OCEAN ECOLOGY
Marine Surveys, Analysis & Consultancy

North Gravir Proposed Baseline Visual Seabed Survey

Technical Report

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Details

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Abbreviations

BIIGLE	Bio-Image Indexing and Graphical Labelling Environment
BFS	Bakkafrost Scotland
BSH	Broadscale Habitat
CAR	Controlled Activities Regulations
CES	Crown Estate Scotland
DDC	Drop Down Camera
dGPS	Differential Global Positioning System
EC	European Commission
EMODnet	European Marine Observation and Data Network
EUNIS	European Nature Information System
FOCI	Features of Conservation Importance
GPS	Global Positioning System
ISS	Initial Site Survey
JNCC	Joint Nature Conservation Committee
LOA	Lease Option Agreement
MPA	Marine Protected Area
NMBAQC	Northeast Atlantic Marine Biological Analytical Quality Control Scheme
OEL	Ocean Ecology Limited
PMF	Priority Marine Features
SAC	Special Area of Conservation
SBAS	Satellite-Based Augmentation System
SEPA	Scottish Environment Protection Agency
SSC	Scottish Salmon Company
UTC	Universal Time Coordinated
UTM	Universal Transverse Mercator

Executive Summary

Ocean Ecology Limited (OEL) were commissioned by Bakkafrost Scotland (BFS) (formerly Scottish Salmon Company (SSC)) to conduct an Initial Site Survey (ISS) of the proposed North Gravir salmon pen fish farm located off the Isle of Lewis, West Coast of Scotland.

Survey Strategy

A drop-down camera (DDC) survey was conducted on the 23rd - 27th February 2023. High-definition seabed imagery was collected along seven pre-determined transects using a DDC system as a means of confirming the seabed habitats present and assessing for the presence/absence of Priority Marine Features (PMFs). Transects were selected to enable optimum vessel and camera use while covering as many varied depths and potential habitats as possible.

EUNIS Habitats / Biotopes

Predicted European Nature Information System (EUNIS) classifications in the vicinity of the proposed site included 'A5.35 - Circalittoral sandy mud', 'A5.37 - Deep circalittoral mud' and 'A4.3 - Atlantic and Mediterranean low energy circalittoral rock'.

The most common EUNIS habitats identified during the survey were 'A5.361 – Sea pens and burrowing megafauna in circalittoral fine mud', 'A5.44 - Circalittoral mixed sediments', and 'A5.35 - Circalittoral sandy mud'. Smaller areas of rocky habitats 'A4.1 - Atlantic and Mediterranean high energy circalittoral rock' and 'A4.211 - *Caryophyllia smithii* and *Swiftia pallida* on circalittoral rock' were also identified in the north section of the proposed site.

Annex I Habitats

Data obtained from the European Marine Observation and Data Network (EMODnet) and the Joint Nature Conservation Committee (JNCC) suggest the presence of Annex I hard/rock substrates within the proposed site. Annex I reef habitat (biogenic/geogenic) is afforded protection under the European Commission (EC) Habitats Directive (92/44/EEC) when designated as a feature within a Special Area of Conservation (SAC).

Annex I reef was observed along two of the transects north of the pens, where still images reported the presence of bedrock, at times covered by a sediment veneer, as well as elements of stony reef.

No Annex I biogenic reef was observed.

Priority Marine Features

The PMF species basking shark (*Cetorhinus maximus*), harbour seal (*Halichoerus grypus*), harbour porpoise (*Phocoena phocoena*) and tall sea pen (*Funiculina quadrangularis*) were previously recorded in proximity to the proposed site. PMF habitats 'Northern sea fan and sponge communities' and 'Burrowed mud' have also been identified in proximity of the proposed site. However, no PMFs were previously attributed to the proposed site or within its immediate surroundings.

The PMF habitat `Burrowed mud` was identified in 466 images and subsequently mapped within the proposed mixing zone and across the majority of the survey area. This PMF is primarily found in deep water or sheltered conditions where there is very little water movement. The PMF species *F. quadrangularis*, which is a component species of the PMF 'Burrowed mud' was observed in 11 of the still images collected, located at the land end of T06 and within the southeast of the survey area. This species is typically restricted to western Scotland and to deep, undisturbed muddy sediments and is extremely sensitive to physical disturbance due to its brittle nature and inability to withdraw into sediment..

The PMF habitat 'Northern sea fans and sponge communities' was observed in three of the still images collected along transect T04A. This habitat is typically restricted to the West Coast of Scotland in UK waters and is threatened by organic enrichment, physical damage, and changes in local current flow.

1. Introduction

1.1. Scope

Bakkafrost Scotland (BFS) (formerly The Scottish Salmon Company (SSC)) operates numerous salmon farms in Scottish waters. Current operational sites have completed a Lease Option Agreement (LOA) from Crown Estate Scotland (CES) and have a Controlled Activities Regulations (CAR) discharge licence from the Scottish Environment Protection Agency (SEPA).

BFS have chosen a potential site (North Gravir) to build, install, and operate a new salmon farm off the Isle of Lewis. West coast of Scotland. As part of the SEPA pre-screening process, BFS is required to undertake an Initial Site Survey (ISS) of the proposed site. The main aims of the ISS were to:

- Identify any protected habitats or species within the proposed site.
- Provide an assessment of the existing environmental status of the seabed, including existing impacts.
- Address any potential risks identified in the wider area.
- Provide regular depth measurements along transects.
- Provide spot depths at proposed cage points as per SEPA guidance.

To inform the ISS, BFS contracted Ocean Ecology Limited (OEL) to undertake a baseline visual transect survey using a Drop-Down Camera (DDC) system at the proposed North Gravir fish farm site.

1.2. Site Information

1.2.1. Site Details

BFS currently hold leases for two marine pen fish farm sites east of the Isle of Lewis including Gravir Outer and Gravir West. The proposed North Gravir marine salmon pen fish farm (proposed site) is located off the eastern shore of the Isle of Lewis and will consist of 5 enclosures (Figure 1).

Figure 1 Proposed pen locations, tidal mixing zone for the North Gravir site.

1.2.2. Designations

The proposed site of the North Gravir marine salmon pen fish farm is situated in Fish Disease Management Area 5a. The proposed site is also within and in the vicinity of several designated Marine Protected Areas (MPAs) This includes two Nature Conservation MPAs (NCMPAs), one SAC, and one Special Protected Areas (SPA). All MPAs within the vicinity of the proposed site are described below and presented in Figure 2.

Inner Hebrides and the Minches SAC

The Inner Hebrides and the Minches (IHM) Special Area of Conservation (SAC) is a 13,800 km^2 area designated in 2016 to protect harbour porpoise (*P. phocoena*)..Annex II species are afforded protection under the EC Habitats Directive (92/44/EEC) It is the second largest MPA for *P. phocoena* in Europe, extending from Stornoway in the North to Crinan in the South. The proposed site is situated within the IHM SAC.

Shiant East Bank NCMPA

The Shiant East Bank (SEB) Nature Conservation MPA (NCMPA) is a 252 km^2 area designated in 2020 to support a biologically diverse and dynamic marine environment, primarily protecting northern sea fan and sponge communities, shelf banks and mounds, circalittoral sands and mixed sediment communities. The Shiant East Bank is a complex underwater landscape, situated in the middle of the Minch where strong tides form a mosaic of irregular banks and mounds comprised of sands and mixed sediments interspaced with rock outcrops. The SEB MPA is situated 11.22 km east of the proposed pen locations.

North-east Lewis NCMPA

The North-east Lewis (NeL) NCMPA is a 907 km^2 area designated in 2020 to protect risso`s dolphin (*Grampus griseus),* sandeels and geomorphological features. The area encompasses a former sandeel fishing ground that supports an important sandeel population (*Ammodytes* marinus / *Ammodytes tobianus*). Sandeels form a key component of the marine food web in Scottish waters, supporting a diverse array of marine species and seabirds. The NeL NCMPA is situated 4.37 km north of the proposed pen locations.

Shiant Isles SPA

The Shiant Islands (SI) Special Protected Area (SPA) is a 69 km^2 area designated in 1992 to protect a notable seabird assemblage including razorbill (*Alca torda*), puffin (*Fratercula arctica*), fulmer (*Fulmarus glacialis*), shag (*Phalacrocorax aristotelis*), kittiwake (*Rissa tridactyla*) and guillemot (*Uria aalge*). The SI SPA is situated 14.45 km south of the proposed pen locations.

North Gravir Baseline Visual Seabed Survey 2022

Conservation Areas

Key

- ☐ Pen Locations
- ☐ Proposed Mixing Zone

SPA
- Shiant Isles

NCMPA
- North-east Lewis
- Shiant East Bank

SAC
- Inner Hebrides and the Minches

RAMSAR
- Lewis Peatlands

World Imagery: Earthstar Geographics

Kilometers
0 0.75 1.5   3

OCEAN ECOLOGY   BAKKAFROST

Coord System: British National Grid

Project: BAKGRA1222

North Gravier Proposed Baseline Visual Seabed Survey Technical Report

Client: Bakkafrost Scotland

System Identifier:				Version:
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Company: OEL	Drawn By: LG	Chk/Aprvd: RG	Drawn Date: 10/05/2023	Status: DRAFT

Figure 2 Location of marine protected areas in the vicinity of the proposed North Gravir marine salmon pen fish farm.

2. Review of Existing Data

2.1. Survey Data

Whilst existing data is available for the general area, there is a paucity of historical data, relating specifically to the habitats and species present within the immediate vicinity of the proposed site. The following section including Figure 3, summarises the findings of all currently available data for the area.

2.2. Acoustic Data

Low resolution bathymetric data is available from EMODnet. It provides a general overview of the bathymetric profile of the area, indicating lower depths across the east of the proposed site and bathymetric highs associated with bedrock features to the west.

2.3. Subsea Infrastructure

No subsea infrastructure is recorded as present within the proposed site or the wider survey area.

2.4. GeMS PMF Species and Habitat Datasets

The Geodatabase of Marine features adjacent to Scotland (GeMS) is a collation of species and habitats where records are attributed to their qualification as protected features of protected areas within the Scottish MPA network. Where appropriate, typical record details include; status as a Scottish PMF or Annex II Species, scientific name, abundance details, date, date range, year, status, accuracy, determiner, and details of where records are sourced from and the intellectual property ownership. No PMF habitats or species were attributed to the proposed site

The PMF species *F. quadrangularis*, associated with burrowed mud habitat, has been recorded 1.47 km northeast of the proposed site. Three records of mobile PMF species, including one elasmobranch (*C. maximus*) one pinniped (*H. grypus*) and one cetacean (*P. phocoena*) were identified to the east of the proposed pen locations (Figure 3).

The PMF habitat 'Northern sea fan and sponge communities' has been recorded 6.65 km to the northwest and 6.91 km southwest of the proposed pen locations, associated with EUSeaMap predicted EUNIS habitat 'A4.3 - Atlantic and Mediterranean low energy circalittoral rock' and Potential Annex I reef..

2.5. EUNIS Habitats

European nature information system (EUNIS) broad-scale predictive habitat map displays predicted classifications in across the proposed site (Vasquez et al. 2021). These include soft sediment habitat 'A5.35 - Circalittoral sandy mud' directly at the proposed pen locations, with 'A4.3 - Atlantic and Mediterranean low energy circalittoral rock' and 'A3.3- Atlantic and

Mediterranean low energy infralittoral rock' to the west and 'A5.37 - Deep circalittoral mud' to the east (Figure 3).

2.6. Habitats Directive (Annex I Habitats)

Data obtained from EMODnet, JNCC and GeMS identified the presence of Annex I habitats in the vicinity of the proposed site.

2.6.1. Annex I Reefs (1170)

Annex I reef habitat is afforded protection under the EC Habitats Directive (92/44/EEC) when designated as a feature within a SAC. The Conservation of Marine Habitats and Species Regulations 2017 (as amended) was introduced to transpose the requirements of the Habitats Directive into UK law; following the UK's exit from the European Union, a number of changes have been made to the above regulations as per the Conservation of Habitats and Species (Amendment) (EU exit) Regulation 2019.

Geogenic reefs can be variable in terms of both their structure and the communities that they support. They provide a suitable substrate to many sessile species such as corals, sponges and sea squirts, and algal species, as well as providing shelter to fish, and crustaceans such as lobsters and crabs. These reefs can be classified as either bedrock or stony reefs depending on the nature of the substrate.

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 fauna and flora. Numerous sites have been designated in UK waters to protect stony reef habitats and associated communities. Such communities can be highly diverse, 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. To be regarded as Annex I stony reef under the EC Habitats directive, areas of cobble/boulder substrate must meet a number of qualifying criteria as defined by (Irving, 2009) (Table 1). This guidance also suggests that "When determining whether an area of the seabed should be considered as Annex I stony reef, if a 'low' is scored in any of the four characteristics (composition, elevation, extent, or biota), then a strong justification would be required for this area to be considered as contributing to the Marine Natura site network of qualifying reefs in terms of the EU Habitats Directive".

Table 1 Characteristics of Annex I stony reef (from (Irving, 2009)).

Characteristic	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 m²	> 25 m²		
Biota	Dominated by infaunal species	> 80 % of species present composed of epibiotal species		

Bedrock Reef

Similar to stony reef, Annex I bedrock reef habitat occurs where hard bedrock rises 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 of fish and crustaceans.

Historical evidence of Potential Annex I Reef of the subtype Bedrock and/or Stony was identified to the west of the proposed site, within the proposed mixing zone and corresponding with EUNIS habitat A4.3.

Biogenic Reef

Biogenic reefs are those that are created by the animals themselves. The EU Habitats Directive identifies three main groups of reef-forming animal in UK waters, polychaetes (e.g *Sabellaria spinulosa, Serpula vermicularis*), bivalves (e.g. *Modiolus modiolus*, *Mytilus* sp.) and cold-water corals (*Desmophyllum pertusa*). No historical evidence of polychaete or cold-water coral reefs was identified within the vicinity of the proposed site however blue mussel (*M. edulis*) reef has been previously recorded 6.59 km southwest of the site. M. edulis reef has not been previously recorded within the proposed site, however, has been recorded 6.59 km southwest.

The blue mussel (*Mytilus edulis*) is a suspension feeding bivalve found as individuals and as dense beds forming biogenic reefs (Holt et al. 1998). *M. edulis* beds occur from the shoreline to the sub-littoral (Connor et al. 2004). The beds enhance local biodiversity by providing an additional substrate for colonisation by a wide array of infaunal and epifaunal species such as barnacles, limpets, polychaetes, and other bivalves as well as stabilising and modifying sedimentary substrates, whilst 'mussel mud' supports a diverse range of infauna. They are the preferred prey

item of many species including starfish, crabs, demersal fish, dog whelks and birds. *M. edulis* beds are afforded protection as a Section 41 priority habitats and Annex I reef features under the Habitats Directive as well as being included on the OSPAR Annex V list of threatened and declining species and habitats.

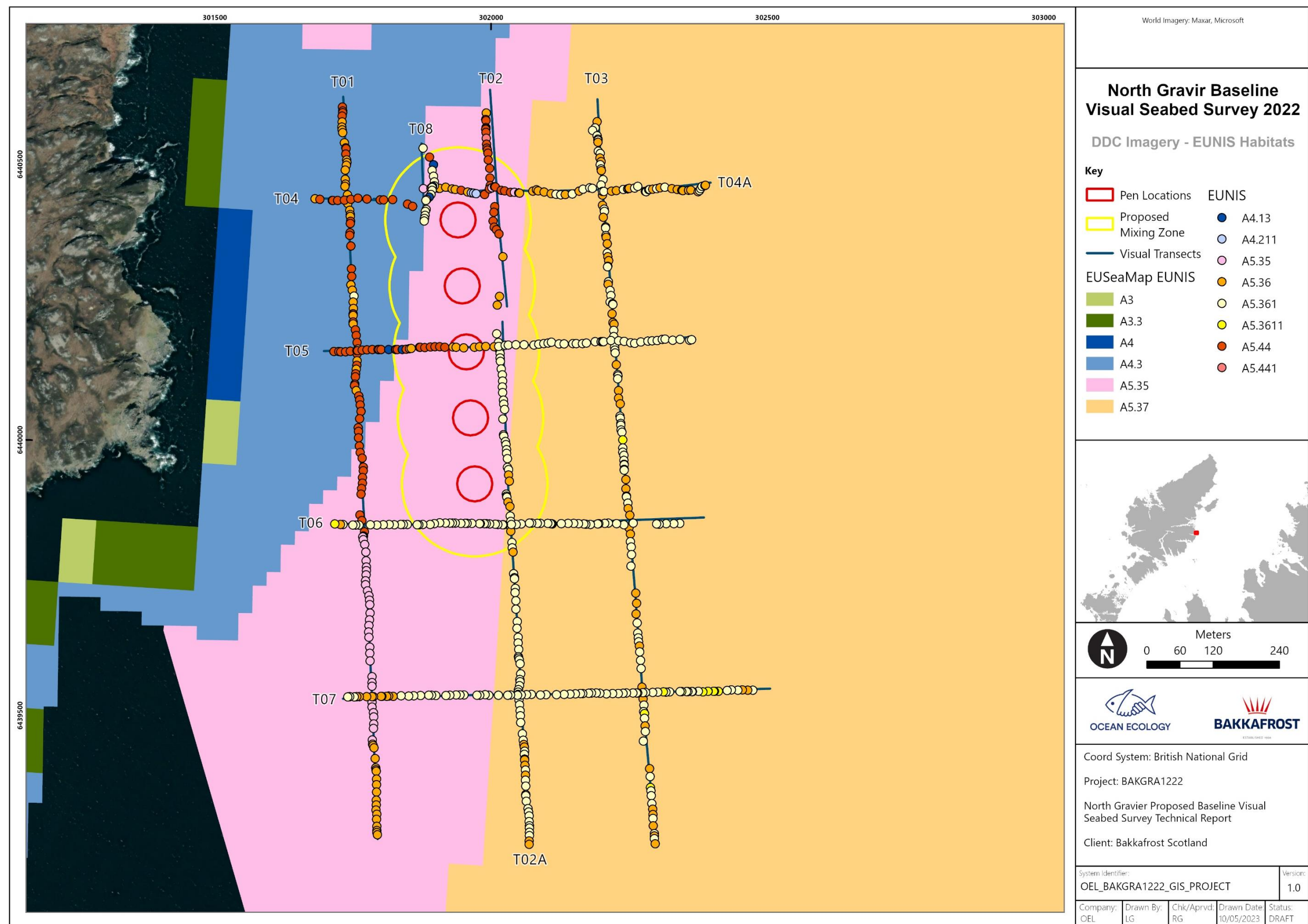### 2.6.2. Mudflats and sandflats not covered by seawater at low tide

Intertidal mudflats and sandflats are submerged at high tide and exposed at low tide. The physical structure of the intertidal flats ranges from mobile, coarse-sand beaches on wave-exposed coasts to stable, fine-sediment mudflats in estuaries and other marine inlets. The flora and fauna communities present vary according to the type of sediment, its stability and the salinity of the water. They usually have no vascular plants but may have rich communities of blue algae, diatoms, eelgrass and invertebrates. Point data observations of Annex I habitats obtained from the GeMS database indicated historical evidence of mudflats and sandflats habitat, 4.22 km north of the proposed pen sites, corresponding with EUNIS habitat A2.24.

2.6.3. Large shallow inlets and bays

Large shallow inlets and bays are large indentations of the coast, predominantly under the influence of salt water but generally more sheltered from wave action than the open coast. They are relatively shallow; with water less than 30m over most of the area. They are effectively habitat complexes that comprise an interdependent mosaic of subtidal and intertidal habitats, many of which are also Annex I habitats (e.g. reefs, sandbanks and mudflats). Consequently, they contain a great diversity of sediments (from mud to sands to rock) and substrates with highly diverse animal and plant communities. Historical evidence of potential Annex I large shallow inlets and bays habitat was identified 3.55 km north of the proposed pen sites utilising point data observations of Annex I habitats obtained from the GeMS database.

2.6.4. Coastal lagoons

Coastal lagoon are areas of shallow, coastal salt water that are wholly or partially separated from the sea by sandbanks, shingle or rocks. The water in lagoons can vary in salinity and water levels can also vary considerably. Flora and fauna communities of lagoons vary according to the physical characteristics and salinity regime of a particular lagoon. Costal lagoons are a relatively uncommon habitat in the UK and have a very restricted distribution. Historical evidence of Annex I coastal lagoons habitat was identified 5.09 km north of the proposed pen sites utilising point data observations of Annex I habitats obtained from the GeMS database..

Figure 3 Existing EUNIS habitats and PMF species across the proposed North Gravir site (EUSeaMap 2021) (Vasquez et al. 2021).

3. Survey Design

3.1. Sampling Array

The survey was conducted on the 23rd-27th February 2023. The sampling array was designed to provide optimum coverage for assessing the presence/absence of PMFs and Annex I habitats within the immediate vicinity of the proposed site. Seven transects were preselected to allow for optimum vessel and camera use while covering as many varied depths and potential habitats as possible (Figure 1 and Table 2).

Three transects (T01-T03) were positioned in a north to south orientation, each 1,330 m in length, and three cross transects were positioned in a west to east orientation, two (T05 and T06) 700 m in length and one (T07) 750 m in length (Table 2 and Figure 1).

Stills imagery was collected at regular intervals (approx. every 15 m) along each transect in order to conduct thorough ground-truthing of the proposed site (Figure 1).

Table 2 Proposed locations for the DDC transects (British National Grid OSGB 1936)

North Gravir Visual Seabed Survey						
Transect	**Transect Start**		**Transect Finish**		**Distance**	**Bearing**
	X	**Y**	**X**	**Y**	**(m)**	**(°)**
1	142814	916457	142873	915131	1330	177
2	143070	916460	143152	915130	1330	177
3	143269	916457	143378	915124	1330	177
4	142760	916278	143459	916299	700	84
5	142785	916000	143432	916020	700	84
6	142815	915688	143451	915685	700	84
7	142828	915375	143580	915382	750	84

4. Methods

4.1.   Survey Methods

The survey was undertaken on the 23rd-27th February 2023 aboard the *Eilean Fraoich* (Plate 1). *Eilean Fraoich* is a fish farm service vessel which was specifically laid out for deployment of seabed survey equipment (length 15 m, width 6 m, draft 1.2 m).

Plate 1 Survey vessel BS fish farm service vessel, *Eilean Fraoich*.

4.2. Equipment

Table 3 Equipment utilised onboard *Eilean Fraoich*.

Equipment	Model
Camera System	High Definition (HD) video and stills drop-down camera system equipped with freshwater housing.
dGPS	Hemisphere V104s GPS Compass
Gyro Compass	Hemisphere V104s GPS Compass
Navigation Software	EIVA NaviPac

4.2.1. Seabed Imagery Collection

4.2.1.1. Camera System

Seabed imagery (simultaneous video and stills) was acquired at each sampling station using OEL's Rayfin PLE Camera System to collect 4K video and high-resolution (up to 21 megapixels (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 freshwater to ensure imagery of suitable quality (Jones et al. 2020), two LED strip lights, two 5 kW green dot lasers (set to 10 cm distance for scale), a coaxial cable and topside computer. The camera was powered with the use of an Uninterruptable Power Supply (UPS) to ensure no damage was caused should the vessel have lost power or cause a power surge. The freshwater housing is 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 OEL's bespoke drop-down camera and deployment frame.

4.2.1.2. Camera Deployment

The camera frame was deployed from the stern of *Eilean Fraoich* using a capstan and deck crane. During deployment, the live feed video signal was monitored on-board the vessel to assess quality of the footage and adjust as necessary.

The camera was deployed at the start of each transect and slowly 'flown' just above the seabed (a bed-hopping approach was used where visibility/tide did not allow) along to obtain both continuous video footage and still imagery at 15 m intervals. The footage was viewed in real-time by the onboard OEL ecologist via an umbilical.

Video footage was overlaid with time, position, and depth during post-processing.

4.2.1.3. Navigation Equipment

The vessel was equipped with a Hemisphere V104s Global Positioning System (GPS) compass system that provided an offset position of the camera equipment when deployed from the stern.

The Hemisphere V104s's internal GPS receiver automatically searches for and uses a minimum of 4 GPS satellites and manages the navigation information required for position to within 3 m 95% accuracy. Since there is some error in the GPS data calculations, the V104s also automatically tracks a Satellite-Based Augmentation System (SBAS) differential correction to improve its position accuracy to better than 1.0 m 95%.

4.2.1.4. Navigation Software

A vessel-based positioning system was employed utilizing EIVA NaviPac V4.2 software which ensured the accurate positioning of the vessel and camera system. A navigation screen, displaying EIVA Helmsman Display was provided at the helm position of the vessel for the Officer on Watch as well as for the ecologist in the wheelhouse.

4.3.   Project Parameters

4.3.1. Horizontal Reference systems

Table 4 Project horizontal geodetic parameters.

Parameter	Value
Datum	OSGB 1936 / British National Grid
Semi Major Axis (m)	89479
Semi Minor Axis (m)	852762
Inverse Flattening (1/f)	OSGB 1936 / British National Grid
Angular unit	Degree

4.3.2. Unit Format and Conversions

The following units were used throughout this project and were expressed using the following conventions.

Table 5 Project unit format and convention details.

Unit Formats and Conventions		
Geographical Coordinates	Latitude	N DD˚MM.mmmmmm' to 6 decimal places.
	Longitude	E/W DD˚MM.mmmmmm' to 6 decimal places.
Grid Coordinates	Meters in the following format:	
	Easting	EEE EEE.eee m to 3 decimal places.
	Northing	NNN NNN.nnn m to 3 decimal places.
Linear distances	Meters to 1 decimal places.	
Kilometre Point (KP) distances	Kilometres to 2 decimal places.	
Offset measurement sign conventions	Meters in the following format:	
	'Y' is positive forward	
	'X' is positive to starboard	
	'Z' values are positives upwards from the waterline	
Time	Local unless otherwise stated.	

4.4.   Seabed Imagery Analysis

All seabed imagery analysis was undertaken using the Bio-Image Indexing and Graphical Labelling Environment (BIIGLE) annotation platform (Langenkämper et al. 2017) and in consideration of the JNCC epibiota remote monitoring interpretation guidelines (Turner et al. 2016) and the latest NMBAQC/JNCC Epibiota Quality Assurance Framework (QAF) guidance and identification protocols. Analysis of still images and videos was undertaken in two stages. The "Tier 1" level consisted of labels that referred to the whole image being assigned, providing appropriate metadata for the image, these included labels such as image quality, broad scale habitat (BSH), EUNIS habitat, features of conservation interest (FOCI), PMFs and INNS. In addition, an Annex I reef assessment and a PMFs assessment were also undertaken for all images and video footage analysed. A full reef habitat assessment was conducted on all images to determine whether habitats met the definitions of Annex I stony reef habitats as detailed in Table 6.

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

A burrowing assessment was carried out through annotation of each burrow present and their related size for images of sufficient quality. This was used to assess the overall density (m^2) of the burrows along each transect location.

Further assessment was conducted using the video footage. EUNIS habitats/biotopes and PMFs were recorded along each transect in segments with reference to their start and end locations in order to identify and delineate habitat boundaries across the survey area.

Table 6 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		

4.5.   Habitat Mapping

All habitat mapping (Annex I and Habitat Map outputs) was undertaken in ESRI ArcPro Version 3.1 by a habitat mapping specialist and reviewed by a secondary senior environmental scientist. This involved overlaying EUNIS classifications and habitat assessment scores (e. g., Annex I reef, PMFs) assigned to each sampling location where seabed imagery was collected and existing EMODnet mapping to delineate polygons representative of similar bedform/ habitat feature.

Analysis of video footage produced start and end coordinates for areas with classifications and habitat assessment scores (habitat or feature boundaries) to guide habitat mapping and increase confidence in the results. A value of 1 (low confidence) or 2 (high confidence) was assigned to each polygon depending on the following:

- 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 either by seabed imagery or acoustic data

Highest scores (2) were assigned to polygons where all data sources identified the same habitat/biotope, with distinct boundaries. Lower scores (1) were assigned to polygons where data was limited, and boundaries not obvious. In these cases, polygons were drawn based upon expert judgement, given the information available.

5. Results

5.1. Survey

The survey was conducted between 23rd – 27th February 2023 onboard the dedicated fish farm service vessel *Eilean Fraoic*.

All seven proposed transects were surveyed (T01-T07). Transects T02 and T04 were interrupted due to the presence of fishing gear and were subsequently restarted and renamed T02A and T04A respectively.

An additional transect (T08) was conducted running in a N/S orientation (177 °) as a cross-section of T04 for 144 m due to the observed presence of rock in-situ along T04. The locations of all transects are presented in Table 7.
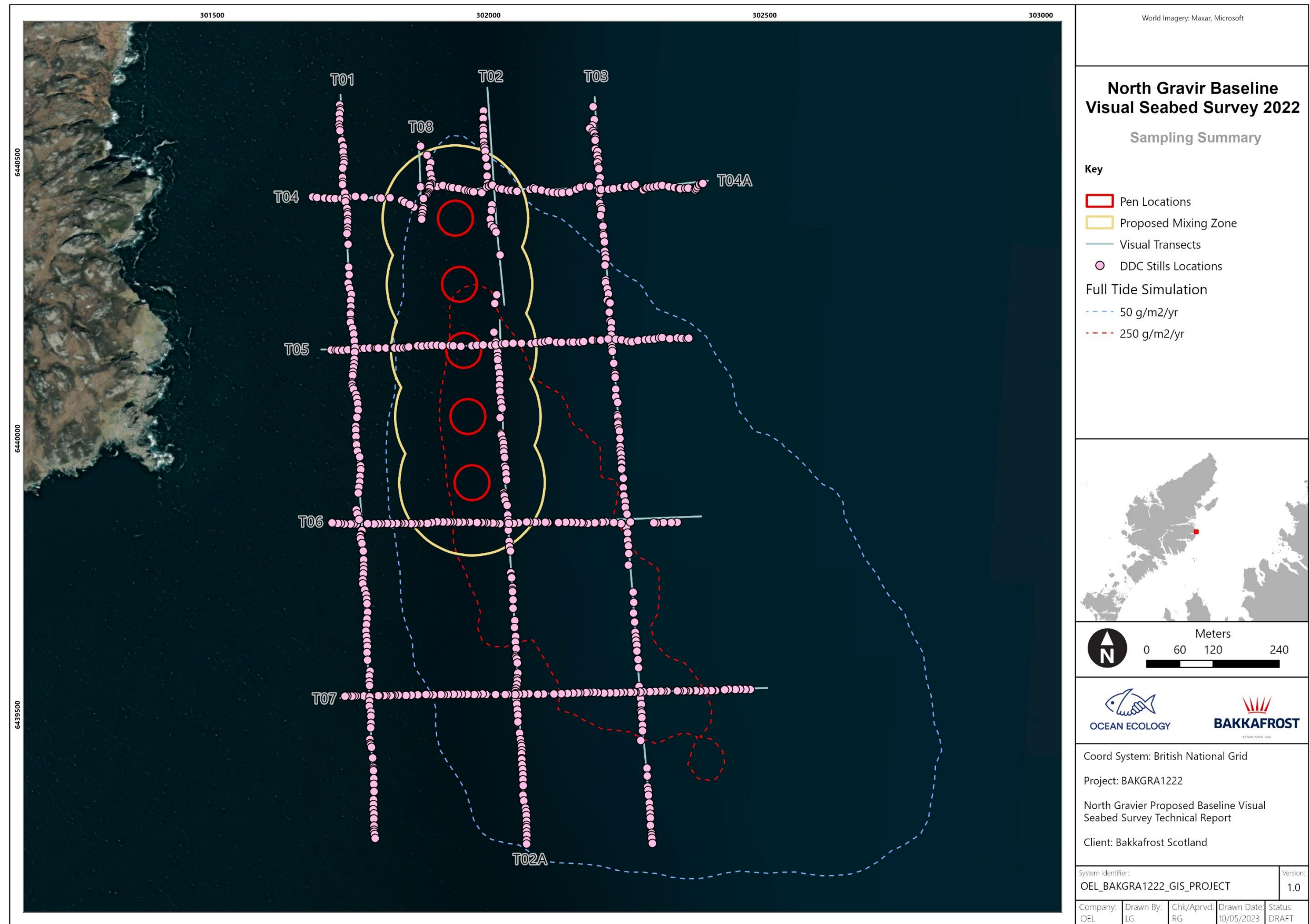
This resulted in the collection 711 high resolution still images and 33 videos.

The seabed imagery collected along these transects provided a thorough ground-truthing of the proposed site for the presence of PMFs and potential Annex I features (Figure 4).

Depth readings were not obtained due to the absence of depth recorders on the vessel. In-situ, charts were used to estimate depths for safe deployment of the camera system, though these depths were not accurate readings and should therefore be interpreted with caution.

Table 7 Actual DDC transect locations (British National Grid OSGB 1936).

North Gravir Visual Seabed Survey						
Transect	Transect Start		Transect Finish		Distance	Bearing
	X	Y	X	Y	(m)	(°)
T01	142814	916457	142873	915131	1330	177
T02	143070	916460	143109	916081	383	176
T02A	143101	916053	143152	915130	948	178
T03	143269	916457	143378	915124	1330	177
T04	142760	916278	142908	916273	152	92
T04A	142956	916295	143459	916299	521	88
T05	142785	916000	143432	916020	700	84
T06	142815	915688	143451	915685	700	84
T07	142828	915375	143580	915382	750	84
T08	142955	916377	142960	916233	144	178

Figure 4 Visual seabed survey summary of DDC transects across the proposed North Gravir salmon pen fish farm site.

5.1.1. Seabed Imagery

A full seabed imagery proforma including PMF and Annex I assessments is included in Appendix I and II. Further assessment was then conducted using the video footage. Habitat boundaries were delineated from the habitats/biotopes and PMFs observed in the segmented video footage.

The dominant BSH was identified as 'A5.3 – Subtidal mud', representing 75% of still images analysed, whilst the remaining BSHs were identified as 'A5.4 – Subtidal mixed sediment' (17%), and high and moderate energy circalittoral rock, A4.1 and A4.2 respectively (8%). A5.44 'Circalittoral mixed sediment' was primarily observed in the Northwest, whilst A5.36 'Circalittoral fine mud' was observed in the East and Southeast (Figure 5). The EUNIS habitats and biotopes recorded across the survey area are presented in Table 8, and example imagery is presented in Plate 3.

Analysis of the stills and video footage indicated a presence of Annex I bedrock and medium stony reef at T04A. This area was classified as a bedrock and medium stony mosaic due to the extent of bedrock present, with the elevation, epifaunal coverage and percentage cover of the boulders. These bedrock and stony features corresponded to the EUNIS classification 'A4.211 – *Caryophyllia smithii* and *Swiftia pallida* on circalittoral rock (Plate 3). Evidence of potential bedrock reef was identified along T08 corresponding to the EUNIS classification 'A4.13 – Mixed faunal turf communities on circalittoral rock'.
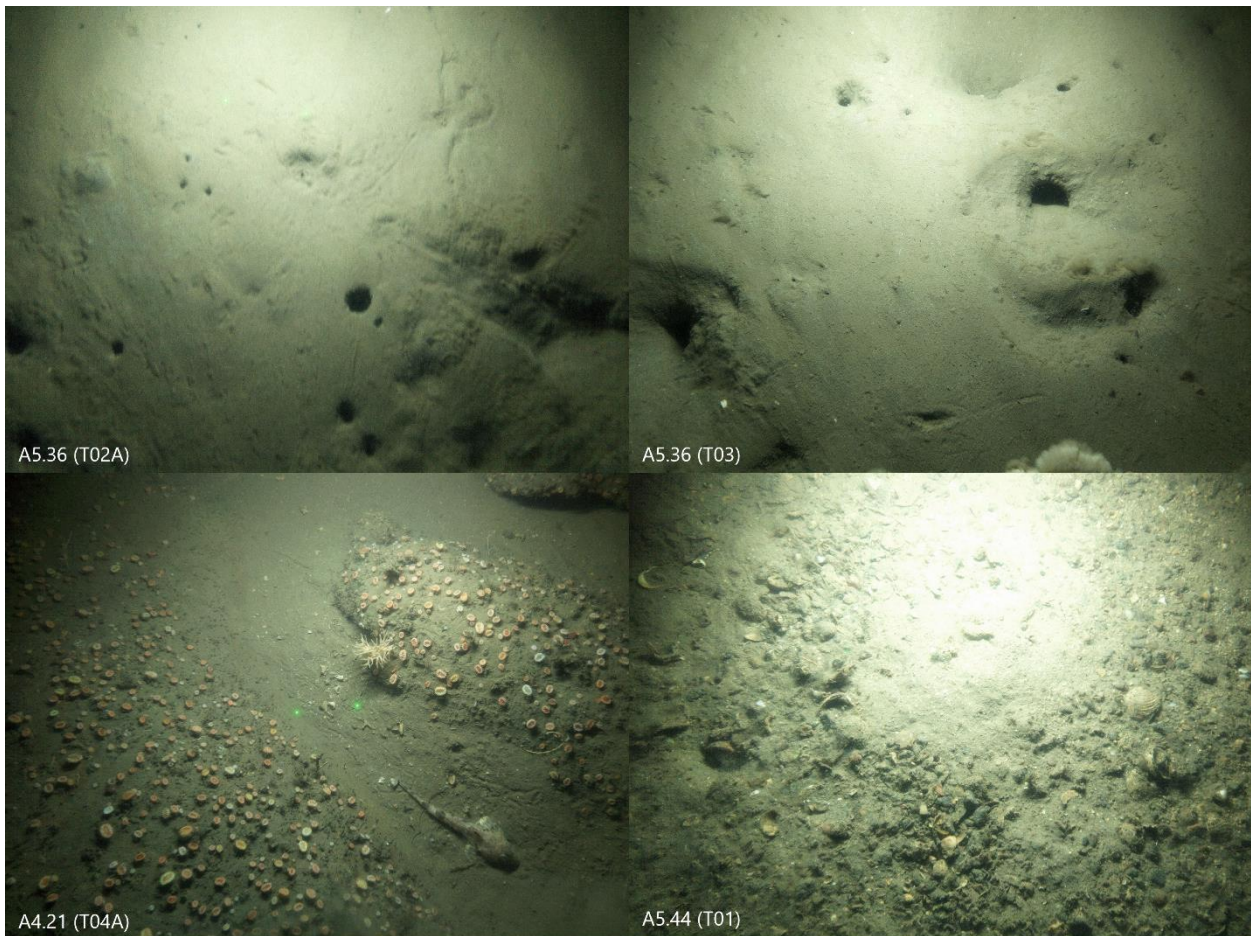
The PMF habitat 'Burrowed mud' was identified along all transects across the site where BSH A5.3 was present. Within the burrowing mud habitat, the PMF species '*F. quadrangularis*' (Tall seapen) was identified in two images along T03 and 8 images along T07 (Plate 4). Images containing this species have been classified as 'A5.3611 – Seapens, including *F. quadrangularis*, and burrowing megafauna in undisturbed circalittoral fine mud'.

The PMF habitat 'Northern sea fan and sponge communities' was identified in two seabed images along transect T04A within the A4.2 biotope identified (Plate 3, Figure 6).

A burrowing assessment was conducted on all images where image quality was assigned as poor or higher. A burrowing assessment was undertaken on 361 images across all transects except T04. The highest density of burrows was observed along T03 (10.2 m^2) and the lowest (2.7 m^2) along T02. The density of *F. quadrangularis* was low compared to the density of burrows, where density was higher along T07 (0.32 m^2) than T03 (0.05 m^2). No *F. quadrangularis* was found along the transect possessing the highest density of burrows. The full burrowing assessment is included in Appendix III.

The PMFs recorded across the survey area are presented in Table 8 Summary table of EUNIS classifications and example imagery is presented in Plate 4.
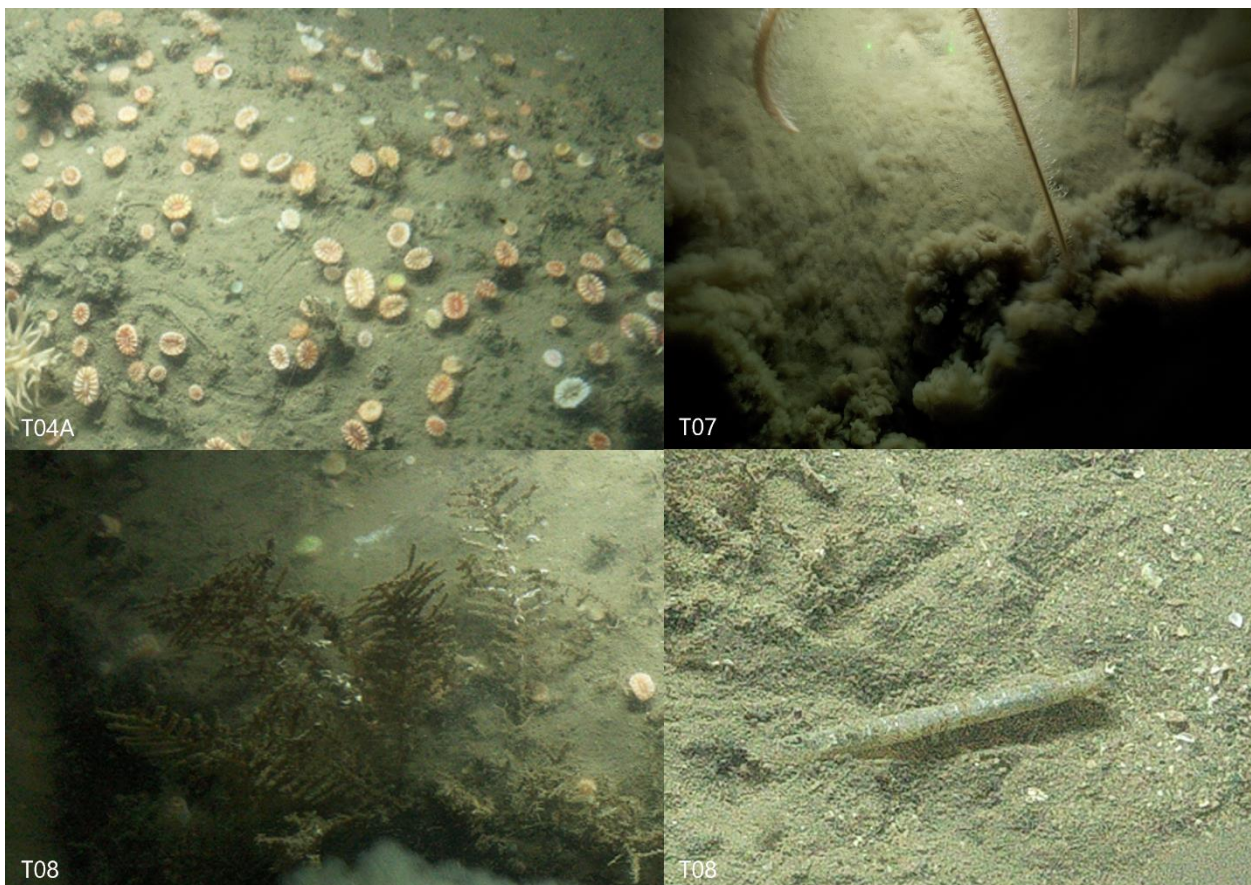
Plate 3 Dominant EUNIS habitats. Top: Circalittoral fine mud habitat and PMF 'Burrowed mud'. Bottom left: A4.211 habitat and PMF 'Northern sea fan and sponge communities'. Bottom right: Mixed sediment habitat found in the North West region of the North Gravir site.

5.2.   Conspicuous Epifauna

The epifaunal community remained homogenous across the survey area. Overall, sparse epifaunal coverage was found across the survey site as an A5.3 dominated habitat can be defined to a greater confidence using infaunal species rather than epifaunal. Within areas of A5.4, coverage of hydrozoans such as Sertulariidae and Sertularellidae were found, where in soft sediments, worm casts, worm tubes (e.g. Onuphidae) and *Spirularia* such as *Cerianthus lloydi* were present. Seapens, specifically the PMF species *F. quadrangularis*, were found predominantly in the south-east of the survey area (Figure 6). Within the rock habitats, *Caryophyllia smithii* dominated, with presence of cushion sponges, sparse *Swiftia pallida* and hydrozoans (Plate 4). No INNS species were observed. A list of taxa found within the site is provided in Appendix IV.
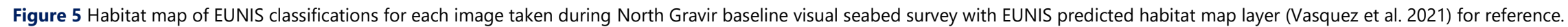

Plate 4 Example images of species encountered across the proposed North Gravir site. *C. smithii* (T04A), *F. quadrangularis (T07)*, hydrozoans (T08) and worm tubes (Onuphidae)(T08).
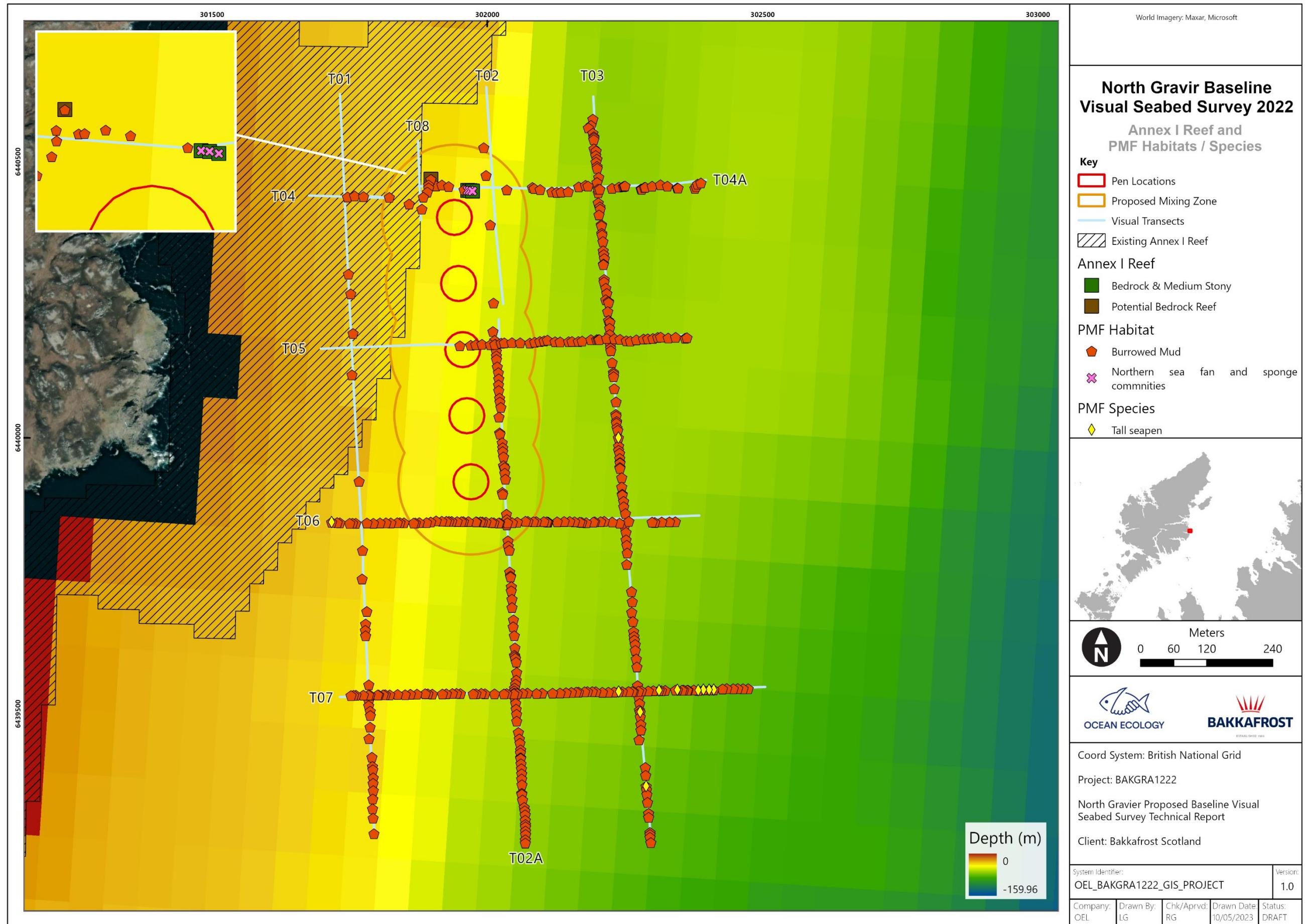
Table 8 Summary table of EUNIS classifications

Transect	BSH	EUNIS Code	PMF	Annex I Reef
T01	A5.3 A5.4	A5.35, A5.36, A5.361, A5.44.	Burrowed Mud	-
T02	A5.3 A5.4	A5.36, A5.44, A5.441	Burrowed Mud	-
T20A	A5.3	A5.36, A5.361	Burrowed Mud	-
T03	A5.3	A5.35, A5.361, A5.3611	Burrowed Mud Tall Seapen (*F. quadrangularis*)	-
T04	A5.3 A5.4	A5.36, A5.44	Burrowed Mud	-
T04A	A4.2 A5.3 A5.4	A4.211, A5.35, A5.36, A5.361, A5.44	Burrowed Mud Northern sea fan and sponge communities.	Bedrock & Medium Stony
T05	A4.1 A5.3 A5.4	A4.13, A5.36, A5.361, A5.44,	Burrowed Mud	-
T06	A5.3	A5.36, A5.361, A5.3611	Burrowed Mud Tall Seapen (*F. quadrangularis*)	-
T07	A5.3	A5.36, A5.361, A5.3611	Burrowed Mud Tall Seapen (*F. quadrangularis*)	-
T08	A4.1 A5.3 A5.4	A4.13, A5.361, A5.44	Burrowed Mud	Potential Bedrock

Figure 5 Habitat map of EUNIS classifications for each image taken during North Gravir baseline visual seabed survey with EUNIS predicted habitat map layer (Vasquez et al. 2021) for reference.

Figure 6 Annex I reef habitats and PMFs identified across the North Gravir baseline visual seabed survey area with available EMODnet bathymetry.
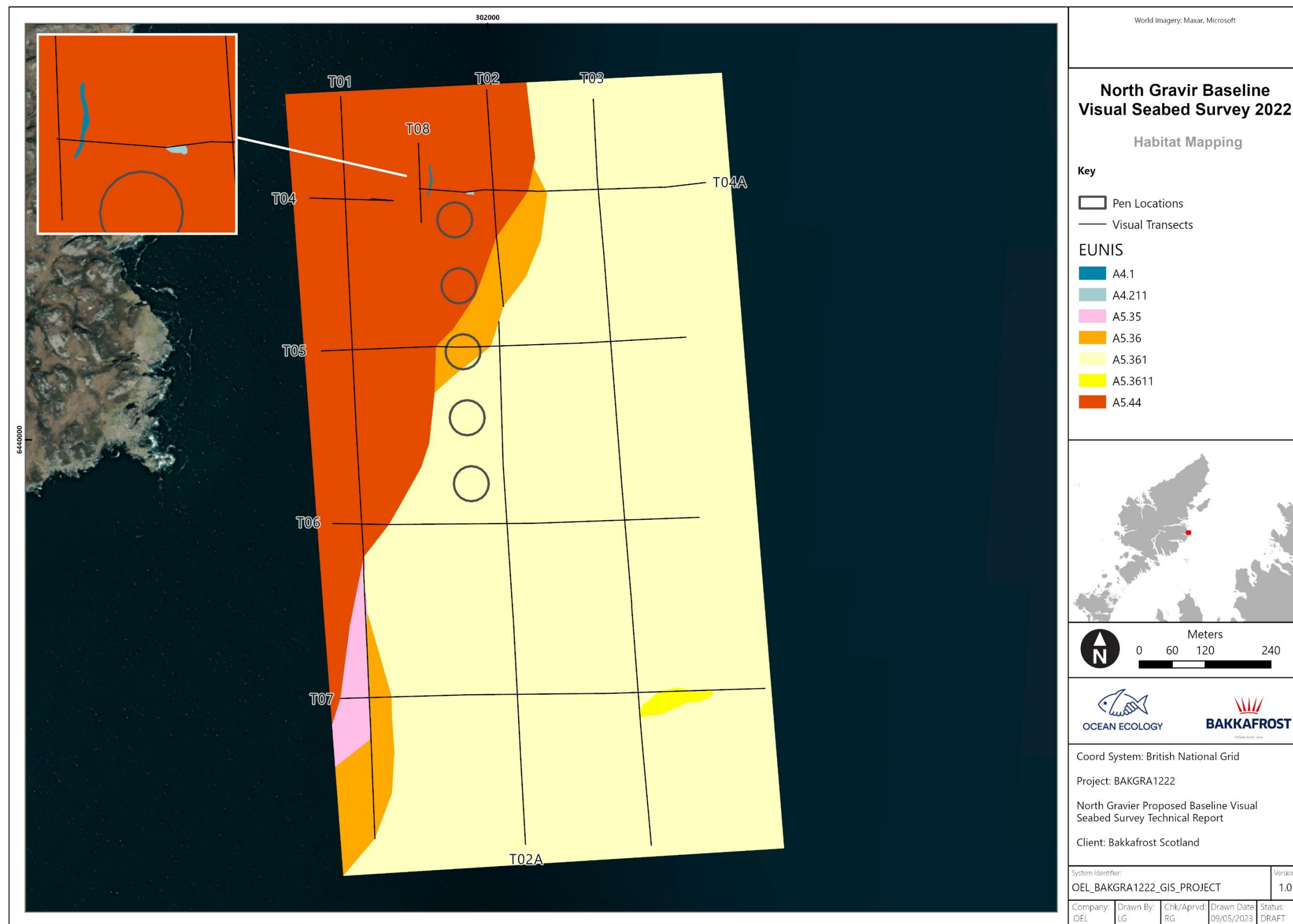
5.3. Habitat / Biotope Mapping

To map the principal habitats/biotopes observed across the survey area, a full interrogation of available bathymetric data and existing EMODnet mapping (Figure 3) was undertaken in combination with seabed imagery and video footage collected along all 8 transects.

The main habitats identified across the survey area at which seabed imagery were obtained are listed in Table 8. The distribution and extent of the habitats identified across the survey area based on all available data are presented in Figure 7. All habitat / biotope mapping is provided in shapefile (.shp) format as Appendix V.

Low resolution bathymetric data obtained from EMODnet limited the analysis of the seabed topography, therefore the confidence of delineated polygons and extent was overall low with a confidence score of one assigned to all polygons.

Figure 7 Habitat map across the proposed North Gravir salmon farm survey area. EUNIS descriptions are as follows: 'A4.1 - Atlantic and Mediterranean high energy circalittoral rock', 'A4.211 - 'A4.211 - Caryophyllia smithii and Swiftia pallida on circalittoral rock', 'A5.35 - Circalittoral sandy mud', 'A5.36 - Circalittoral fine mud', 'A5.361 - Seapens and burrowing megafauna in circalittoral fine mud', 'A5.3611 - Seapens, including *F. quadrangularis*, and burrowing megafauna in undisturbed circalittoral fine mud' and 'A5.44 - Circalittoral mixed sediments'.

6. Discussion

This report presents the findings and habitat mapping outputs of the North Gravir salmon pen fish farm survey undertaken in February 2023. The survey involved the collection of seabed imagery along 8 transects (T01 to T08). The key objective was to map the distribution and extent of BSHs, biotopes and life forms present with a focus on confirming the presence/absence of PMFs and any other habitats and/or features of conservation interest across the proposed North Gravir salmon pen fish farm site, mixing zone, and adjacent areas.

The majority of the proposed site was found to be characterised by soft sediment habitats, including circalittoral fine mud and sandy mud, with some areas found to support seapens and burrowing megafauna. Fine mud sediment graduated to circalittoral mixed sediment towards the shore, with interspersed areas of rocky habitat. The presence of rock habitat is in contrast with existing EMODnet mapping for the area which assigned the rocky habitat 'A4.3 - Atlantic and Mediterranean low energy circalittoral rock' in correspondence with the west of the proposed site (Figure 3). This highlights the importance of baseline visual seabed surveys.

Three PMFs which included several habitats and component species were observed throughout the site. The PMF habitat northern sea fans and sponge communities was observed in three of the still images collected along transect T04A within the EUNIS A4.211 on bedrock and medium stony reef and is typically restricted to the West Coast of Scotland in UK waters. Threats to this PMF habitat include organic enrichment, physical damage, and changes in local current flow. Physical damage from the use of bottom gear on rocky seabed areas, such as potting, some fixed nets and trawling, may lead to the detachment of sessile species within this habitat (Tyler-Walters et al. 2016).

The PMF habitat 'Burrowed mud' was identified in 466 images and subsequently mapped within the proposed mixing zone and across the majority of the survey area. This PMF is primarily found in deep water or sheltered conditions where there is very little water movement. The PMF species *F. quadrangularis*, which is a component species of the PMF 'Burrowed mud' was observed in 11 of the still images collected, located at the land end of T06 and within the southeast of the survey area. This species is typically restricted to western Scotland and to deep, undisturbed muddy sediments and is extremely sensitive to physical disturbance due to its brittle nature and inability to withdraw into sediment (Tyler-Walters et al. 2016).

Evidence of Annex I bedrock and medium stony reef was observed at T04A, situated to the east of the historical Potential Annex I reef. The mapped Annex I bedrock and medium stony reef corresponded to EUNIS classification 'A4.211 – *Caryophyllia smithii* and *Swiftia pallida* on circalittoral rock''. It should be noted that the confidence in defining the extent of these reef locations was recorded as low as the bathymetry data available did not allow for an accurate assessment of topographic highs which would normally be used to delineate the extent bedrock or stony features. It is possible that there is a greater extent of reef present than

observed from stills and video analysis alone. Further to this, it is likely that a sediment veneer covering the bedrock features hindered their identification based on the still and video analysis alone. This could potentially explain the discrepancy between the EMODnet predictive mapping for the area and the current efforts or alternatively, this could be due to a lack of ground truth data in the predictive mapping.

Evidence of potential Annex I bedrock reef was observed at T08. The EUNIS classification 'A4.13 – Mixed faunal turf communities on circalittoral rock' was recorded in one image. Using video footage, the presence of a bedrock community with an extent of over 25 m^2 was deemed likely, though coverage of the transect put in place did not allow for a full assessment.

No evidence of Annex I biogenic reef or other species and habitats of conservation interest were observed or recorded. No evidence of pre-existing impacts were observed (including marine litter or INNS).

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