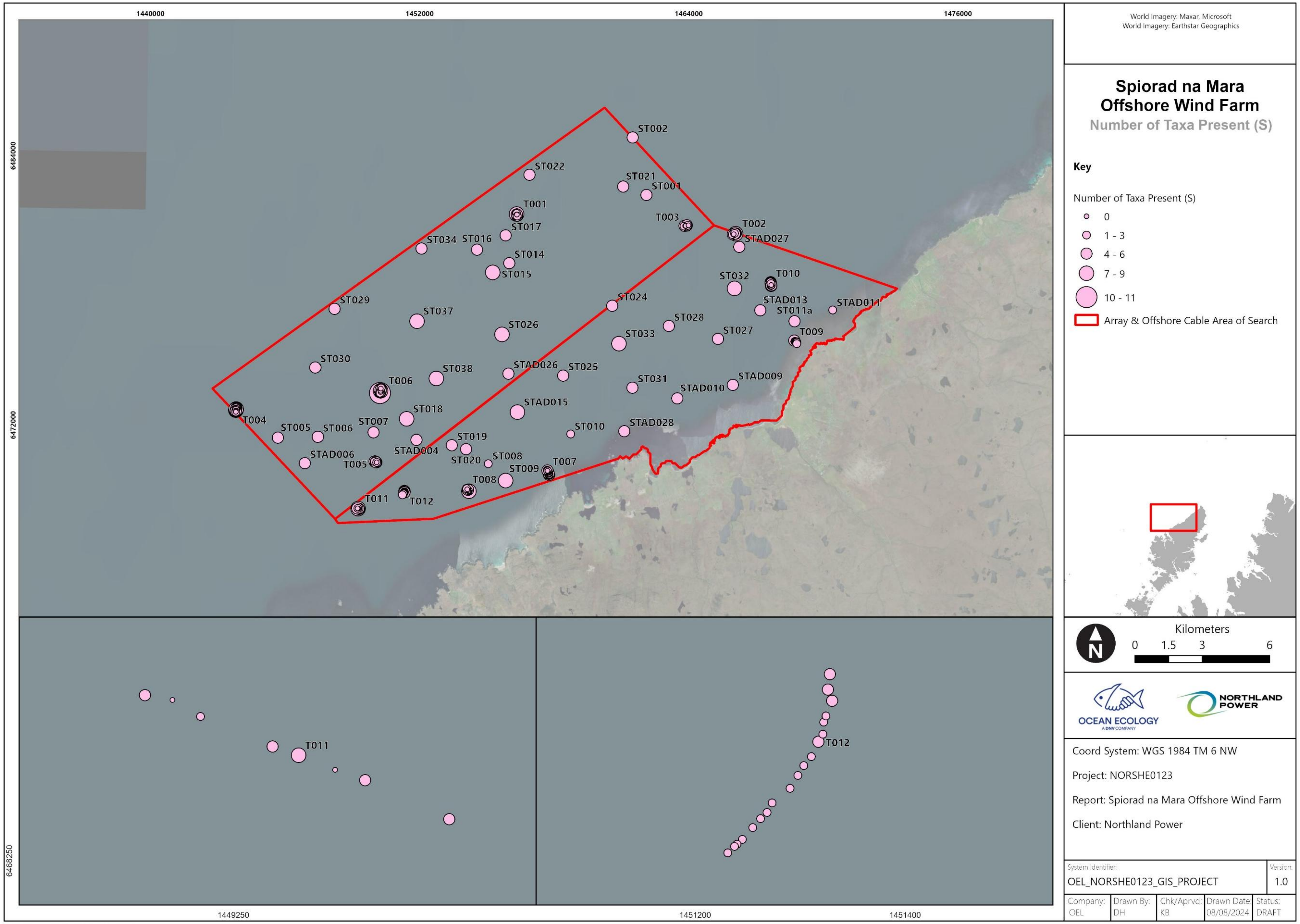


**Figure 22** Spatial distribution of the number of taxa (S) observed in imagery representing Annex I geogenic reef across the Project Area.

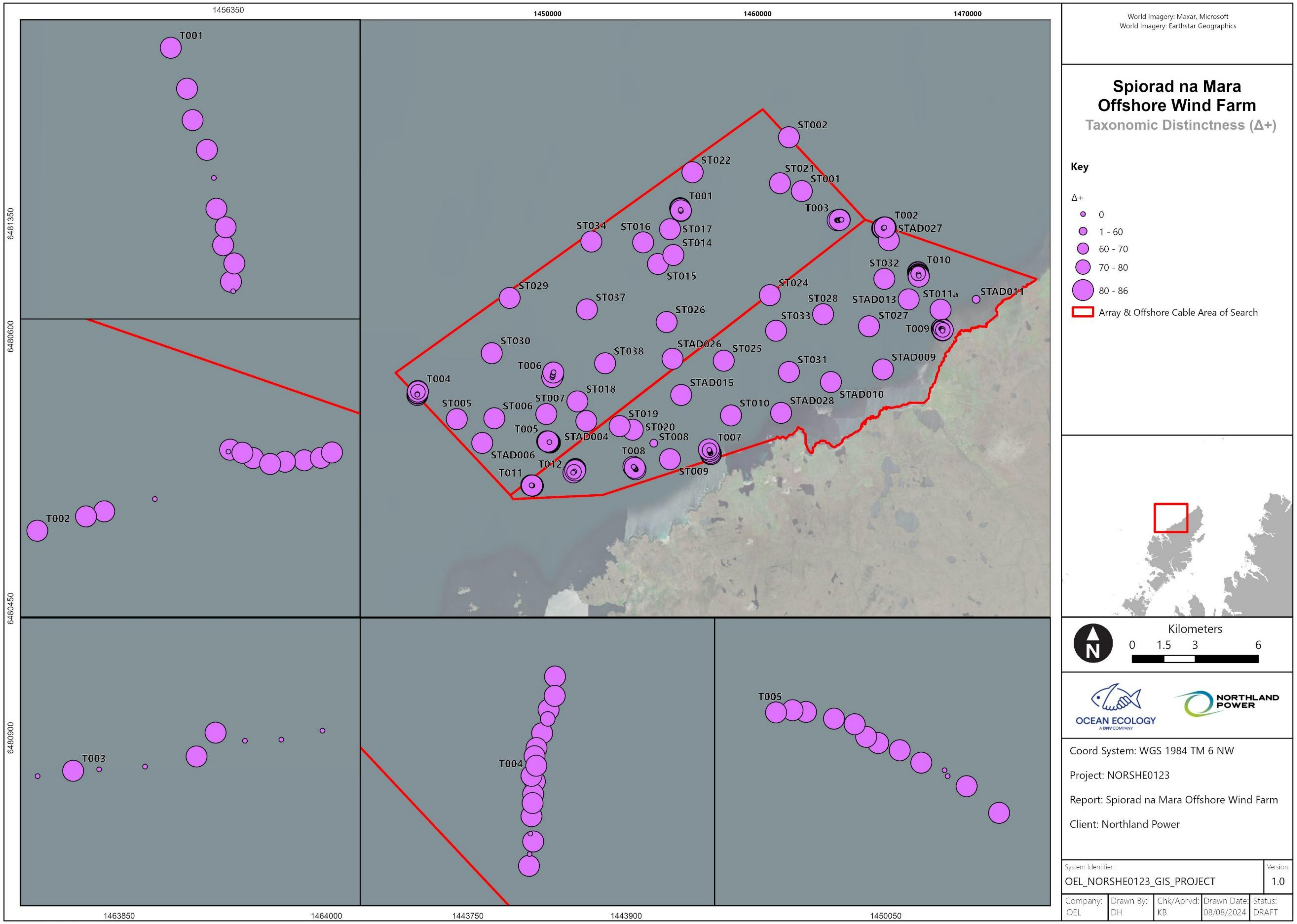


**Figure 23** Spatial distribution of taxonomic distinctness (Δ⁺) derived from seabed imagery representing Annex I geogenic reef across the Project Area.

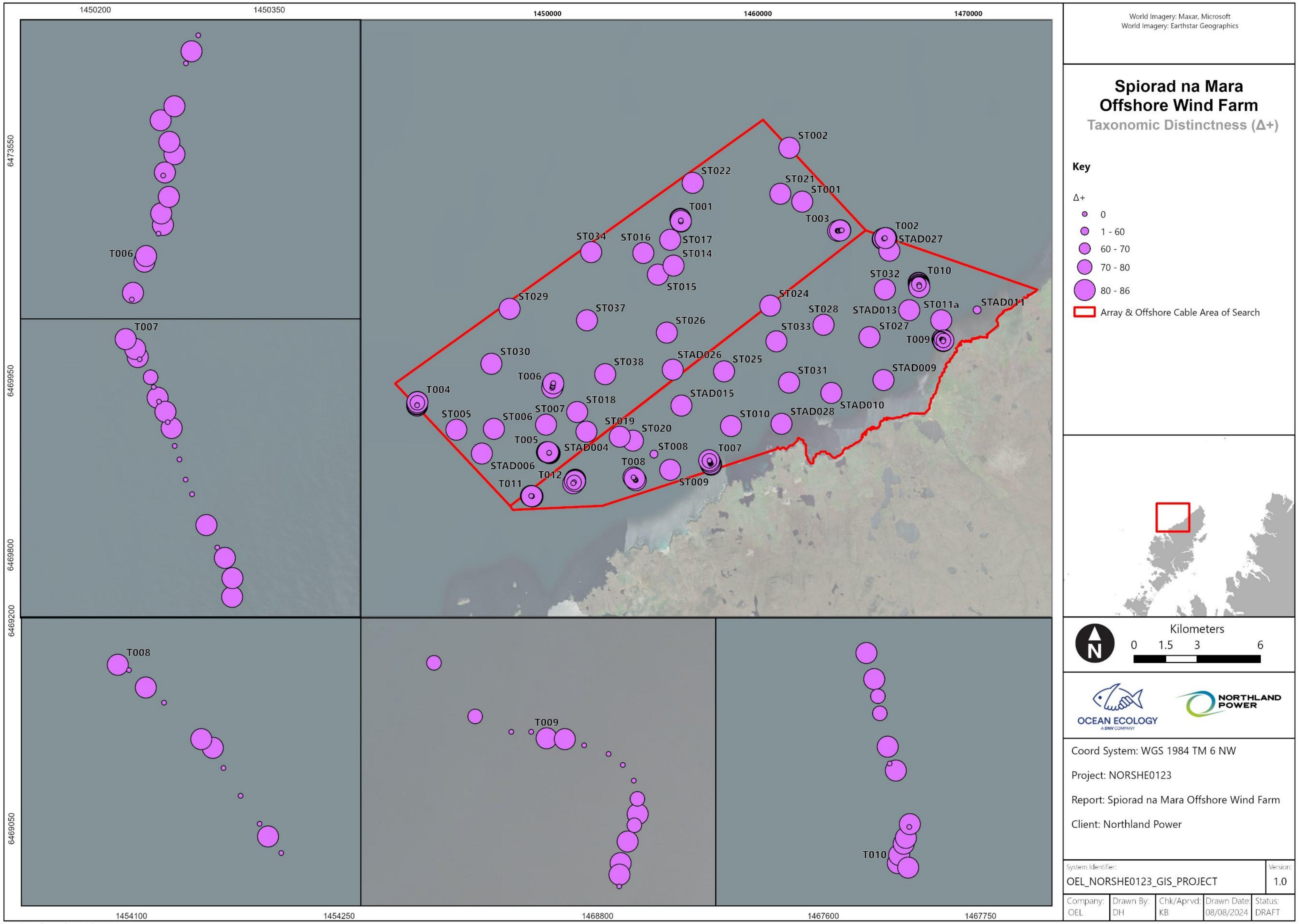


**Figure 24** Spatial distribution of taxonomic distinctness (Δ⁺) derived from seabed imagery representing Annex I geogenic reef across the Project Area.

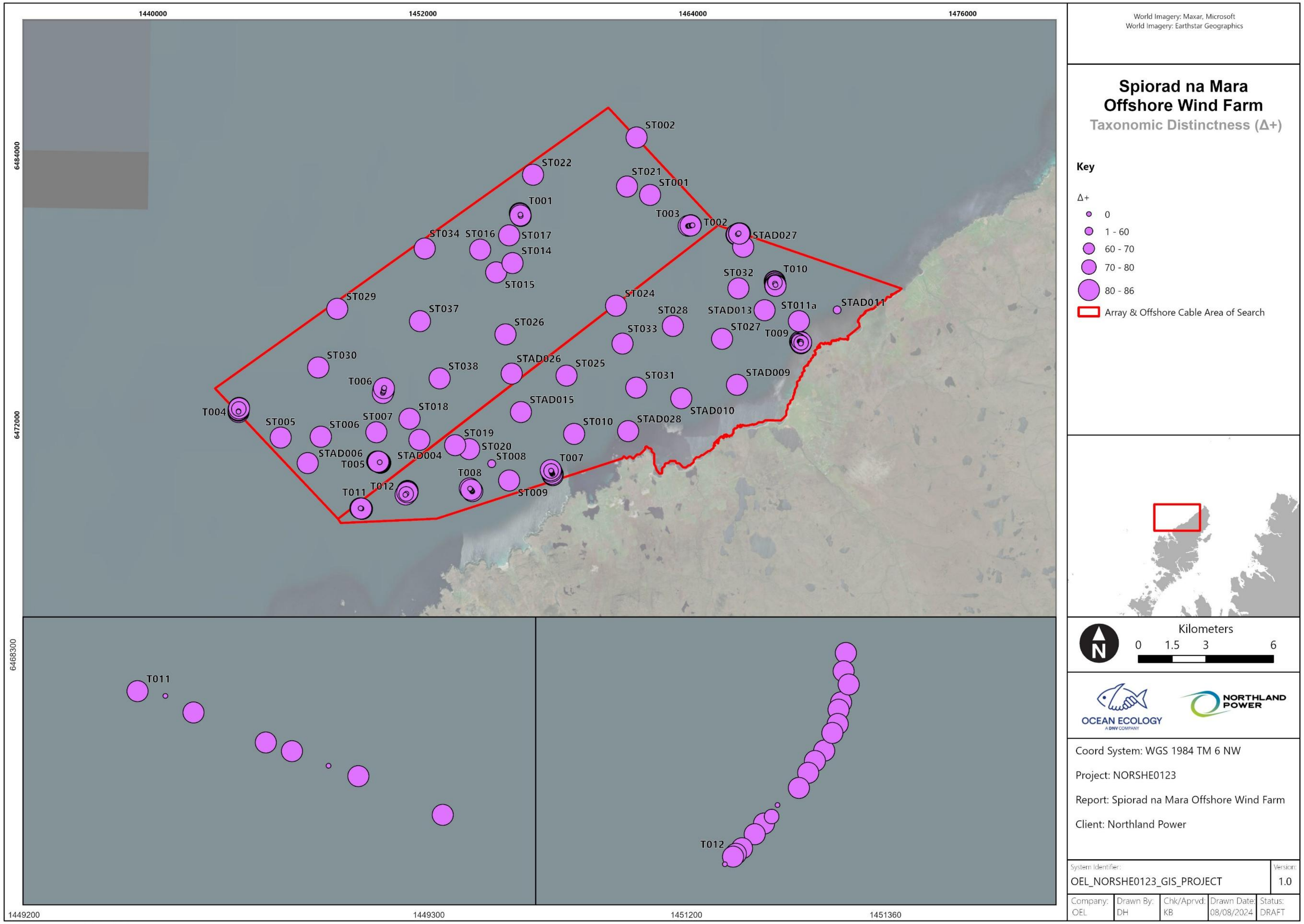


Figure 25 Spatial distribution of taxonomic distinctness (Δ+) derived from seabed imagery representing Annex I geogenic reef across the Project Area.

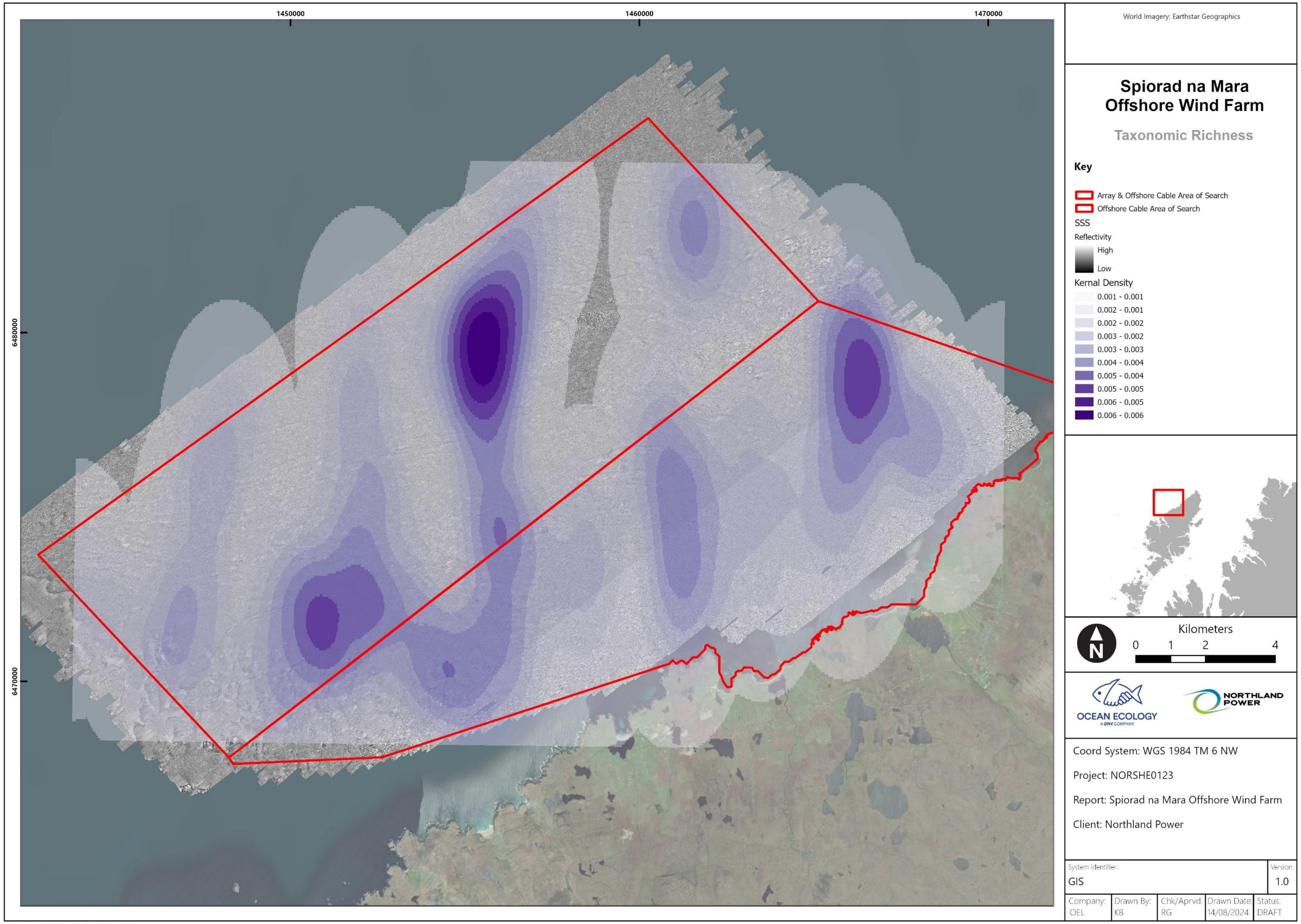


**Figure 26** Heat map based on taxonomic richness (S) showing diversity 'hot spots' (dark colour) where a more complex reef community was observed.

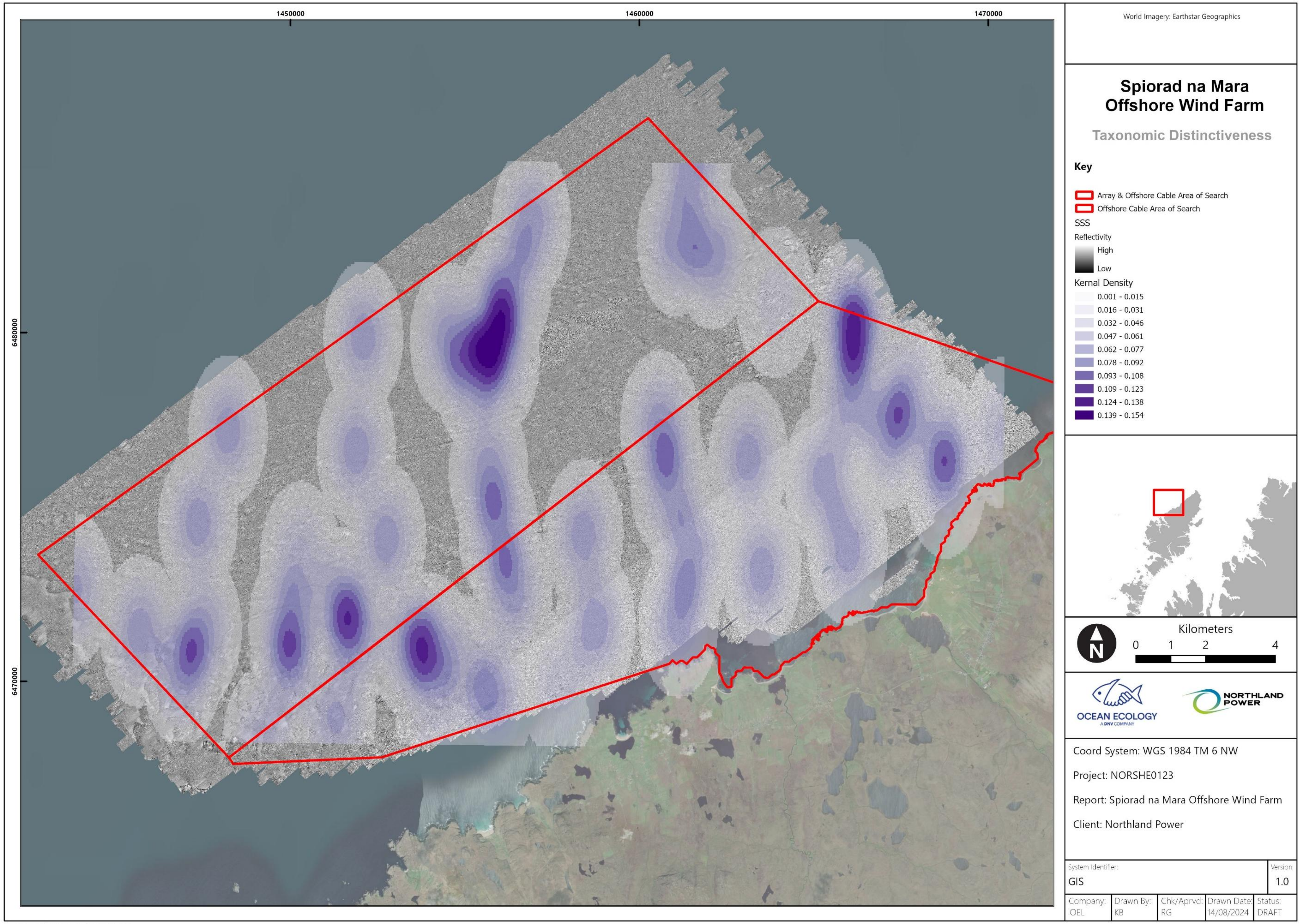


**Figure 27** Heat map based on taxonomic distinctness (Δ+) showing 'hot spots' (dark colour) where a more complex reef community was observed.

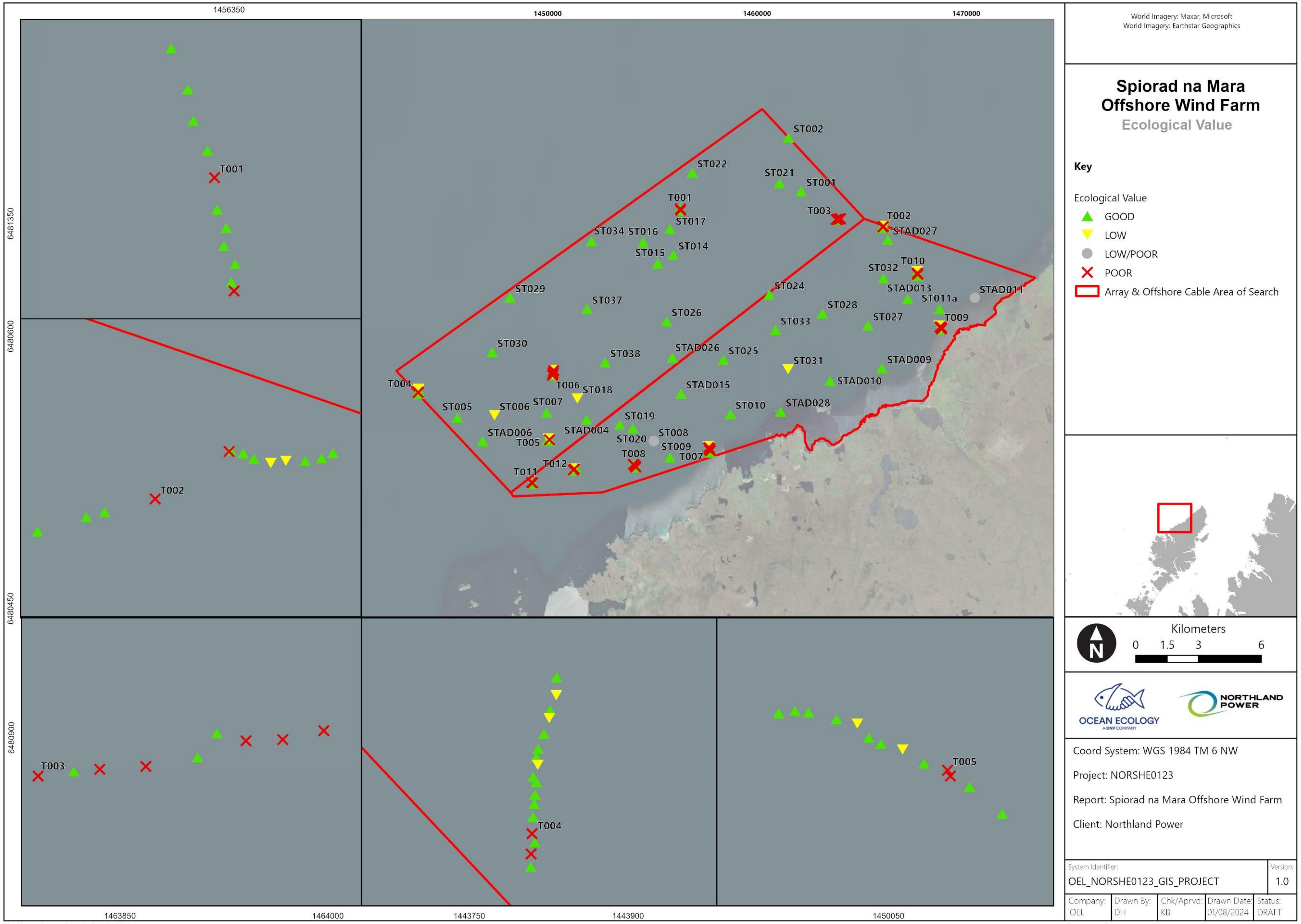


**Figure 28** Results of the reef EV assessment across the Project Area.

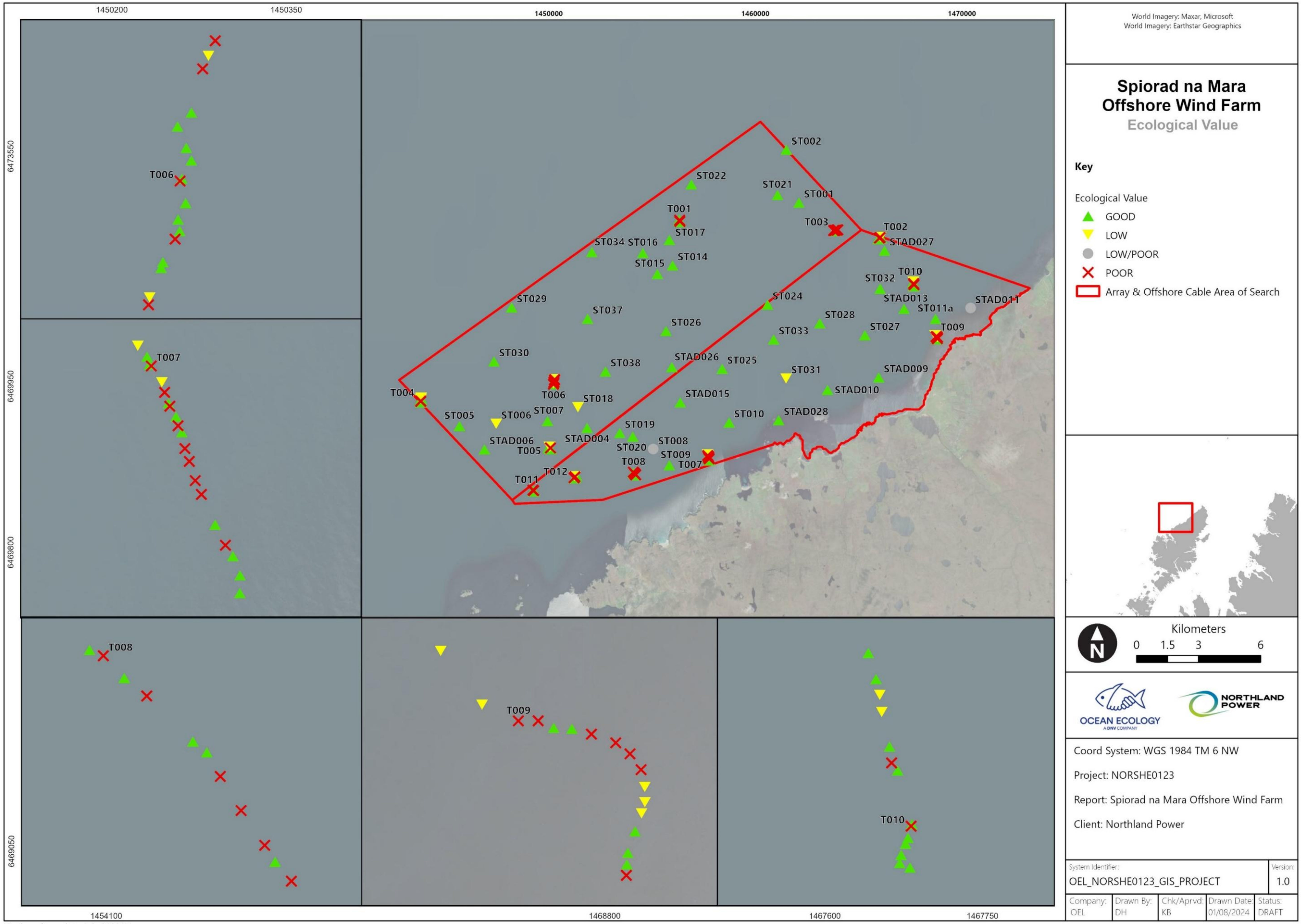


**Figure 29** Results of the reef EV assessment across the Project Area.

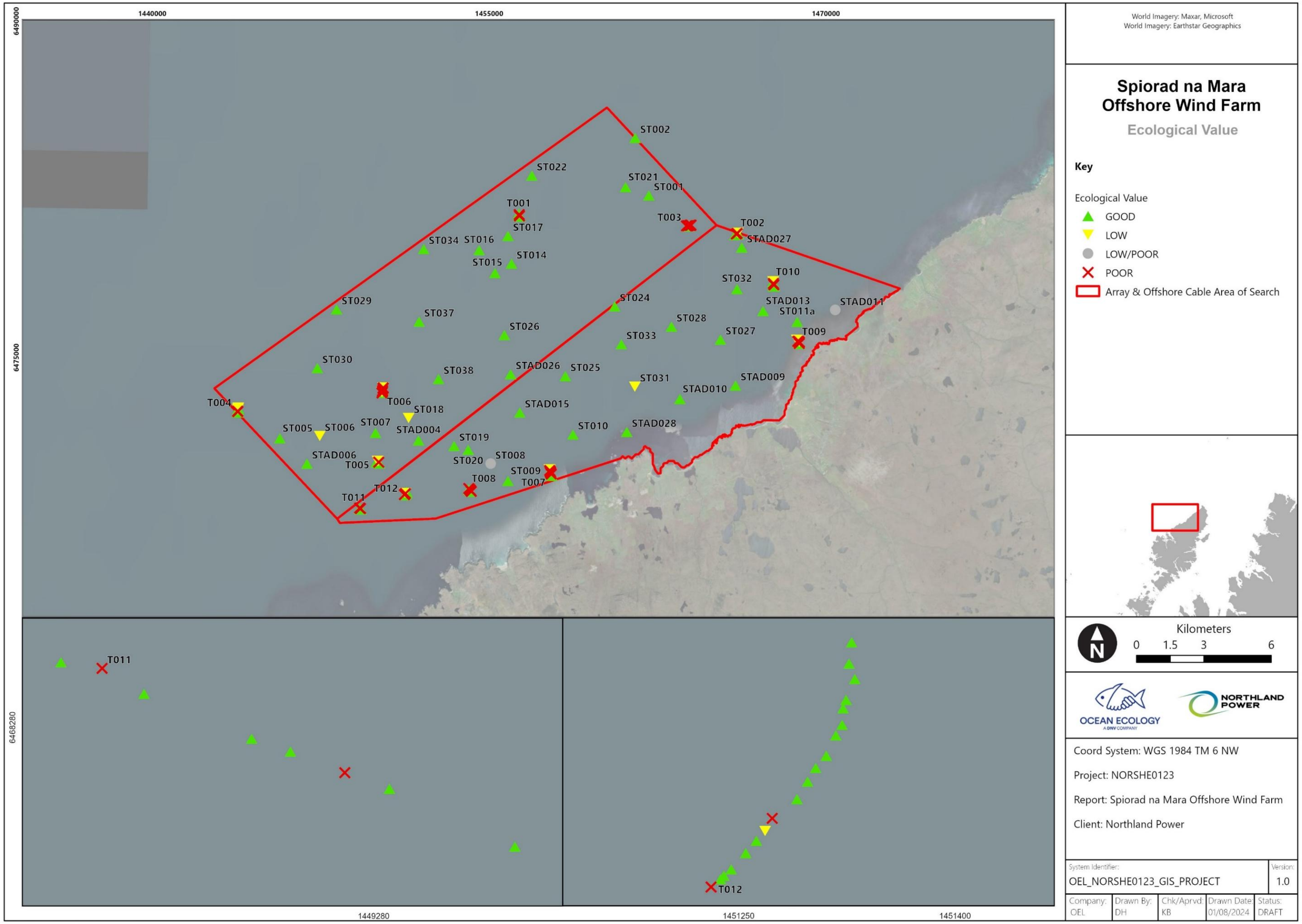


**Figure 30** Results of the reef EV assessment across the Project Area.

### *8.3.1.4. PMF Assessment*

The biotope A3.214 '*Laminaria hyperborea* and foliose red seaweeds on moderately exposed infralittoral rock' was identified in 16 images from two DDC transects (T007 and T009 within the OCAS). This constitutes the PMF habitat 'Kelp beds' (Plate 15). This PMF habitat was further assessed based on the results of the PMF survey and the analysis of ROV and UAV imagery as reported below.

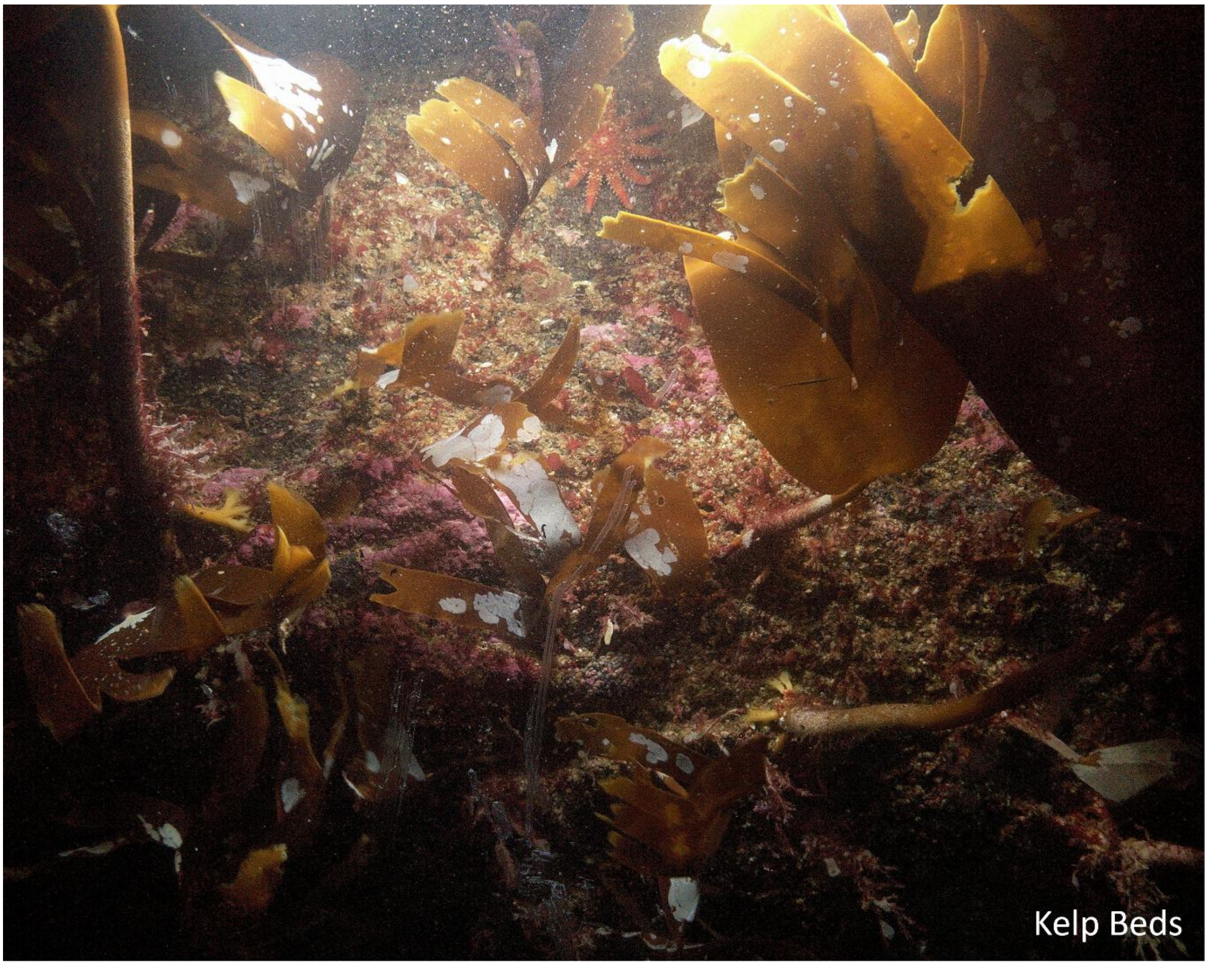


**Plate 15** Example of PMF corresponding to biotope A3.214 '*Laminaria hyperborea* and foliose red seaweeds on moderately exposed infralittoral rock'.

### 8.3.2. ROV

Across the area investigated by ROV during the PMF survey, a total of five EUNIS Level 3 BSH, five EUNIS Level 4 habitat complexes, nine EUNIS Level 5 biotope complexes and two EUNIS Level 6 biotopes were identified in seabed imagery. The most commonly occurring of these was A3.214 '*Laminaria hyperborea* and foliose red seaweeds on moderately exposed infralittoral rock', identified in 339 of the 730 total images followed by A3.2142 '*Laminaria hyperborea* park and foliose red seaweeds on moderately exposed lower infralittoral rock' and A3.116 'Foliose red seaweeds on exposed lower infralittoral rock' which were present in 143 and 125 images respectively (Table 16 and Figure 31 to Figure 33 ).

A total of 75 of the 730 images analysed were described as mosaic habitats including images acquired along transects TROV3, TROV9, TROV10, TROV11, TROV12, TROV13, TROV14 and TROV15. The most commonly occurring mosaic habitats were found in areas where infralittoral rock described as A3.214 was surrounded by cobbles and pebbles representing habitats/biotopes like A3.116, or where A3.214/A3.124 'Dense *Desmarestia* spp. with filamentous red seaweeds on exposed infralittoral cobbles, pebbles and bedrock was surrounded by areas of fine sands and sparse fauna representative of A5.231 'Infralittoral mobile clean sand with sparse fauna' (Figure 31 to Figure 33).

Example imagery is provided in Plate 16 to Plate 18. The full DDC proforma for the PMF survey is provided in Appendix XVIII.

**Table 16** Summary of the BSHs, habitats, biotopes and PMFs identified during the PMF survey

| BSH | EUNIS Code | EUNIS Description | PMF Habitat |
|---|---|---|---|
| A3.1 'High Energy Infralittoral Rock' | A3.11 | Kelp with cushion fauna and/or foliose red seaweeds | Kelp beds |
| | A3.115 | *Laminaria hyperborea* with dense foliose red seaweeds on exposed infralittoral rock | Kelp beds |
| | A3.116 | Foliose red seaweeds on exposed lower infralittoral rock | - |
| | A3.124 | Dense *Desmarestia* spp. with filamentous red seaweeds on exposed infralittoral cobbles, pebbles and bedrock | - |
| | A3.125 | Mixed kelps with scour-tolerant and opportunistic foliose red seaweeds on scoured or sand-covered infralittoral rock | - |
| A3.2 'Moderate Energy Infralittoral Rock' | A3.21 | Kelp and red seaweeds (moderate energy infralittoral rock) | - |
| | A3.213 | *Laminaria hyperborea* on tide-swept infralittoral mixed substrata | Kelp beds / Tide-swept algal communities |
| | A3.214 | *Laminaria hyperborea* and foliose red seaweeds on moderately exposed infralittoral rock | Kelp beds |

| BSH | EUNIS Code | EUNIS Description | PMF Habitat |
|---|---|---|---|
| | A3.2141 | *Laminaria hyperborea* forest and foliose red seaweeds on moderately exposed upper infralittoral rock | Kelp beds |
| | A3.2142 | *Laminaria hyperborea* park and foliose red seaweeds on moderately exposed lower infralittoral rock | Kelp beds |
| A4.2 'Atlantic and Mediterranean moderate energy circalittoral rock' | - | - | - |
| | A4.21 | Echinoderms and crustose communities on circalittoral rock | - |
| | A4.214 | Faunal and algal crusts on exposed to moderately wave-exposed circalittoral rock | - |
| A5.1 'Subtidal Coarse Sediment' | A5.13 | Infralittoral coarse sediment | - |
| | A5.131 | Sparse fauna on highly mobile sublittoral shingle (cobbles and pebbles) | |
| A5.2 'Subtidal Sand' | A5.23 | Infralittoral fine sand | - |
| | A5.231 | Infralittoral mobile clean sand with sparse fauna | |

#### *8.3.2.1. Epifauna*

The most commonly occurring epifauna observed in the seabed imagery acquired during the PMF survey was the edible sea urchin *Echinus esculentus*, identified in 449 of the 730 images analysed. This was followed by *Laminaria* sp. (kelp) which was identified in 417 images and the encrusting bryozoan *Membranipora membranacea* (sea mat) found in 399 images. The full list of taxa present in ROV imagery is provided in Appendix XVIX.

No INNS were observed during the PMF survey.

#### *8.3.2.2. Annex I Reef Assessment*

A full Annex I reef assessment was carried out on 712 of the 730 images obtained during the PMF survey. Those not assessed were duplicate images. The results of this assessment are summarised in Table 17 and displayed in Figure 34 to Figure 36. The full Annex I reef assessment for the PMF survey are provided in Appendix XX. Example imagery of the different types of reef observed are provided in Plate 19 and Plate 20.

Annex I reef was present, potentially present or predicted to be present in 687 of the images assessed. Bedrock reef was the most commonly occurring reef type observed in 410 images followed by low stony which was observed in 100 images. Seventy-five images contained predicted or potential Annex I reef with the most common being potential bedrock accounting for 33 of these images.

Due to obstructions caused by dense algae and kelp, the 'geogenic' label was used in instances where a geogenic structure was present, potentially or predicted to be present, but the exact reef qualification (e.g. bedrock or low stony) could not be determined.

**Table 17** Annex I reef assessment summary for images acquired during the PMF survey.

| Annex I | EUNIS | Images | Transects |
|---|---|---|---|
| Bedrock | A3.116, A3.124, A3.125, A3.21, A3.213, A3.214, A3.2142 | 410 | TROV1, TROV3, TROV5, TROV6, TROV7, TROV8, TROV9, TROV10, TROV11, TROV12, TROV13, TROV14, TROV15 |
| Bedrock and Low Stony | A3.116, A3.214, A4.214 | 49 | TROV1, TROV2, TROV3, TROV7, TROV8, TROV9, TROV10, TROV11, TROV14, TROV15 |
| Bedrock and Medium Stony | A4.21, A4.214 | 9 | TROV1 |
| Geogenic | A3.214, A3.2142 | 11 | TROV4, TROV6, TROV9, TROV10 |
| Low Stony | A3.116, A3.21, A3.213, A3.214, A3.2142, A4.214 | 100 | TROV4, TROV5, TROV6, TROV8, TROV9, TROV10, TROV11, TROV12, TROV14, TROV15 |
| Low Stony and Bedrock | A3.116, A3.214 | 4 | TROV5, TROV8 |
| Medium Stony | A3.116, A3.21, A3.214, A4.21, A4.214 | 29 | TROV1, TROV5, TROV7, TROV8, TROV9, TROV11, TROV15 |
| Potential Bedrock | A3.21, A3.214, A3.2142 | 33 | TROV6, TROV7, TROV9, TROV11 |
| Potential Geogenic | A3.214, A3.2142 | 18 | TROV5, TROV6, TROV9 |
| Potential Stony | A3.21, A3.214, A3.2142 | 6 | TROV4, TROV6, TROV9 |
| Predicted Bedrock | A3.115, A3.125, A3.2142 | 3 | TROV6, TROV10 |
| Predicted Geogenic | A3.2141, A3.2142 | 10 | TROV3, TROV6 |
| Predicted Stony | A3.21, A3.2142 | 5 | TROV4 |
| Not a Reef | A3.124, A3.214, A3.2142, A4.2, A5.13, A5.23 | 24 | TROV1, TROV5, TROV8, TROV10, TROV12, TROV14, TROV15 |

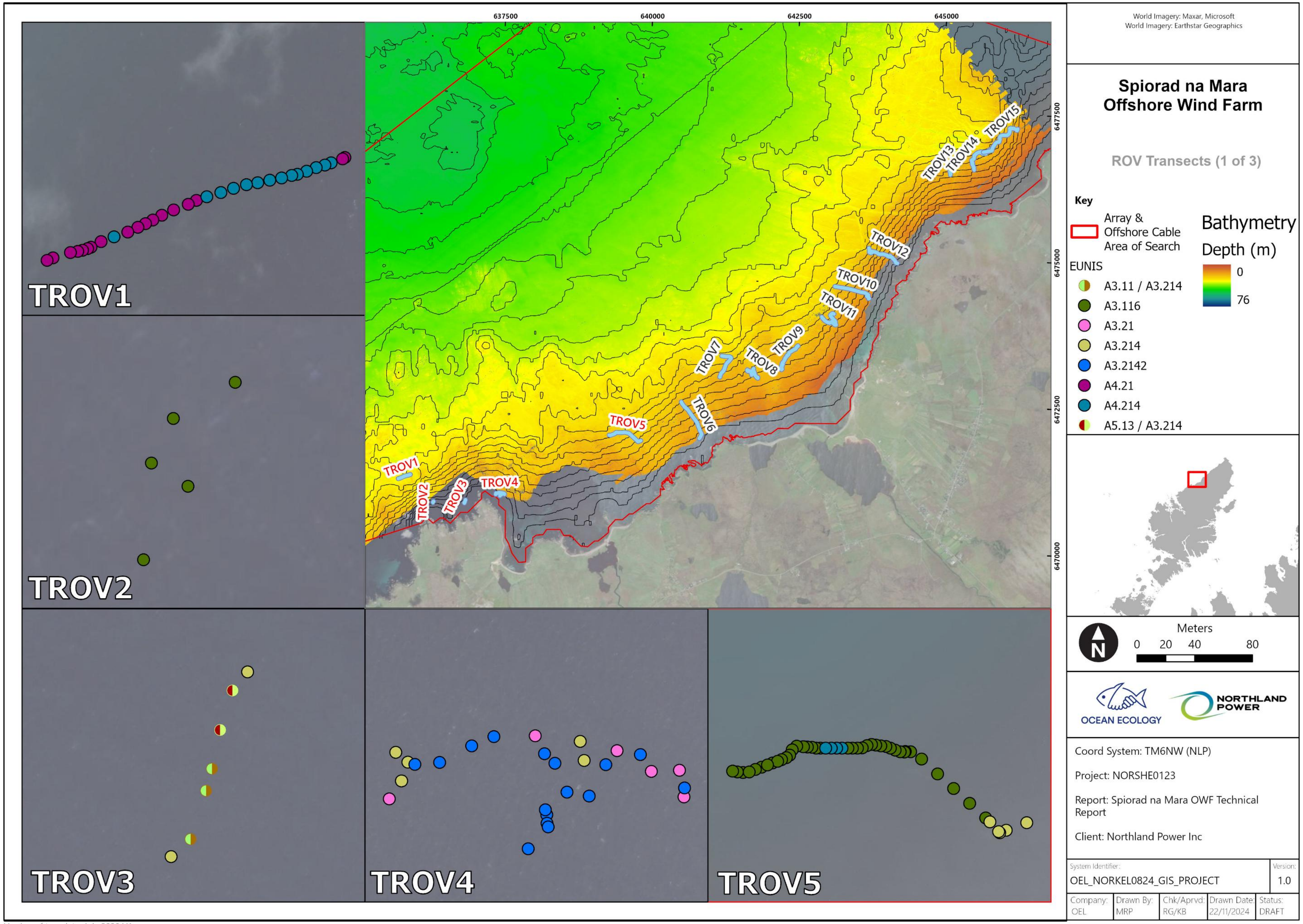


**Figure 31** EUNIS classifications derived from seabed imagery collected along ROV transects across the PMF survey area (1/3).

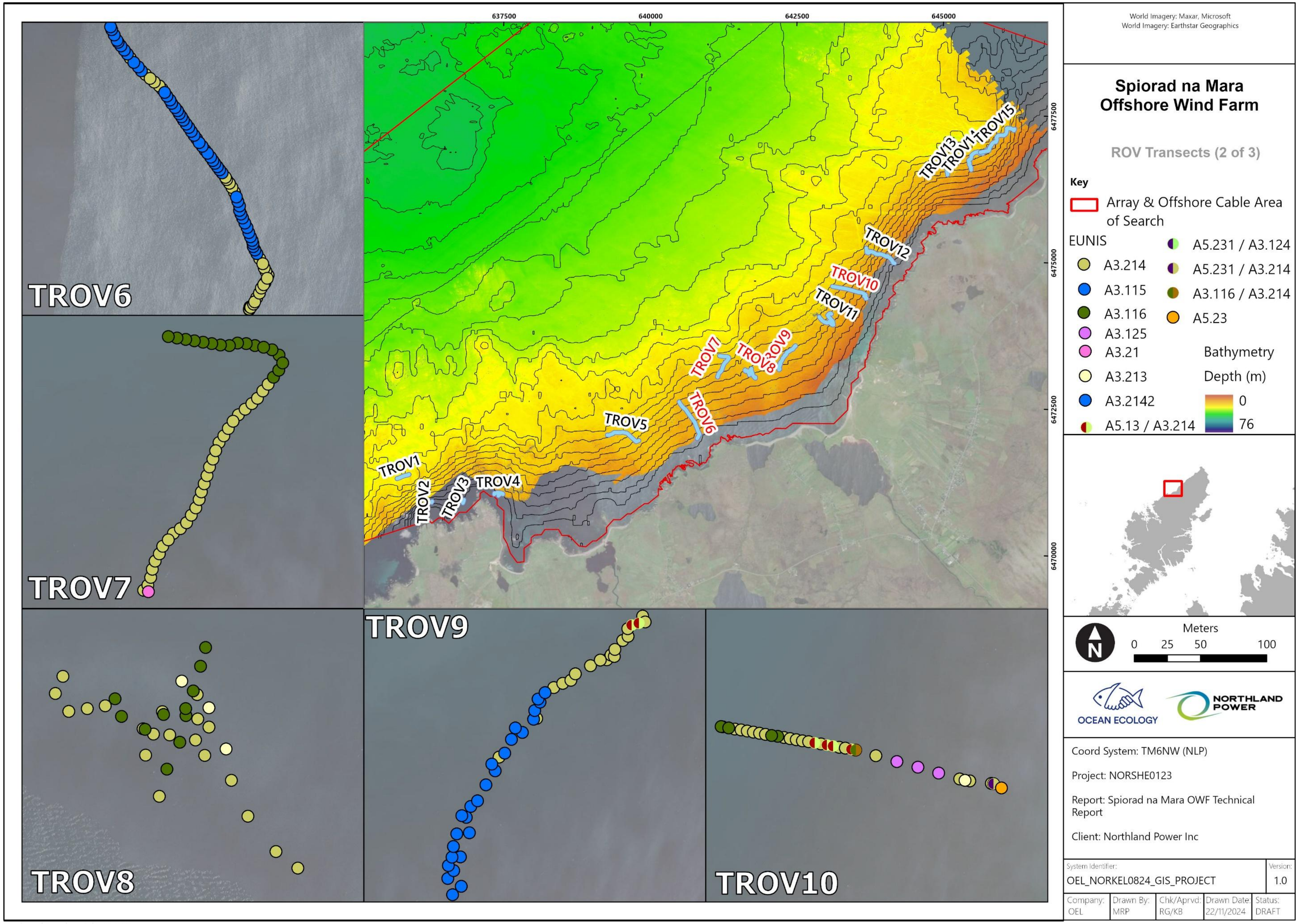


**Figure 32** EUNIS classifications derived from seabed imagery collected along ROV transects across the PMF survey area (2/3).

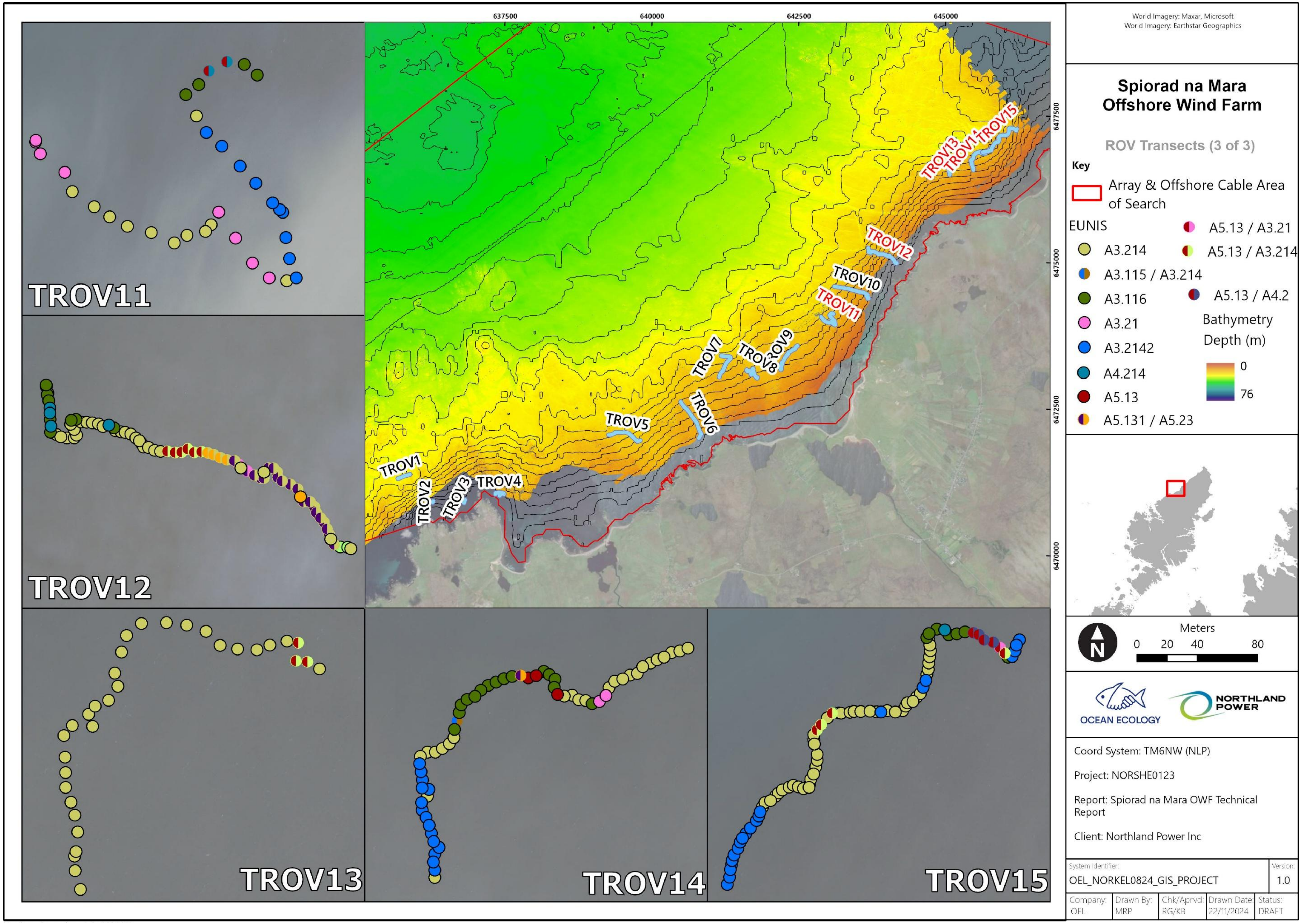


**Figure 33** EUNIS classifications derived from seabed imagery collected along ROV transects across the PMF survey area (3/3).

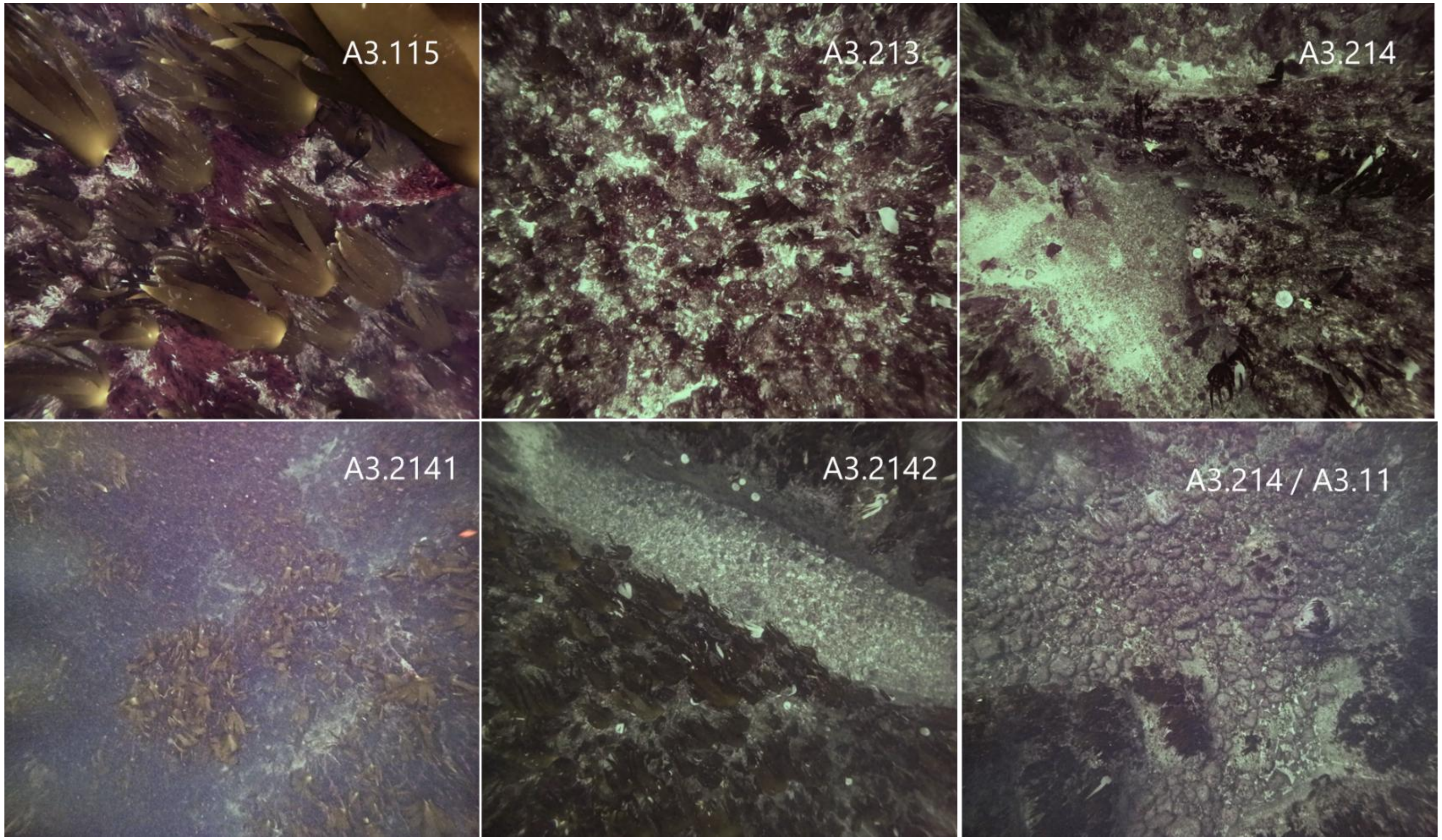


**Plate 16** Example imagery of kelp supporting habitats/biotopes obtained during the PMF survey.[10]

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[10] A3.11: Kelp with cushion fauna and/or foliose red seaweeds
A3.115: *Laminaria hyperborea* with dense foliose red seaweeds on exposed infralittoral rock
A3.213: *Laminaria hyperborea* on tide-swept infralittoral mixed substrata
A3.214: *Laminaria hyperborea* and foliose red seaweeds on moderately exposed infralittoral rock
A3.2141: *Laminaria hyperborea* forest and foliose red seaweeds on moderately exposed upper infralittoral rock
A3.2142: *Laminaria hyperborea* park and foliose red seaweeds on moderately exposed lower infralittoral rock

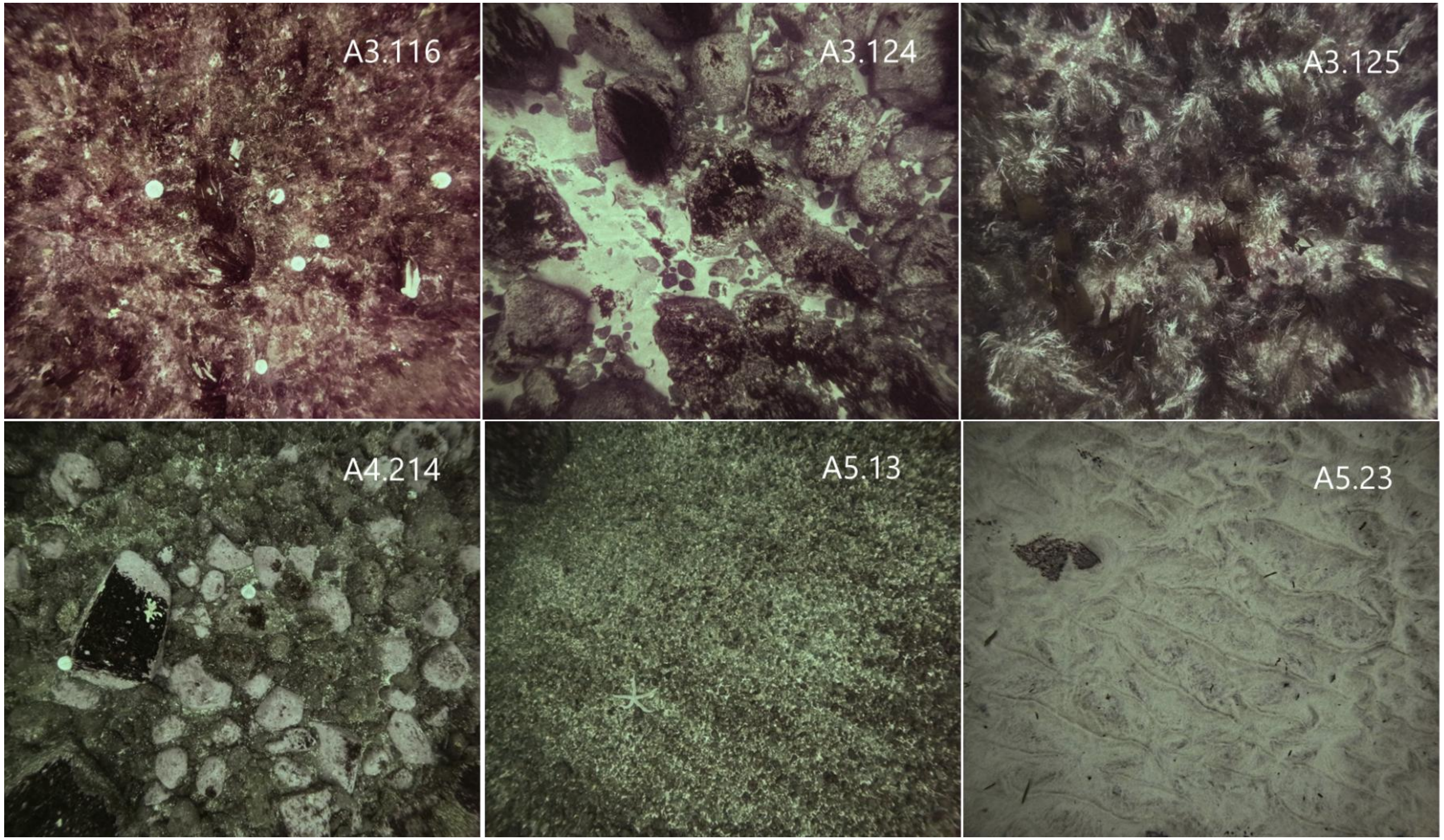


**Plate 17** Example imagery of non-kelp supporting habitats /biotopes obtained during the PMF survey[11].

[11] A3.116: Foliose red seaweeds on exposed lower infralittoral rock
A3.124: Dense *Desmarestia* spp. with filamentous red seaweeds on exposed infralittoral cobbles, pebbles and bedrock
A3.125: Mixed kelps with scour-tolerant and opportunistic foliose red seaweeds on scoured or sand-covered infralittoral rock
A4.214: *Laminaria hyperborea* and foliose red seaweeds on moderately exposed infralittoral rock
A5.13: Infralittoral coarse sediment
A5.23: Infralittoral fine sand

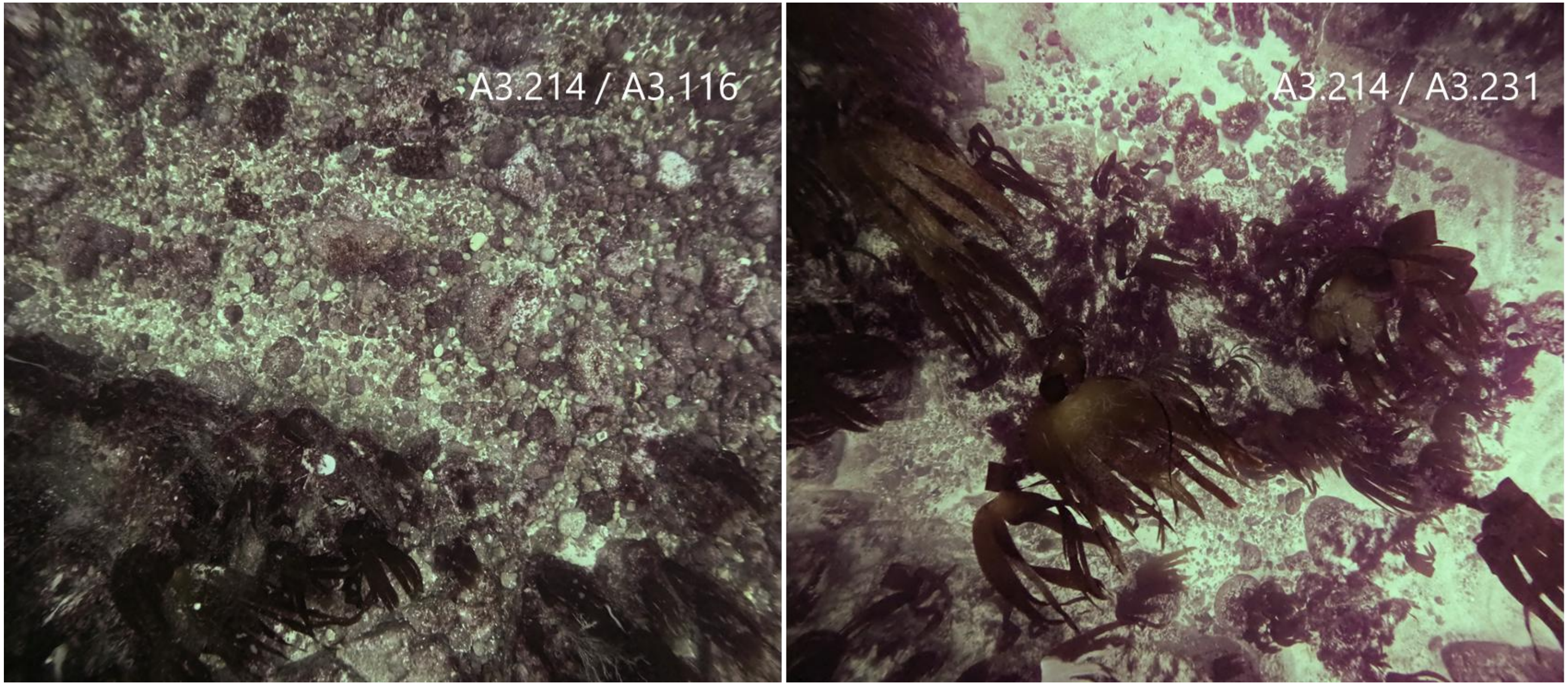


**Plate 18** Examples of habitat mosaics identified during the PMF survey.

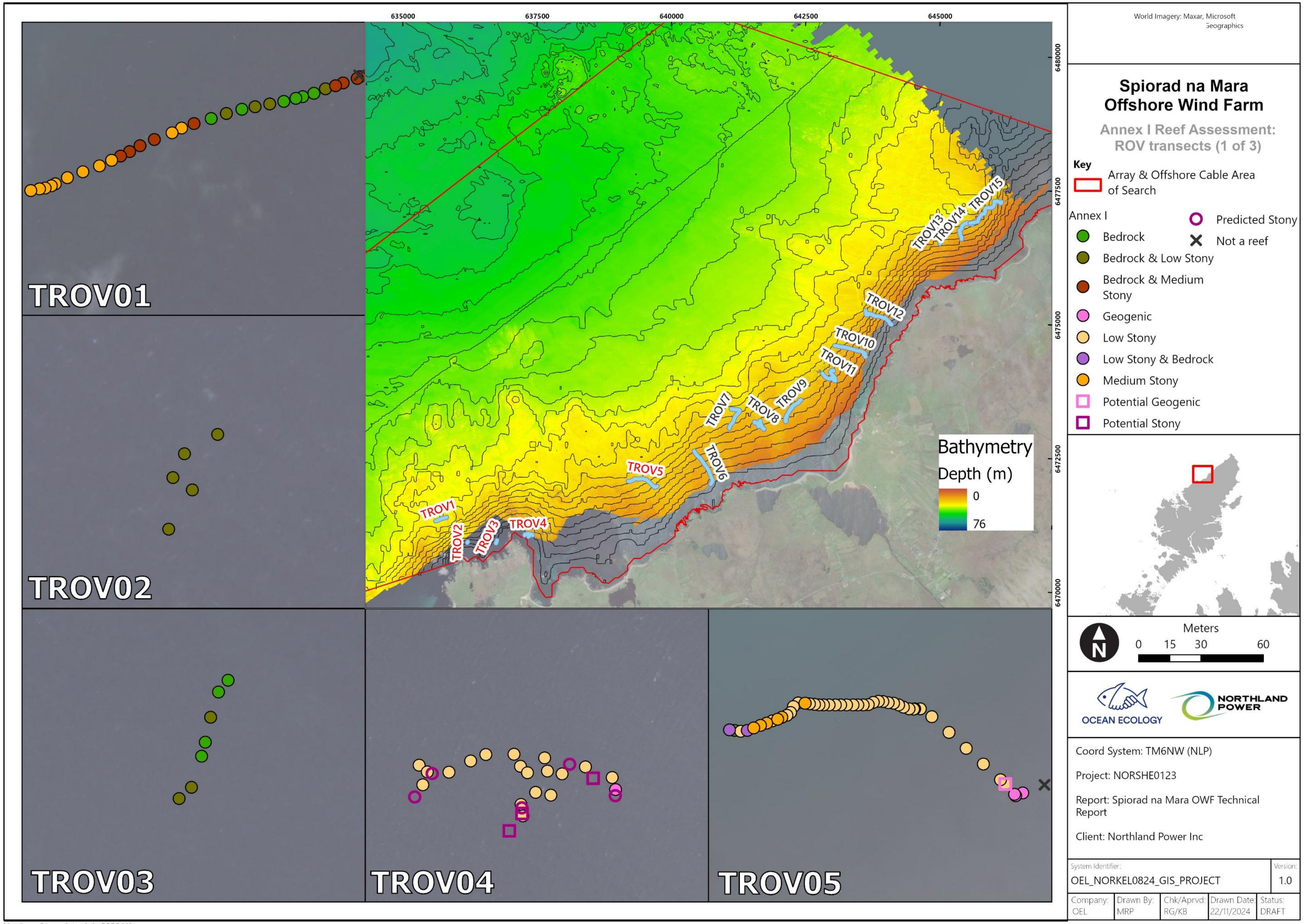


**Figure 34** PMF survey Annex I reef assessment (1/3).

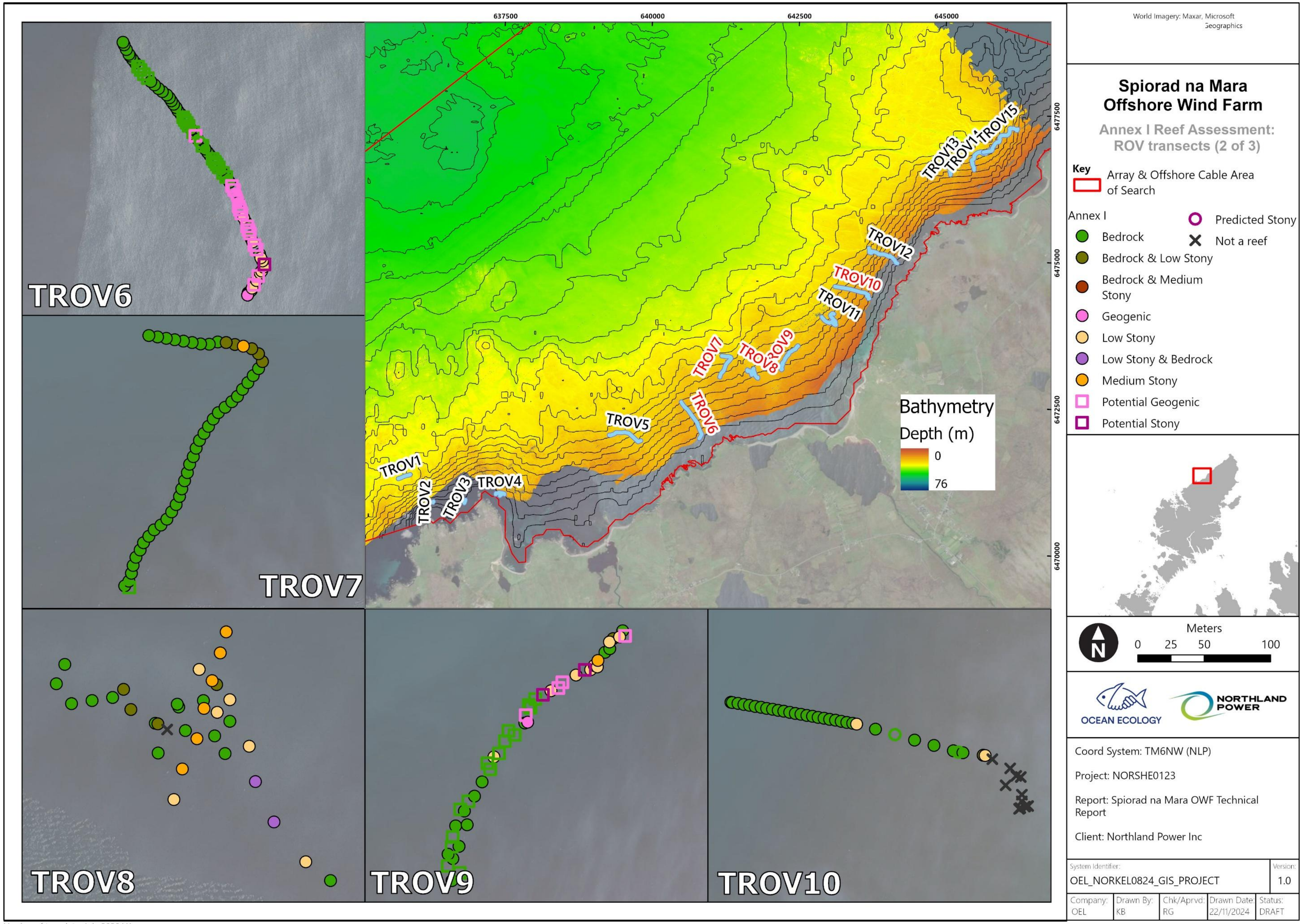


**Figure 35** PMF survey Annex I reef assessment (2/3).

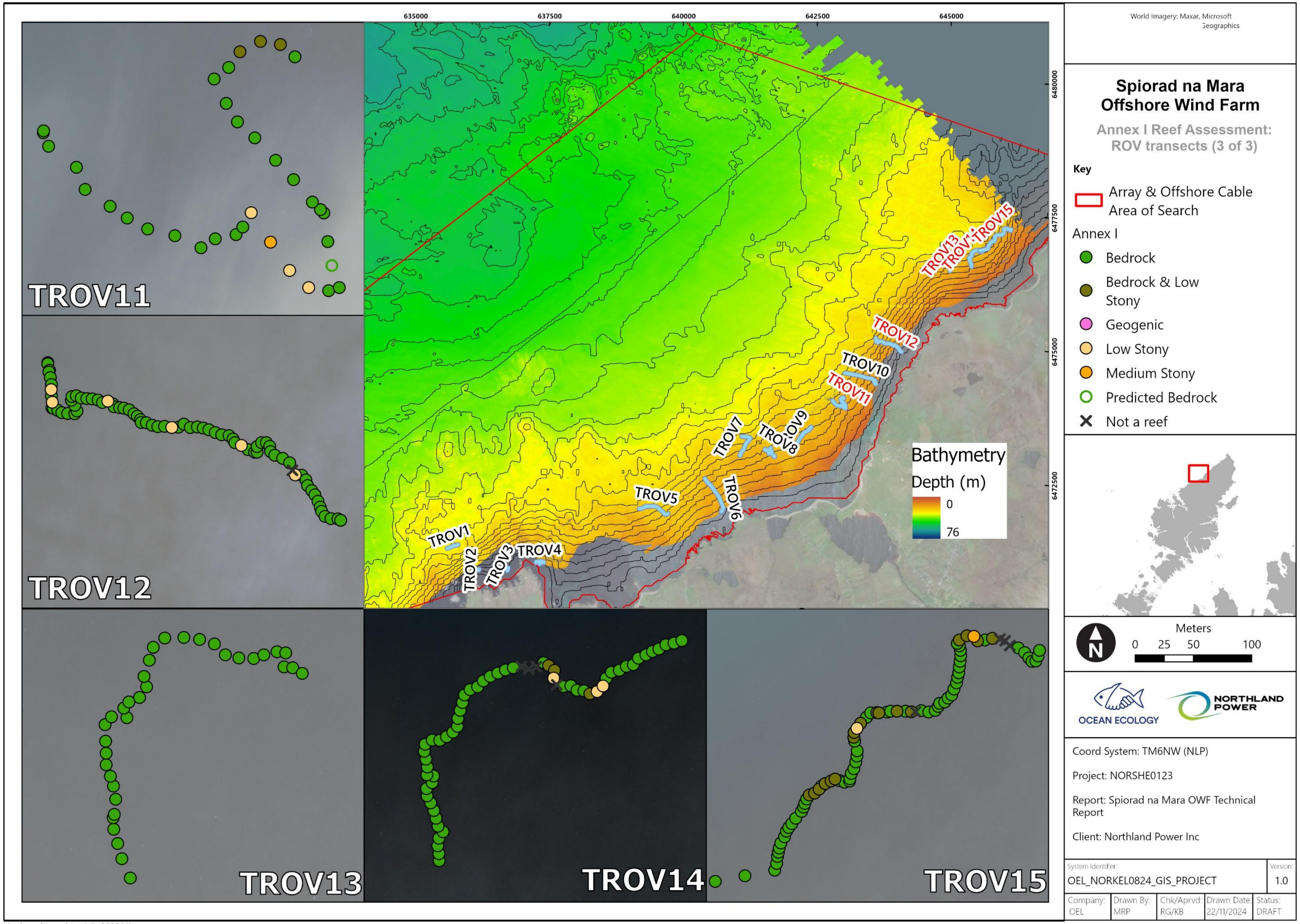


**Figure 36** PMF survey Annex I reef assessment (3/3).

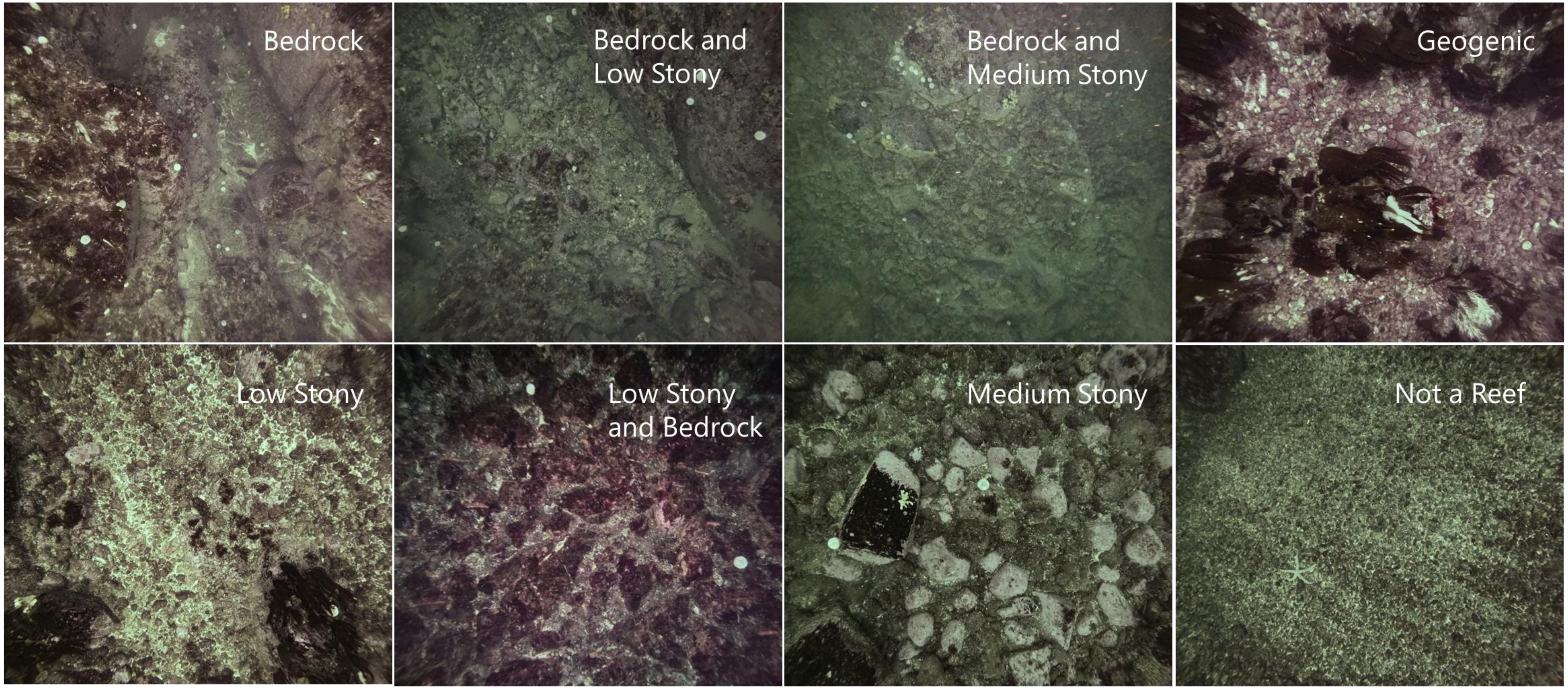


**Plate 19** Example imagery of Annex I reef observed during the PMF survey.

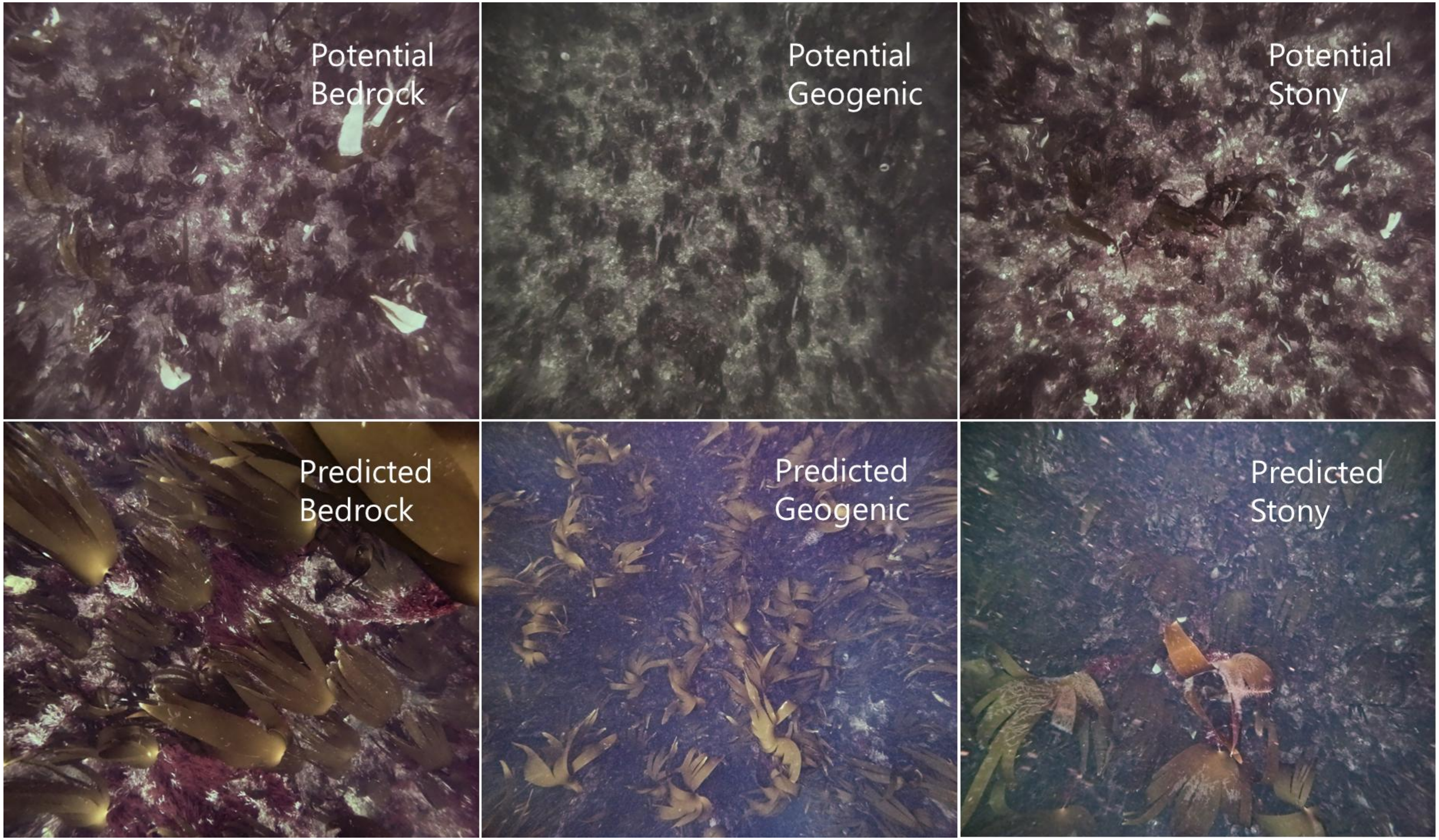


**Plate 20** Example imagery if potential and predicted Annex I reef observed during the PMF survey.

#### *8.3.2.3. PMFs Assessment*

Of the 730 images analysed during the PMF survey, a total of 495 were observed as supporting the PMF habitat 'Kelp beds'. A summary of the kelp bed assessment is shown in Table 18 and the results mapped in Figure 37 to Figure 39. The full kelp bed assessment results are provided in the imagery analysis proforma (Appendix XVIII). A summarised list of the different habitats that supported kelp beds is provided in Table 18 with example imagery of kelp and non-kelp habitats shown in Plate 16 and Plate 17.

Transects TROV6 which was located in the central region of the nearshore OCAS, running perpendicular to the shore and TROV15 which ran parallel to the shore in the northern region of the OCAS had the highest number of images containing kelp. Transects TROV1 and TROV2 were the only not to contain any kelp (Table 18, Figure 37 to Figure 39).

The EUNIS biotope complex A3.214 '*Laminaria hyperborea* and foliose red seaweeds on moderately exposed infralittoral rock' was found to be the most common habitat supporting kelp beds, accounting for 338 of the 495 images containing kelp.

**Table 18** Kelp bed assessment summary for images acquired during the PMF survey.

| Transect | Number of Images Containing Kelp Beds |
|---|---|
| TROV1 | 0 |
| TROV2 | 0 |
| TROV3 | 16 |
| TROV4 | 23 |
| TROV5 | 9 |
| TROV6 | 78 |
| TROV7 | 30 |
| TROV8 | 23 |
| TROV9 | 45 |
| TROV10 | 46 |
| TROV11 | 21 |
| TROV12 | 59 |
| TROV13 | 35 |
| TROV14 | 40 |
| TROV15 | 70 |

.

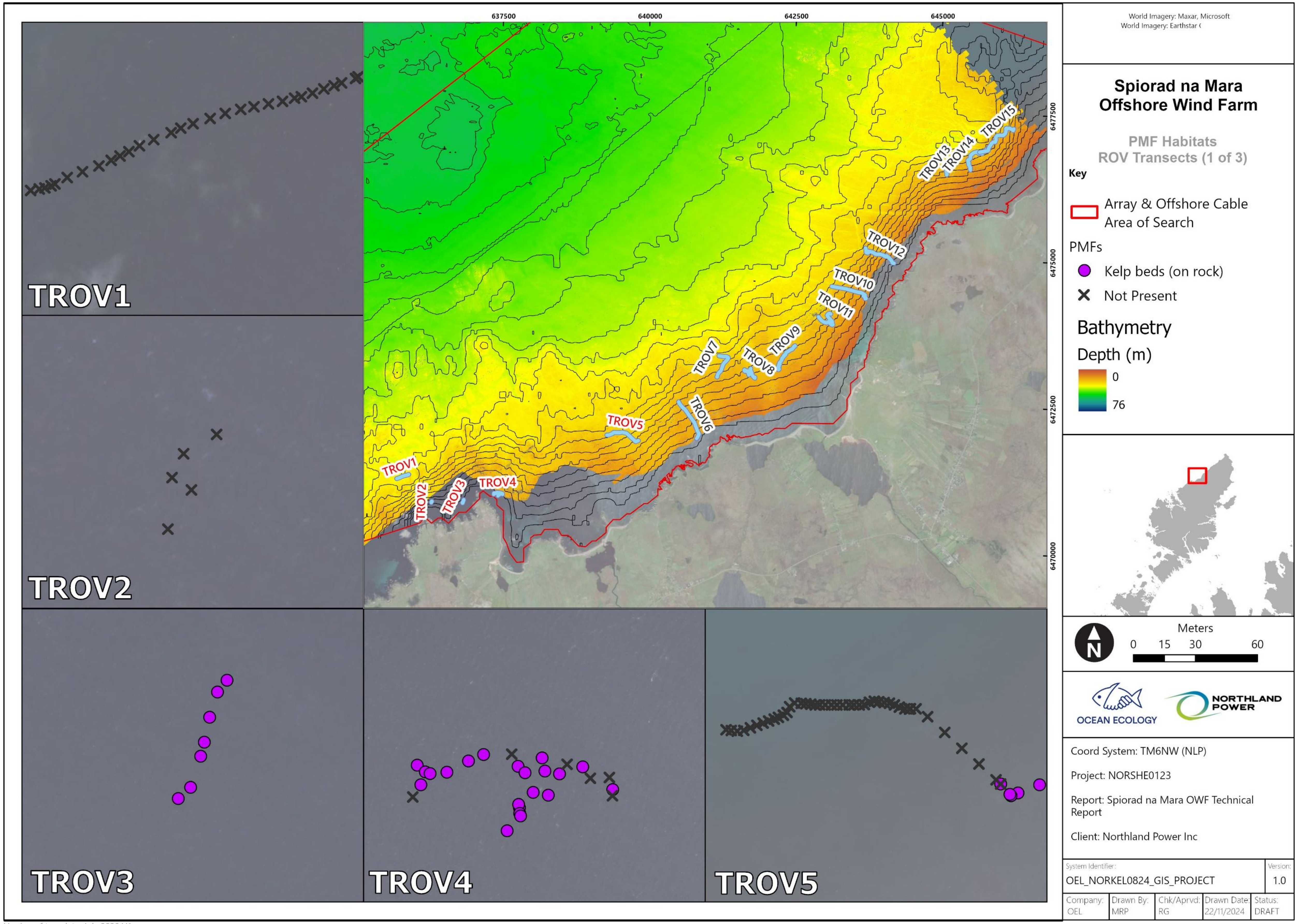


**Figure 37** Location of PMF habitats within the PMF survey area (1/3).

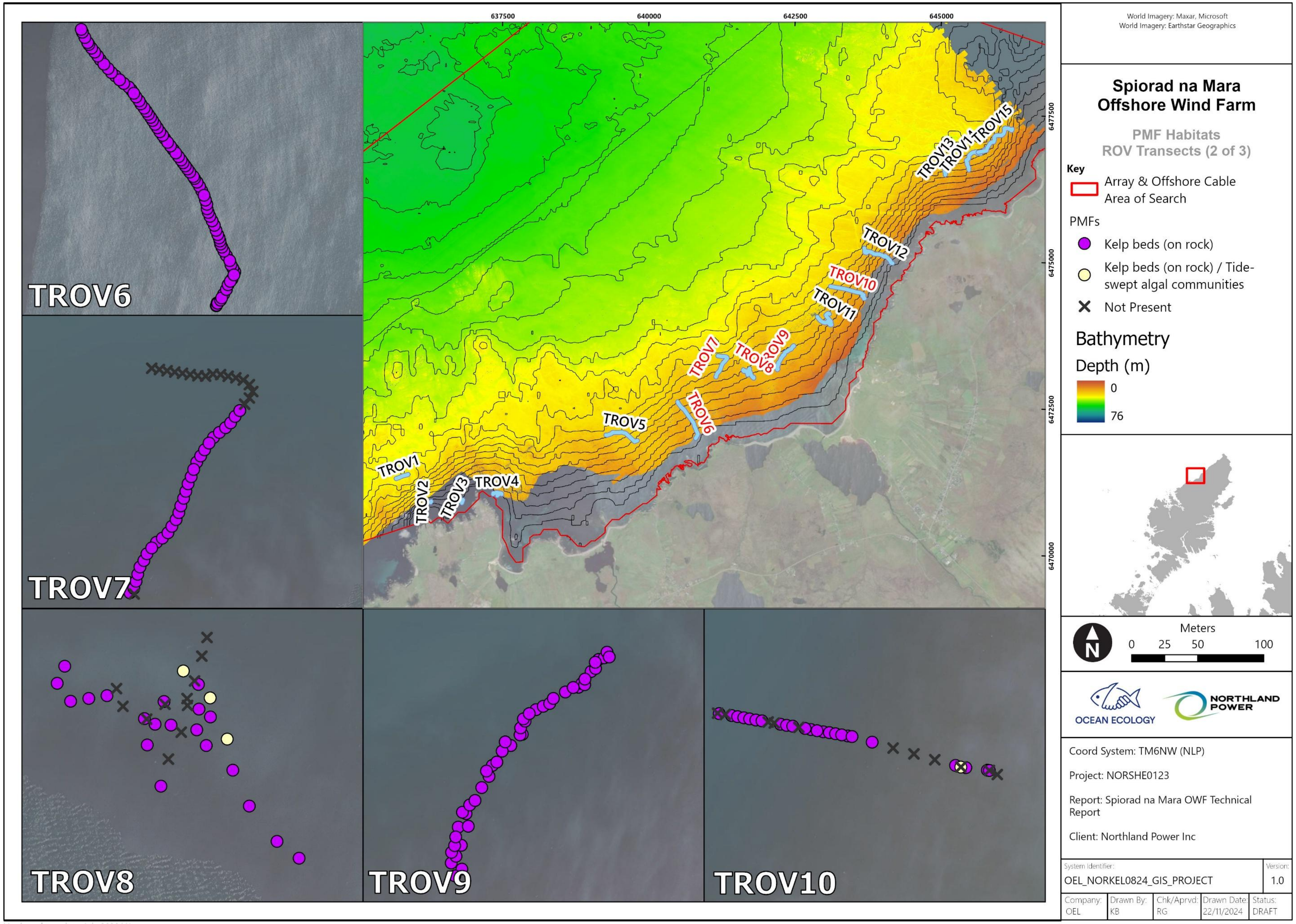


**Figure 38** Location of PMF habitats within the PMF survey area (2/3).

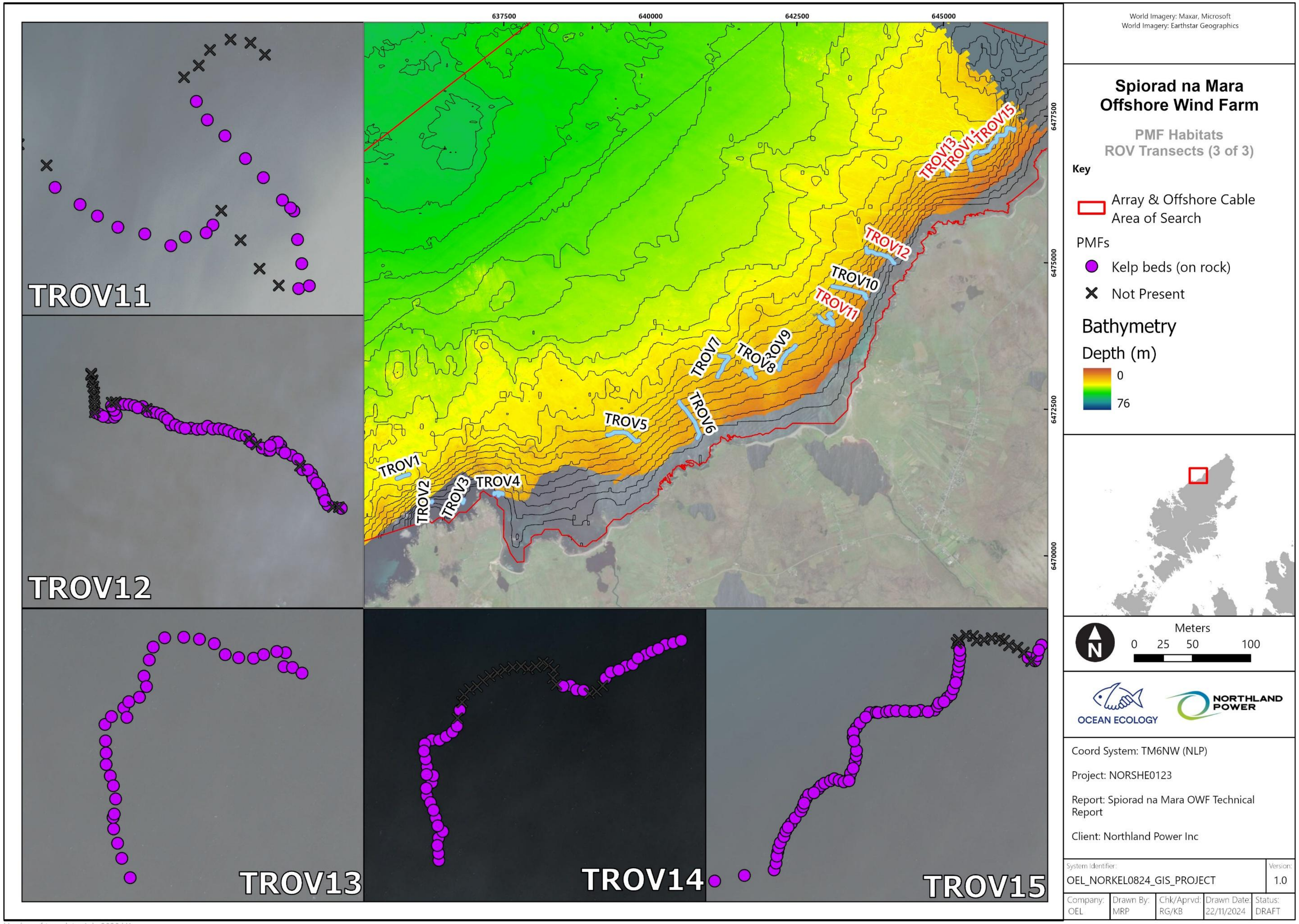


**Figure 39** Location of PMF habitats within the PMF survey area (3/3).

The PMF habitat 'Tide-swept algal communities' was also found to be present in three images obtained from transect TROV8 and two from transect TROV10. In all instances it was found alongside the PMF 'Kelp beds' (Figure 38 and Plate 21).

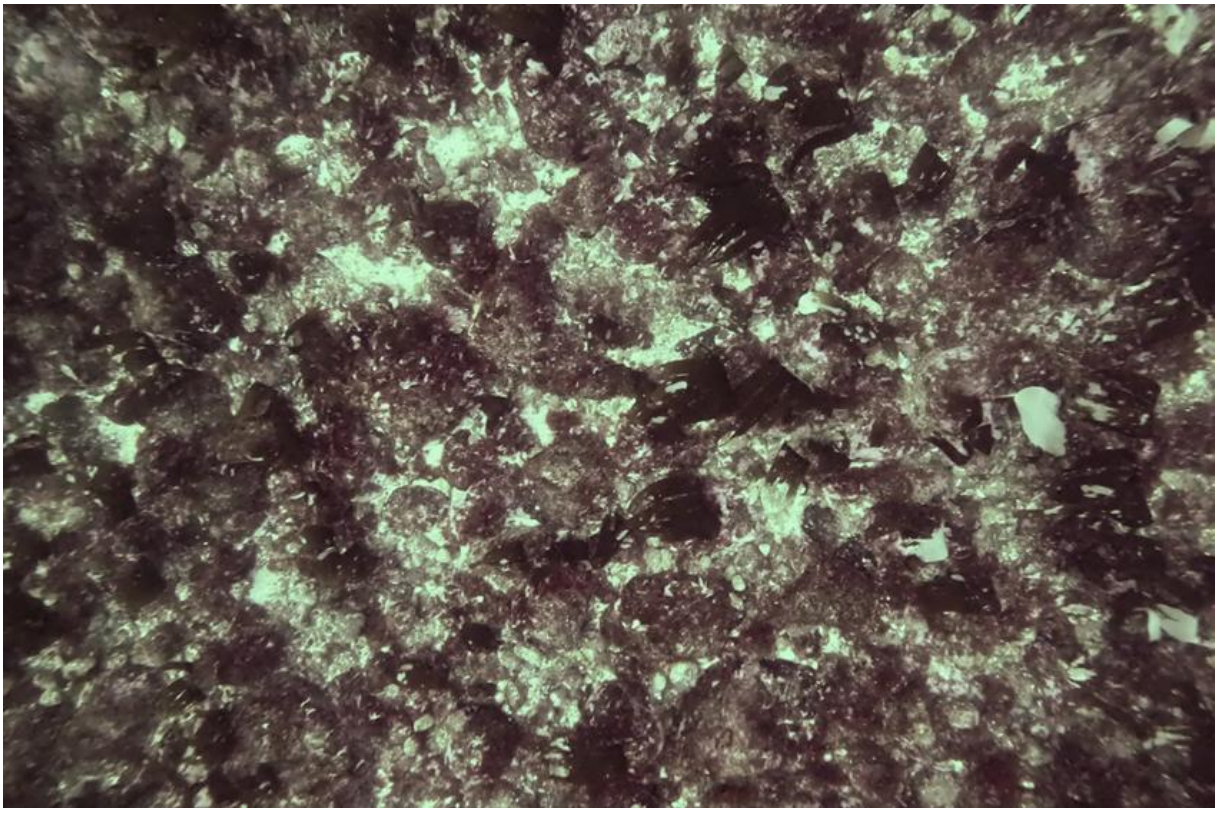

**Plate 21** PMF 'Tide-swept algal communities' observed at transect T08.

### 8.3.3. BRUV Analysis

Full sample logs for the BRUV sampling programme with detailed analysis proforma are presented in Appendix VII. Example images are presented in Plate 22.

**Mobile Epifauna and Demersal Fish Communities**

A diverse range of taxa were identified in the BRUV footage collected from across the Project Area, with six major morphological groups observed:

- Bony fish (e.g. species belonging to the family Gadidae, cods),
- Cartilaginous fish (Squalidae (dog fish) and Scyliorhinidae (cat sharks),
- Crustacea (e.g. hermit crabs of the family Paguridae),
- Echinoderms (e.g. *Echinus esculentus* (edible sea urchin)),
- Molluscs (e.g. cuttlefish of the family Sepiidae),
- Marine mammal (Grey seal, *Halichoerus grypus*).

Total abundance per station was calculated as the sum of *MaxN* for all taxa. Station B007 had the highest total abundance of 106 individuals observed driven by *Ammodytes sp.* with a *MaxN* of 100 individuals per frame. The second highest total abundance was calculated at station

B009 with a total abundance of 47, driven by *Trisopterus minutus* with a MaxN of 25 individuals per frame. The station which recorded the lowest total abundance of 13 was B005 (Figure 40).

The station with the highest diversity was B010 where 7 different species were recorded. Whilst having the highest total abundance, station B007 recorded the lowest species diversity with two different species recorded (Figure 41).

Seventeen of the taxa recorded were of economic and/or conservation importance. These taxa are summarised in Table 19 and their presence mapped in Figure 42 (points represent presence/absence of a taxa at each station with pie charts showing instances where more than one taxa of conservation importance was present at one station).

**Table 19** Species of economic and conservation significance observed during analysis of BRUV footage collected at 7 stations across the Project Area.

| Taxa | Status | Total abundance |
|---|---|---|
| *Ammodytes sp.* (sand lance) | Economically important species, UK list of Priority Habitats and Species, PMF species | 100 |
| *Gadus morhua* (Atlantic cod) | Economically important species, Vulnerable under the International Union for Conservation of Nature (IUCN) Red List of Threatened Species (2010), OSPAR List of Threatened and/or Declining Species and Habitats (2008), UK list of Priority Habitats and Species, PMF species | 1 |
| *Trisopterus minutus* (Poor cod) | Economically important species, Least Concern under the IUCN Red List of Threatened Species | 42 |
| *Molva molva* (Ling) | Economically important species, UK list of Priority Habitats and Species, PMF species | 3 |
| *Labrus mixtus* (Cuckoo wrasse) | Economically important species, Least Concern under the IUCN Red List of Threatened Species | 5 |
| *Melanogrammus aeglefinis* (Haddock) | Economically important species | 8 |
| *Helicolenus dactylopterus* (Black belly rosefish) | Economically important species | 1 |
| *Limanda limanda* (Common dab) | Economically important species | 2 |
| *Squalus acanthias* (Spiny dogfish) | Economically important species, Endangered under the IUCN Red List of Threatened Species (2010), OSPAR List of Threatened and/or Declining Species and Habitats (2008), UK list of Priority Habitats and Species, PMF species | 6 |
| *Scyliorhinus stellaris* (Nursehound) | Economically important species, Vulnerable under the IUCN Red List of Threatened Species | 1 |
| *Halichoerus grypus* (Grey seal) | Annex V of the EU Habitats Directive, Schedule IV of The Conservation of Habitats and Species Regulations, Appendix II of the Conservation of Migratory Species, PMF species | 2 |
| *Pandalus montagui* (Pink shrimp) | Economically important species | 21 |
| Brachyura (True crab) | Economically important taxon | 1 |
| Galatheoidea (Squat lobster) | Economically important species | 5 |
| *Echinus esculentus* (Edible sea urchin) | Economically important species | 16 |
| Sepiidae (Cuttlefish) | Economically important taxon | 1 |
| *Buccinum undatum* (Common whelk) | Economically important species | 1 |

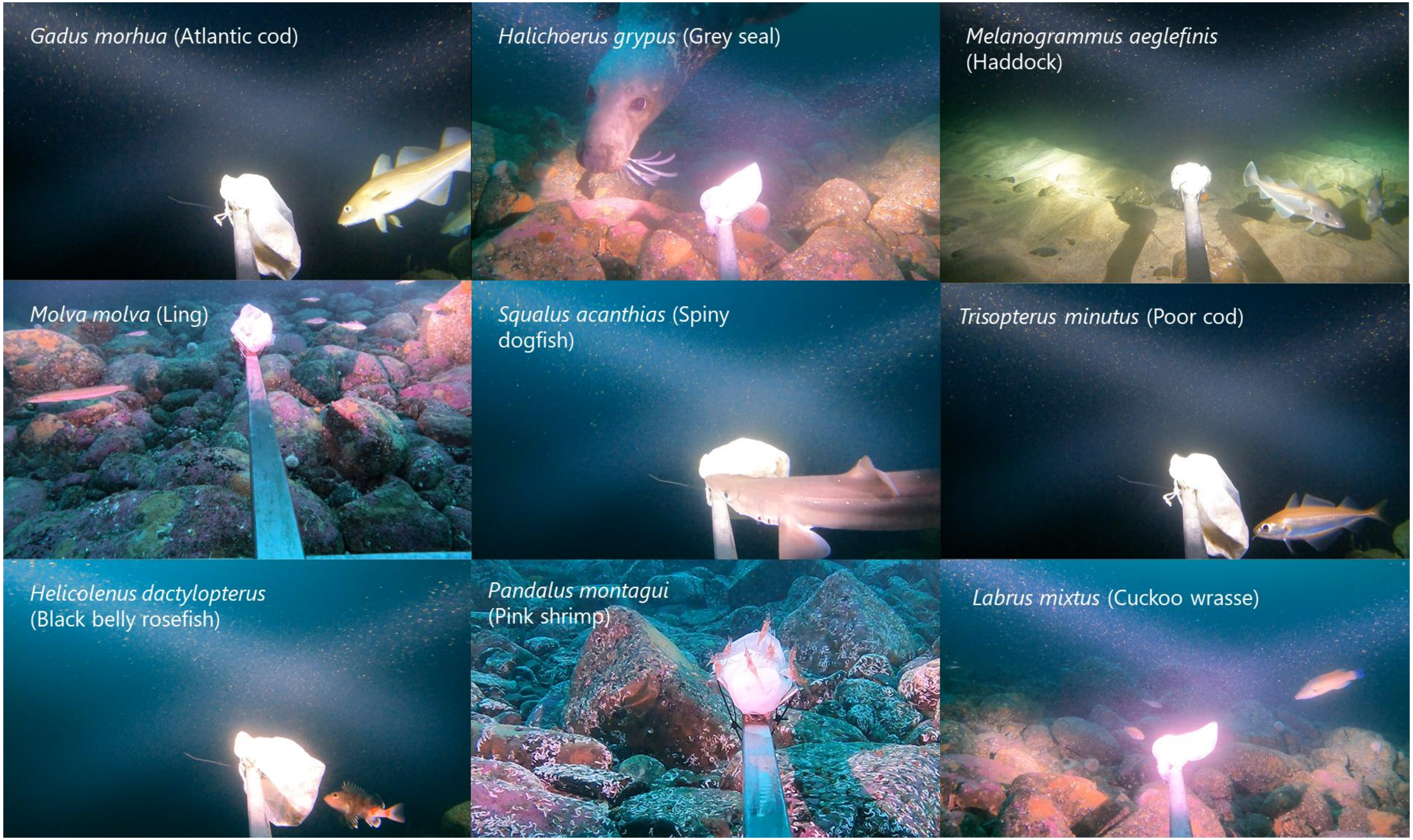


**Plate 22** Examples of taxa observed during analysis of BRUV footage across the Project Area.

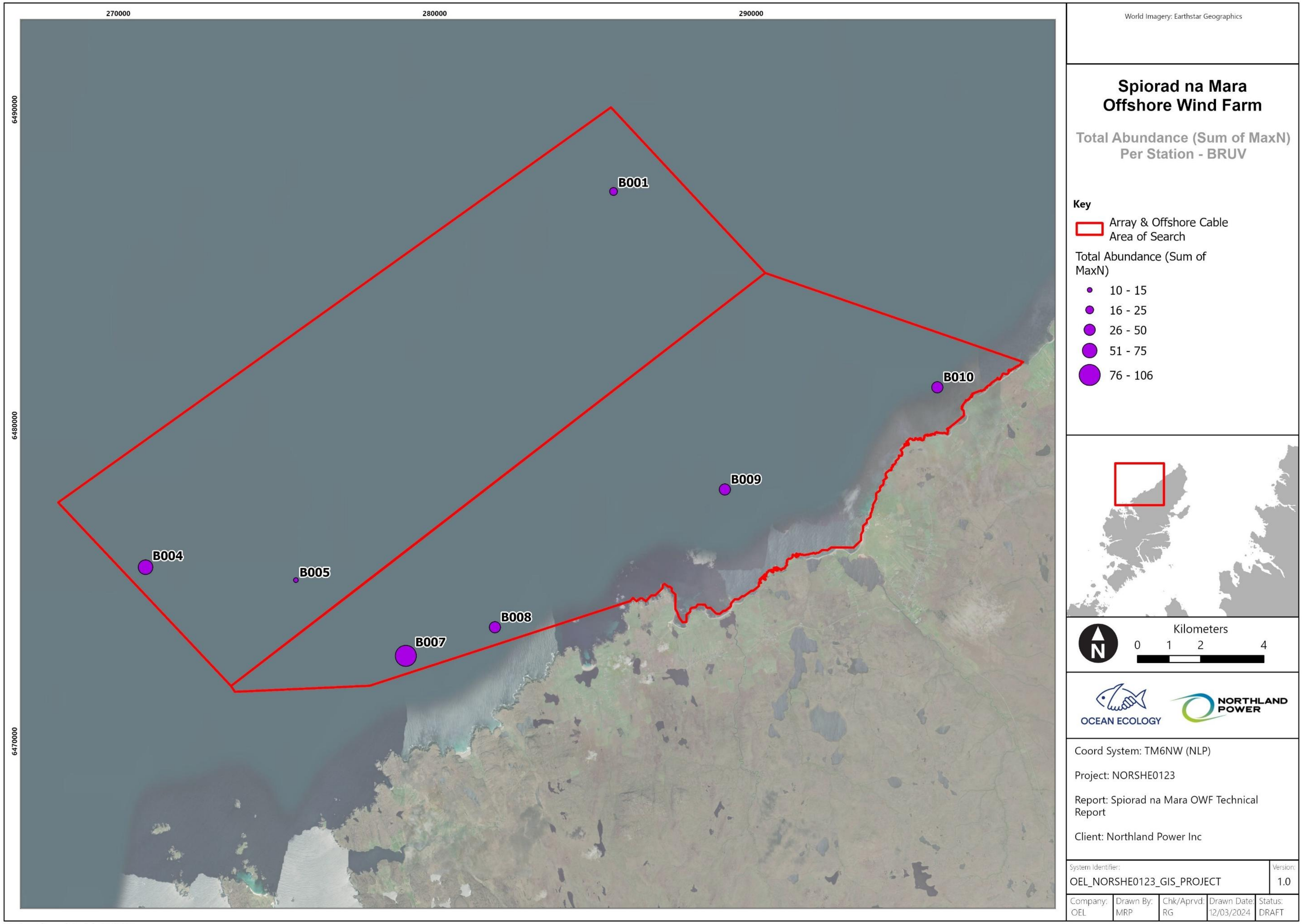


**Figure 40** Total abundance (Sum of *MaxN*) per station as observed in the BRUV footage.

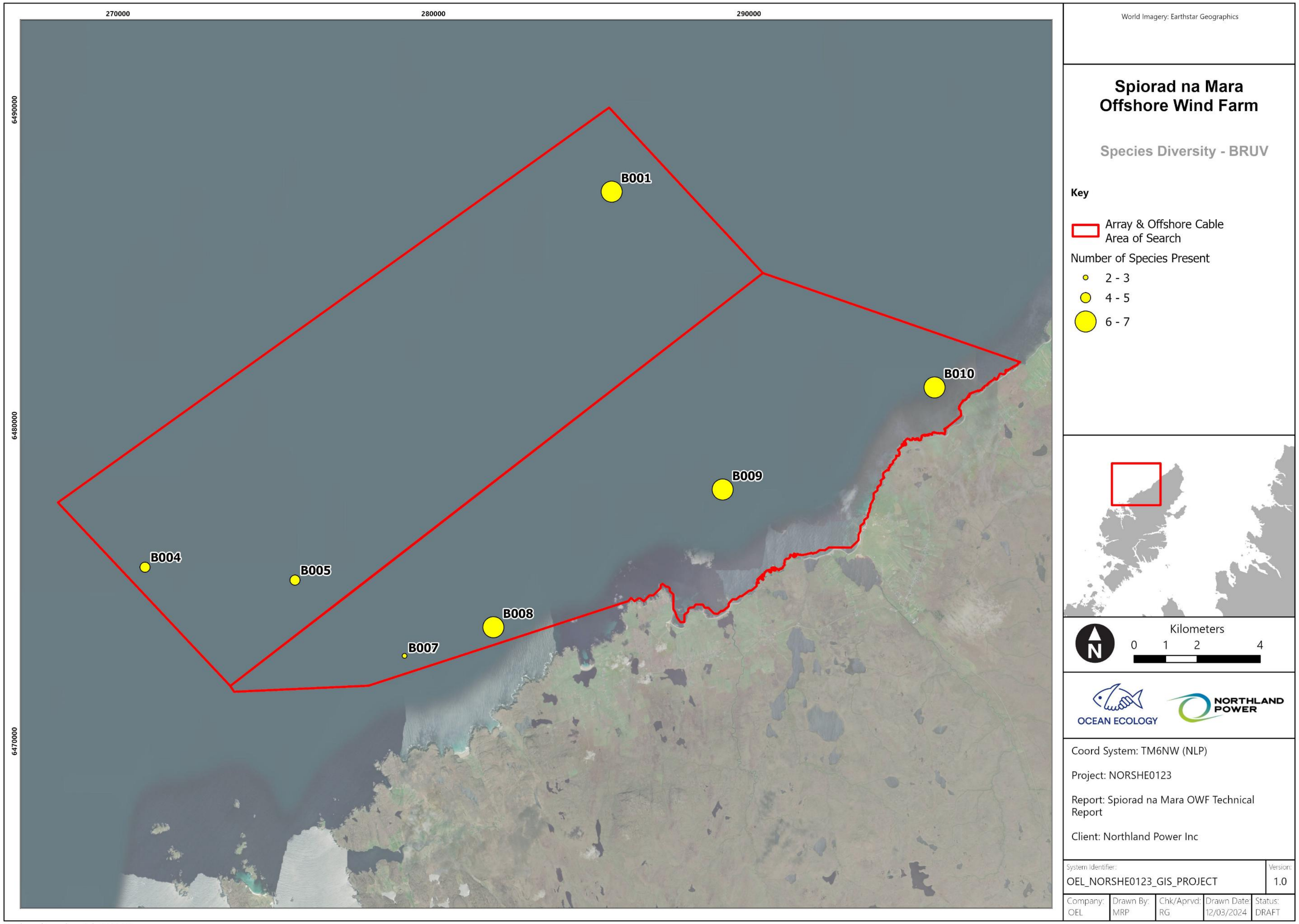


**Figure 41** Total number of species (diversity) identified at each station in BRUV footage.

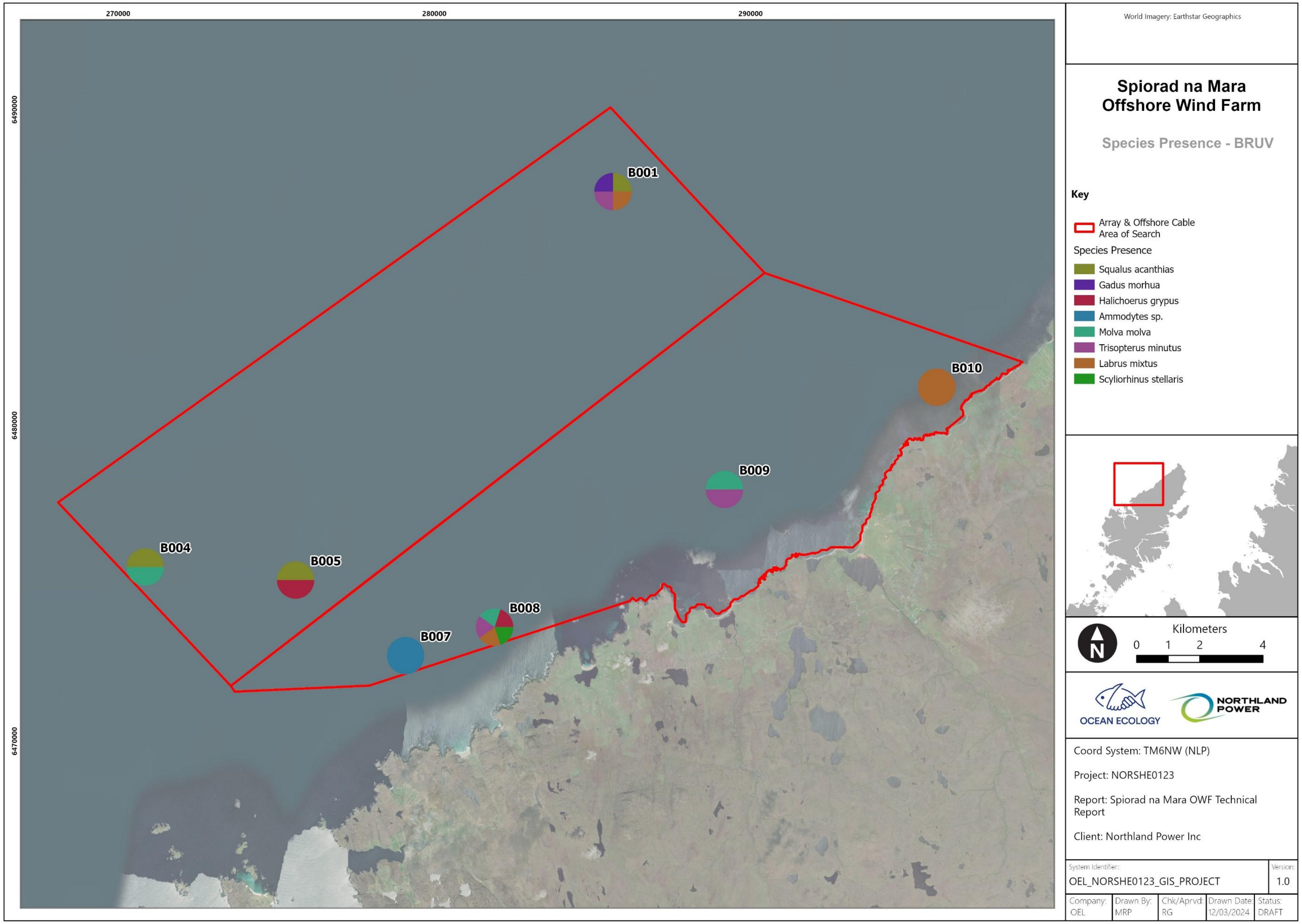


**Figure 42** Presence of species of conservation interest (as shown in Table 19).

## 8.4. PSD Analysis

Due to the predominance of rock substrate across the Project Area only 11 stations could be sampled by grab and analysed for full particle size classification. The following section only focuses on sediment data. Example images of all sampled sediment types are presented in Plate 23 with full particle size data provided in Appendix VIII and summary data provided in Appendix IX.

### 8.4.1. Sediment Type

Sediment types, as classified using the Folk triangle (Folk 1954), for each station sampled across the Project Area are presented in Figure 43. Each Folk classification was converted to BSH Type (EUNIS Level 3) using the adapted Folk triangle (Long 2006) (Figure 43). Sediments were relatively homogenous across the Project Area with sand dominating across all but station STAD002 which was dominated by Gravels. Sediment textural group and BSH are mapped in Figure 44 and Figure 45.

Of the 11 stations sampled, 7 stations represented BSH A5.2 'Sand and Muddy Sand', were well or moderately well sorted and classed as Slightly Gravelly Sand ((g)S) (n = 5) and Sand (S) (n = 2). Sediments from the remaining four stations represented BSH A5.1 'Coarse Sediment', with three having been classed as moderately sorted Gravelly Sand (gS) and one as poorly sorted Sandy Gravel (sG).

### 8.4.2. Sediment Composition

Sediments across the Project Area were characterised predominantly by sand, with varying but generally low gravel content and very low mud content. The percentage of gravels (>2 mm), sands (0.63 mm to 2 mm), and fines (< 63 µm) at each station are presented in Figure 46. The mean proportion (± SE) of sands across all stations was 90 % (± 5 %), the mean (± SE) gravel and mud content across the Project Area was 9 % (± 5 %) and 0.3 % (± 0.03 %) respectively. Spatial trends of sediment composition are mapped in Figure 45.


**Plate 23** Example images of sediment types obtained during grab sampling. Clockwise from top left ST003, STAD007, ST023, STAD02.

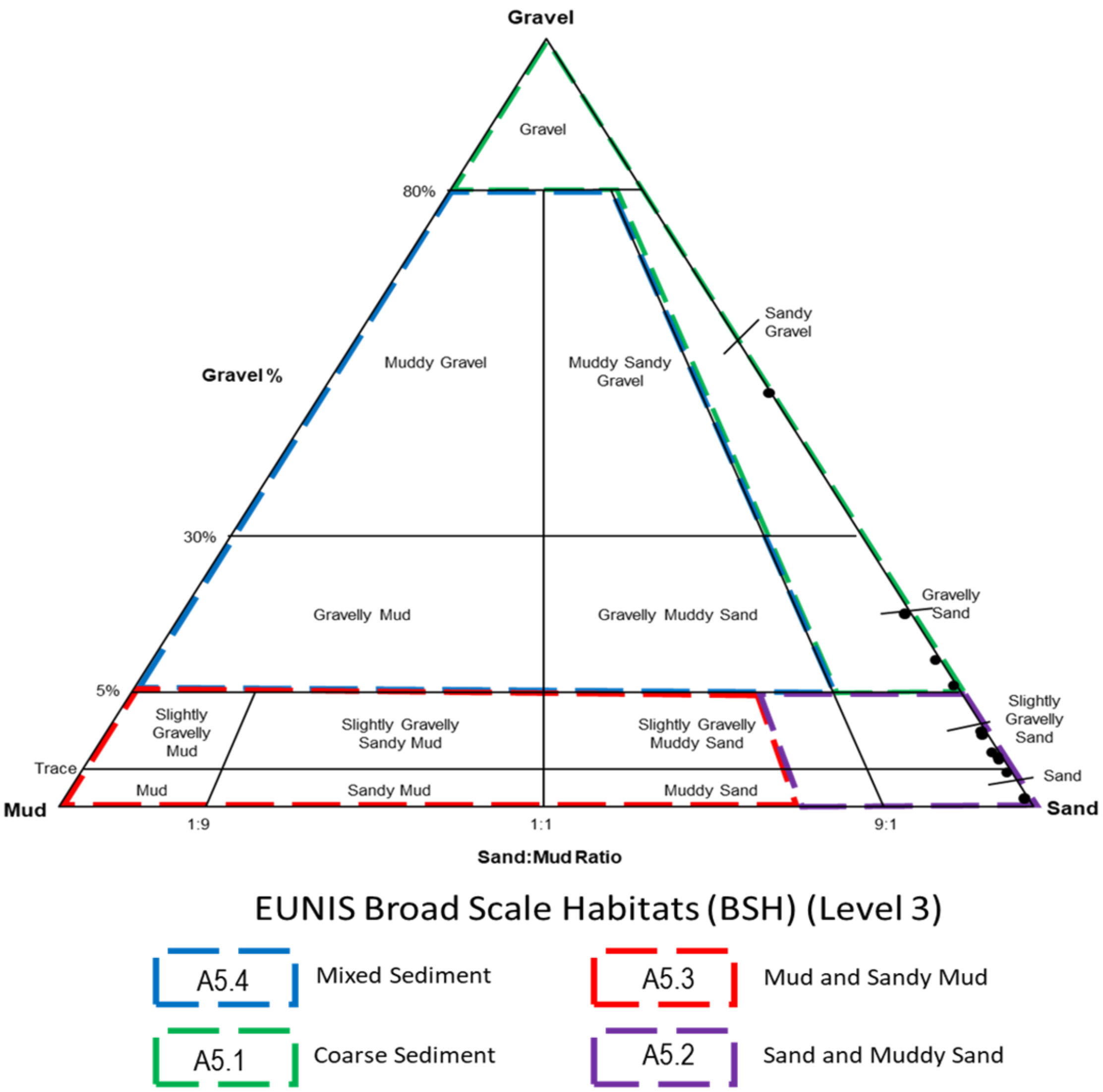


**Figure 43** (Folk 1954) triangle classifications of sediment gravel percentage and the sand-to-mud ratio of samples collected during the survey, overlain by the modified Folk triangle for determination of mobile sediment BSHs under the EUNIS habitat classification system (adapted from (Long 2006).

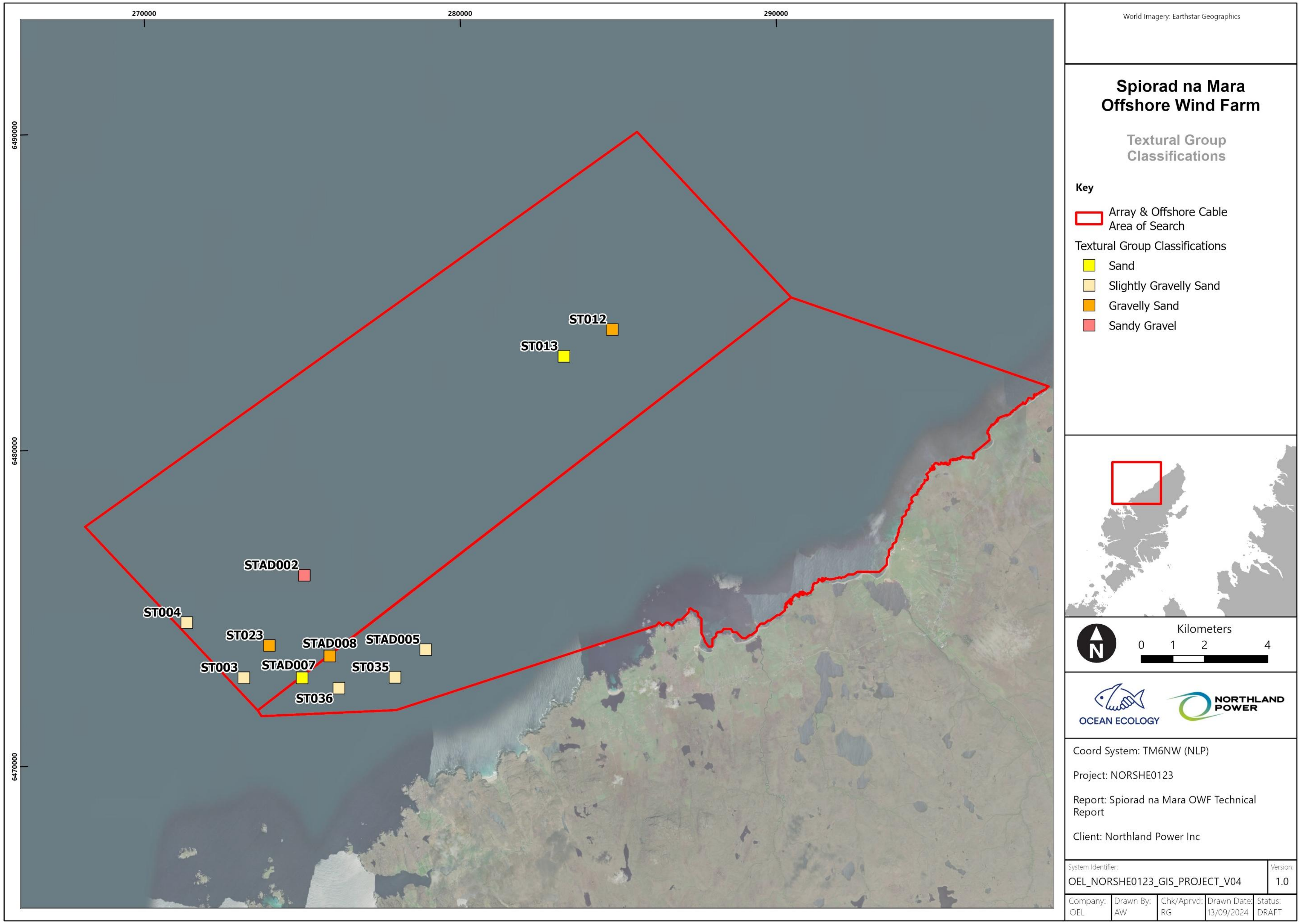


**Figure 44** Textural groups as determined from PSD analysis of samples acquired across the Project Area.

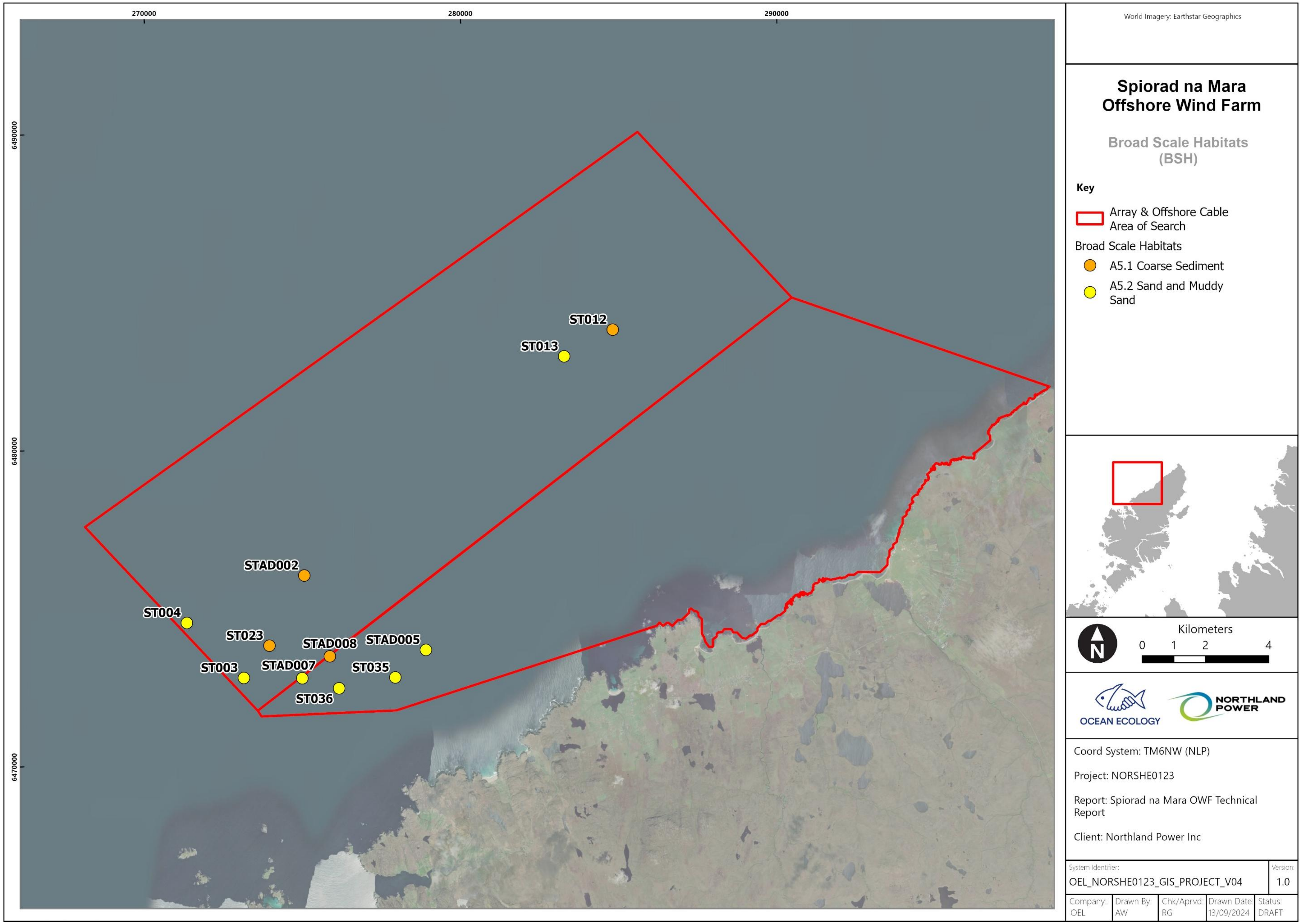


**Figure 45** EUNIS BSH classification as determined based on PSD of samples acquired across the Project Area.

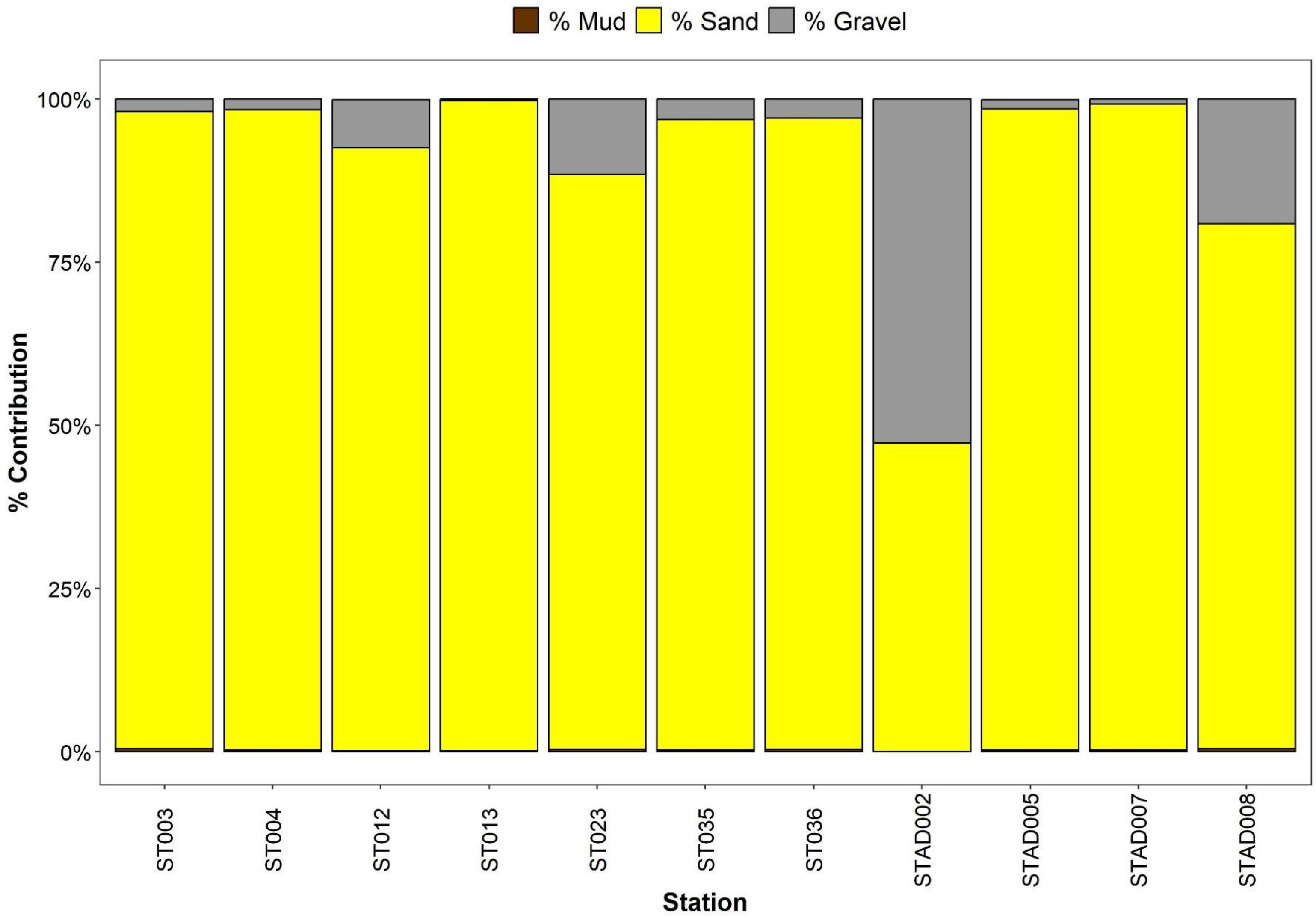


**Figure 46** Relative contribution to the volume of sediment at each sampling station across the project are

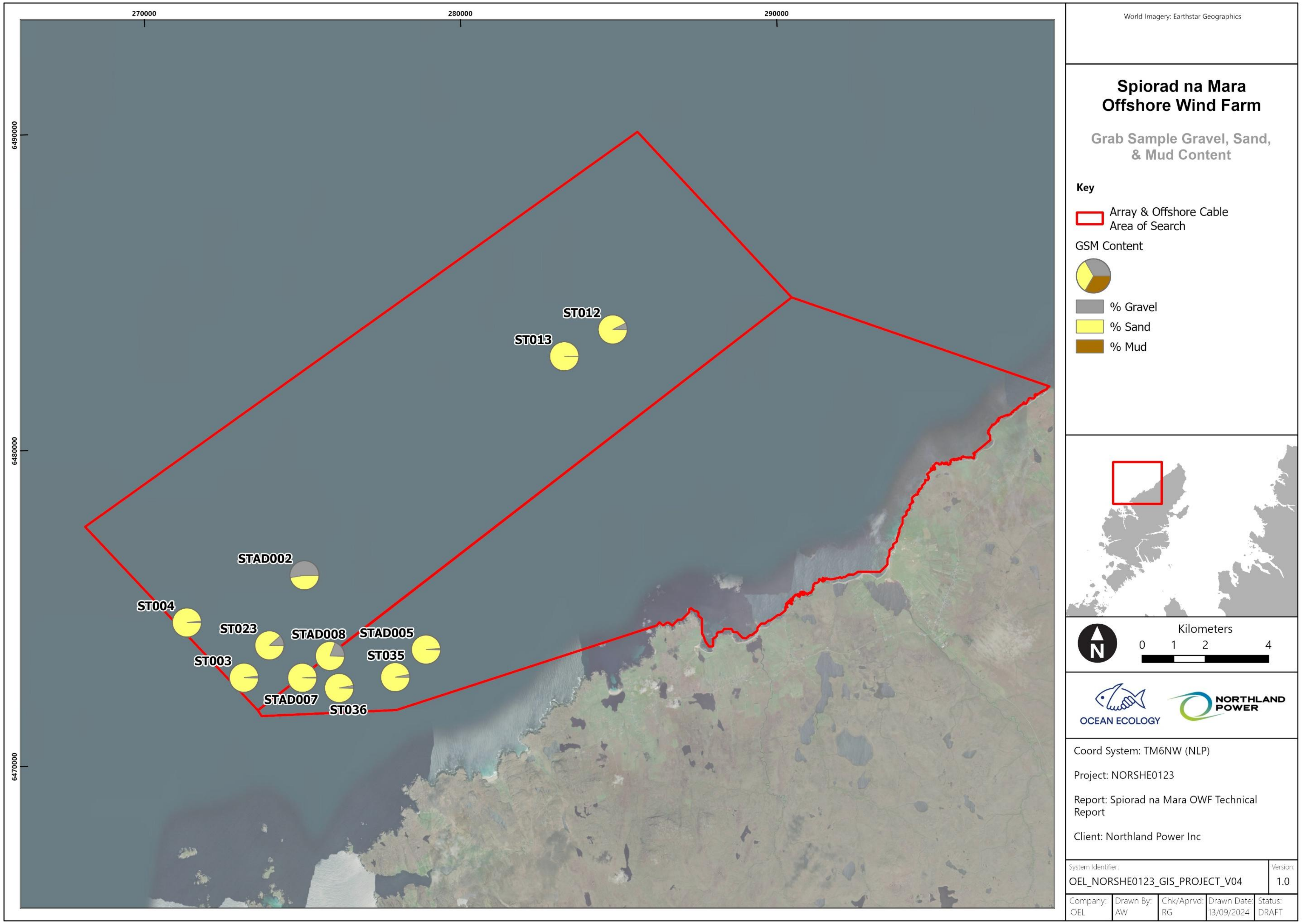


**Figure 47** The principal sediment components (gravel, sand, mud) as determined from PSD analysis of samples acquired during the survey

## 8.5. Sediment Chemistry

A total of 7 sediment samples were analysed for TOC, heavy and trace metals, PAHs and THCs, organotins and OCPs. Raw sediment chemistry data are provided in Appendix X.

### 8.5.1. Total Organic Carbon

Total Organic Carbon ranged from 0.26 % at station ST023 to 0.47 % at station STAD007. The mean (± SE) TOC across the Project Area was 0.38 % ± 0.02 %.

### 8.5.2. Heavy and Trace Metals

A total of eight heavy and trace metals were analysed from sediment samples and could be compared to national and international reference levels. These were: Arsenic (As), Cadmium (Cd), Chromium (Cr), Copper (Cu), Lead (Pb), Mercury (Hg), Nickel (Ni) and Zinc (Zn).

Data for the eight main heavy and trace metals (dry-weight concentration, mg $kg^{-1}$) are shown in Table 20 together with available reference levels. Stations ST023 and STAD008 both exceeded CEFAS AL1 for Nickel with STAD008 also exceeding the OSPAR BAC for this contaminant. No other reference levels were exceeded. None of the other metals measured exceeded any of the reference levels.

The metal occurring in the highest concentration was Ni which ranged from 7.7 mg $kg^{-1}$ at station ST004 to 58.2 mg $kg^{-1}$ at station STAD008 with a mean (± SE) concentration across all stations of 19.8 mg $kg^{-1}$ ± 6.4 mg $kg^{-1}$. This was followed by Zn which ranged from 9.7 mg $kg^{-1}$ at station ST023 to 30.6 mg $kg^{-1}$ at station STAD008. The mean (± SE) concentration of Zn across all stations was 13.9 mg $kg^{-1}$ ± 2.5 mg $kg^{-1}$. Zn remained below reference levels at all stations.

Hg concentrations were below the Limit of Detection (LOD) at all but station STAD005.

**Table 20** Summary of heavy and trace metal concentrations (mg kg$^{-1}$) across the Project Area. Red shading indicates concentrations above CEFAS AL1.

| Station | As | Cd | Cr | Cu | Pb | Hg | Ni | Zn |
|---|---|---|---|---|---|---|---|---|
| ST003 | 5.7 | 0.11 | 4.2 | 3.2 | 3.5 | < 0.01 | 9.8 | 10 |
| ST004 | 5.6 | 0.07 | 4.3 | 3.9 | 4.9 | < 0.01 | 7.7 | 10.7 |
| ST023 | 5.3 | 0.06 | 10.7 | 14.7 | 3 | < 0.01 | 28.5 | 9.7 |
| ST035 | 5.2 | 0.1 | 3.7 | 2.8 | 3.9 | < 0.01 | 13.3 | 12.1 |
| STAD005 | 2.9 | 0.17 | 5 | 5.3 | 3.2 | 0.01 | 12.4 | 13.9 |
| STAD007 | 4.8 | 0.11 | 4.7 | 3 | 3.3 | < 0.01 | 8.4 | 10 |
| STAD008 | 5.6 | 0.09 | 23.1 | 25 | 4 | < 0.01 | 58.2 | 30.6 |
| Min | 2.9 | 0.06 | 3.7 | 2.8 | 3 | 0.01 | 7.7 | 9.7 |
| Max | 5.7 | 0.17 | 23.1 | 25 | 4.9 | 0.01 | 58.2 | 30.6 |
| Mean | 5.01 | 0.10 | 7.96 | 8.27 | 3.69 | 0.01 | 19.76 | 13.86 |
| SE | 0.34 | 0.01 | 2.48 | 2.97 | 0.23 | - | 6.43 | 2.64 |
| CEFAS AL1 | 20 | 0.4 | 40 | 40 | 50 | 0.3 | 20 | 130 |
| CEFAS AL2 | 100 | 5 | 400 | 400 | 500 | 3 | 200 | 800 |
| OSPAR BAC | 25 | 0.31 | 81 | 27 | 38 | 0.07 | 36 | 122 |
| ERL | 8.2* | 1.2 | 81 | 34 | 47 | 0.15 | 21* | 150 |
| TEL | 7.24* | 0.7 | 52.3 | 18.7 | 30.2 | 0.1 | - | 124 |
| PEL | 41.6 | 4.2 | 160 | 108 | 112 | 0.7 | - | 271 |

*The ERL and TEL's for As and Ni are below the BACs therefore As and Ni concentrations are usually assessed only against the BAC.

### 8.5.3. PAHs

The full range of EPA PAHs were tested and raw data reported in Appendix X. PAH concentrations were compared to CEFAS AL1 (no CEFAS AL2 concentrations are available for PAHs), OSPAR BAC levels, ERLs, TELs and PELs where possible. All the PAHs analysed were measured < LOD. It was not possible to calculate ratios and predict the source origin of hydrocarbons as all values were < LOD.

### 8.5.4. THC

The total THC in sediment samples collected across the Project Area was < LOD at all but stations ST003 and STAD005. At these stations, total THC concentrations were 2.96 mg kg$^{-1}$ and 1.01 mg kg$^{-1}$ respectively.

### 8.5.5. PCBs

All analysed PCBs were measured < LOD at all stations across the Project Area.

### 8.5.6. Organotins

Dibutyltin (DBT) and tributyltin (TBT) were < LOD at all stations across the Project Area.

### 8.5.7. OCPs

OCP concentrations were < LOD at all stations.

## 8.6. Macrobenthos

A total of 11 samples were analysed for macrobenthic abundance and diversity. The full abundance matrix is provided in Appendix XI which presents the abundance of each taxon in all samples collected across the array area.

### 8.6.1. Macrobenthic Composition

The macrobenthic community identified across the Project Area consisted of a total of 957 individuals and 95 taxa recorded. The mean (± SE) number of taxa per station was 21 ± 2 taxa and mean (± SE) abundance was 100 ± 14 individuals per station.

As shown in Figure 48, individuals of the phylum Nematoda were the most abundant taxon sampled accounting for 20.7 % of all individuals recorded. This was followed by the triangular astarte *Goodallia triangularis* and the polychaete *Pisione remota* which accounted for 17.5 % and 16.9 % of total abundance respectively. The family of polychaete Polygordius, *P. remota* and Nematoda (roundworms) were the most frequently occurring species appearing in all of the 11 samples. Nematoda also showed the highest average density of 20.9 individuals per 0.1 $m^2$, followed by *G. triangularis*. Nematoda were also recorded the maximum number of times in a single sample with 59 individuals recorded at station ST035.

Figure 49 illustrates the relative contributions to total abundance and diversity of the major taxonomic groups in the macrobenthic community sampled across the Project Area. Annelida taxa contributed the most to overall abundance, accounting for approximately 49 % of all individuals recorded whilst Miscellaneous taxa and Mollusca were the second and third most abundant, accounting for approximately 25 % and 22 % respectively. Annelida taxa also contributed the most to the overall diversity of the macrobenthic assemblages accounting for 50 %.

The highest abundance was observed at station STAD008 (n = 174), followed by station ST036 (n = 161). The highest number of taxa was also recorded at station STAD008 with a total of 38 taxa identified (Figure 50).

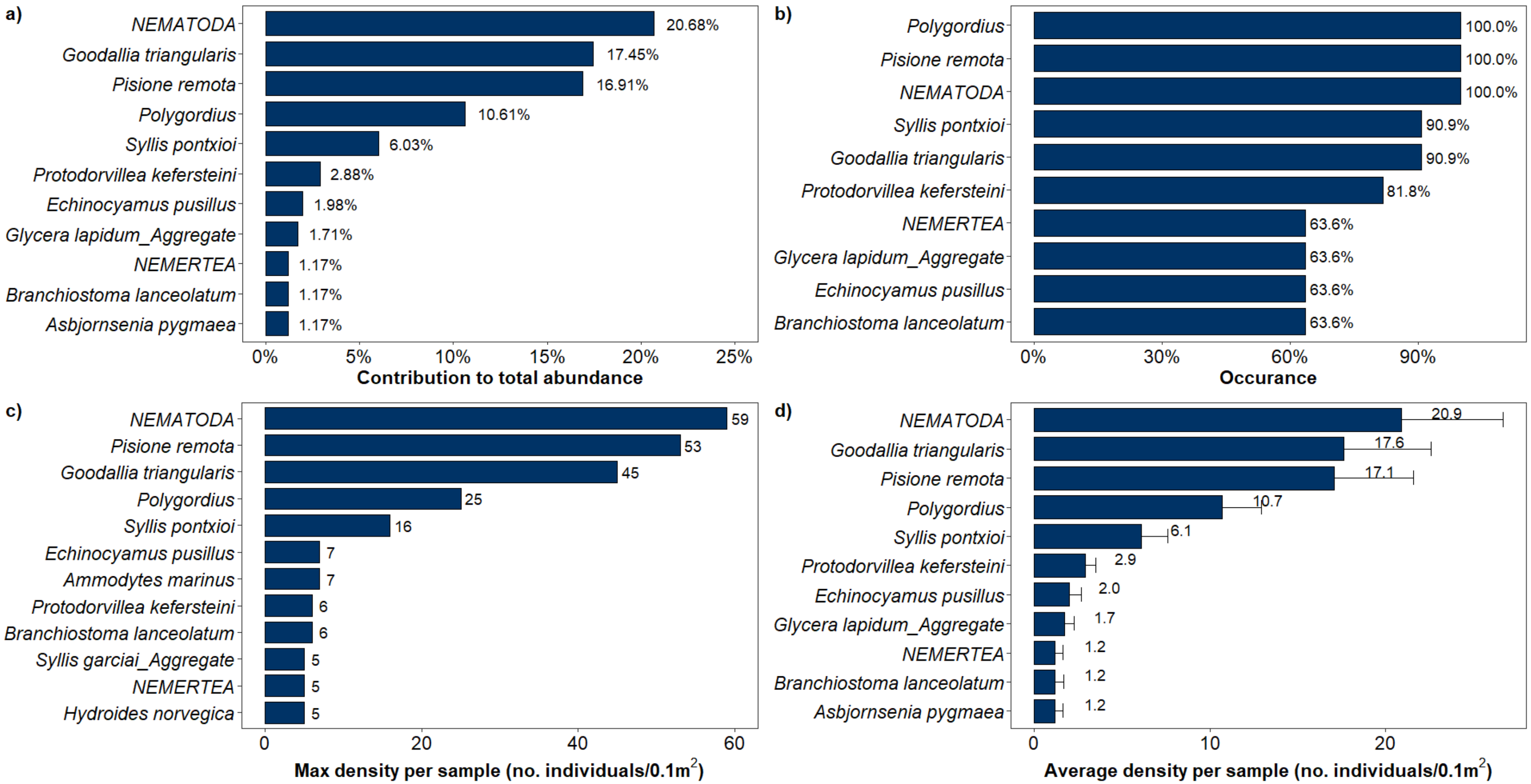


**Figure 48** Percentage contributions of the top 10 macrobenthic taxa to total abundance (a) and occurrence (b) from samples collected across the Project Area. Also shown are the maximum densities of the top 10 taxa per sample (c) and average densities of the top 10 taxa per sample (d).

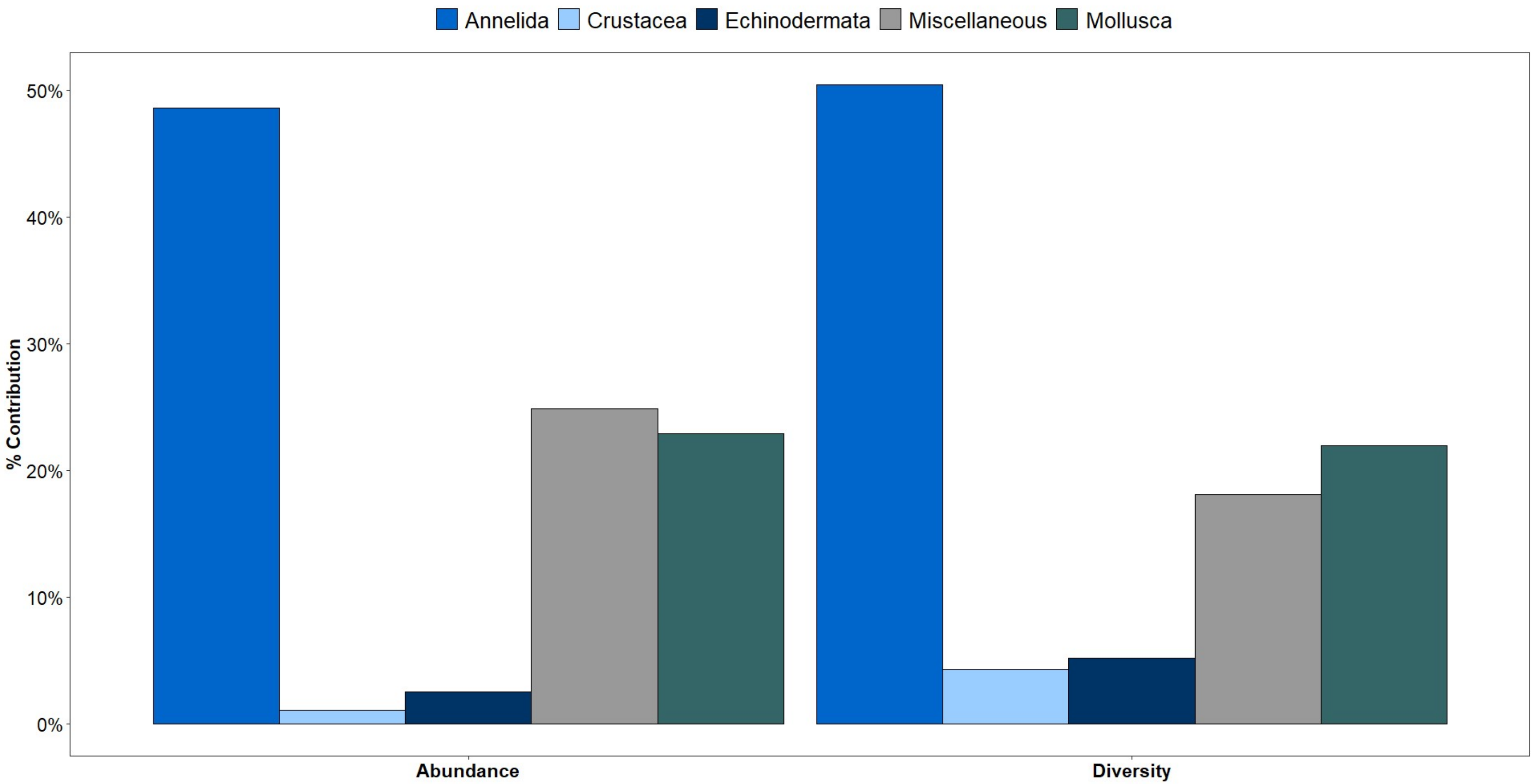


**Figure 49** Relative contribution of the major taxonomic groups to the total abundance and diversity of the macrobenthos sampled across the Project Area.

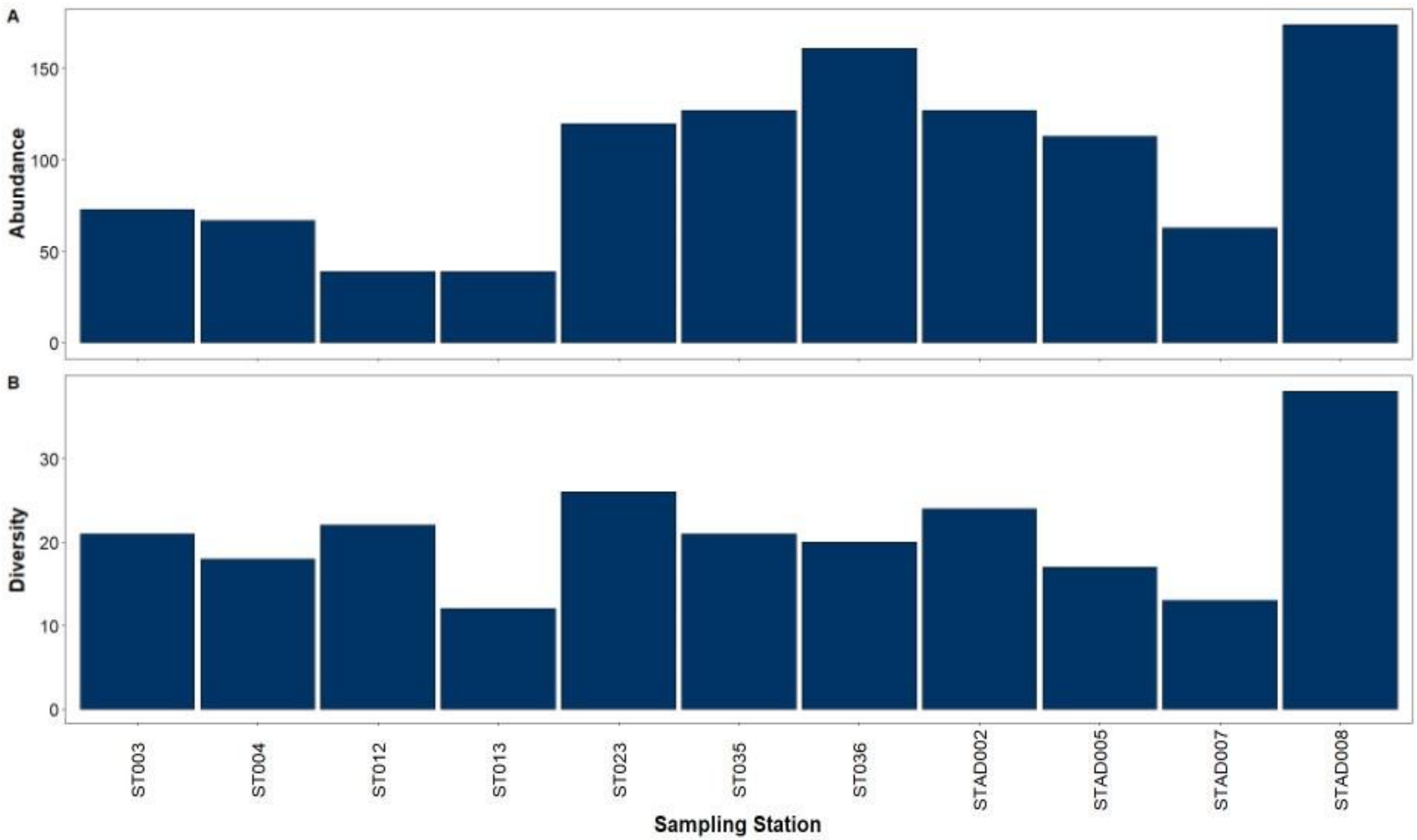


**Figure 50** Abundance and diversity per station across the Project Area.

### 8.6.2. Notable Taxa

Across the Project Area, two taxa of interest were identified. The INNS of polychaete *Goniadella gracilis* was observed once at station STAD002 and once at STAD007. One juvenile belonging to the economically important family of clams Veneridae was recorded at STAD008. No species of conservation interest were found in the grab samples.

### 8.6.3. Macrobenthic Groupings

Multivariate analysis was undertaken on the macrobenthic grab abundance data, which was first square root transformed to identify spatial distribution patterns in the macrobenthic assemblages across the Project Area and identify characterising taxa present.

Cluster analysis of the macrobenthic data was performed on a Bray-Curtis similarity matrix to analyse the spatial similarities in macrobenthic communities recorded across all samples across the Project Area. The dendrogram resulting from the cluster analysis and associated Type 1 SIMPROF (similarity profile routine) permutation test of all nodes within the dendrogram, identified just one statistically significantly similar group ($p > 0.05$). The dendrogram resulting from the cluster analysis and associated Type 1 SIMPROF permutation test is provided in Appendix XII.

To visualise the relationships between the sampled macrobenthic assemblages, a nMDS ordination plot was generated on abundance data. The nMDS represents the relationships between the communities sampled based on the distance between sample points (station). The stress value of the nMDS ordination plot (0.1) indicates that the two-dimensional plot provides a reasonable representation of the similarity between stations.

SIMPER analysis was used to identify the key taxa contributing to the within group similarity of macrobenthic group A; the full SIMPER results are provided in Appendix XIII.

**Macrobenthic Group A** (all 11 samples) - Characterising taxa present in samples were Nemetoda, *P. remota*, the polychaete family Polygordius, the bivalve *G. triangularis* and the polychaete *Syllis pontxioi*. Average similarity of this group was 45.29 %.

### 8.6.4. Biotope Assignment

For Macrobenthic Group A determined using cluster analysis, an attempt was made to assign a biotope or habitat in line with JNCC guidance based upon their faunal and physical characteristics (Parry 2019). However, due to the lack of key taxa present in the assemblage it was not possible to assign the stations falling into macrobenthic group A to any of the known EUNIS biotopes. Based on seabed imagery and sediment PSD analysis as well as MBES data which described depths as > 70 m, this group were assigned as the EUNIS Level 4 habitats A5.27 ‘Deep circalittoral sand’ and A5.15 ‘Deep circalittoral coarse sediment’.

## 8.7. Habitat Mapping

Habitats and biotopes were mapped based on the interpretation of the seabed imagery (DDC, ROV and UAV), PSD and macrobenthic data from grab samples, and acoustic data (MBES and SSS). The habitats and biotopes identified across the Project Area are shown in Table 21 and mapped in Figure 51.

Imagery obtained by ROV during the PMF Survey was analysed and a PMF assessment was conducted on all images. The results of this assessment were used alongside the UAV and acoustic data to delineate boundaries and map the extent of the PMF habitat 'Kelp beds' within the nearshore region of the OCAS (Table 22 and Figure 52).

A full Annex I reef assessment was carried out on imagery obtained by DDC and ROV during the environmental characterisation survey and PMF Survey and utilised alongside acoustic and UAV data to map reef features across the Project Area (Table 23). The Annex I reef map is provided in Figure 53.

### 8.7.1. Biotope Mapping

**Array**

Seabed imagery acquired from within the array area corroborated the geophysical data interpretation of stony seabed features which were mapped with high confidence as A4.21 'Echinoderms and crustose communities on circalittoral rock' scattered with smaller areas characterised as biotope A4.214 'Faunal and algal crusts on exposed to moderately wave-exposed circalittoral rock'. This same biotope was also mapped with high confidence over a larger area of low stony reef and bedrock reef in the north / east region of the array.

The central aspect of the array area was predominantly characterised by habitat complex A4.21 interspersed with discrete areas of habitats A5.14 'Circalittoral coarse sediments' towards the northeast and A5.26 'Circalittoral muddy sand' towards the southwest.

Habitats within the southern and southeastern regions of the array area were more varied. These deeper areas, ground-truthed by stations ST003, ST004, STAD012, and transect T004, were predominantly characterised by circalittoral coarse sediment and circalittoral muddy sand. A patch of bedrock and high stony reef was identified in the southeast region of the array area, as indicated by DDC imagery from transect T005, which featured EUNIS biotope components A5.25, A4.2146 '*Caryophyllia smithii* with faunal and algal crusts on moderately wave-exposed circalittoral rock', and A4.21 'Echinoderms and crustose communities on circalittoral rock', A4.212 '*Caryophyllia smithii*, sponges and crustose communities on wave-exposed circalittoral rock'. However, the latter was not mapped as full biotope due to its limited extent and unclear boundaries in the acoustic data.

Generally, seabed imagery in the array area aligned well with the acoustic data, with changes in seabed bathymetry and SSS reflectivity generally corresponding with changes in the habitats and biotopes identified.

**OCAS**

Seabed imagery analysis (DDC, ROV and UAV combined) described the majority of areas sampled within the OCAS as A4.21. The rocky habitats observed within the northernmost corner of the OCAS were classified as circalittoral rock biotope A4.214. The shallow area of seabed to the northeast of the OCAS featured hard substrates supporting kelp and seaweed wherein the EUNIS habitats identified were A3.21 'Kelp and red seaweeds (moderate energy infralittoral rock)' and A3.11 'Kelp with cushion fauna and/or foliose red seaweeds' with the former representing the PMF habitat 'Kelp beds'.

As was the case within the array area, biotopes identified within the OCAS area became more varied towards the southernmost region. This area was interpreted primarily as medium stony reef habitat A4.21, but with extensive areas of A5.14 'Circalittoral coarse sediment' occurring throughout. DDC imagery acquired at transect T011 confirmed that the deeper region within the southeastern corner of the Project area at the boundary between array and OCAS areas corresponds to A5.26 'Circalittoral muddy sand'.

Overall, the habitat mapping within the OCAS area aligned well with the habitats inferred from the acoustic data (Figure 10 and Figure 11), with changes in seabed depth and SSS reflectivity generally corresponding with changes in biotope and sediment type identified via seabed imagery.

**Table 21** Area of the different habitats/biotopes mapped across the Project Area.

| EUNIS Classification | EUNIS Description | Area ($km^2$) | Area (% of Project Area) |
|---|---|---|---|
| A3.11 | Kelp with cushion fauna and/or foliose red seaweeds | 18.6 | 6.4 |
| A3.21 | Kelp and red seaweeds (moderate energy infralittoral rock) | 9.7 | 3.3 |
| A4.21 | Echinoderms and crustose communities on circalittoral rock | 238.6 | 82.3 |
| A4.214 | Faunal and algal crusts on exposed to moderately wave-exposed circalittoral rock | 5.0 | 2.4 |
| A4.2146 | *Caryophyllia smithii* with faunal and algal crusts on moderately wave-exposed circalittoral rock | 0.0 | 0 |
| A5.14 | Circalittoral coarse sediment | 8.1 | 2.8 |
| A5.25 | Circalittoral fine sand | 0.0 | 0 |
| A5.26 | Circalittoral muddy sand | 4.4 | 1.5 |

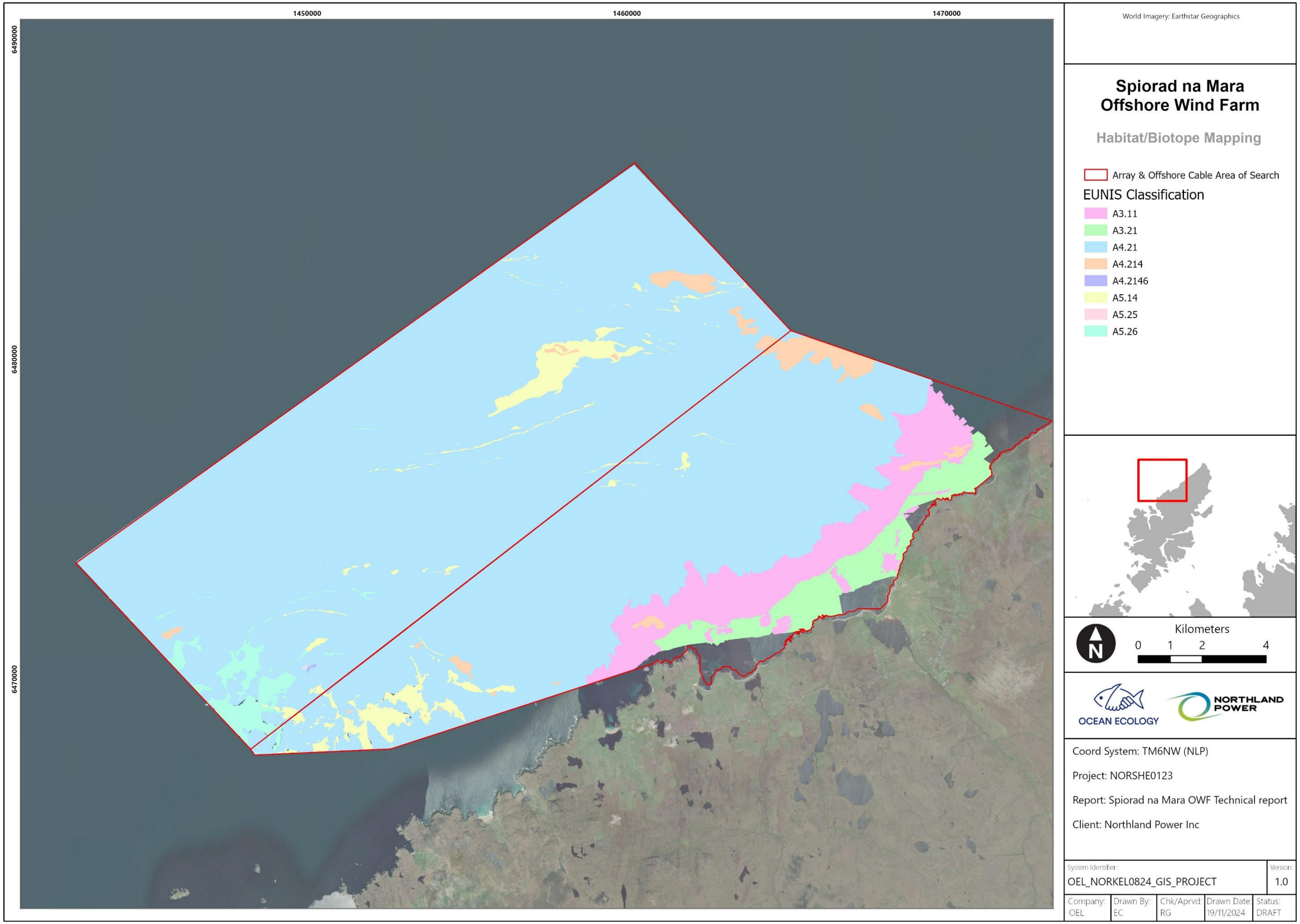


**Figure 51** EUNIS habitat / biotope mapping across the Project Area. Approx 95 % of the survey area was classified as hard substrate, and approx. 5 % was classified as sediments.

### 8.7.2. PMF Mapping

The shallow (< 20 m) eastern area of the OCAS features a large expanse of bedrock and stony reef supporting kelp wherein the dominant EUNIS biotope identified in both DDC and ROV imagery was A3.214 '*Laminaria hyperborea* and foliose red seaweeds on moderately exposed infralittoral rock'. This area represents the PMF habitat 'Kelp beds'.

Seabed imagery depicting the 'Kelp beds' PMF is shown in Plate 15 and mapped in Figure 52. High confidence in the boundaries of the kelp bed was attributed to the easternmost section of this PMF habitat where ROV and UAV ground-truthing data was available while low confidence was assigned to the remaining section as ground-truthing data was sparser.

**Table 22** Area of the PMF habitats mapped across the Project Area.

| PMF Habitat | Area ($km^2$) | Area (% of Project Area) |
|---|---|---|
| Kelp Beds | 9.7 $km^2$ | 3.3 |

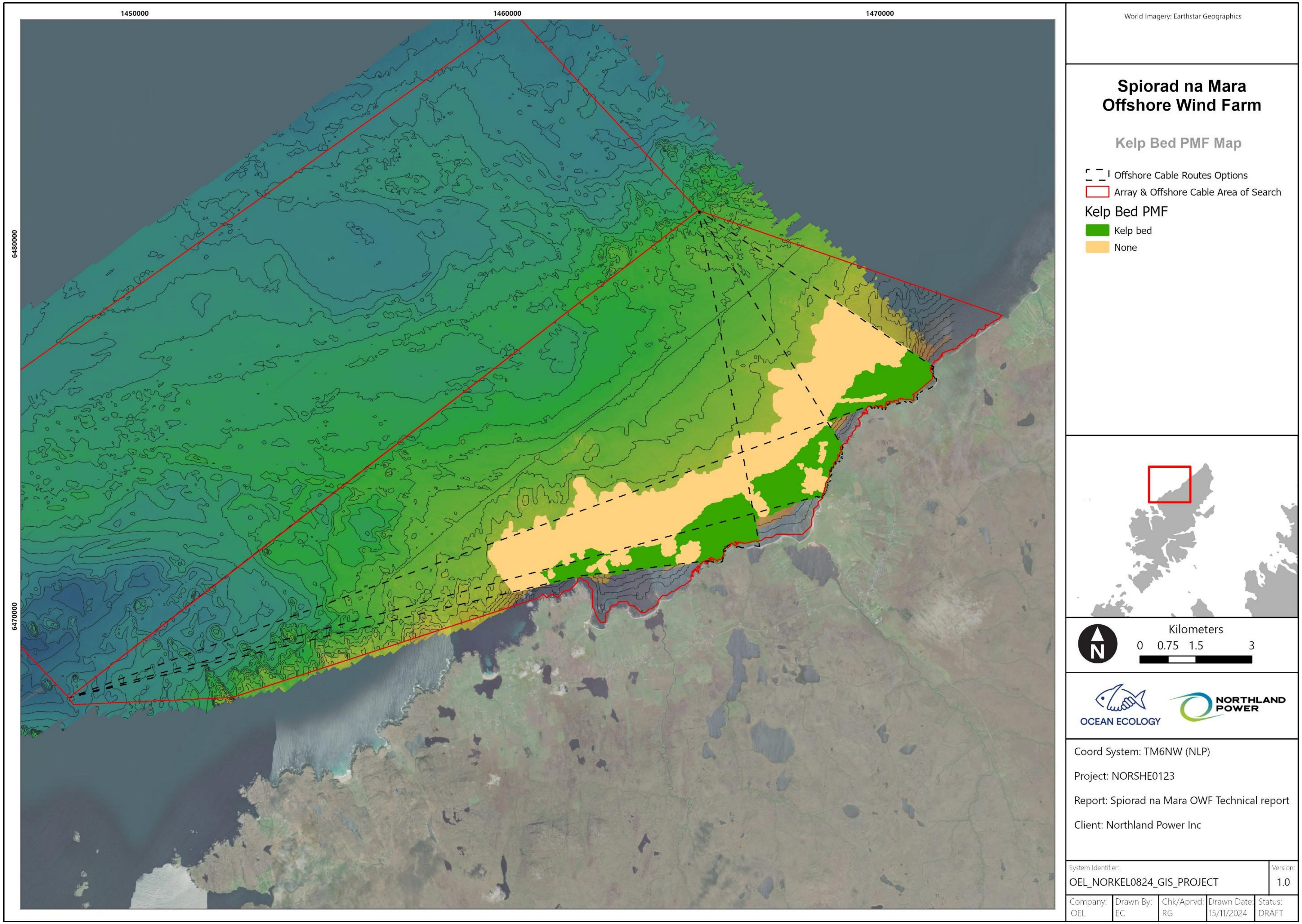


**Figure 52** PMF survey habitat mapping.

### 8.7.3. Annex I Reef Mapping

Annex I reef covered an approximate area of 265 $km^2$, accounting for ~ 95 % of the total survey area (Figure 53). Of this reef cover, 255 $km^2$ was mapped with high confidence, and 10 $km^2$ with low confidence.

The vast majority of the survey site was found to be comprised of medium stony reef, with areas of low stony reef and bedrock reef located towards the northeast site boundary, and an extensive area of bedrock reef situated within the northeastern most corner of the site. Annex I reef features are mapped in Figure 16, Figure 17 and Figure 18. Examples of DDC imagery featuring Annex I reef are shown in Plate 14.

**Array Area**

The majority of the array area was characterised predominantly by Annex I medium stony reef habitats, with patches of low stony and/or bedrock reef towards the northern boundary, and an extensive region of coarse sediment situated towards the centre of the array. Lower-elevation areas of coarse sediment and muddy sand were mapped towards the deeper southernmost boundaries and along the southeastern boundary with the OCAS.

While the stony substrate exhibits overall homogeneity, variations in texture and composition become noticeable. In deeper regions towards the north of the array area, patches of low stony substrate coexist with areas of rock and coarse sediment, and mosaic formations of cobbles with coarse sediment. In the western corner of the array area, extending towards greater depths, there are patches of medium stony reef, bedrock reef, and low stony substrate, forming mosaics of bedrock and medium stony reef interspersed with areas of low stony reef.

**OCAS**

Seabed imagery obtained via DDC allowed for the ground-truthing of a large area of bedrock reef within the northernmost corner of the OCAS. The central region, and majority of the OCAS area, was interpreted as medium stony reef, aligning with the broadly homogenous SSS reflectivity interpreted along the length of the OCAS. Similar to the array area, the deeper, southernmost region of the OCAS was predominantly interpreted as medium stony reef. However, within this region, there were interspersed low-elevation areas characterized by a mixture of soft and coarse sediments.

Areas where the PMF 'Kelp Beds' was found to be present during the PMF Survey were mapped as Geogenic Reef due to obstructions caused by dense algae and kelp making it impossible to delineate boundaries between reef type in this area.

**Table 23** Area of Annex I reef mapped across the Project Area.

| Annex I Reef | Area ($km^2$) | Area (% of Project Area) |
|---|---|---|
| Bedrock | 4.0 | 1.4 |
| High Stony | 0.3 | 0.1 |
| Geogenic | 9.7 | 3.3 |
| Low Stony | 1.3 | 0.4 |
| Medium Stony | 256.7 | 88.5 |
| Not a Reef | 12.4 | 4.3 |

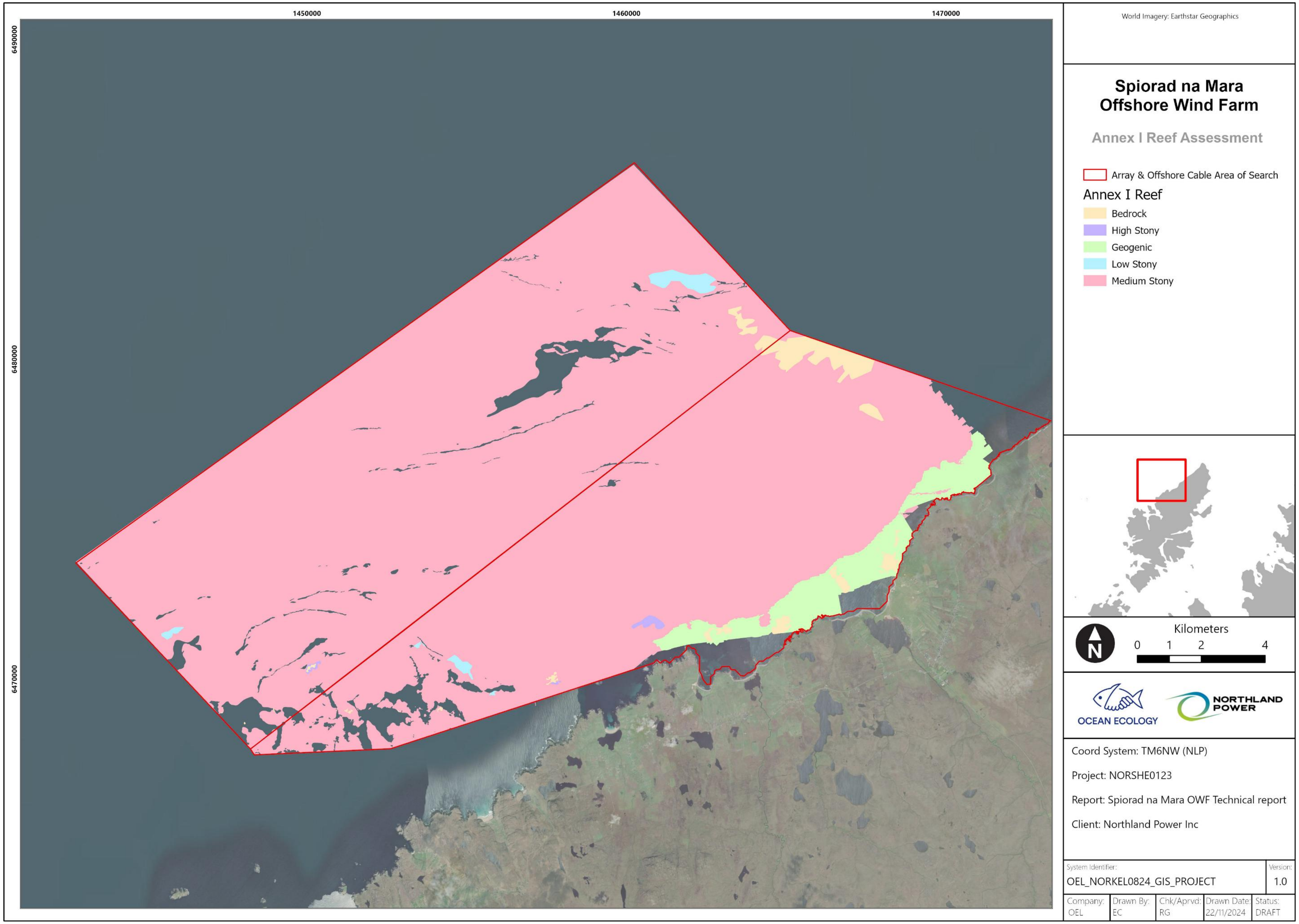


**Figure 53** Spatial distribution and extent of Annex I stony and bedrock reef and the kelp bed PMF across the Project Area.

## 8.8. Predictive Mapping of Reef Ecological Value

None of the individual variables showed correlation with taxonomic distinctness. The highest correlation coefficient (0.124) was with terrain rugosity index.

The mean ± SD (Standard Deviation) cross-validation $R^2$ index from the Random Forest model runs was 0.0302 ± 0.0455 indicating that very little of the variation in taxonomic distinctness is predicted by the predictor variables, and any relationship is inconsistent among model runs, suggesting that it is most likely by random chance. The model performance following dimension reduction using PCA was worse, with a mean ± SD $R^2$ of 0.0123 ± 0.011.

# 9. Discussion

This report presents the results and interpretation of the seabed imagery analysis obtained with both DDC and ROV, sediment PSD, chemistry analyses and macrobenthic analysis with the aim of characterising habitats and biological communities and their variability across the Project Area.

## 9.1. Seabed Imagery and Geophysical Data

An integrated interpretation of seabed imagery and acoustic data suggested a predominantly heterogenous high reflectivity seabed interpreted as hard seabed features. The seabed throughout the site was comprised predominantly of cobbles and mobile coarse sediments. A general, broad-scale trend was observed across the Project Area with stony features being predominant. The prevalent benthic habitat identified across the Project Area based on DDC imagery was A4.214 'Faunal and algal crusts on exposed to moderately wave-exposed circalittoral rock'.

Across the array, habitats and biotopes present in DDC imagery included circalittoral rock habitats such as A4.2145 'Faunal and algal crusts with *Pomatoceros triqueter* and sparse *Alcyonium digitatum* on exposed to moderately wave-exposed circalittoral rock' and circalittoral coarse sediments (A5.14) and sand (A5.26).

The OCAS displayed a varied succession of habitats and biotopes. An intertidal rocky habitat supporting kelp was recorded in DDC imagery to the northeast, mostly represented by biotope A3.214 '*Laminaria hyperborea* and foliose red seaweeds on moderately exposed infralittoral rock' which is a component biotope of the 'Kelp beds' PMF. ROV imagery collected during the PMF Survey indicated the presence of a complex seascape with diverse rock habitats and biotopes typical of the tide-swept environments often associated with the west coast of Scotland (Brig 2008). In shallower areas closer to the shore, this supported biotope complexes such as A3.116 'Foliose red seaweeds on exposed lower infralittoral rock' and A3.214 '*Laminaria hyperborea* and foliose red seaweeds on moderately exposed infralittoral rock', and in deeper areas such as along transect TROV1 to the south of the area surveyed during the PMF Survey and the westernmost section of transect TROV12, the biotope complex A4.214 'Faunal and algal crusts on exposed to moderately wave-exposed circalittoral rock'. Diverse kelp and mixed red seaweeds dominated these habitats.

Annex I stony and bedrock reef was present in at least one image collected from 41 of the 55 DDC stations and all 12 DDC transects (approximately 74 % of the images analysed during the environmental characterisation survey) during the environmental characterisation survey. Biotope A4.214 'Faunal and algal crusts on exposed to moderately wave-exposed circalittoral rock' dominated across both the array and the OCAS. Similarly, Annex I stony and bedrock reef was present in most of the ROV imagery collected along the shallow, nearshore section of the OCAS as part of the PMF survey. Biotope A3.214 '*Laminaria hyperborea* and foliose red seaweeds on moderately exposed infralittoral rock' dominated this area, however, characterising the substrate within this area was challenged by dense algal and kelp cover obscuring a view of the seabed. Therefore, an adapted seabed imagery analysis method was adopted resulting in some predicted habitats based on the biota visible. Predicted reef areas were identified despite no reef being visible in the ROV imagery due to kelp and algal cover obscuring the seabed. This was done with the support of acoustic data indicating the presence of hard substrate. The 'geogenic' reef label was assigned where a rock feature was identified or predicted but the exact nature (i.e., bedrock or stony reef) could not be determined. Annex I reef was present, or predicted to be present, in 97 % of images, with all 15 ROV transects surveyed containing reef. The majority of the reef observed across the nearshore OCAS was bedrock which dominated the central and northern regions from transect TROV6 – TROV15. Small areas of low stony and medium stony reef interspersed the bedrock and were the dominant reef type at transects TROV4 and TROV5 located in the southern central region of the nearshore OCAS. Some geogenic reef that could not be qualified due to obstruction by dense kelp was also observed at transects TROV6 and TROV9.

A comprehensive imagery analysis assessment based on ROV imagery obtained during the PMF Survey found the PMF habitat 'Kelp beds' to be present in 68 % of all images. Of those ROV images containing evidence of kelp beds, 97 % were found to be representative of either A3.214 '*Laminaria hyperborea* and foliose red seaweeds on moderately exposed infralittoral rock' or A3.2142 '*Laminaria hyperborea* park and foliose red seaweeds on moderately exposed lower infralittoral rock'. Kelp beds were identified along all but ROV transects TROV1 and TROV2 located in the far southwestern corner of the PMF Survey area. In the case of TROV1, water depth which ranged from 19.8 – 22.5 m might have been too deep to support kelp which is typically found at a maximum depth of 20 – 30 m (Tyler-Walters et al. 2016).

Seabed imagery analysis described the habitats and epibenthic communities found along transect TROV2 as typical of high energy, exposed environments. This may be the reason why kelp beds were not present along this ROV transect. Whilst kelp beds are known to occur across a wide range of wave exposure conditions, a general trend was observed during the PMF Survey, with just 13 of the 145 images described by the BSH A3.1 'High Energy Infralittoral Rock' containing kelp. Kelp beds were found to be almost continuously present along the entire length of the nearshore region of OCAS. In the northern and central regions of the nearshore OCAS, kelp was mapped with high confidence during the PMF Survey due to the large number of images obtained in this area showing kelp to be present. This was further corroborated by the UAV imagery. In the southern nearshore region of this area, lower confidence scores were given due to fewer ground-truthing data points. Kelp was mapped as not present at water depths deeper than 20 m based on the known distribution of kelp and ROV imagery. This combined with the interpretation of the acoustic data identified some potential gaps in the extent of kelp. The most prominent of these was located in the northern central region of the nearshore OCAS, within the area of search of cable route option 2B. This possible gap measured approximately 300 m across at its narrowest point. Habitat mapping based on the findings of the 2023 environmental characterisation survey suggest that this area likely comprises of rocky habitats.

The ‘Kelp beds’ PMF mapped during the PMF Survey built on the existing mapping derived from the GeMS database as shown in Figure 1 wherein kelp bed habitats were indicated within the northeast corner and along the southeast boundary of the OCAS area. In deeper waters, the OCAS was characterised by rocky habitats of moderate energy such as A4.21 ‘Echinoderms and crustose communities on circalittoral rock’ and A4.215 ‘*Alcyonium digitatum* and faunal crust communities on vertical circalittoral bedrock’ interspersed with circalittoral coarse (A5.14), sand (A5.26) and mixed (A5.44) sediments.

In Scotland, kelp biotopes are estimated to cover 8,000 $km^2$ (Stamp et al. 2023). The component biotope A3.214 ‘*Laminaria hyperborea* and foliose red seaweeds on moderately exposed infralittoral rock’ has been widely recorded around all coasts of the Scottish mainland and islands, but particularly off the west coast, around the Hebrides and Northern Isles (Tyler-Walters et al. 2016). Kelp beds occur in shallow waters (to a maximum of 20-30 m), on bedrock and boulders in a range of wave exposure regimes and tidal conditions. Kelp such as *L. hyperborea* provide a canopy under which a wide range of animals and other seaweeds thrive. A rich diversity of red seaweeds may grow among the kelp and on the kelp stipes, and sea mats and sea firs may colonise the fronds, depending on conditions. The rocks below the kelp are often encrusted with coralline algae or support cushion forming fauna, such as sea anemones, sponges and sea squirts. Small crustaceans and worms live among the kelp holdfasts, while sea urchins and sea snails graze on the seaweeds, and fish find shelter from predators among the fronds (Tyler-Walters et al. 2016, Stamp et al. 2023). In UK coastal waters, kelp biotopes, of which *L. hyperborea* is dominant within subtidal rocky reefs, account for approximately 45% of primary productivity, and also support magnified secondary productivity (Smale et al. 2013).

NatureScot and JNCC have collated data from various sources forming the GeMS which among other habitats and features of conservation interest include national records of Annex I reef used as the core evidence to support the Scottish MPA network. These records show that Annex I reef is common and widespread around Scotland, especially on the West coast of Scotland. From a regional perspective, records of Annex I bedrock and stony reef on the northwest coast of Lewis were assigned to BSHs A3.2 for the intertidal zone and A4.2 for the circalittoral zone. Similarly, EMODnet broad scale predictive habitat map (EUSeaMap) for the region indicated the presence of rock substrates in the nearshore as presented in Figure 1. Findings from this assessment showed that most of the Project Area was characterised as BSH A4.2 with an area of BSH A3.2 within the boundaries of the OCAS in the nearshore, meaning that the extent of rock substrates is larger than what was predicted in the EMODnet habitat mapping and recorded so far in the GeMS. A complex reef system was observed across the Project Area, mostly made of medium stony reef of good EV. This constitutes new and improved evidence of the distribution of rocky reef around Scotland which qualify as Annex I reef but are not afforded protection as they do not occur within the boundaries of an MPA/SAC designated for the protection of this feature. Predictive modelling of reef EV was attempted to assess the EV of the reef across the Project Area, however, model performance was very low and had high variability, indicating that predictions of taxonomic distinctness are inconsistent and most likely due to chance. Therefore, in this context the physical environmental properties that can be derived from acoustic and hydrodynamic data cannot be used to predict taxonomic distinctness, and therefore EV.

The soft sediments encountered across the Project Area represent the PMF habitat 'Offshore Subtidal Sands and Gravels'. This is one of the most common habitat types found around the British Isles, often home to diverse infaunal communities dominated by polychaetes and small bivalves (Tyler-Walters et al. 2016).

## 9.2. BRUV

A diverse range of mobile epifauna and demersal fish communities were identified in the BRUV footage collected from across the Project Area with 21 different species recorded. Bony and cartilaginous fish, Crustacea, Echinoderms, Molluscs and marine mammals were all observed in footage. For the purpose of analysis, total abundance per station was calculated as the sum of *MaxN* for all taxa whilst diversity included just those taxa recorded to species level to avoid overestimating diversity in instances where taxa were recorded to phylum or family level, as well as to species level within those taxonomic groups.

Station B007 had higher total abundance than all other stations with 106 individuals compared to the next highest, B009 where 47 individuals were observed. This station also exhibited the lowest diversity with just two species recorded. High total abundance at this site were due to the high number (*MaxN* = 100) of the sand lance *Ammodytes* sp. The highest diversity was recorded at station B010 with 7 different species recorded. Whilst this was only slightly higher than the diversity of other stations, this footage was recorded from within the area interpreted through analysis of seabed imagery as A3.214 '*Laminaria hyperborea* and foliose red seaweeds on moderately exposed infralittoral rock' and also qualified as the PMF habitat 'Kelp beds'. Kelp beds provide a canopy under which a wide range of animals and other seaweeds can thrive and could therefore be the reason for higher species diversity in this BRUV frame (Tyler-Walters et al. 2016).

Many the species identified in BRUV footage were of economic and or conservation importance (Table 19). A number of species identified are listed as Priority Species under the UK List of Priority Habitats and Species, the IUCN Red List of Threatened Species (2010) and the OSPAR List of Threatened and/or Declining Species and Habitats (2008). These species have been recognised on a UK., European and International level as species requiring increased conservation effort. Five of the species identified (sand lance, Atlantic cod, ling, spiny dogfish and grey seal) are designated as Scottish PMFs. While many of these are protected through the existing network of MPAs, others occur outside of these areas. Marine Scotland is considering the implementation of management measures to further protect these features in places where they have been recorded outside of existing protected areas (Gov.scot). These species of conservation interest were relatively evenly distributed across the array and OCAS, likely due to the mobile nature of the taxa observed.

The grey seal (*Halichoerus grypus*) was recorded twice in BRUV footage, once at both stations B005 and B008 within the southwest of the Project Area. This species is protected under Annex V of the EU habitats directive which has been transposed to UK law and is now protected under Schedule IV of The Conservation of Habitats and Species Regulations as 'Animals which may not be captured or killed in certain ways', the means of which are listed here. The grey seal is also listed under Appendix II of the Conservation of Migratory Species. This United Nations (UN) legislation aims to 'facilitate close cooperation on the conservation of migratory species between the countries through which these animals travel on their annual journeys'. 'Appendix II contains species with an unfavourable conservation status that would significantly benefit from the international co-operation that could be achieved through international agreements for their conservation and management' (UN.org). Within the UK, species listed under Appendix I of this act are protected through the Wildlife & Countryside Act (1981 as amended); however, there is currently no formal legislation in place for the protection of species listed under Annex II.

No INNS species were identified during analysis of BRUV footage.

### 9.3. Sediment PSD

Due to the presence of cobbles and boulders, as identified during DDC pre-screening of the Project Area, it was not possible to collect sediment samples at several of the proposed stations in the original scope of the environmental characterisation sampling plan. Subsequently, grab sampling was attempted at 13 sampling stations, of which 11 were successfully sampled for PSD and macrobenthic analyses.

Sediments across the samples collected within the Project Area were relatively homogenous with high sand content across all but station STAD002. Gravel content at station STAD002 was higher than all other stations, with the second highest gravel content of 19.1 % recorded at STAD008. This station was located slightly further towards the centre of the array area than the other grab stations located in this region and may represent an area of transition between soft and hard substrate. The soft sediments encountered during grab sampling across the Project Area may represent the PMF habitat 'Offshore Subtidal Sands and Gravels'. This is one of the most common habitat types found around the British Isles, often home to diverse infaunal communities dominated by polychaetes and small bivalves (Tyler-Walters et al. 2016).

## 9.4. Sediment Chemistry

As mentioned above in Section 9.1, it was not possible to collect grab samples covering the full spatial extent of the Project Area and only 7 stations were successfully sampled for sediment chemistry analysis. However hard substrates are less prone to contamination as they do not absorb contaminants as readily as soft sediments do.

Several guidelines exist to assess the degree of contamination and likely ecological impacts of contaminants in marine sediments. These regulations defined the levels below which effects are of no concern and/or rarely occur (AL1, BAC, TEL) and the levels above which adverse biological effects are considerable and/or occur frequently (AL2, ERL, PEL). *Ad hoc* decisions need to be made when contaminant concentrations fall between these levels. To note that CEFAS ALs1 are typically the most conservative measures to assess sediment contamination and often result in "false positives", meaning that non-toxic sediment samples fail to pass this screening test. Conversely, ALs2 tend to be rather permissive, allowing samples with relatively high contaminant concentrations to fall between AL1 and AL2 and thus requiring expert judgment to further assess their potential toxicity (MMO 2015, Mason et al. 2020). Recent studies have been revising these ALs with the goal of reducing the range of concentrations falling between AL1 and AL2 and minimise the number of samples requiring an *ad hoc* treatment; however, no policy has been made yet based on these recommendations and suggestions (MMO 2015, Mason et al. 2020). TEL and ERL values have been used for reference where possible throughout this assessment as these are the only guideline values that provide a measure of environmental toxicity compared to OSPAR BAC and CEFAS ALs that instead provide information on the degree of contamination in the sediments.

Among all metals measured within the Project Area, Ni was the only metal with concentrations above reference levels at stations ST023 and STAD008. At both stations, concentrations exceeded CEFAS AL1 whilst STAD008 also exceeded OSPAR BAC concentrations. However, Cefas AL2 was not exceeded at any of the stations. No obvious pattern emerged when comparing stations with elevated Ni concentrations with mud content, TOC or PAH concentrations. Both stations were located in the southwestern region of the Project Area, however, none of the surrounding stations experienced elevated concentrations. The Ni concentrations recorded at station STAD008 was higher than that observed at other stations (58.2 mg $kg^{-1}$ compared to 28.5 mg $kg^{-1}$ at ST023). Ni concentrations for the northeast of Lewis are known to vary between 11.2 mg $kg^{-1}$ and 39.0 mg $kg^{-1}$ with occasional peaks of 60.9 mg $kg^{-1}$ (EMODnet validated dataset). Ni along with other heavy metal contaminants are often associated with waste produced by industrial activity (Wuana & Okieimen 2011); however, given the nature of the surrounding land use along with the fact that low concentrations were recorded at the surrounding stations, the cause of this unusually high concentration is not obvious.

Elevated metal sediment concentrations do not necessarily imply toxicity to benthic communities (Rees et al. 2007) as the bioavailability of these metals is more important than simply concentration levels. Despite the elevated Ni concentrations recorded at these two stations, across the Project Area as a whole, no macrobenthic anomalies were identified to suggest any adverse effects were present. No stations had metals concentrations above AL2 concentrations, overall meaning that adverse biological effects are unlikely.

THC in sediment samples collected across the Project Area was < LOD at all but two where it ranged between 2.96 mg $kg^{-1}$ and 1.01 mg $kg^{-1}$. These values are below the background value of 6.89 mg $kg^{-1}$ for THC in the North Sea (UKOOA 2001).

All PAHs measured were < LOD at all stations across the Project Area, and therefore did not exceed thresholds in any instances. Ratios of hydrocarbons are typically used to assess the source origin of hydrocarbons and gain a better understanding of whether these contaminants are derived from anthropogenic activities or are of natural origin (Kafilzadeh et al. 2011). However, as hydrocarbons were < LOD at all stations this assessment could not be carried out, overall indicating that hydrocarbon concentrations across the Project Area are of no concern. All PCBs, OCPs and organotins were also measured < LOD at all stations.

## 9.5. Macrobenthos

Within the 11 macrobenthic samples collected from across the Project Area, a total of 957 individuals and 95 taxa recorded. Nematoda (roundworms) were the most abundant taxa closely followed the triangular Astarte, *G. triangularis* and the Polychaete, *P. remota*. Annelida taxa were significantly the highest contributors to overall abundance and diversity with 35 different annelids recorded to species level and 536 individuals counted. A high diversity and abundance of bivalves were also recorded in samples.

Abundance and diversity were evenly spread across the Project Area; however, station STAD008 recorded the highest for both metrics. This was largely driven by a high abundance and diversity of Annelida taxa (N = 109, S = 20). This station was one of the four described by sediment PSD analysis as BSH A5.1 'Coarse Sediment'; however, no pattern of increased abundance/diversity was seen among other stations categorised as this BSH.

Macrobenthic communities can be highly heterogenous as they are heavily influenced by ambient environmental conditions such as sediment composition (Cooper et al. 2011), hydrodynamic forces and physical disturbance (Hall 1994), depth (Ellingsen 2002), and salinity (Thorson 1966). This was reflected in the macrobenthic community observed across the Project Area, which was relatively homogenous as grab samples were only collected in localised sections of the Project Area where soft sediments were present (as shown in sediment PSD analysis). Multivariate analysis on macrobenthic data identified just one macrobenthic group characterised by the presence of Nematoda, *P. remota*, the polychaete family Polygordius, *G. triangularis* and the polychaete, *S. pontxioi*, none of which are biotope defining key taxa of any of the EUNIS classification as per JNCC (2018). This group was therefore assigned as the EUNIS Level 4 habitats A5.27 'Deep circalittoral sand' and A5.15 'Deep circalittoral coarse sediment' based on interpretation of MBES, seabed imagery and sediment PSD data. Sediment PSD analysis and MBES data, which described depths at these stations as > 70 m, were used as the primary information source in determining final EUNIS codes due to the challenges associated between differentiating between sands and mud during seabed imagery analysis.

Across the Project Area, one INNS was recorded in the macrobenthic samples: the polychaete *G. gracilis*. This species is a native of South Africa and the northeast coast of the USA with the first record in the U.K. from Liverpool Bay in the summer of 1970. It is believed to have entered the U.K. via anchoring trans-Atlantic ships (Walker 1972). The ecological impact of this species on the local environment is still not known (JNCC 1997). No rare species or species of conservation interest were found in the grab samples.

## 9.6. Habitat Mapping

Confidence scores were assigned to each polygon with 'high' scores assigned to polygons drawn based on both acoustic and ground-truthing data while 'low' scores were assigned to polygons drawn based only on acoustic data where no ground-truthing from seabed imagery and/or grab samples was available.

An integrated interpretation of seabed imagery, sediment and macrobenthic data and acoustic data suggested a predominantly heterogenous high reflectivity seabed interpreted as hard seabed features. The seabed throughout the site was comprised predominantly of a mosaic of cobbles and mobile coarse sediments. A general, broad-scale trend was observed across the survey area with stony features being predominant. The most prevalent benthic habitat identified across the Spiorad na Mara OWF array and OCAS areas was biotope A4.214 'Faunal and algal crusts on exposed to moderately wave-exposed circalittoral rock' however it was mapped as A4.21 'Echinoderms and crustose communities on circalittoral rock' due to the unclear boundaries in the acoustic data between A4.21 and A4.214 and based on expert judgement it was preferred to map with high confidence at a lower level of habitat resolution (EUNIS level 4) rather than attempting to map at a higher level of habitat resolution (EUNIS level 5) but with low confidence.

Annex I medium stony reef was present across over 95 % of the survey area. Regions of low stony reef and bedrock reef were mapped towards the north and northeast of the site, respectively. These areas were found to support biotopes such as A4.214 and A4.2146. An area of approximately 10 $km^2$ mapped as A3.21 'Kelp and red seaweeds (moderate energy infralittoral rock)' was identified in the nearshore area of the OCAS as the 'Kelp beds' PMF. Most of the imagery collected in this nearshore region of the OCAS were assigned to biotope A3.214 '*Laminaria hyperborea* and foliose red seaweeds on moderately exposed infralittoral rock' however it was mapped as A3.21 due to the unclear boundaries in the acoustic data between A3.21 and A3.214. Based on expert judgement it was preferred to map with high confidence at a lower level of habitat resolution (EUNIS level 4) rather than attempting to map at a higher level of habitat resolution (EUNIS level 5) but with low confidence.

As 95 % of the survey area was mapped as Annex I reef, further assessments of the reef EV were carried out to provide a better understanding of baseline conditions across the survey area. The reef EV predictive model was unable to accurately predict taxonomic distinctness (mean ± SD $R^2$ = 0.0302 ± 0.0455), and therefore reef EV, based on the physical characteristics of the Project Area and so it was not possible to produce a comprehensive map of reef EV. Heat maps were used to illustrate biodiversity hot spots where the reef was colonised by a rich (Figure 26) and complex community (Figure 27).

Areas of coarse sediments were identified within the central to northern regions of the array area and southernmost regions of the OCAS and were deemed representative of biotope complex A5.14 'Circalittoral coarse sediment'. Throughout the southernmost boundary of the array area, and overlapping slightly with the OCAS area, areas of biotope complex A5.26 – 'Circalittoral muddy sand' were identified.

The habitat mapping presented herein contrasts significantly with the EMODnet EUSeaMap predictive habitat mapping presented in Figure 1, whereby the majority of the array area was predicted to be EUNIS complex A5.14. Predictive habitat mapping heavily relies on high-degree interpolation of sparse ground-truthing data and can fail to represent highly variable substrates or patchy/mosaiced habitats as seen across the Spiorad na Mara OWF survey area. To note that the acoustic data and DDC imagery for the OCAS support the existing mapping, wherein Annex I reef was indicated throughout the entirety of the OCAS area except for the south westernmost corner. This demonstrates the importance of this type of assessment based on the integrated interpretation of geophysical data, seabed imagery and sediment, macrobenthic data as ground-truthing data to provide a more accurate understanding of environmental baseline conditions.

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