APPENDIX 8.2

Intertidal Survey

Ocean Ecology

Marine Surveys, Analysis & Consultancy

Iona & Fionnphort Marine Access Improvement Project - Intertidal Habitat Assessment

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Updates

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Abbreviations

BSH	Broadscale Habitat
CAA	Civil Aviation Authority
DEM	Digital Elevation Model
EIA	Environmental Impact Assessment
EMODnet	European Marine Observation and Data Network
EUNIS	European Nature Information System
GPS	Global Positioning System
GSD	Ground-Sampling Distance
INNS	Invasive Non-Native Species
JNCC	Joint Nature Conservation Committee
MHWS	Mean High Water Springs
MLWS	Mean Low Water Springs
MNCR	Marine Nature Conservation Review
NMPi	National Marine Plan Interactive
OEL	Ocean Ecology Limited
PfCO	Permission for Commercial Operations
PMF	Primary Marine Feature
RPQs	Remote Pilot Qualification
SAC	Special Area of Conservation
UAV	Unmanned Aerial Vehicle

1. Non-Technical Summary

This report presents the findings of two intertidal surveys conducted at Iona and Fionnphort for the Marine Access Improvement Project. The key aim was to characterise and map the key benthic habitats present across the foreshore to inform the drafting of an Environmental Impact Assessment (EIA).

The surveys took place at Iona and Fionnphort between the 22nd and 24th of August 2021 and involved the collection of Unmanned Aerial Vehicle (UAV) imagery accompanied by quadrat sampling to gather detailed information on the benthic communities present for subsequent biotope mapping purposes. A full suite of images and quadrats were collected across the full extent of the intertidal foreshore at each site between Mean Low Water Springs (MLWS) and Mean High Water Springs (MHWS).

An intricate landscape was encountered across the Fionnphort survey area with a strandline of varying width (EUNIS A2.21) giving way to a large area of littoral sand (A2.2, A2.231, A2.241) in the upper shore and rocky biotopes (A1.113, A1.211 and A1.212) in the mid to lower shore. Fionnphort was also flanked by rock cliffs and ledges covered in lichens (B3.1) in some areas.

A typical zonation was observed at Iona; this included supralittoral rocks and cliffs covered in lichens and green seaweeds (B3.1 and B3.11) and upper shore zones characterised by rocky habitats and biotopes supporting a number of marine invertebrate taxa and fucoids (A1.1131, A1.2141 and A1.211). The lower shore was characterised by fine sand (A2.22) with areas dominated by polychaete species (A2.24) with patches of rocks and sediments covered in kelp (*Laminaria digitata*) (A3.21 and A5.52).

Both survey areas fall within the boundaries of the Inner Hebrides and the Minches Marine SAC in their component below the MHWS mark. This site is not however designated to protect benthic features meaning that the EUNIS rock classifications meeting the qualifying criteria for Annex I bed rock reef habitat are not afforded protection under the Habitats Directive. Nevertheless, EUNIS classifications B3.1 and B3.11 are included under 'Supralittoral Rock: Cliff and Slopes' on the list of Section 2(4) Habitat of Principal Importance under the Nature Conservation (Scotland) Act 2004. Similarly, EUNIS classification A1.1133 and A1.2142 are listed as 'Littoral Rock: Intertidal Underboulder Communities'.

There were no observations of Priority Marine Features (PMFs) such as intertidal seagrass beds; however, seagrass debris were recorded at two locations in Fionnphort. Similarly, no maerl or kelp beds, two other PMFs with the potential of occur in or close to the survey areas, were recorded across the survey areas; however, kelp habitats were observed in the shallow subtidal areas at low water potentially forming kelp beds, into the infralittoral zone representative of EUNIS classifications A3.21 and A5.52 and the PMFs 'Kelp beds' and 'Kelp and seaweed communities on sublittoral sediment'. These habitas were investigated during the subtidal survey conducted concurrently to the intertidal surveys and reported separately.

2. Introduction

2.1. Project Overview

Argyll and Bute Council appointed RPS to carry out an expert review of all works undertaken to date and draft a detailed Environmental Impact Assessment (EIA) to support a marine access improvement project at Iona and Fionnphort, two sites in the Sound of Iona.

Iona is a small island located west of Mull, on the west coast of Scotland. A ferry service connects Iona to Fionnphort located in the southwest of Mull. Current facilities at both ports need upgrading and improving as difficulties have been identified in their use by all parties operating from each port (e.g., inter-island ferry, fishery and leisure boats). Several feasibility studies (Simoes & Salmon 2020a b) have been carried out over the years to propose different options for the Iona and Fionnphort marine access improvement works with the selected projects consisting of a new rock armour breakwater, berthing piles and dredging in Iona and of a new rock armour breakwater, overnight berthing facilities and dredging in Fionnphort (ByrneLooby 2019).

2.2. Project Background

RPS commissioned Ocean Ecology Limited (OEL) to conduct intertidal Unmanned Aerial Vehicle (UAV) and Phase I and II walkover surveys at both Iona and Fionnphort to inform the drafting of the EIA. The surveys involved the collection of UAV imagery and a Phase I and II walkover survey to characterise and map the soft-and-hard substrates and associated benthic communities of the two sites located within the Sound of Iona. Fionnphort is to the east of the survey area on the Isle of Mull (Figure 1) while Iona is to the west within St Ronan's Way on the Isle of Iona (Figure 1). Both sites are located at the pre-existing inter-island ferry terminals for the Fionnphort to Iona ferry service. The survey area is shallow with water depths up to 6m and drying heights in intertidal areas of 2m. The key objective was to map the distribution and extent of individual or groups of broadscale habitats, biotopes, biotope complexes and life forms present with a focus on confirming the presence/absence of any habitats and/or features of conservation interest across the Sound of Iona (e.g., Primary Marine Features (PMFs) such as seagrass beds).

This report provides a summary of the survey methodologies employed and detailed mapping of the habitats encountered during the survey. Habitats were determined through detailed interpretation of the UAV imagery and walkover data allowing for the determination of European nature Information System (EUNIS) habitats and biotopes (where possible) and subsequent creation of full coverage habitat/biotope mapping across the survey areas.

2.3. Current Understanding

Nature Scot (previously Scottish Natural Heritage) identified a number of benthic habitats and marine species as PMFs (Tyler-Walters et al. 2016). Several of these important and sensitive habitats are known to occur around the West coast of Scotland (Fuller 1999, NatureScot 2021) and have the potential to occur within or near the survey area.

Existing habitat mapping obtained from the European Marine Observation and Data Network (EMODnet) and the Scottish National Marine Plan Interactive (NMPi) suggests the habitats present within the survey areas primarily consist of intertidal sandy shores with moderate-high energy intertidal rock with the potential of representing PMFs including biogenic habitats like seagrass beds known to occur north of the survey area in Fionnphort (Figure 1). Other PMFs that have been recorded on both Isles (Mull and Iona) include kelp and maerl beds which could potentially occur within the survey area.

The Sound of Iona lies within the boundaries of the Inner Hebrides and the Minches Special Area of Conservation (SAC) designated to protect harbour porpoises (*Phocena phocena*) as per Annex II of the Habitat Directive (The Council Directive 92/43/EEC).

2.3.1. Seagrass Beds

Seagrasses (also known as eelgrass) are marine flowering plants found in shallow coastal areas down to approximately 10m, often growing in dense beds or meadows. The plants can be annual or perennial and stabilise the sediment, creating productive habitats that provide shelter and food for a wide variety of plants and animals (including other species of conservation importance and commercially valued fish species), as well as being important for carbon sequestration.

Seagrass 'beds' formed by the genus *Zostera* are generally classed as having plant densities that provide at least 5% cover (OSPAR 2009). Typically, *Zostera* spp. plant densities provide greater than 30% cover and in favourable conditions, extensive beds may form with up to 95% cover (Lancaster et al. 2014). A minimum area of 5 m x 5 m with at least 5% cover of *Zostera* spp. is required to qualify as a seagrass bed.

Zostera spp. beds are usually found in sands and muds from the upper shore down to 10m, in areas at least moderately sheltered from wave action such as sea lochs, inlets, bays, sounds, channels and lagoons. *Z. marina* is predominantly subtidal, whilst the narrow-leaved variant, *Z. marina var. angustifolia*, can occur in the shallow subtidal and intertidally on the mid to lower shore. Meadows of seagrass formed by either or both species are protected in Scotland through designations as the PMF broad habitat 'Seagrass Beds' (Tyler-Walters et al. 2016), through inclusion on the OSPAR list of threatened and/or declining species and habitats and as a Section 2(4) Habitat of Principal Importance under the Nature Conservation (Scotland) Act 2004.

A consultation relating to the distribution of PMFs across Scotland reported the presence of *Z. marina var. angustifolia* beds to the north of the Fionnphort survey area whilst a single record

from Seagrass Spotter[1] reports the presence of a notable *Z. marina* bed in the shallow subtidal with the potential to extend into the intertidal zone (Figure 1).

2.3.2. Maerl Beds

Maerl is a collective term for several species of red seaweed, with hard, chalky skeletons that grow as unattached rounded nodules or short, branched shapes on the seabed. As a result, maerl can form large beds, where layers of dead maerl build up with a thin layer of pink, living maerl on the top. These beds are a priority habitat under Section 2(4) of the Nature Conservation (Scotland) Act 2004 as they form an important habitat for many different types of marine life, which live amongst or are attached to the surface of maerl, or burrow in the coarse gravel of dead maerl beneath the top living layer. Maerl beds can be of importance to sustainable fisheries, providing nursery grounds for commercial species of fish and shellfish.

Due to the fragility of maerl, the beds are easily damaged and have probably declined substantially in some areas. Pressures on maerl beds include scallop dredging, bottom trawling, aquaculture, and pollution. Maerl beds are very slow to develop and are unlikely to return if removed or lost. As such, they should be treated as a non-renewable resource.

Maerl beds are granted protection under the EC Directive on the Conservation of Natural Habitats and Wild Fauna and Flora (92/43/ECC), through inclusion on the OSPAR list of threatened and/or declining species and habitats and as the PMF broad habitat 'Maerl Beds' (Tyler-Walters et al. 2016). There are no known existing records of maerl within the Sound of Iona.

2.3.3. Kelp Beds

Beds of the kelps such as *Laminaria hyperborea* and *Laminaria digitata* 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 thrive. A rich diversity of red seaweeds grows among the kelp and on the kelp stipes, while depending on conditions, sea mats and sea firs may colonise the fronds. 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.

Kelp beds occur in shallow waters (to a maximum of 20-30m), on bedrock and boulders in a range of wave exposure regimes and tidal conditions and are protected in Scotland through designation as the PMF broad habitat 'Kelp beds'. There are no existing records of the PMF broad habitat 'Kelp Beds' within the Sound of Iona however this is likely due to the lack of sampling rather than true absence given the rocky subtidal habitats known to occur across the area.

[1] https://seagrassspotter.org/sighting/271

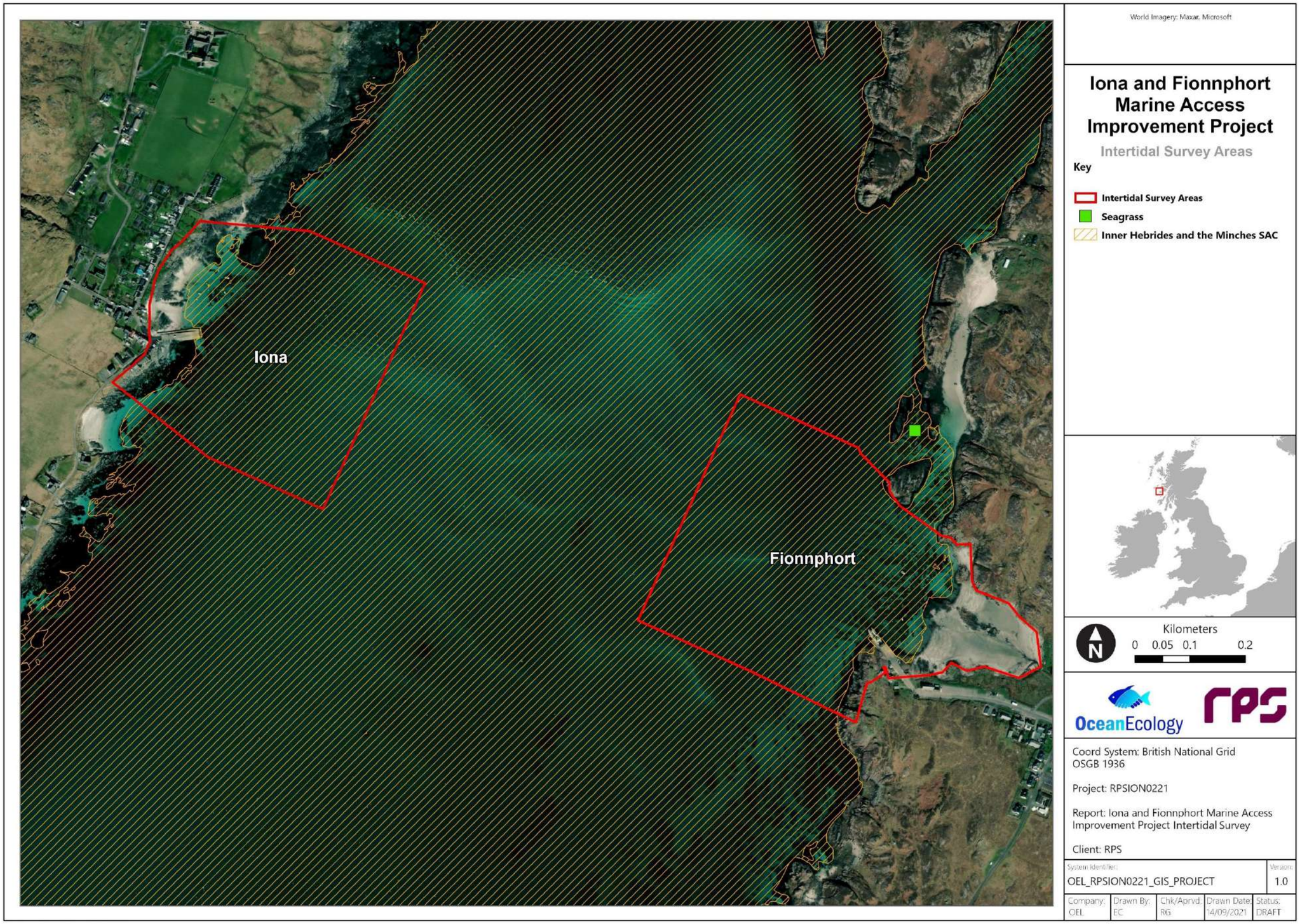

Figure 1 Location of the intertidal survey areas in Fionnphort and Iona within the Inner Hebrides and The Minches SAC. Note the existing seagrass bed record north of the Fionnphort site.

3. Methods

3.1. Survey Design

The intertidal surveys covered the area extending from Mean Low Water Springs (MLWS) to Mean High Water Springs (MHWS) at each location. An UAV survey was undertaken to collect high-resolution imagery across the survey areas at low water. Additionally, a total of 178 quadrat locations (92 at Fionnphort and 86 at Iona) were selected across the survey areas to supplement ground truth the UAV imagery and inform the subsequent habitat / biotope mapping.

3.2. Survey Methods

3.2.1. Walkover Survey

The Phase I and II intertidal walkover surveys were undertaken during low tide periods using ESRI ArcCollector on a tablet device equipped with a Bad Elf GPS & GLONASS providing 2.5 m positional accuracy. The surveys were undertaken in consideration of guidance in the Marine Monitoring Handbook (Davies et al. 2001), CCW Handbook for Marine Intertidal Phase I Survey and Mapping (Wyn et al. 2006) and latest guidance for characterising intertidal rocky shore and sediment habitats (NRW 2019, Wales 2019). EUNIS habitats and biotopes were identified in line with JNCC guidance on assigning benthic biotopes (Parry 2019). These were correlated to the Marine Habitat Classification for Britain and Ireland (MNCR) and, where possible, boundaries of habitats / biotopes were tracked as polygons in ESRI ArcCollector.

Representative examples of each habitat / biotope encountered were photographed whilst target notes were taken at any notable change in habitat / substrate and identified the presence of any notable features (e.g. intertidal rockpools) and habitats of conservation interest. These were accompanied by GPS fixes and close-up photographs of each feature, along with aspect photographs to the North, East, South and West from each sample location to capture wider site information. The presence of any Invasive Non-Native Species (INNS) was also to be noted and their location recorded. Other information recorded included general site conditions, sediment surface features (e.g. polychaetes casts), sediment type and characteristics, topography and evidence of any anthropogenic pressures.

3.2.2. UAV Mapping

The UAV mapping was carried out in consideration of JNCC guidance for use of UAVs in marine benthic monitoring (Crabb et al. 2019). All flights were conducted by OELs Qualified UAV Pilots (Remote Pilot Qualification (RPQs) under its Permission for Commercial Operations (PfCO) (CAA ID: 2654) granted by the Civil Aviation Authority (CAA). The UAV used was a DJI Phantom 4 multi-rotor quadcopter. The flight(s) were pre-planned using in Drone Deploy software at a flight height

of 60 m to achieve a target orthomosaic Ground-Sampling Distance (GSD) of 2-3 cm/px with an accuracy[2] of between 2-3m.

3.3. Analysis

3.3.1. UAV Imagery Analysis

Following initial screening to remove any erroneous images, all images collected during the UAV mapping flights underwent Terain (2D) processing in the Drone Deploy software and were 'stitched' together to generate orthomosaic and Digital Elevation Model (DEM) outputs[3] for both intertidal survey areas. Achieved image resolution across both sites was 12 mega pixels with an average orthomosaic image density of 12 images per pixel. A detailed processing and output quality report for each intertidal survey area is provied in Appendix II.

The outputs were then used as base maps in GIS to facilitate subsequent habitat / biotope mapping by visual interrogation and delineation of boundaries.

3.3.2. EUNIS Classification Mapping

EUNIS habitats, biotope complexes and biotopes were identified in line with JNCC guidance on assigning benthic biotopes (Parry 2019) to allow for the production of a full coverage habitat/biotope map. All habitat / biotope determination was undertaken through consideration of the following:

- Existing habitat mapping (derived from EMODnet and NMPi)
- UAV imagery interpretation
- Review and interpretation of target field notes and quadrat imagery
- General site imagery

All habitat mapping was undertaken in ESRI ArcPro Version 2.8.1 by a habitat mapping specialist and reviewed by a secondary senior environmental scientist. Analysis of quadrat and site photos along with the UAV imagery allowed for polygons to be drawn around areas of a certain habitat/ biotope.

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

- Whether target filed notes and quadrats were available within the polygon
- Whether UAV imagery confirmed/suggested the presence of the same habitat / biotope within a polygon

[2] Measured as Root Mean Square Errors (RMSE).

[3] Note that Ground Control Points (GCPs) were not used to georeference the DEM outputs using real-time kinematic (RTK) GPS coordinates. As such the real-world position of the DEM output are presented subject to error associated with the drone's GPS accuracy whilst the elevation data is presented relative to the take-off position of the drone rather than absolute elevation (i.e. Mean Sea Level - MSL). As such the DEM outputs were only used to broadly inform the habitat mapping and should not be used for construction planning and/or navigation purposes.

- Whether the boundaries of the habitat / biotope were clearly defined either by UAV imagery, target field notes or quadrats

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.

3.3.3. Feature of Interest

After assigning EUNIS habitats and biotopes to the survey area based on UAV imagery analysis and walk over data (quadrats and target notes), an assessment of the presence of PMFs and other designated or protected habitats was carried out, and where appropriate, the extent of these features was calculated.

4. Results

4.1. Survey Progress

The UAV and intertidal walkover surveys were undertaken at Fionnphort and Iona during low tide periods between the 22nd and 24th of August 2021. Table 1 provides a summary of the sampling and information collected during the surveys.

Table 1 Summary of sampling undertaken and information collected during the intertidal surveys.

Sampling	Fionnphort	Iona
Quadrats	92	86
Target Notes	92	86
UAV imagery	860 images	385 images

4.2. UAV Survey

UAV mapping was undertaken at Fionnphort and Iona around low water on 22 August 2021. An 42:08 minute flight was undertaken at Fionnphort and a 21:06 minute flight at Iona. Flight height was maintained at 60 m for the Fionnphort flight and 75 m for the Iona flight. Weather conditions (e.g. wind / precipitation) remained favourable for data collection throughout.

The UAV flight of Fionnphort successfully captured 860 high-resolution nadir images across a coverage area of 0.98 km^2 to produce a high resolution orthomosaic model (GSD = 2.60cm/px) and DEM (GSD = 10.41cm/px) (Figure 2) with average RSME accuracy level of 2.31m. The UAV survey of Iona successfully captured 385 high-resolution nadir images across a coverage area of 0.34 km^2 to produce a high resolution orthomosaic model (GSD= 3.29 cm/px) and DEM (GSD = 13.17cm/px) (Figure 3) with average RSME accuracy level of 2.16m. Example aerial images are provided in Plate 1. The full orthomosaic, DEM and 3D model outputs are provided as Appendix II along with processing reports.

Plate 1 Example site UAV imagery at Fionnphort (left) and Iona (right).

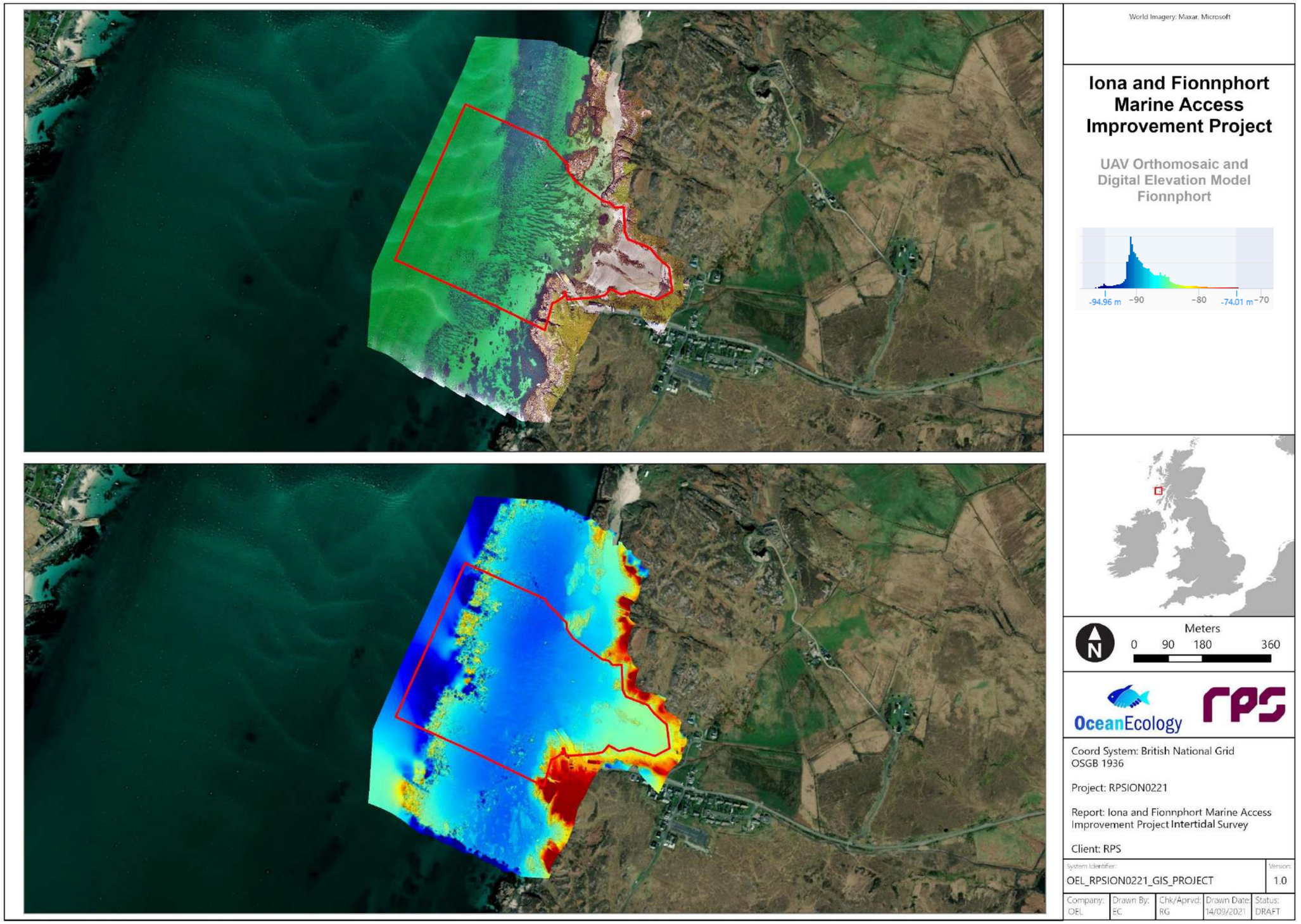

Figure 2 UAV orthomosaic (top) and Digital Elevation Model (DEM) (bottom) generated from the UAV imagery collected during the intertidal survey of the Fionnphort survey area.

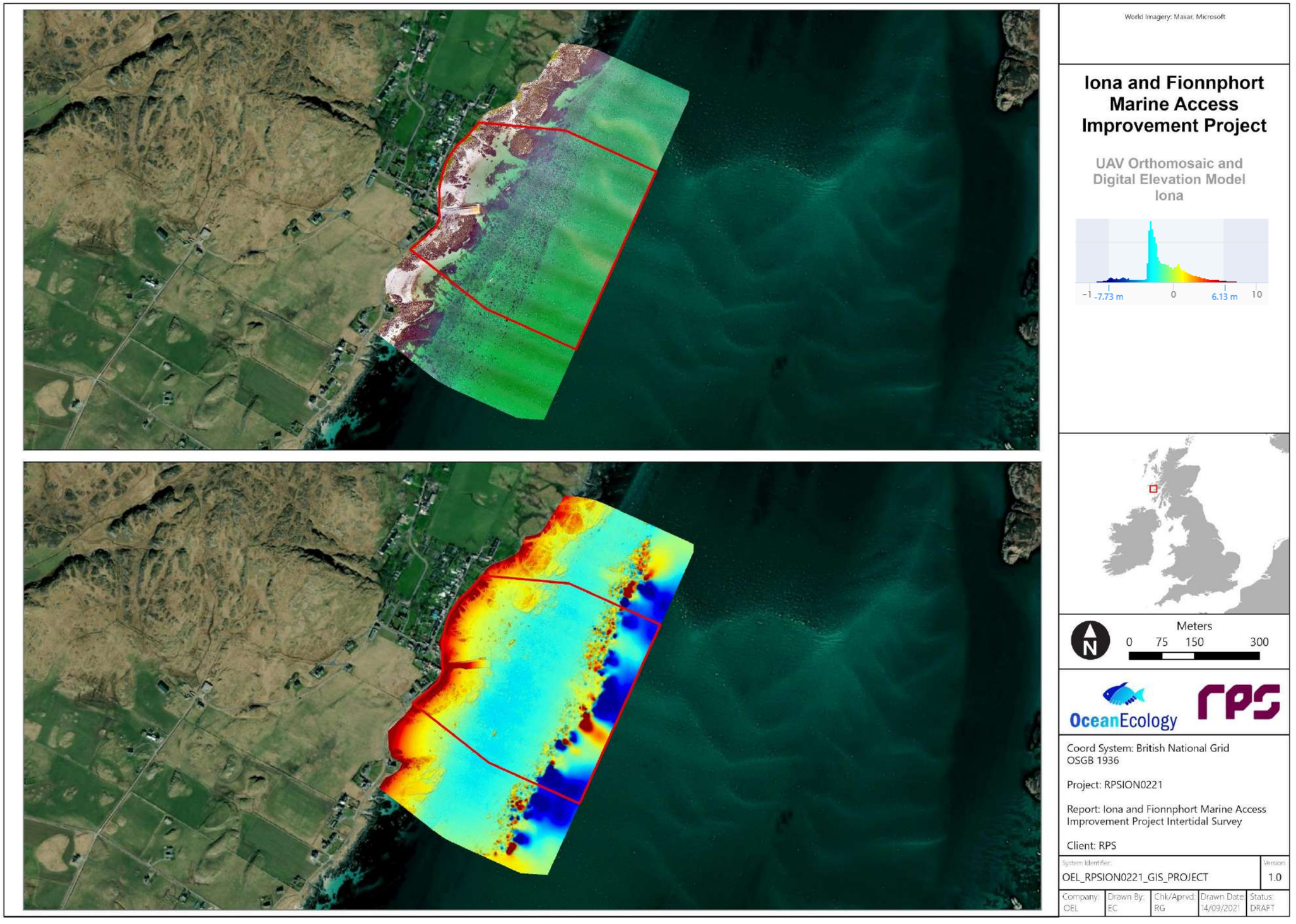

Figure 3 UAV orthomosaic (top) and Digital Elevation Model (DEM) (bottom) generated from the UAV imagery collected during the intertidal survey of Iona survey area.

4.3. Phase I Sampling

In total, target notes and quadrats were taken at 178 locations (92 at Fionnphort and 86 at Iona) to provide localised information on habitats and features of interest present across the intertidal areas and assign EUNIS classifications *in situ* to assist in ground truthing of UAV aerial imagery (Figure 4 and Plate 2).

Plate 2 Top left: Quadrat at Fionnphort. Top Right: High energy rocky sore at Fionnphort (Object ID 73). Bottom left: Quadrat at Iona, Bottom right: High energy rocky shore covered in seaweeds at Iona (Object ID 18)

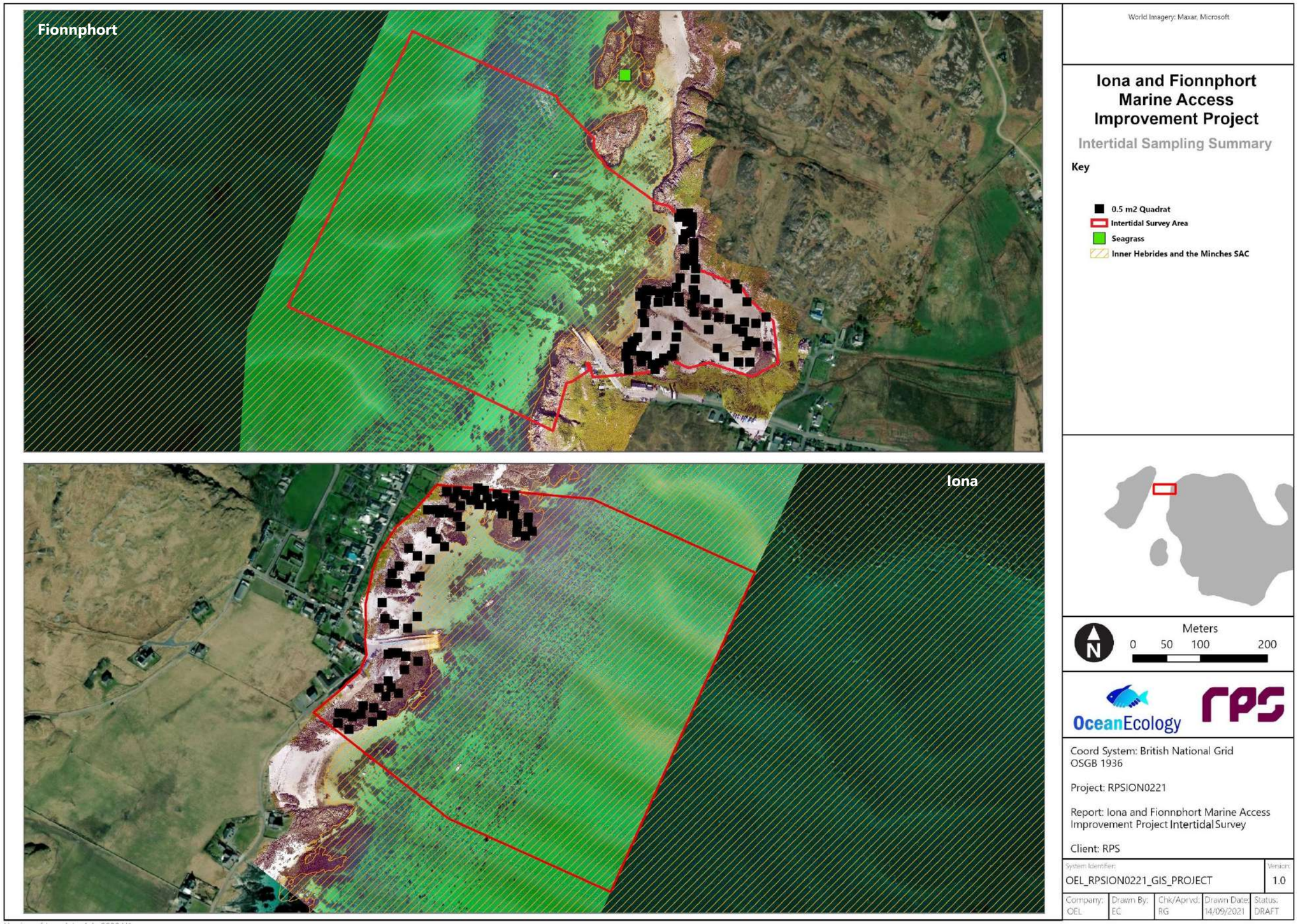

Figure 4 Location of target notes and quadrats collected across the Fionnphort (top) and Iona (bottom) survey areas.

4.4. Habitat / Biotope Mapping

4.4.1. Fionnphort

There was a total of 15 unique biotopes (EUNIS level 5 or above) from the 10 Broad Scale Habitats (BSH) (Table 2) observed across the Fionnphort survey area as mapped in Figure 5. The designation status of each is set out in Table 2 and discussed further in Section 5.

The upper shore was characterised by a wide strandline (A2.21) narrowing towards the north followed by a wide area of littoral sand and muddy sand (A2.2) grading into rocky habitats closer to the MLWS mark (A1.1, A1.2 and A1.3). The flanks of the survey area were bordered by rock cliffs and ledges covered in lichens (B3.11) in some areas. The portion of the survey area south of the existing slipway was dominated by a range or rocky habitats and biotopes (Table 2, Figure 5 and Plate 3).

A north to south zonation as well as a seaward gradient characterised the Fionnphort survey area. High to moderate energy rocky habitats (A1.1 and A1.2) were encountered at the north and south ends of the survey area grading from rocks dominated by mussel and/or barnacle (A1.1131) to rocks dominated by *Pelevetia caniculata* (A1.211), *F. spiralis* (A1.212) *F. serratus* (A1.214). The central portion of the Fionnphort survey area was characterised by sand and muddy sand (A2.22) in the upper shore grading into sand supporting polychaetes (A2.231) as well as *Macoma balthica* and *Arenicola marina* (A2.241) in the mid to lower shore. Patches of rock habitats of varying exposures as well as intertidal mixed sediments (A2.43) were scattered across the central portion of the survey area, including low energy rock habitats covered by *P. caniculata* (A1.311) and *F. spiralis* (A1.312).

A summary of EUNIS classifications recorded during the walkover survey is provided in Appendix I while the full set of intertidal photographs collected across the Fionnphort survey area provided as Appendix III. The EUNIS classification presented in Figure 5 is provided as Appendix IV in shapefile (.shp) format.

Table 2 Key EUNIS classifications recorded across the Fionnphort survey area.

EUNIS BSH	EUNIS Code	EUNIS Description	Designation Status
A1.1 - High energy littoral rock	A1.1131	*Semibalanus balanoides, Patella vulgata* and *Littorina* spp. on exposed to moderately exposed or vertical sheltered eulittoral rock	
	A1.1133	*Semibalanus balanoides* and *Littorina* spp. on exposed to moderately exposed eulittoral boulders and cobbles	'Littoral Rock: Intertidal boulder communities' Habitat of Principle Importance (Nature Conservation (Scotland) Act 2004)
	A1.12	Robust fucoid and/or red seaweed communities	
A1.2 - Moderate energy littoral rock	A1.211	*Pelvetia canaliculata* and barnacles on moderately exposed littoral fringe rock	
	A1.212	*Fucus spiralis* on full salinity exposed to moderately exposed upper eulittoral rock	
	A1.214	*Fucus serratus* on moderately exposed lower eulittoral rock	
	A1.2142	*Fucus serratus* and under-boulder fauna on exposed to moderately exposed lower eulittoral boulders	'Littoral Rock: Intertidal boulder communities' Habitat of Principle Importance (Nature Conservation (Scotland) Act 2004)
A1.3 - Low energy littoral rock	A1.31	Fucoids on sheltered marine shores	
	A1.311	*Pelvetia canaliculata* on sheltered littoral fringe rock	
	A1.312	*Fucus spiralis* on sheltered upper eulittoral rock	
A1.4 – Features of littoral rock	A1.45	Ephemeral green or red seaweeds (freshwater or sand-influenced) on non-mobile substrata	
A2.1 – Littoral Coarse sediment	A2.11	Shingle (pebble) and gravel shores	
A2.2 – Littoral sand and muddy sand	A2.21	Strandline	
	A2.231	Polychaetes in littoral fine sand	
	A2.241	*Macoma balthica* and *Arenicola marina* in muddy sand shores	
A2.4 - Littoral mixed sediment	A2.43	Species-poor mixed sediment shores	
B3 - Rock cliffs, ledges and shores, including the supralittoral	B3.11	Lichens or small green algae on supralittoral and littoral fringe rock	'Supralittoral rock' Habitat of Principle Importance (Nature Conservation (Scotland) Act 2004)
J4.5	-	Hard-surfaced areas of ports	

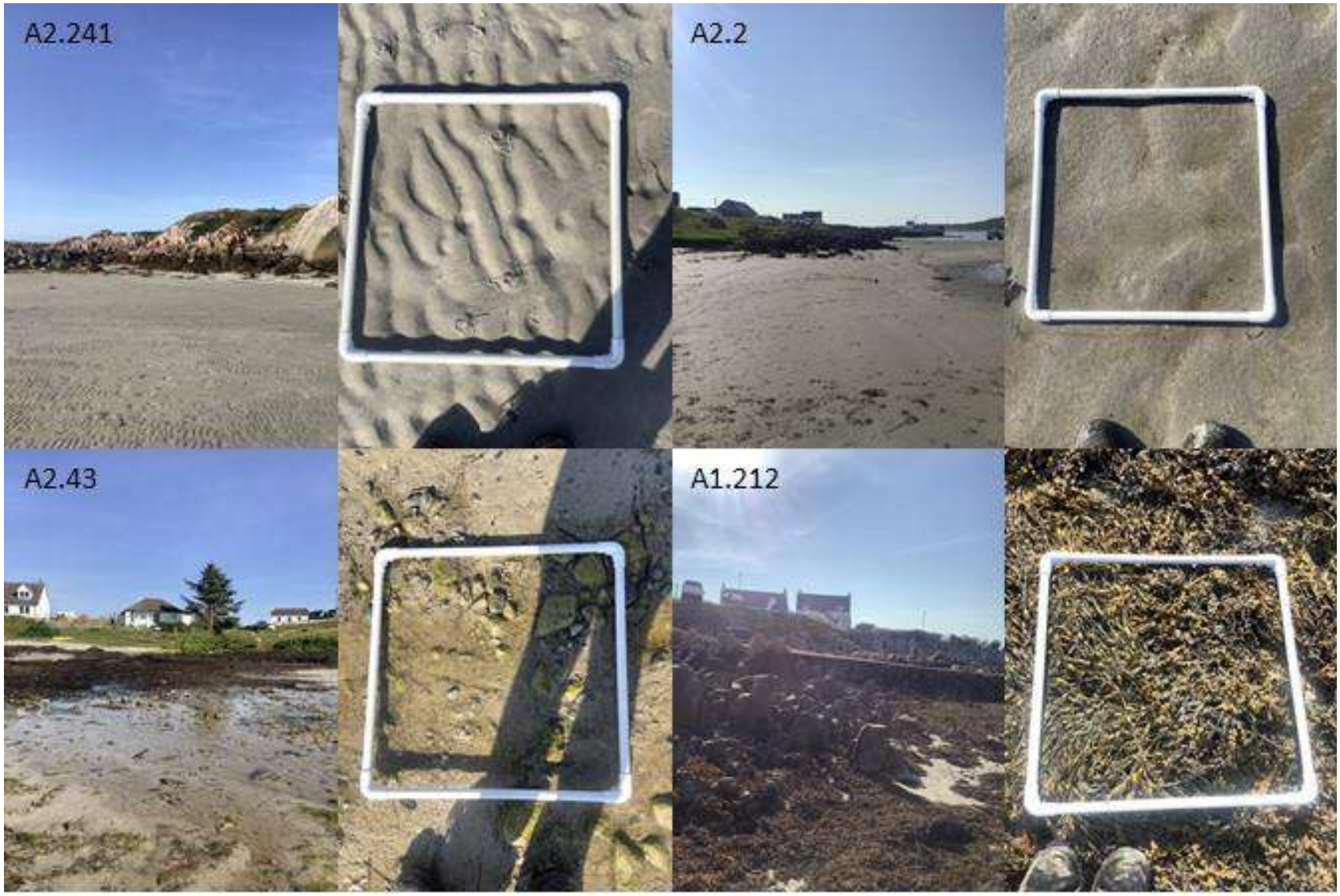

Plate 3 Example images of the main habitats/biotopes encountered across the Fionnphort survey area.

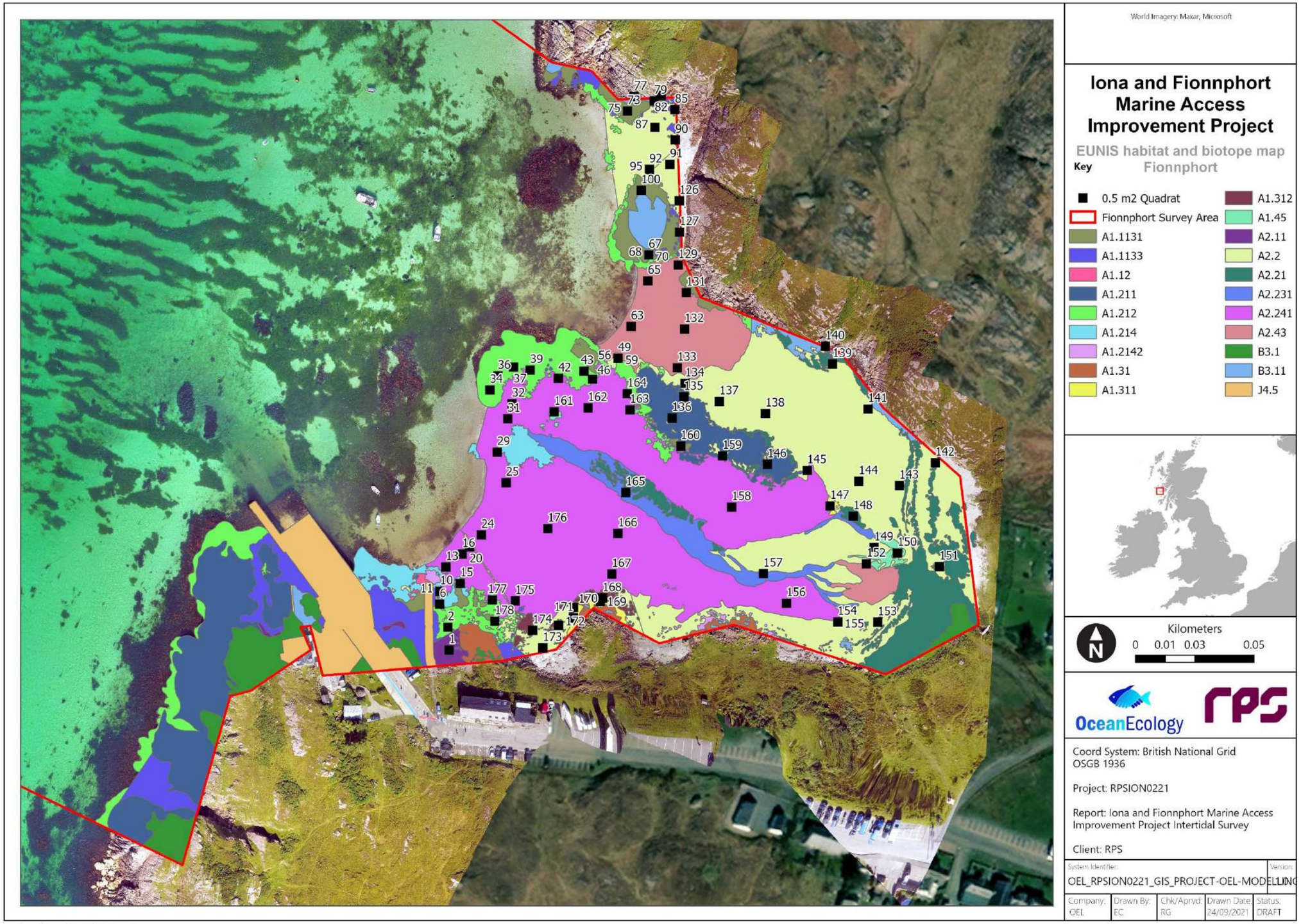

Figure 5 EUNIS habitat and biotope mapping with sampling locations visited during the intertidal survey of the Fionnphort survey area overlain on the orthomosaic derived from UAV imagery.

4.4.2. Iona

There was a total of 18 unique biotopes (EUNIS level 5 or above) from the 13 BSH (Table 3) observed across the Iona survey area as mapped in Figure 6. The designation status of each is set out in Table 3 and discussed further in Section 5.

The majority of the Iona survey area was characterised by high to moderate energy littoral rock habitats (A1.1 and A1.2) and sand and muddy sand (A2.2). The portion of the survey area closer to land was fringed by supralittoral and littoral fringe rock covered in lichens or small green algae (B3.11); while moving down the shore, the middle shore was interspersed with rocky habitats of different exposures (e.g., A1.2 and A1.3), littoral sand and mixed sediments (A2.4), with the lower and extreme lower shores dominated by sand and including patches of both rocks and sediments covered kelp and seaweed communities (A3.21 and A5.52). Barren littoral shingle (A2.111) was patchy in extent and mostly localised in the upper shore of the northern reaches of the survey area and just south of the existing slipway (Table 3, Figure 6 and Plate 4).

A clear zonation characterised the portion of the Iona survey area north of the existing slipway where lichens or green algae occurred on supralittoral and littoral fringe rock (B3.11) giving way in the upper to middle shore to exposed bedrock and large boulders representative of biotopes A1.1131 and A1.1133 with fucoids present in the fissures and crevices of the bedrock (A1.1132). The middle to lower shore comprised of sand (A2.2) with a mosaic of rocky habitats covered in fucoids, including *F. serratus* (A1.2141 and A1.2142), *Pelvetia caniculata* (A1.211) and *Himanthalia elongata* (A1.123), most frequent in the northern reaches of the survey area. The low and extremely low shore was dominated by sand with patches covered in kelp (*L. digitata*) and seaweeds (A5.52) in the central part, while kelp on rock (A3.21) was present to the north (Figure 6). South of the existing slipway, the survey area was mostly dominated by rock habitats, yet showing a similar zonation as that observed north of the pier, with the notable difference that a much wider area of rock covered by fucoids was present extending to the mid and lower shore (A1.2141) while sand was more confined.

A summary of EUNIS classifications recorded during the walkover survey is provided in Appendix I while the full set of intertidal photographs collected across the Iona survey are provided as Appendix III. The EUNIS classification presented in Figure 6 is provided as Appendix IV in shapefile (.shp) format.

Table 3 Key EUNIS classifications recorded at Iona.

EUNIS BSH	EUNIS Code	EUNIS Description	Designation Status
A1.1 - High energy littoral rock	A1.1131	*Semibalanus balanoides, Patella vulgata* and *Littorina* spp. on exposed to moderately exposed or vertical sheltered eulittoral rock	
	A1.1132	*Semibalanus balanoides, Fucus vesiculosus* and red seaweeds on exposed to moderately exposed eulittoral rock	
	A1.1133	*Semibalanus balanoides* and *Littorina* spp. on exposed to moderately exposed eulittoral boulders and cobbles	'Littoral Rock: Intertidal boulder communities' Habitat of Principle Importance (Nature Conservation (Scotland) Act 2004)
	A1.123	*Himanthalia elongata* and red seaweeds on exposed lower eulittoral rock	
A1.2 - Moderate energy littoral rock	A1.211	*Pelvetia canaliculata* and barnacles on moderately exposed littoral fringe rock	
	A1.2141	*Fucus serratus* and red seaweeds on moderately exposed lower eulittoral rock	
	A1.2142	*Fucus serratus* and under-boulder fauna on exposed to moderately exposed lower eulittoral boulders	'Littoral Rock: Intertidal boulder communities' Habitat of Principle Importance (Nature Conservation (Scotland) Act 2004)
A1.3	-	Low energy littoral rock	
A1.4 – Features of littoral rock	A1.421	Green seaweeds (*Enteromorpha* spp. and *Cladophora* spp.) in shallow upper shore rockpools	
A2.1 – Littoral Coarse sediment	A2.111	Barren littoral shingle	
A2.2 – Littoral sand and muddy sand	A2.21	Strandline	
	A2.22	Barren or amphipod-dominated mobile sand shores	
	A2.24	Polychaete/bivalve-dominated muddy sand shores	
A2.4 – Littoral mixed sediment	A2.43	Species-poor mixed sediment shores	
A2.8 – Features of littoral sediment	A2.82	Ephemeral green or red seaweeds (freshwater or sand-influenced) on mobile substrata	
A3.2 - Atlantic and Mediterranean	A3.21	Kelp and red seaweeds (moderate energy infralittoral rock)	Potential PMF Kelp bed

EUNIS BSH	EUNIS Code	EUNIS Description	Designation Status
moderate energy infralittoral rock			
A5.5 - Sublittoral macrophyte-dominated sediment	A5.52	Kelp and seaweed communities on sublittoral sediment	Potential PMF Kelp and seaweed communities on sublittoral sediment
B3 - Rock cliffs, ledges and shores, including the supralittoral	B3.11	Lichens or small green algae on supralittoral and littoral fringe rock	'Supralittoral rock' Habitat of Principle Importance (Nature Conservation (Scotland) Act 2004)
I2.2	-	Small-scale ornamental and domestic garden areas	
J4.5	-	Hard-surfaced areas of ports	

Plate 4 Example images of the main habitats/biotopes encountered at Iona.

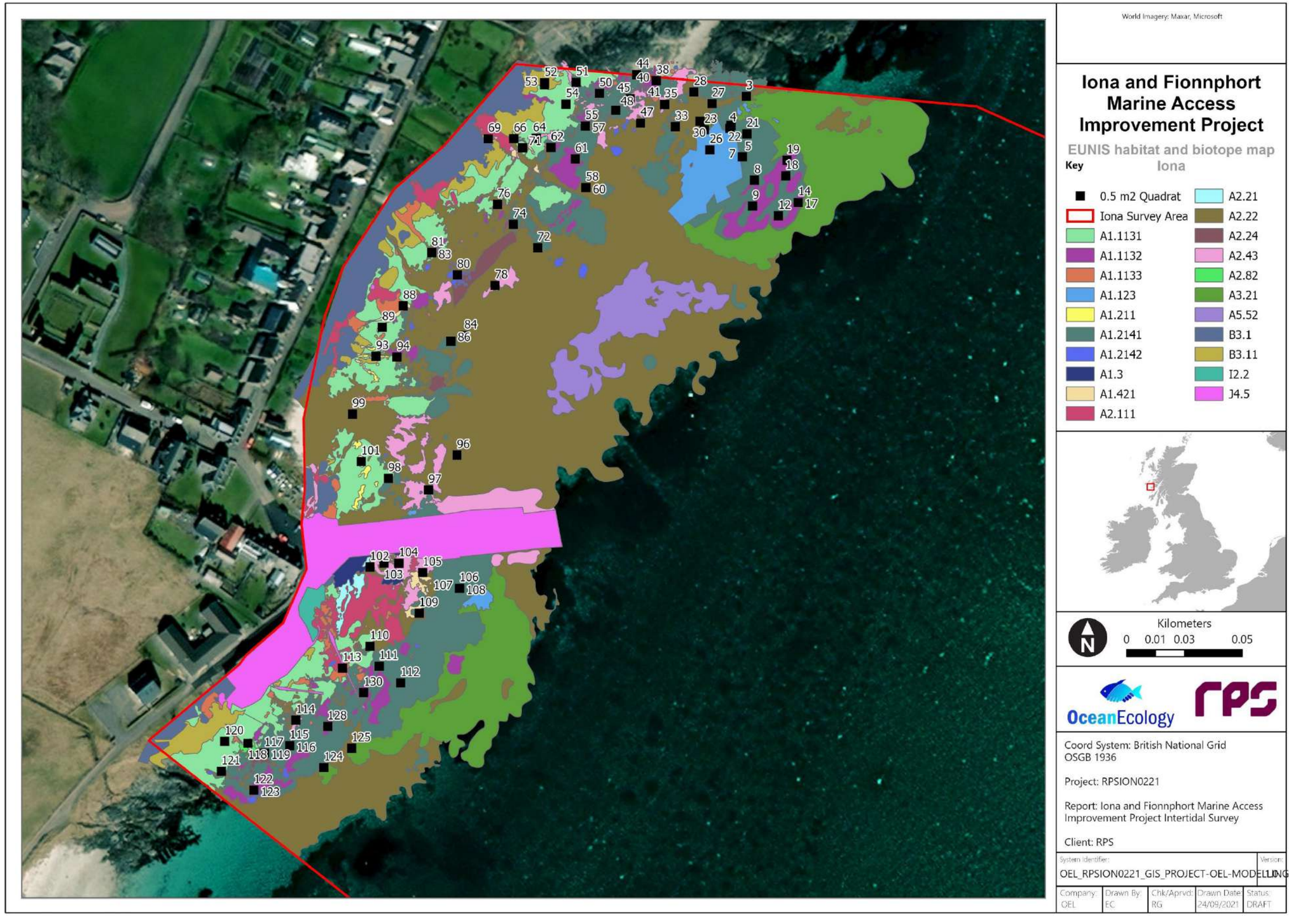

Figure 6 EUNIS habitat and biotope mapping with sampling locations visited during the intertidal survey of the Iona survey area overlain on the orthomosaic derived from UAV imagery.

4.5. Features of Interest

4.5.1. Habitats of Principle Importance

A number of habitats have been identified as being the most threatened and requiring conservation action under Section 2(4) of the Nature Conservation (Scotland) Act 2004. Habitats assigned to EUNIS classification B3.1 and B3.11 were deemed to be included under 'Supralittoral rock: Maritime Cliff and Slopes' on this list. Similarly, biotopes assigned EUNIS classification A1.1133 and A1.2142 were deemed to be representative of 'Littoral Rock: Intertidal boulder communities' under Section 2(4) of the Nature Conservation (Scotland) Act 2004.

4.5.2. Seagrass Bed (PMF)

Detached seagrass shoots were recorded at quadrat locations 16 and 133 either side of the wide area of sand in the central portion of the Fionnphort survey area (Plate 5 and Figure 5). These were not deemed to meet the criteria of seagrass beds and therefore were not mapped (Lancaster et al. 2014; OSPAR 2009). However, from review of the UAV imagery covering the shallow subtidal areas it was clear seagrass was present across large shallow subtidal portions of the survey area at both sites (Iona and Fionnphort) as mapped as part of the subtidal benthic survey reported separately.

Plate 5 Dettached seagrass shoots recorded at quadrat locations 16 and 133 within the Fionnphort survey area.

4.5.3. Kelp Beds and Kelp and seaweed communities on sublittoral sediment (PMFs)

Kelp was observed at quadrat location 33 (Plate 6) and noted at target point 12 both located in the northern reaches of the Iona survey area. Additionally, kelp was also recorded in a few UAV images as mapped in Figure 6. However, these observations alone were not enough to confidently define the boundaries and extent of these features (low confidence scores) potentially representative of kelp bed habitats (Table 2 and Table 3). Due to the subtidal nature of kelp habitats, the assessment of these features has been carried out in detail as part of the subtidal benthic assessment reported separately.

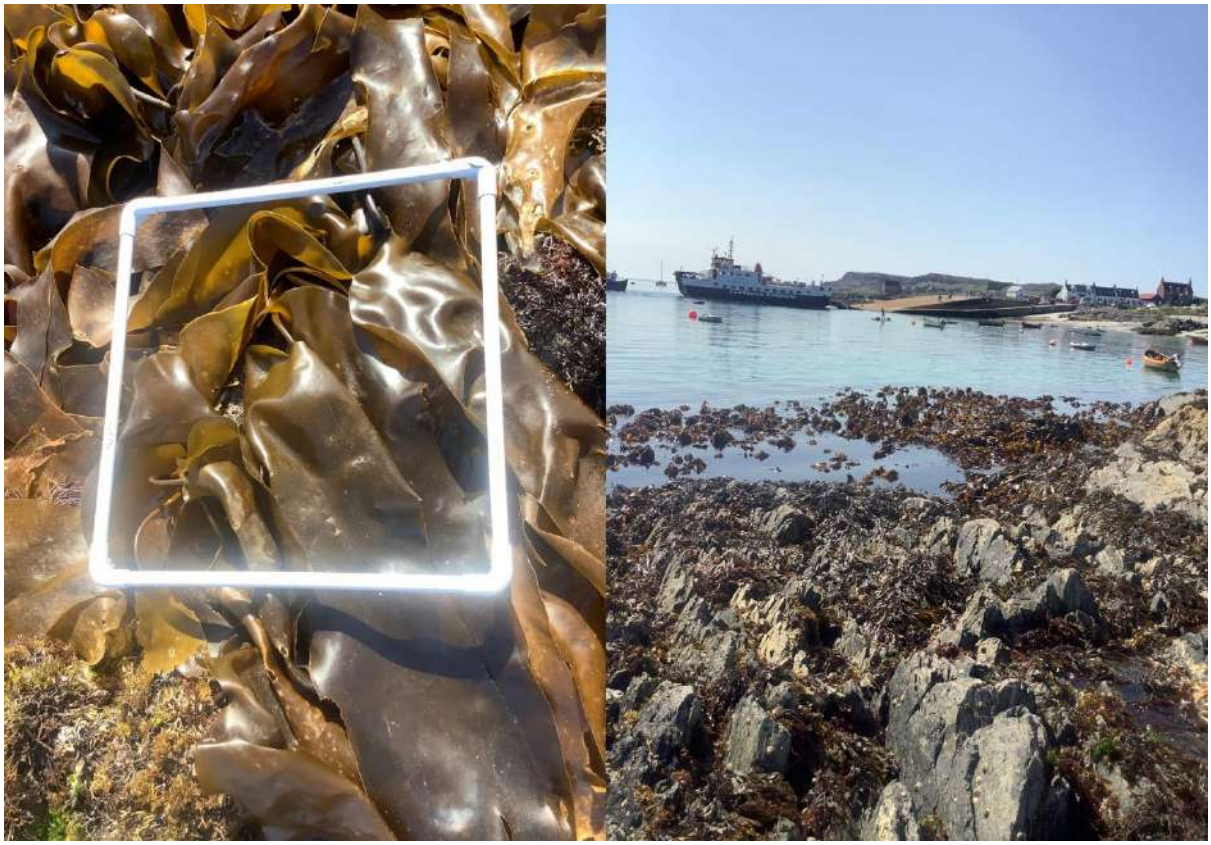

Plate 6 Kelp – *Laminaria digitata* Left: object ID 33. Right: target point 12 Southern aspect.

4.5.4. Annex I Habitats

Both survey areas were characterised by large areas of rocky habitats comprising a mosaic of exposed bedrock, boulders and cobbles; these were deemed to be representative of different biotopes spanning from high to low energy rock habitats with some supporting a variety of fucoids and other seaweeds.

Despite the EUNIS rock classifications assigned during these surveys in the mid to lower shore falling within the boundary of the Inner Hebrides and the Minches Marine SAC, the site is not designated to protected benthic features meaning that the EUNIS rock classifications meeting the qualifying criteria for Annex I bed rock reef habitat are not afforded protection under the Habitats Directive. No specific guidelines exist to determine whether intertidal rocky biotopes

correspond to Annex I reefs, however the Marine Habitat Classification for Britain and Ireland (JNCC 2015) states that 'intertidal areas are only included within this Annex I type where they are connected to subtidal reefs'. Based on the habitat mapping presented here not all of the intertidal rocky features extend from the intertidal zone into the subtidal zone, meaning that only some, if any, of these features can be deemed to qualify as Annex I reefs.

Similarly, some of the sandy habitats observed across both survey areas and falling within the boundary of the Inner Hebrides and the Minches SAC could be representative of the Annex I habitat 'mudflats and sandflats not covered by seawater at low tide'. However, as this is not a qualifying feature of the Inner Hebrides and Minches SAC, they are not afford protected by this designation.

4.5.5. Other feature of Interest

No INNS or maerl (dead or alive) were recorded across the two survey areas.

5. Discussion

This report presents the findings and habitat mapping outputs of the intertidal surveys conducted across the Iona and Fionnphort survey areas as part of the intertidal habitat assessment for the Marine Access Improvement Project. The surveys involved the collection of UAV aerial imagery accompanied by an intertidal walkover survey where target field notes and quadrat data were obtained. The key objective was to map the distribution and extent of individual or groups of BSH, biotopes, biotope complexes and life forms present with a focus on confirming the presence/absence of any habitats and/or features of conservation interest across the two sites (e.g. seagrass beds).

An intricate complex of habitats and biotopes characterised the Fionnphort survey area. The flanks of this survey area were bordered by supralittoral rock and ledges above the MHWS mark covered in lichens (EUNIS B3.11) in some areas encasing a wide area of littoral sand and muddy sand (A2.2) in the upper shore, and various rocky habitats and biotopes in the mid to lower shore as well as to the north and south ends of the survey area. These rocky habitats and biotopes included bedrock and large boulder covered in *S. balanoides*, *P. vulgata* and *Littorina* sp. (A1.113) and in *F. serratus* (A1.214).

A clear zonation was observed across the Iona survey area, the full range of which was more evident in the central and northern reaches of this site. This included lichens or small green algae on supralittoral and littoral fringe rock (B3.11) giving way in the upper to mid shore to exposed bedrock and large boulders representative of biotopes A1.1131 and A1.1133. The mid to lower shore comprised of a mosaic of rocky habitats supporting fucoids (e.g. A1.2141 and A1.123) and in the lower shore kelp (A3.21); while the lower shore was mostly dominated by sand (A2.22) with patches covered in *L. digitata* (A5.52) in the extremely low shore. Sediments were more prevalent in the central portion of the Iona survey area where shingle occurred in the upper shore, while mixed sediment occurring in patches across the mid shore supporting occasional rock pools (A1.421).

Both survey areas fall within the boundaries of the Inner Hebrides and the Minches Marine SAC in their component below the MHWS mark. This site is not however designated to protect benthic features meaning that the EUNIS rock classifications meeting the qualifying criteria for Annex I bed rock reef habitat are not afforded protection under the Habitats Directive. Nevertheless, EUNIS classifications B3.1 and B3.11 are included under 'Supralittoral Rock: Cliff and Slopes' on the list of Section 2(4) Habitat of Principal Importance under the Nature Conservation (Scotland) Act 2004. Similarly, EUNIS classification A1.1133 and A1.2142 are listed as 'Littoral Rock: Intertidal Underboulder Communities'.

Of the rock habitats identified across both survey areas, those assigned EUNIS classification B3 and B3.11, and A1.1133 and A1.2142 were included in the list of habitats of principal importance under Section 2(4) of the Nature Conservation (Scotland) Act 2004 as 'Supralittoral

Rock: Marine Cliffs and Slopes' and 'Littoral Rock: Intertidal Underboulder Communities', respectively.

Detached seagrass shoots, probably of *Zostera marina var. angustifolia*, were recorded at two locations on the lower shore within the Fionnphort survey area. This area was not deemed to represent a seagrass bed as the seagrass was not attached to the substrate. However, it should be noted that dense patches of *Z. marina var. angustifolia* were noted during review of the UAV imagery of the shallow subtidal areas covered and confirmed during the subtidal benthic survey reported separately. Seagrass beds are therefore present in the subtidal zone within both survey areas however these beds were not observed to extend into the intertidal zone at either site.

Kelp was identified at two target locations and observed during review of the UAV imagery at the northern end of the Iona survey area. Due to the difficulties encountered in defining the boundaries of these features (low confidence scores), no in-depth assessment on the presence and extent of kelp habitats representative of the PMFs 'kelp beds' and 'kelp and seaweed communities on sublittoral sediment' was carried on in this report. However, the subtidal benthic survey confirmed kelp to be abundant in the subtidal area as reported separately. No maerl beds or INNS were observed across either of the Iona or Fionnphort survey areas.

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APPENDIX 8.3

Subtidal Survey

Ocean Ecology

Marine Surveys, Analysis & Consultancy

Iona & Fionnphort Marine Access Improvement Subtidal Benthic Survey

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Details

Version	Date	Description	Author(s)	Reviewed By
V01	30/09/2021	Draft	Elena Lo Giudice Cappelli, Robyn Jones & Samuel Holmes	Ross Griffin

Updates

Contents

1. Non-Technical Summary

This report presents the findings of a subtidal benthic ecology survey conducted at Iona and Fionnphort for the Marine Access Improvement Project. The key aim was to characterise and map the key benthic habitats present within the subtidal areas within the proposed development areas to inform the drafting of an Environmental Impact Assessment (EIA).

The survey took place at Iona and Fionnphort between the 20th and 23rd of August 2021 and involved the completion of 21 Drop-Down Camera (DDC) stations, 28 DDC transects and collection of 20 grab samples. DDC sampling resulted in the collection of 1,033 still images. Grab sampling stations were micro-sited to avoid the notable seagrass beds that were identified during the in-field interpretation of the seabed imagery collected across both areas.

Sediments within both the Iona and Fionnphort survey areas were found to be dominated by sand, with the majority of sediment samples classified as Slightly Gravelly Sand ((g)S). Mud content was consistently low across both survey areas.

Diverse macrobenthic communities were identified across the survey areas with a total of 2,270 individuals and 336 taxa recorded. The amphipod *Bathyporeia guilliamsoniana* was present in 80% of all macrobenthic samples, while the bivalve *Goodallia triangularis* was the most abundant species recorded, accounting for 15.24% of all individuals. Four distinct macrobenthic groups were identified among sampled stations, with eight of the 20 sampled stations falling into Group D. This group was characterised by the presence of Nematoda, *B. guilliamsoniana,* Nemerteans and *Nephtys cirrosa*. The presence of *B. guilliamsoniana* and *N. cirrosa* and identification of sand dominated sediments led to the classification of sediments under the EUNIS biotope 'A5.233 *Nephtys cirrosa* and *Bathyporeia* spp. in infralittoral sand'.

A total of 11 DDC stations and 15 DDC transects contained areas considered to be representative of the Priority Marine Feature (PMF) 'Seagrass beds', across both the Iona and Fionnphort survey areas, with areas of dense seagrass coverage (76-100%) identified at a six DDC stations and 11 DDC transects. Seagrass extent as well as the percentage cover of seagrass in DDC still images was subsequently mapped. The mapping was based on the seabed imagery interpretation and orthomosaic of the shallow subtidal created using the aerial imagery collected across both survey areas during the corresponding intertidal surveys (OEL, 2021).

The PMFs 'Kelp and seaweed communities on sublittoral sediment' and 'Kelp beds' were also observed and mapped throughout both the Iona and Fionnphort survey areas.

2. Introduction

2.1. Project Overview

Argyll and Bute Council appointed RPS to carry out an expert review of all works undertaken to date and draft a detailed Environmental Impact Assessment (EIA) to support marine access improvement works at Iona and Fionnphort, two sites in the Sound of Iona.

Iona is a small island located west of Mull, on the west coast of Scotland. A ferry service connects Iona to Fionnphort located in the southwest of Mull. Current facilities at both ports need upgrading and improving as difficulties have been identified in their use by all parties operating from each port (e.g., inter-island ferry, fishery and leisure boats). Several feasibility studies (Simoes & Salmon, 2020a, 2020b) have been carried out over the years to propose different options for the Iona and Fionnphort marine access improvement works with the selected projects consisting of a new rock armour breakwater, berthing piles and dredging in Iona and of a new rock armour breakwater, overnight berthing facilities and dredging in Fionnphort (ByrneLooby, 2019).

2.2. Project Background

RPS commissioned Ocean Ecology Limited (OEL) to conduct a subtidal benthic ecology survey within the Sound of Iona to inform the drafting of an Environmental Impact Assessment for Iona and Fionnphort marine access improvements. A Drop-Down Camera (DDC) survey was undertaken involving the collection of seabed imagery (video and still images) across two transect grids located at both Iona and Fionnphort survey areas (Figure 1). The seabed imagery underwent detailed analysis to provide an understanding of the key benthic habitats present within the subtidal areas with a particular focus on Priority Marine Features (PMFs). Additionally, subtidal macrobenthic and sediment samples were collected at 20 sampling stations (10 stations at each sampling site) using a grab sampler to help characterise the sediment habitats. The samples underwent macrobenthic and particle size distribution (PSD) analysis allowing for the production of a full coverage habitat/biotope map for the two survey areas when considered alongside the seabed imagery and aerial imagery collected during corresponding intertidal surveys (OEL, 2021).

2.3. Current Understanding

Nature Scot (previously Scottish Natural Heritage) identified a number of benthic habitats and marine species as PMFs (Tyler-Walters et al., 2016). Several of these important and sensitive habitats are known to occur around the West coast of Scotland (Fuller, 1999; NatureScot, 2021) and have the potential to occur within or near the survey area.

Existing habitat mapping obtained from the European Marine Observation and Data Network (EMODnet) and the Scottish National Marine Plan Interactive (NMPi) suggests the habitats present within the survey areas primarily consist of intertidal sandy shores with moderate-high energy intertidal rock with the potential of representing PMFs including biogenic habitats like seagrass beds known to occur north of the survey area in Fionnphort (**Error! Reference source not**

found.). Other PMFs that have been recorded on both Isles (Mull and Iona) include kelp and maerl beds which could potentially occur within the survey area.

The Sound of Iona lies within the boundaries of the Inner Hebrides and the Minches Special Area of Conservation (SAC) designated to protect harbour porpoises (*Phocena phocena*) as per Annex II of the Habitat Directive (The Council Directive 92/43/EEC).

2.3.1. Seagrass Beds

Seagrasses (also known as eelgrass) are marine flowering plants found in shallow coastal areas down to 10 m, often growing in dense beds or meadows. The plants can be annual or perennial and stabilise the sediment, creating productive habitats that provide shelter and food for a wide variety of plants and animals (including other species of conservation importance and commercially valued fish species), as well as being important for carbon sequestration.

Seagrass 'beds' formed by the genus *Zostera* are generally classed as having plant densities that provide at least 5% cover (OSPAR, 2009). Typically, *Zostera* spp. plant densities provide greater than 30% cover and in favourable conditions, extensive beds may form with up to 95% cover (Lancaster et al., 2014). A minimum area of 5 m x 5 m with at least 5% cover of *Zostera* spp. is required to qualify as a seagrass bed.

Zostera spp. beds are usually found in sands and muds from the upper shore down to 10 m, in areas at least moderately sheltered from wave action such as sea lochs, inlets, bays, sounds, channels and lagoons. *Z. marina* is predominantly subtidal, whilst the narrow-leaved variant, *Z. marina var. angustifolia*, can occur in the shallow subtidal and intertidally on the mid to lower shore. Meadows of seagrass formed by either or both species are protected in Scotland through designations as the PMF broad habitat 'Seagrass Beds' (Tyler-Walters et al., 2016), through inclusion on the OSPAR list of threatened and/or declining species and habitats and as a Section 2(4) Habitat of Principal Importance under the Nature Conservation (Scotland) Act 2004.

A consultation relating to the distribution of PMFs across Scotland reported the presence of *Z. marina var. angustifolia* beds to the north of the Fionnphort survey area whilst a single record from Seagrass Spotter[1] reports the presence of a notable *Z. marina* bed in the shallow subtidal with the potential to extend into the intertidal zone (Figure 1).

2.3.2. Maerl Beds

Maerl is a collective term for several species of red seaweed, with hard, chalky skeletons that grow as unattached rounded nodules or short, branched shapes on the seabed. As a result, maerl can form large beds, where layers of dead maerl build up with a thin layer of pink, living maerl on the top. These beds are a priority habitat under Section 2(4) of the Nature Conservation (Scotland) Act 2004 as they form an important habitat for many different types of marine life, which live

[1] https://seagrassspotter.org/sighting/271

amongst or are attached to the surface of maerl, or burrow in the coarse gravel of dead maerl beneath the top living layer. Maerl beds can be of importance to sustainable fisheries, providing nursery grounds for commercial species of fish and shellfish.

Due to the fragility of maerl, the beds are easily damaged and have probably declined substantially in some areas. Pressures on maerl beds include scallop dredging, bottom trawling, aquaculture, and pollution. Maerl beds are very slow to develop and are unlikely to return if removed or lost. As such, they should be treated as a non-renewable resource.

Maerl beds are granted protection under the EC Directive on the Conservation of Natural Habitats and Wild Fauna and Flora (92/43/ECC), through inclusion on the OSPAR list of threatened and/or declining species and habitats and as the PMF broad habitat 'Maerl Beds' (Tyler-Walters et al., 2016). There are no known existing records of maerl within the Sound of Iona.

2.3.3. Kelp Beds

Beds of the kelps such as *Laminaria hyperborea* and *Laminaria digitata* 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 thrive. A rich diversity of red seaweeds grows among the kelp and on the kelp stipes, while depending on conditions, sea mats and sea firs may colonise the fronds. 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.

Kelp beds occur in shallow waters (to a maximum of 20-30m), on bedrock and boulders in a range of wave exposure regimes and tidal conditions and are protected in Scotland through designation as the PMF broad habitat 'Kelp beds'. There are no existing records of the PMF broad habitat 'Kelp Beds' within the Sound of Iona however this is likely due to the lack of sampling rather than true absence given the rocky subtidal habitats known to occur across the area.

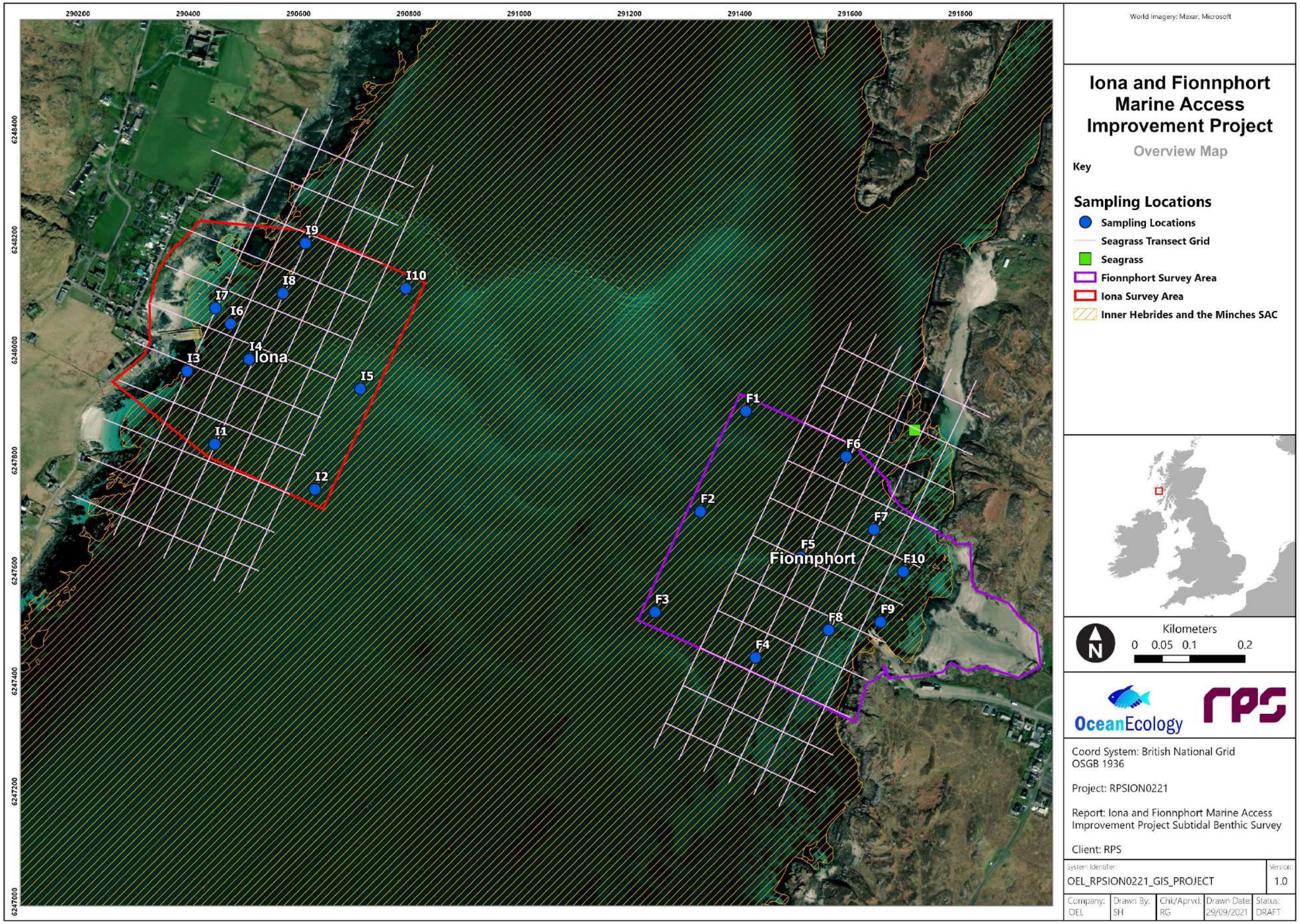

Figure 1 Location of sampling stations and seagrass transect grids within the Fionnphort and Iona survey areas located in the Inner Hebrides and the Minches SAC. Note the existing seagrass bed mapped north of the Fionnphort site.

3. Methods

3.1. Survey Design

Initially, the survey design comprised 20 sampling locations at which seabed imagery was to first be collected following by grab samples. The design was updated following the preliminary in-field review of the seabed imagery collected at these 20 locations. This identified extensive seagrass beds across both sites, requiring greater coverage of each survey area to fully map their extent whilst also allowing for micro-siting of the grab sampling stations as to not damage the seagrass beds. The updated sampling array included two grids of transect across each survey area along which seabed imagery was collected (Figure 1). Ten grab sampling stations were then positioned across each survey area (20 in total) in areas of sediment habitat where seagrass was confirmed to be absent (Figure 1).

3.2. Timings

All seabed imagery was obtained between 20th and 22nd August 2021 followed by the collection of the grab samples on 23rd August 2021 (Figure 1).

3.3. Field Methods

3.3.1. Survey Vessel

All seabed imagery and grab samples were collected aboard OEL's 10.0 m dedicated survey vessel, '*Seren Las*' (**Error! Reference source not found.**). The vessel was equipped with a Hemisphere V104s GPS Compass system that provided an offset position of the DDC and grab sampler when deployed from the stern. This provided a GPS feed to a dedicated survey navigation PC operating TimeZero Navigator v3 marine navigation with routing module and EIVA NaviPac.

Plate 1 Dedicated survey vessel, *Seren Las*, employed for the Iona and Fionnphort subtidal benthic survey.

3.3.2. Seabed Imagery

DDC sampling was undertaken at each target location and along each transect . At each location, video and still imagery was collected throughout the deployment using OEL's height-adjustable freshwater housing camera system providing a variety of options for view, lighting and focal length to maximise data quality with respect to prevailing conditions. Video footage was digitally overlaid with information including project, date, time and dGPS position (as a minimum) and recorded in a digital format to 5 MB or better. A laser scaling array was projected into the field of view to provide a method for determining scale.

Seabed imagery (simultaneous video and stills) was acquired along each DDC transect and at each DDC location using OEL's Rayfin PLE Camera System to collect High Definition (HD) video and high-resolution (up to 21 megapixels (MP)) still images. The camera system (**Error! Reference source not found.**) consisted of a SubC Imaging Rayfin PLE camera, seabed frame equipped with freshwater housing (Jones et al., 2021), two LED strip lights, a 300m umbilical 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 lose power or cause a power surge. The freshwater housing 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 OEL's drop-down camera and deployment frame.

All DDC transects were sampled in line consideration of the JNCC epibiota remote monitoring operational guidelines (Hitchin et al., 2015). Along each DDC transect, a 'bed-hopping' approach was employed to ensure representative imagery is collected along the full transect with still images taken every 5-10m along with continuous video recording. All footage underwent a preliminary review *in situ* by the OEL's marine ecologists.

3.3.3. Grab Sampling

Grab sampling was only conducted once suitable seabed videos and stills of the seabed were collected and no obstructions and/or features of interest (e.g. seagrass beds) were identified. Sampling was conducted using OEL's 0.1m^2 Day grab and sediment samples were collected within 20m of the target sampling location. Single grab samples were collected at each station to obtain approximately 10L of sediment from which a sub-sample of a minimum volume of 500ml was removed for characterisation of the physical nature of the substrate (particle size distribution (PSD) analysis) and frozen on board. The reminder of the sediment sample was sieved onboard over a 1.0mm sieve net, backwashed into a suitable plastic container and preserved in a 10% formalin seawater solution for subsequent macrobenthic analysis in the laboratory.

Pooling of samples was not undertaken. At stations where the initial samples did not achieve the required volume of at least 5L, repeat sampling was carried out until a valid sample was acquired.

3.4. Laboratory & Analytical Methods

On arrival to the laboratory, all samples were logged in and entered into the project database created in OEL's web-based data management application ABACUS in line with in-house Standard Operating Procedures (SOPs) and OEL's Quality Management System (QMS).

3.4.1. Seabed Imagery Analysis

Following the methods described in Section **Error! Reference source not found.**, digital photographic stills and video footage were successfully obtained along all transects and DDC stations and subsequently analysed to aid in the identification and delineation of Broad Scale Habitats (BSH), EUNIS habitats, PMFs and other possible features of interest across the survey areas. Prior to analysis, seabed images were enhanced using the open-source image editing software GNU Image Manipulation Program. 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) latest NMBAQC/JNCC Epibiota Quality Assurance Framework (QAF) guidance and identification protocols.

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. The second stage, "Tier 2", was used to assign percentage cover of reef types by drawing polygons. A full seagrass assessment was carried out on all images during the "Tier 1" stage whereby the percentage cover of seagrass in images was estimated based on the following percentage cover categories: 0, <5, 5-25, 26-50, 51-75 and 76-100% cover. To qualify as the PMF seagrass bed, the area covered by seagrass must have at least 5% coverage (Tyler-Walters et al., 2016). The "Tier 1" analysis also included a full reef habitat assessment on all images to determine whether habitats met the definitions of Annex I reef habitats as detailed in Table 1 and Table 2. 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.

Table 1 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		

Table 2 Characteristics of *Sabellaria* spinulosa reef (Gubbay, 2007).

Characteristic	'Reefiness'			
	Not a Reef	Low	Medium	High
Elevation (cm)	< 2	2 - 5	5 – 10	> 10
Extent (m^2)	< 25	25 – 10,000	10,000 – 1,000,000	> 1,000,000
Patchiness (% Cover)	< 10	10 - 20	20 – 30	> 30

3.4.2. Particle Size Distribution (PSD) Analysis

Particle Size Distribution (PSD) analysis of sediment samples was undertaken by in-house laboratory technicians at OEL's NMBAQC (NE Marine Biological Analytical Quality Control Scheme) participating laboratory, in line with NMBAQC best practice guidance (*NMBAQC's Best Practice Guidance - Particle Size Analysis (PSA) for Supporting Biological Analysis*, 2016).

3.4.2.1. Sample Preparation

Frozen sediment samples were first transferred to a drying oven and thawed at 80°C for at least six hours prior to 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 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 1mm sieve to sort coarse and fine fractions.

3.4.2.2. Dry Sieving

The >1mm fraction was then returned to a drying oven and dried at 80°C for at least 24 hours prior to dry sieving. Once dry, the sediment sample was 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 3.

Table 3. Sieve series employed for Particle Size Distribution (PSD) analysis by dry sieving (mesh size in mm).

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 (63 mm) 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. A further 10 minutes of shaking was undertaken if there was evidence that particles had not been properly sorted.

3.4.2.3. Laser Diffraction

The fine fraction residue (<1mm sediments) was 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. For silty sediments, ultrasound was used to agitate particles and prevent aggregation of fines.

3.4.2.4. Data Merging

The dry sieve and laser data were 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 v8 software.

Sediment were described by their size class based on the Wentworth classification system (Wentworth, 1922) (Table 4). Statistics such as mean and median grain size, sorting coefficient, skewness and bulk sediment classes (percentage silt, sand and gravel) were also derived in accordance with the Folk classification (Folk, 1954).

3.4.2.5. Sediment Classification

Sediment PSD statistics for each sample were calculated from the raw data using Gradistat V8.0 (Blott, 2010) and converted into Broad Scale Habitats (BSH) (EUNIS Level 3) using the adapted Folk trigon (Long, 2006).

Table 4. Classification used for defining sediment type based on the Wentworth Classification System (Wentworth, 1922).

Wentworth Scale	Phi Units (φ)	Sediment Types
>64000 µm	<-6	Cobble and boulders
32000 – 64000 µm	-5 to -6	Pebble
16000 – 32000 µm	-4 to -5	Pebble
8000 – 16000 µm	-3 to -4	Pebble
4000 - 8000 µm	-3 to -2	Pebble

Wentworth Scale	Phi Units (φ)	Sediment Types
2000 - 4000 µm	-2 to -1	Granule
1000 - 2000 µm	-1 to 0	Very coarse sand
500 - 1000 µm	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

3.4.3. Macrobenthic Analysis

All elutriation, extraction, identification and enumeration of the grab samples was undertaken at OEL's NMBAQC scheme participating laboratory in line with the NMBAQC Processing Requirement Protocol (PRP) (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 fresh water, 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 macrobenthos 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 utilised the live link within ABACUS to the WoRMS REST webservice (World Register of Marine Species), to ensure the most up to date taxonomic classifications were recorded. Colonial fauna (e.g. hydroids and bryozoans) were recorded as present (P). For the purposes of subsequent data analysis, taxa recorded as P were given the numerical value of 1.

Following identification, all specimens from each sample were pooled into five major groups (Annelida, Crustacea, Mollusca, Echinodermata and Miscellaneous taxa) in order to measure

blotted wet weight major group biomass to 0.0001g. As a standard, the conventional conversion factors as defined by Eleftheriou & Basford (1989) were applied to biomass data to provide equivalent dry weight biomass (Ash Free Dry Weight, AFDW). The conversion factors applied are as follows:

- Annelida = 15.5 %
- Crustacea = 22.5 %
- Mollusca = 8.5 %
- Echinodermata = 8.0 %
- Miscellaneous = 15.5 %

3.4.3.1. Data Truncation and Standardisation

The macrobenthic species 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.

3.4.3.2. 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 (Team & R Core Team, 2020) and PRIMER v7 (Clarke & Gorley, 2015) software packages. To note that no replicate samples were available for macrobenthic analysis thus no mean values could be calculated per sampling station.

3.4.3.3. 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 was 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. A detailed description of analytical routines is provided in Appendix IV.

3.4.3.4. Determining EUNIS Classifications

Macrobenthic assemblages were characterised based on their community composition, with hierarchical clustering used to identify groupings of sampling stations that could be grouped together as a habitat type or community. Setting these groupings as factors within PRIMER, SIMPER analysis was then applied to identify which taxa contributed the most to the similarity within that community. EUNIS classifications were then assigned based on the latest JNCC guidance (Parry, 2019).

3.4.4. Habitat / Biotope mapping

Habitats and / or biotopes were identified and classified in accordance with the EUNIS habitat classification system, in consideration of JNCC guidance on assigning benthic biotopes (Parry 2019). Classifications were assigned based on the combined analysis of seabed imagery and broad scale habitat (BSH) data derived from both PSD and macrobenthic analyses, alongside existing habitat maps (EMODnet and NMPI). Seabed features were assigned as high-level classification as possible. All habitat / biotope determination was undertaken through consideration of the following:

- Existing habitat mapping (derived from EMODnet and Scotland's NMPI)
- Review and interpretation of seabed imagery
- PSD analysis results for determination of BSH (textual groups, sediment % contribution and mean grain size)
- Macrobenthic analysis results for the assignment of biotope where key and characterising taxa were identified
- Orthomosaic created using the aerial imagery collected across both survey areas during the corresponding intertidal benthic surveys (OEL, 2021).

All the above data sources were then used to manually delineate the boundaries (polygons) of the various habitats and biotopes encountered across the two survey areas. Confidence scores were assigned to all polygons to give an indication of their accuracy. Values ranged from 1 (one data source) to 3 (all data sources) depending on the following:

- Whether ground-truth data (seabed imagery, PSD and/or macrobenthic) 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 either by seabed imagery or thee aerial imagery orthomosaic

The 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.

4. Results

4.1. Sediment Type

All 20 grab samples (10 at each site) were analysed for full particle size classification. Full PSD and summary statistics are provided in Appendices V and VI.

4.1.1. Fionnphort

Sediment types at each of the 10 grab sampling stations as classified by the Folk (1954) classification are illustrated in Figure 2. Each Folk classification was converted to BSH type (EUNIS Level 3) using the adapted Folk triangle (Long, 2006). Despite some variation in sediment types between stations, most stations were dominated by sand. Mud content was overall low, with only 3 stations having mud content between 1% and 3%. Gravel content was variable with station F9 being made up of over 40% of gravel. Six out of 10 stations were dominated by sand and classified as Slightly Gravelly Sand ((g)S) representing EUNIS BSH A5.2 (Sand and Muddy Sand), while three stations were classified as Gravelly Sand (gS) and one as Sandy Gravel (sG, Station F9) representing EUNIS BSH A5.1 (coarse sediment) (Figure 3).

Most stations were classified as moderately to moderately well sorted as they mostly comprised medium to coarse sand while two stations classified as poorly sorted due to the mixed composition of all three principal sediment types (gravel, sand and mud).

4.1.2. Iona

Sediment types at each of the 10 grab sampling station as classified by the Folk (1954) classification are illustrated in Figure 2. Sediments were less variable than at Fionnphort with all stations dominated by sand. Mud content was low, with a maximum of 1.6% at stations I3 and I8. Gravel content was variable with station I9 being made up of over 20% of gravel. Eight out of 10 stations represented EUNIS BSH A5.2 (Sand and Muddy Sand) with two stations being classified as Sand (S) and 8 stations as Slightly Gravelly Sand ((g)S); conversely 2 stations were classified as Gravelly Sand (gS) and represented EUNIS BSH A5.1 (coarse sediment) (Figure 3).

All stations but one classified as moderately to moderately well sorted as they comprised sand with station I9 being classified as poorly sorted due to its relatively high gravel content.

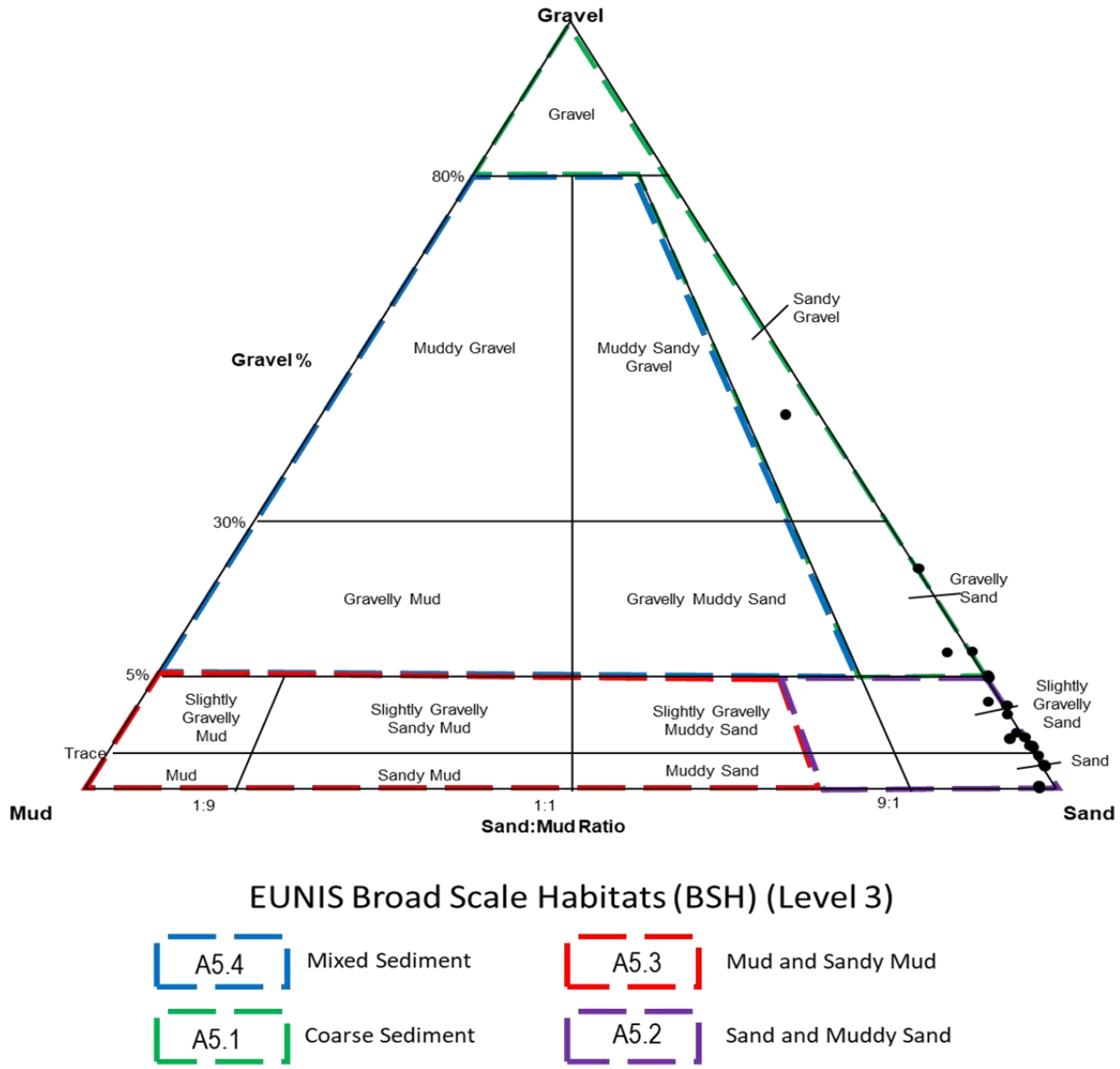

Figure 2 Folk (1954) triangle classifications of sediment gravel percentage and sand to mud ratio of samples collected across the Project Erebus Offshore Floating Wind Farm survey area, overlain by the modified Folk triangle for determination of mobile sediment BSHs under the EUNIS habitat classification system (adapted from (Long, 2006)).

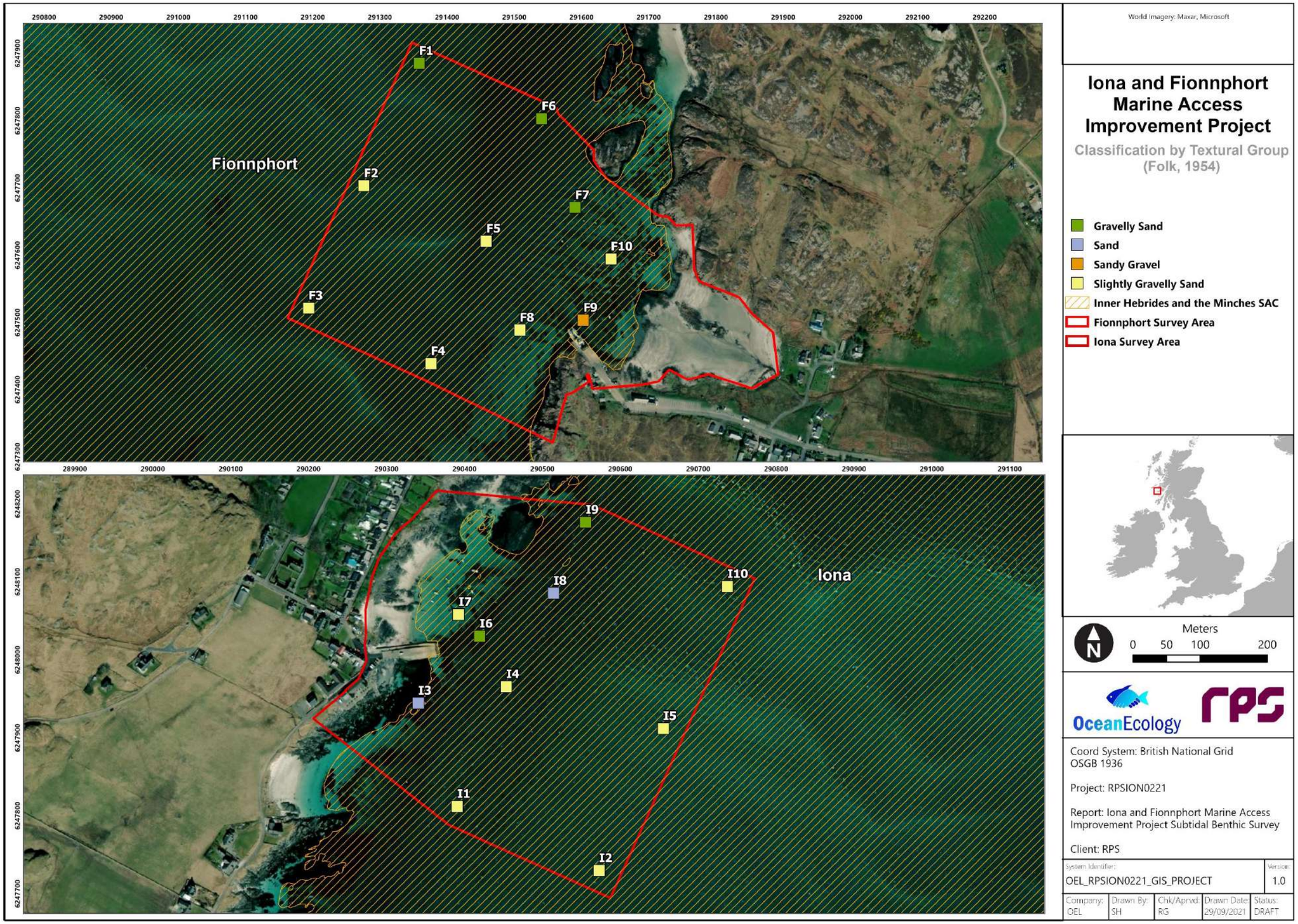

Figure 3 Folk (1954) sediment types as determined from PSD analysis of samples acquired during the survey.

4.2. Sediment Composition

The percentage contribution of gravels (> 2 mm), sands (0.63 mm to 2 mm) and fines (< 63 µm) at each station are presented in Table 5 and Figure 5. Sand was the main sediment fraction present at all stations, comprising the largest percentage contribution across the survey area as a whole. The mean proportion (± Standard Error, SE) of sand across all stations was 93.2 % (± 2.6), while the mean (±SE) mud and gravel content across the survey area was 0.6 % (± 0.2) and 6.2 (± 2.5) respectively. Sand content was greatest at station I5 and the lowest at station F9. The mean grain size at sampling stations ranged from 214.1 µm at station I3 to 1,535.0 µm at station F9 (Figure 4).

Table 5 PSD data of samples collected across the survey area.

Survey Area	Station	Textural Group Classification	Mean µm	Major Sediment Fractions		
				% Gravel	% Sand	% Mud
Fionnphort	F1	Gravelly Sand	572.1	10.4%	89.6%	0.0%
	F2	Slightly Gravelly Sand	509.7	0.4%	99.6%	0.0%
	F3	Slightly Gravelly Sand	487.5	1.4%	98.6%	0.0%
	F4	Slightly Gravelly Sand	565.0	1.9%	98.0%	0.1%
	F5	Slightly Gravelly Sand	626.2	1.3%	98.7%	0.0%
	F6	Gravelly Sand	710.1	6.5%	93.5%	0.0%
	F7	Gravelly Sand	330.4	10.3%	87.7%	2.0%
	F8	Slightly Gravelly Sand	453.6	2.1%	97.3%	0.6%
	F9	Sandy Gravel	1535.0	47.3%	50.0%	2.7%
	F10	Slightly Gravelly Sand	347.2	1.8%	96.9%	1.3%
Iona	I1	Slightly Gravelly Sand	596.3	3.2%	96.4%	0.4%
	I2	Slightly Gravelly Sand	492.1	1.4%	98.5%	0.2%
	I3	Sand	214.1	0.0%	98.4%	1.6%
	I4	Slightly Gravelly Sand	542.9	0.8%	99.2%	0.0%
	I5	Slightly Gravelly Sand	536.0	0.4%	99.6%	0.0%
	I6	Gravelly Sand	550.6	6.1%	93.9%	0.0%
	I7	Slightly Gravelly Sand	243.6	4.0%	94.8%	1.2%
	I8	Sand	235.4	0.0%	98.4%	1.6%
	I9	Gravelly Sand	951.9	24.1%	75.8%	0.1%
	I10	Slightly Gravelly Sand	543.4	3.7%	96.3%	0.0%

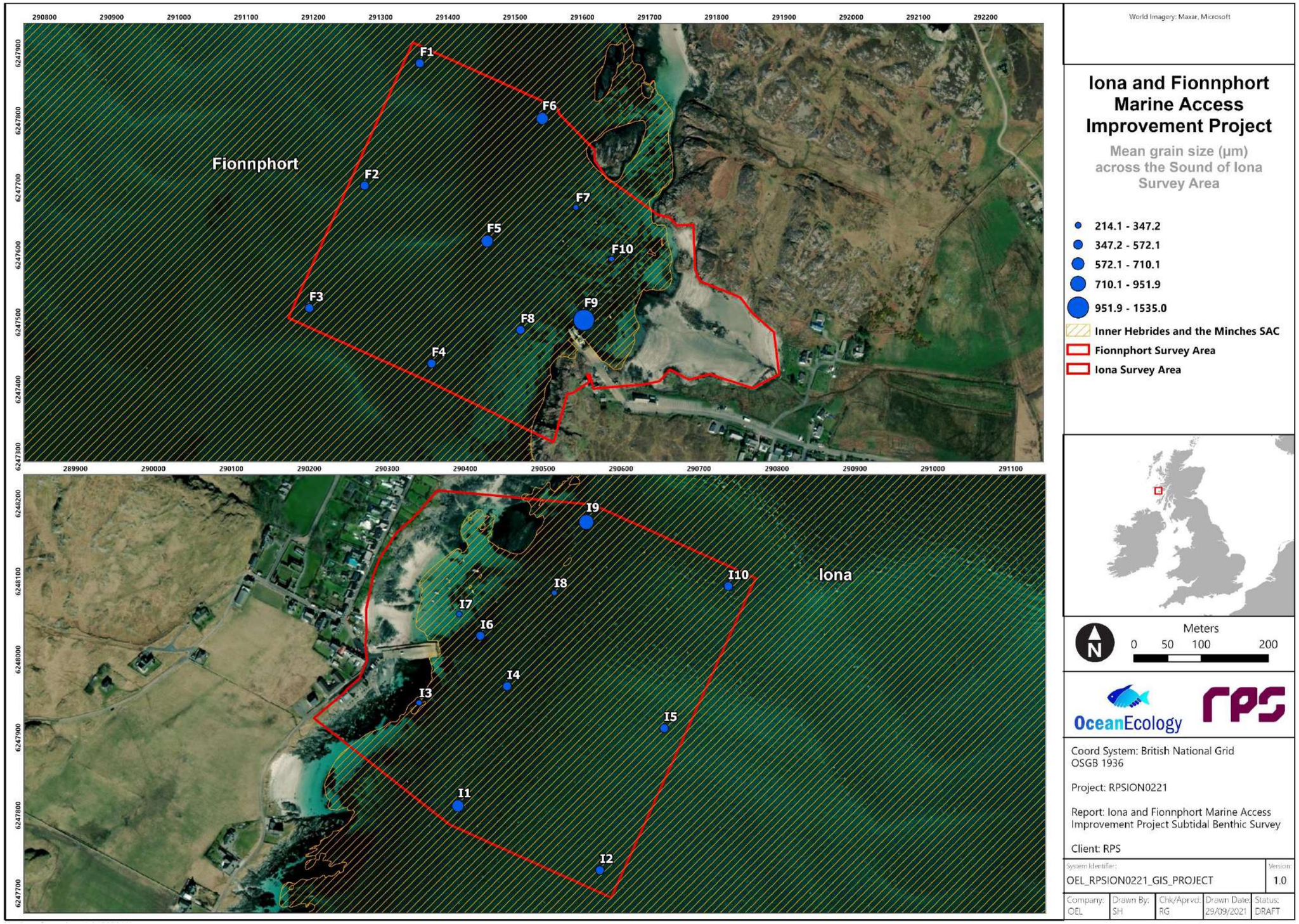

Figure 4 Comparison of mean sediment grain size (µm) of sediment samples collected across the survey area.

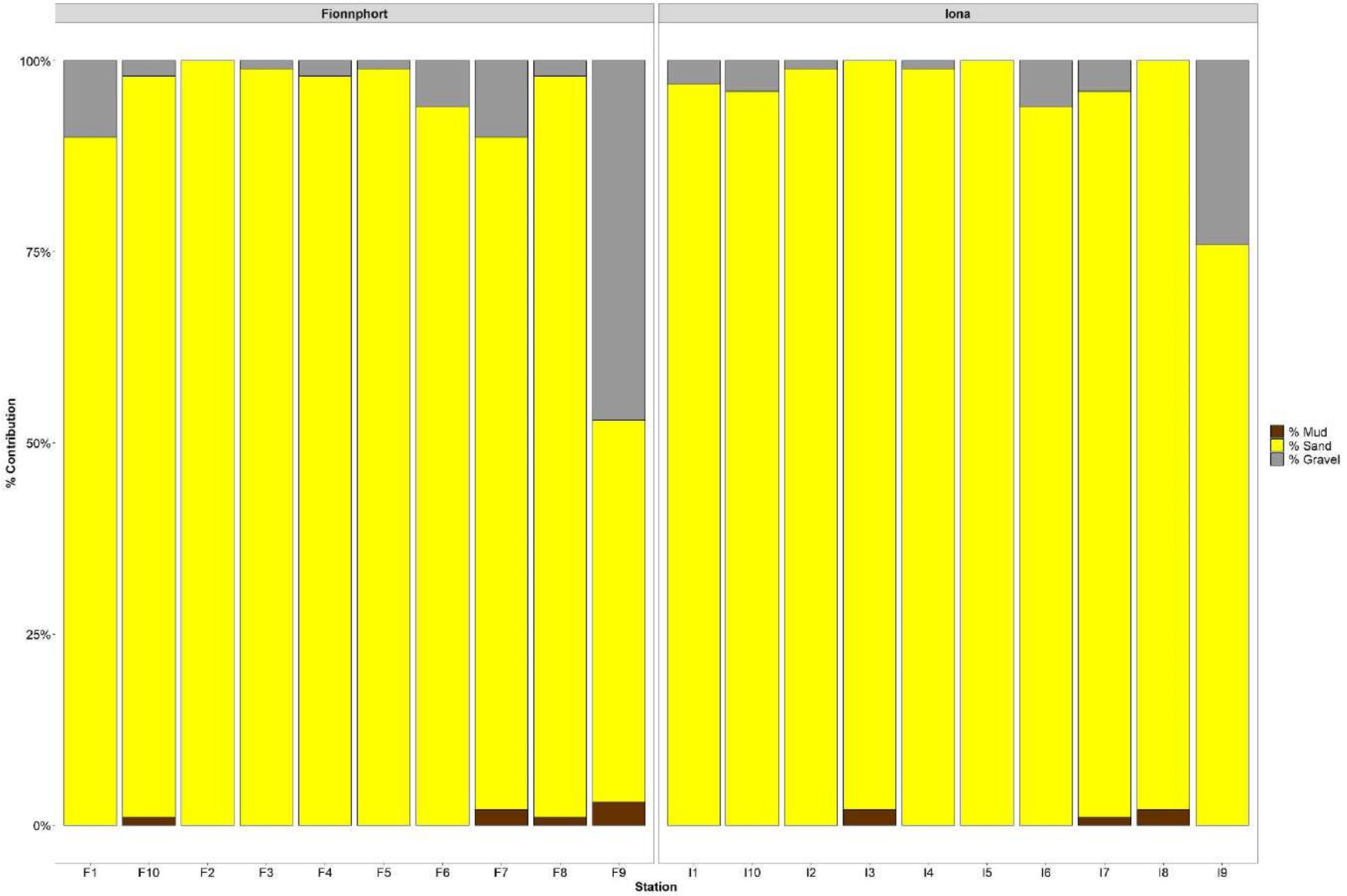

Figure 5 Percentage contribution of gravel, sand and mud at each sampling station across the two survey areas.

4.3. Seabed Imagery Analysis

Seabed imagery was collected at a total of 21 DDC stations and along 28 DDC transects across the two survey areas resulting in the collection of 1,033 still images. Full sample logs are presented in Appendix I and II.

The dominant BSH habitats across both survey sites identified through the analysis of the seabed imagery were A3.1 – High Energy Infralittoral Rock, A5.1 – Subtidal Coarse Sediment, A5.2 – Subtidal Sand and A5.5 - Subtidal Macrophyte Dominated Sediment.

4.3.1. Fionnphort

The DDC stations (F1 to F10) and DDC transects (T_001 to T_004, and T010 to T_016) sampled across the Fionnphort survey area were characterised by the following EUNIS habitats: A3.125 - Mixed kelps with scour-tolerant and opportunistic foliose red seaweeds on scoured or sand-covered infralittoral rock (3 image stills), A5.13 - Infralittoral coarse sediment (4 image stills), A5.23 - Infralittoral fine sand (119 image stills), A5.52 - Kelp and seaweed communities on sublittoral sediment (228 image stills), and A5.5331 - *Zostera marina/angustifolia* beds on lower shore or infralittoral clean or muddy sand (238 image stills) (Figure 6). Example images of these EUNIS habitats identified are presented in **Error! Reference source not found.**.

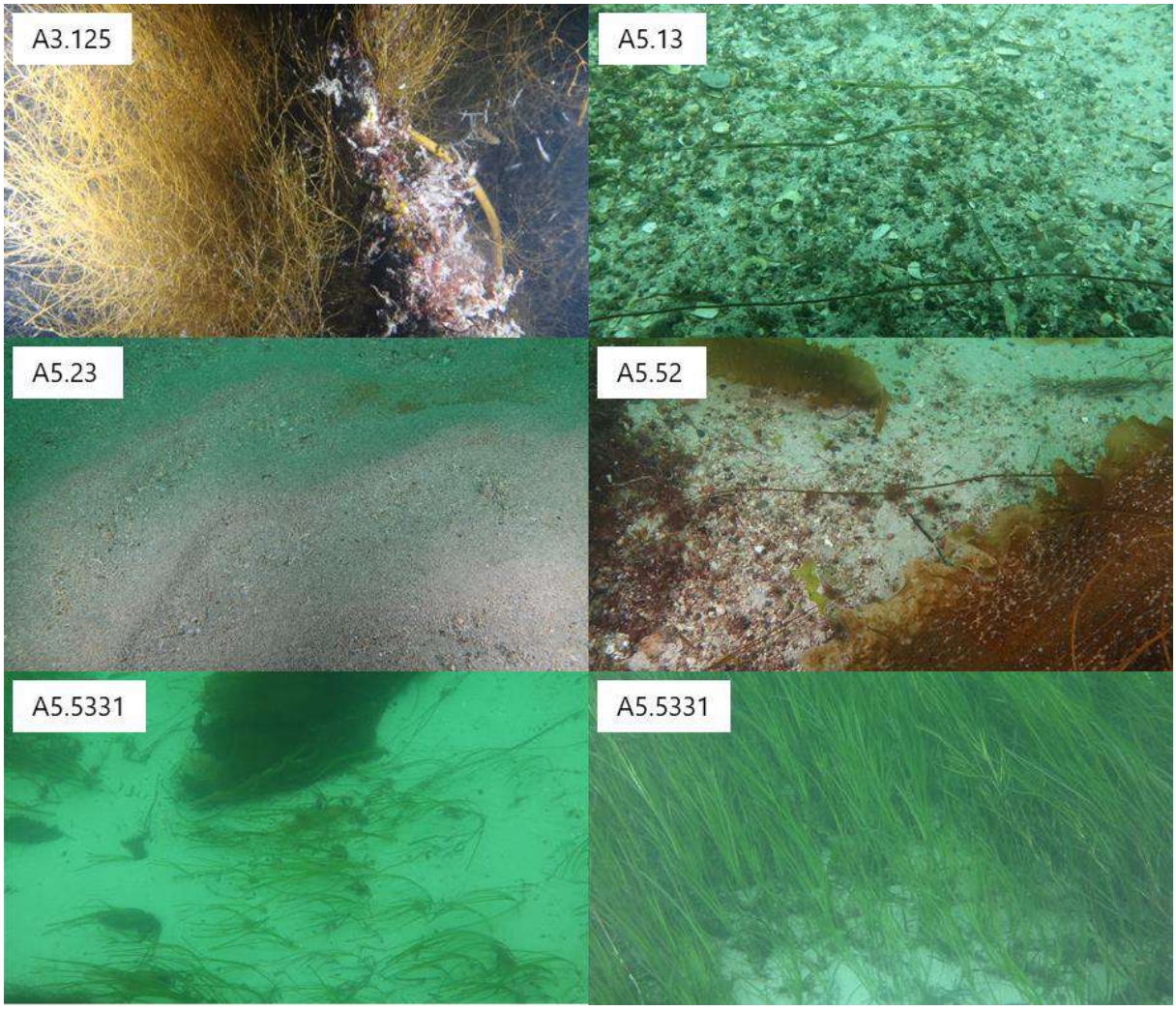

Plate 3 Example imagery of EUNIS classifications identified across the Fionnphort survey area. Bottom images represent PMF seagrass bed: left image 5-25 % seagrass coverage; right image 76-100 % seagrass coverage.

4.3.1.1. Seagrass Assessment

A full seagrass assessment was conducted on all images to determine coverage and whether habitats met the criteria of the PMF 'Seagrass beds' (> 5 % seagrass coverage), the results of which are presented in Table 6.

Table 6 Summary of seagrass assessment for each station and transect across Fionnphort. Numbers indicate number of pictures at each station/transect displaying seagrass.

Station / Transect	Seagrass Beds	Seagrass Cover (%)					
		0	<5	5-25	26-50	51-75	76-100
F1	0	6	0	0	0	0	0
F2	0	5	0	0	0	0	0
F3	0	6	0	0	0	0	0
F4	9	3	2	7	2	0	0
F5	4	5	3	1	1	2	0
F6	0	7	0	0	0	0	0
F7	13	6	1	6	2	2	3
F8	17	7	2	6	5	1	5
F9	15	4	4	3	0	4	8
F10	27	3	0	4	4	9	10
T_001	36	39	5	12	9	6	9
T_002	41	22	9	11	9	10	11
T_003	1	69	0	0	1	0	0
T_004	30	37	1	6	5	7	12
T_010	8	14	0	1	3	3	1
T_011	6	13	6	2	1	1	2
T_012	12	15	0	2	1	1	8
T_013	0	18	0	0	0	0	0
T_014	8	12	0	3	3	0	2
T_015	0	13	0	0	0	0	0
T_016	11	17	0	4	3	0	4
Seagrass	0	11	0	0	0	0	0

Areas considered to be representative of the PMF 'Seagrass beds' were identified across 6 stations and 8 transects within the Fionnphort survey area. Areas of 76-100% seagrass coverage were identified across 4 stations and 7 transects, most extensively at T_002 and T_004 with T_002 recording the highest number of images with seagrass beds present (41) (Figure 7).

4.3.1.2. Annex I Reef Assessment

A full reef habitat assessment was conducted on all images to determine whether habitats met the definitions of Annex I reef habitats as detailed in Table 1. Evidence of bedrock reef was identified in three images across T_004. No evidence of stony or biogenic reef which would qualify as Annex I reef were observed.

4.3.1.3. Other Priority Marine Features

In addition to seagrass beds, the PMFs 'Kelp and seaweed communities on sublittoral sediment' and 'Kelp beds' were also observed in 239 and 2 images respectively across the Fionnphort survey area. Dead maerl was observed across stations F1, F2 and F3, and transects T_003, T_010, T_011, T_012 and T_014.

4.3.2. Iona

The DDC stations (I1 to I10) and DDC transects (T018,T_020, T_024 toT_025 and T_027 to T_032) sampled at the Iona were characterised by the following EUNIS habitats: A3.125 - Mixed kelps with scour-tolerant and opportunistic foliose red seaweeds on scoured or sand-covered infralittoral rock (12 image stills), A5.13 - Infralittoral coarse sediment (15 image stills), A5.23 - Infralittoral fine sand (37 image stills), A5.52 - Kelp and seaweed communities on sublittoral sediment (263 image stills) and A5.5331 - *Zostera marina/angustifolia* beds on lower shore or infralittoral clean or muddy sand (95 image stills) (Figure 6). Example images of these EUNIS habitats identified are presented in Plate 4.

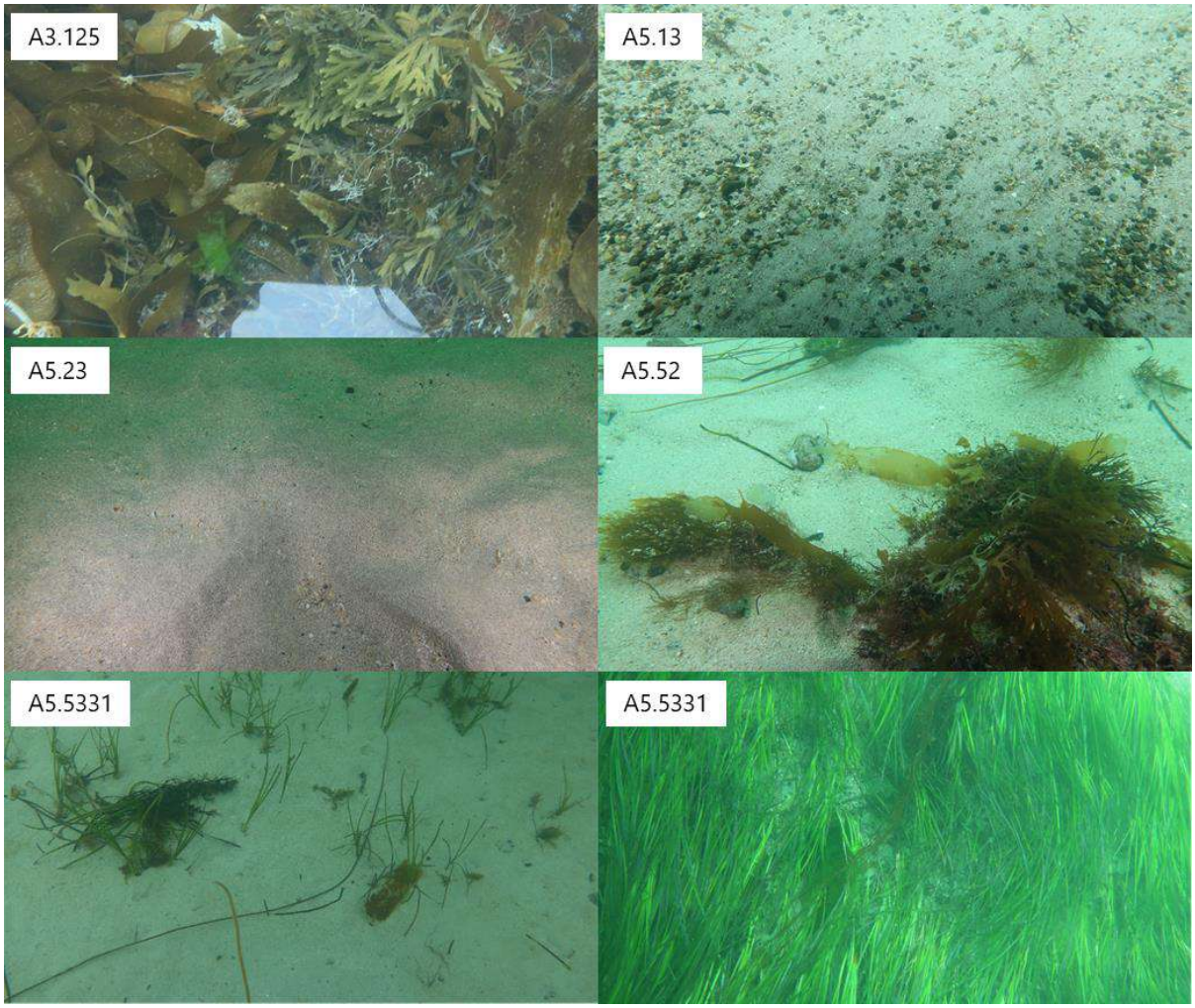

Plate 4 Example imagery of EUNIS classifications identified across the Iona survey area. Bottom images represent the PMF 'seagrass bed': left image 5-25 % seagrass coverage; right image 76-100 % seagrass coverage.

4.3.2.1. Seagrass Assessment

A full seagrass assessment was conducted on all images to determine coverage and whether habitats met the criteria of the PMF 'Seagrass beds' (> 5 % seagrass coverage), the results of which are presented in Table 7.

Table 7 Summary of seagrass assessment for each station and transect across Iona.

Station / Transect	Seagrass Beds	Seagrass Cover (%)					
		0	<5	5-25	26-50	51-75	76-100
I1	0	6	0	0	0	0	0
I2	0	7	0	0	0	0	0
I3	3	17	5	0	1	0	2
I4	5	4	1	0	4	1	0
I5	0	6	0	0	0	0	0
I6	1	5	1	1	0	0	0
I7	6	5	0	4	0	1	1
I8	1	7	1	1	0	0	0
I9	0	6	1	0	0	0	0
I10	0	6	0	0	0	0	0
T_018	13	37	19	3	6	2	2
T_020	32	58	7	11	12	3	6
T_024	7	11	3	2	2	0	3
T_025	4	13	5	4	0	0	0
T_027	0	15	1	0	0	0	0
T_028	13	9	11	3	4	5	1
T_029	0	10	7	0	0	0	0
T_030	5	4	15	2	3	0	0
T_031	0	6	4	0	0	0	0
T_032	5	7	7	2	0	1	2

Areas considered to be representative of the PMF 'Seagrass beds' were identified across 5 stations and 7 transects within the Iona survey area. Areas of 76-100% seagrass coverage were identified across 2 stations and 5 transects, most extensively at T_020 with this transect also recording the highest number of images with seagrass beds present (32) (Figure 7).

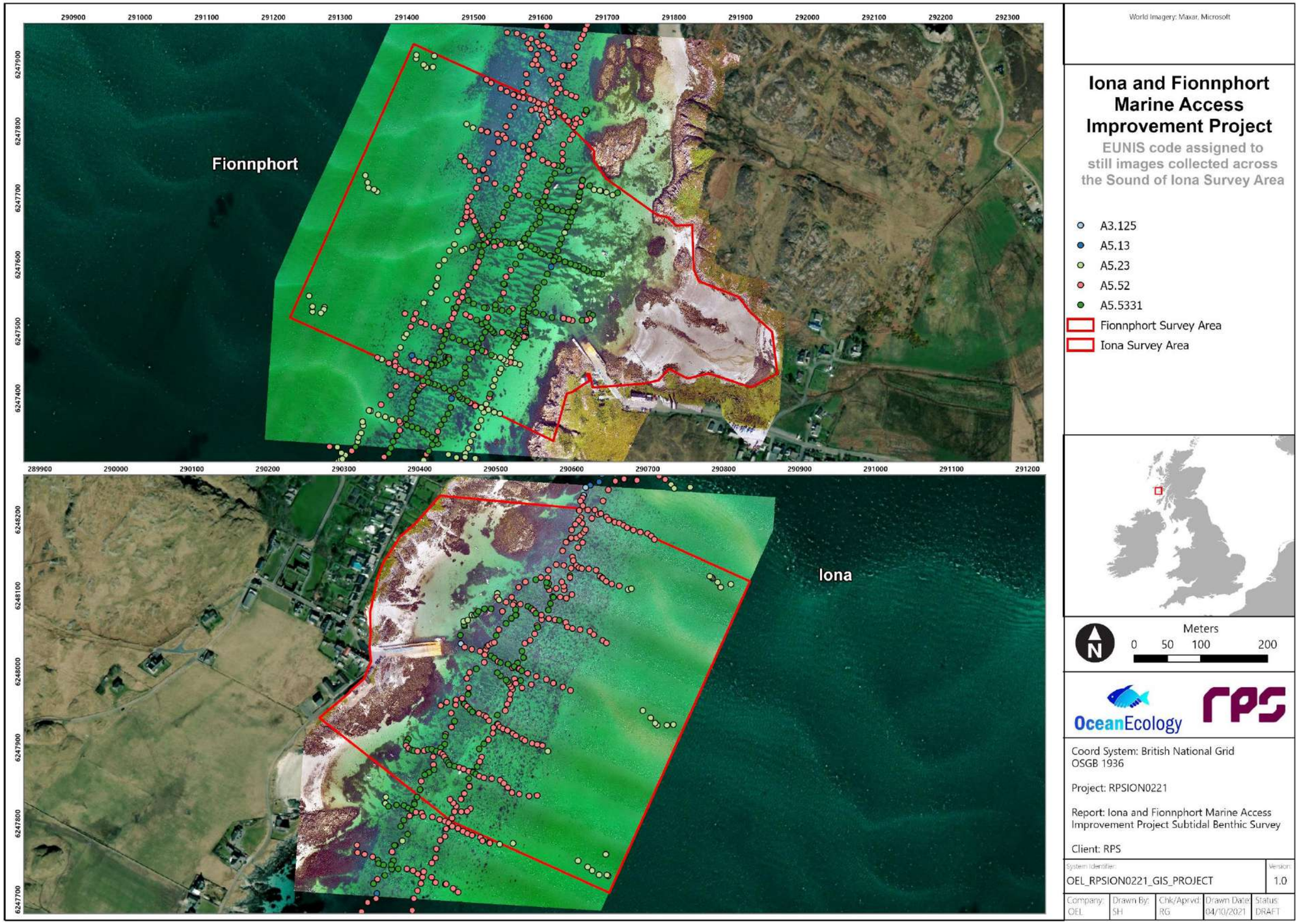

Figure 6 EUNIS Classifications of images collected across the survey area.

Figure 7 Seagrass assessment given to images collected across the survey area.

4.3.2.2. Annex I Reef Assessment

A full reef habitat assessment was conducted on all images to determine whether habitats met the definitions of Annex I reef habitats as detailed in Table 1. Evidence of bedrock reef was identified in 7 images across T_020. No evidence of stony or biogenic reef which would qualify as Annex I reef were observed during this survey.

4.3.2.3. Other Priority Marine Features

In addition to seagrass beds, the PMFs 'Kelp and seaweed communities on sublittoral sediment' and 'Kelp beds' were also observed in 263 and 12 images respectively across the Iona survey area. Dead maerl was observed across stations I3, I4 and I10, and transects T_018, T_020, T_024, T_025, T_027 and T_031.

4.3.2.4. Anthropogenic Activity

Evidence of a metal mooring chain was observed in two images across T_020 (RPSION0221_T20_21_08_21_476.JPG and RPSION0221_T20_21_08_21_496.JPG) (Plate 5).

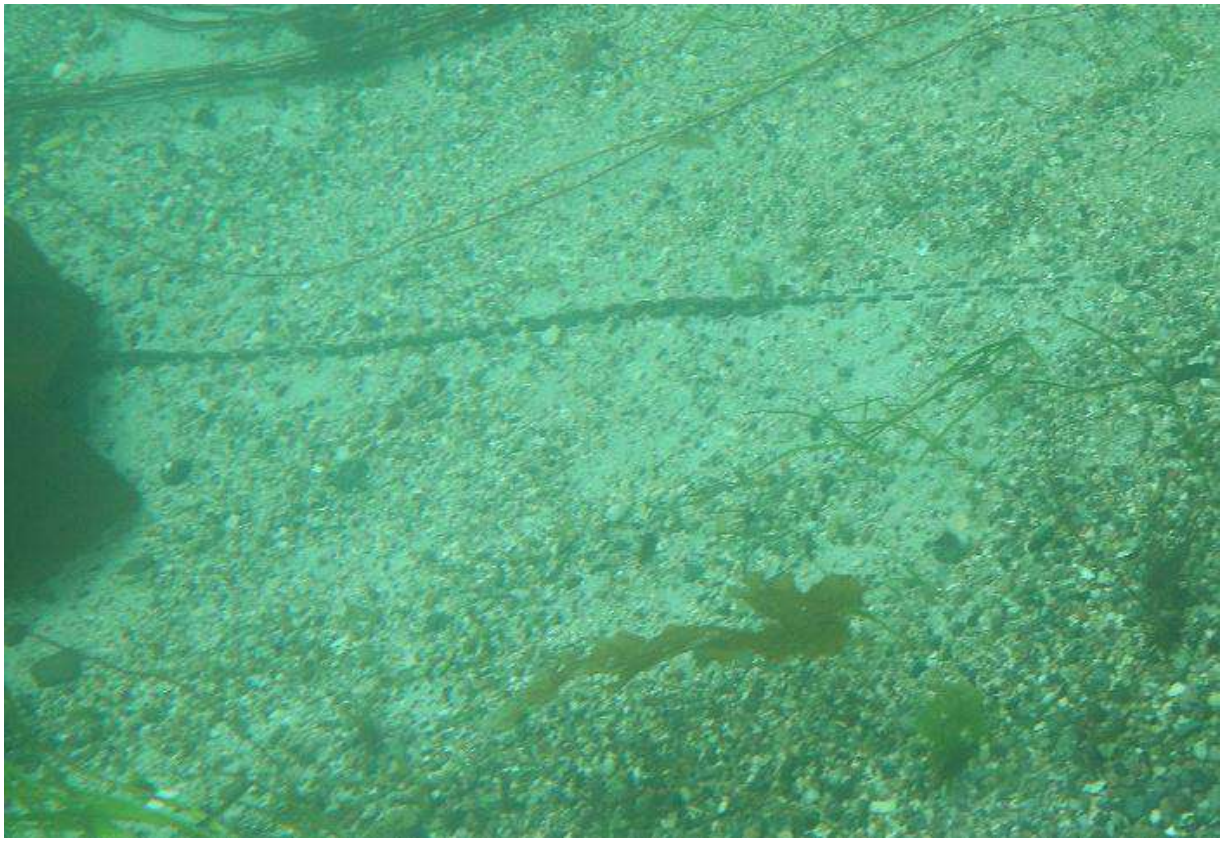

Plate 5 Metal chain observed at T_020.

4.4. Macrobenthos

4.4.1. Macrobenthic Composition

A total of 2,270 individuals and 336 taxa were recorded across the two survey areas. The mean (± SE) number of taxa per sample was 16.8 ± 3.2, with a mean abundance per sample of 113.5 ± 38.2 and mean biomass per sample of 0.197 ± 0.093 gAFDW.

The full abundance matrix is provided in Appendix VII. The biomass (gAFDW) of each major taxonomic group (Annelida, Crustacea, Mollusca, Echinodermata and Miscellaneous) in each sample collected is presented in Appendix VIII.

As shown in Figure 8, the bivalve *Goodallia triangularis* was the most abundant species recorded, accounting for 15.24% of all individuals recorded across both survey areas. *G. triangularis* also exhibited the maximum recorded abundance within a single sample and the greatest average density per sample (Figure 8c and Figure 8d). The amphipod *Bathyporeia guilliamsoniana* was another key taxon being the most frequently occurring macrobenthic species, occurring in 80% of all samples (Figure 8b).

Station F9 exhibited the highest recorded abundance of all stations at 741 individuals, followed by Station I1, the most station exhibiting the greatest abundance in the Iona survey area, with 385 individuals (Figure 10). Four hundred and fifty-six of the 741 individuals recorded from Station F9 were accounted for by three crustacean taxa, the amphipod family Gammaridae and amphipod *Nototropis swammerdamei*. and the isopod genus Idotea. Station F9 also had the highest recorded diversity of all stations at 66 recorded taxa, 36 of which were crustacean taxa (Figure 11). The most diverse station within the Iona survey area was Station I9, with 23 recorded taxa (Figure 11).

Biomass ranged between 0.0085 and 1.9 gAFDW, with the highest biomass recorded at Station F10 resulting from a high annelid biomass of 1.8 gAFDW (Figure 12). Annelida biomass was also the highest recorded major group biomass pooled across all sampled stations, however this was again driven by the large biomass recorded at Station F10. When considering data from stations excluding F10, Echinodermata biomass was the greatest contributor to total biomass. Figure 9 illustrates the relative contributions to total abundance, diversity, and biomass of the major taxonomic groups in the macrobenthic community sampled across both survey areas (all) and within the Fionnphort nearshore (middle panel) and Iona (bottom panel) survey areas.

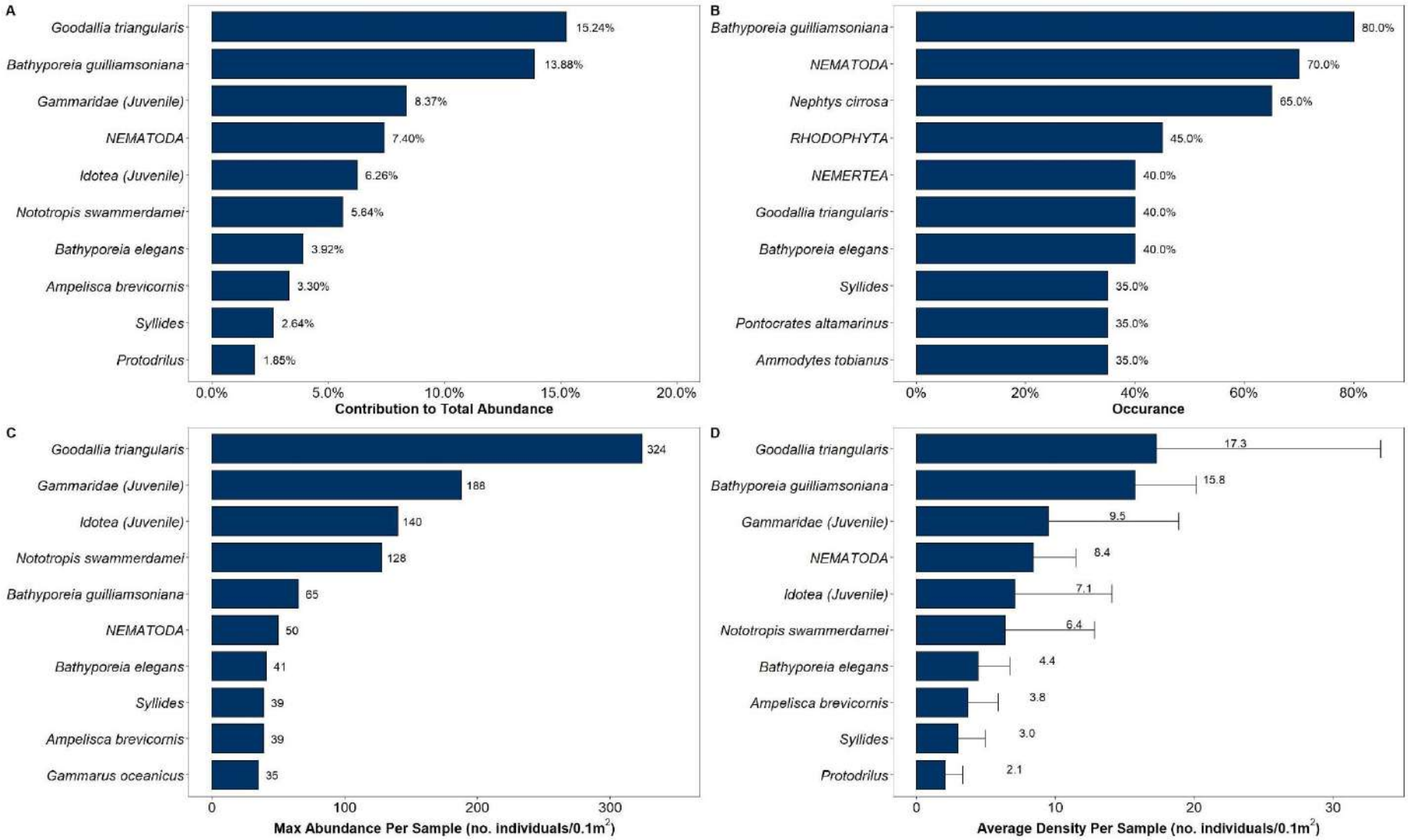

Figure 8 Percentage contributions of the top 10 macrobenthic taxa to total abundance (a) and occurrence (b) from samples collected across the two survey areas. Also shown are the maximum abundance of the top 10 taxa per sample (c) and average densities of the top 10 taxa per sample (d).

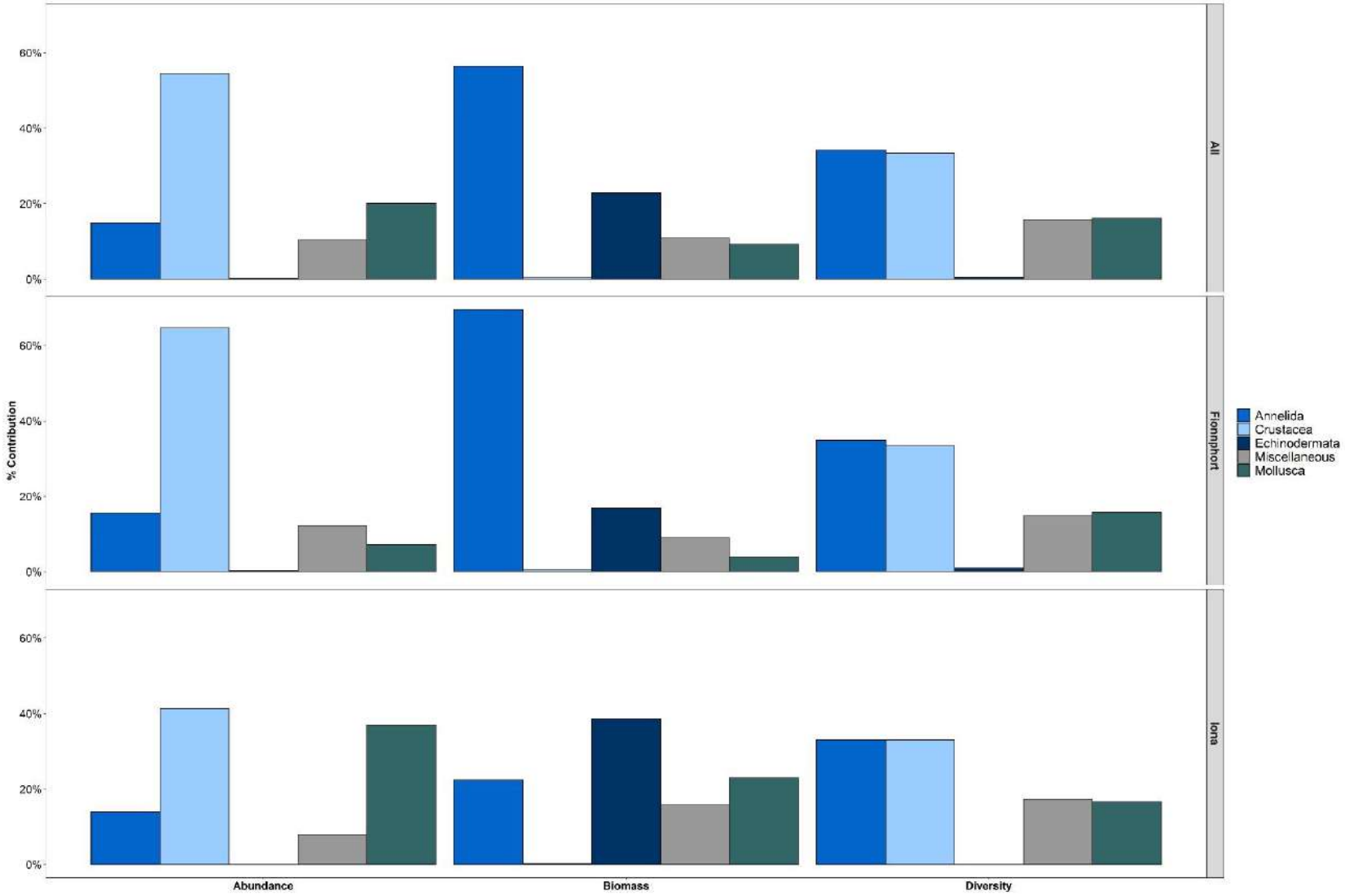

Figure 9 Relative contribution of the major taxonomic groups to the total abundance, diversity and biomass of the macrobenthos sampled across the two survey areas. Abundance counts exclude colonial taxa.

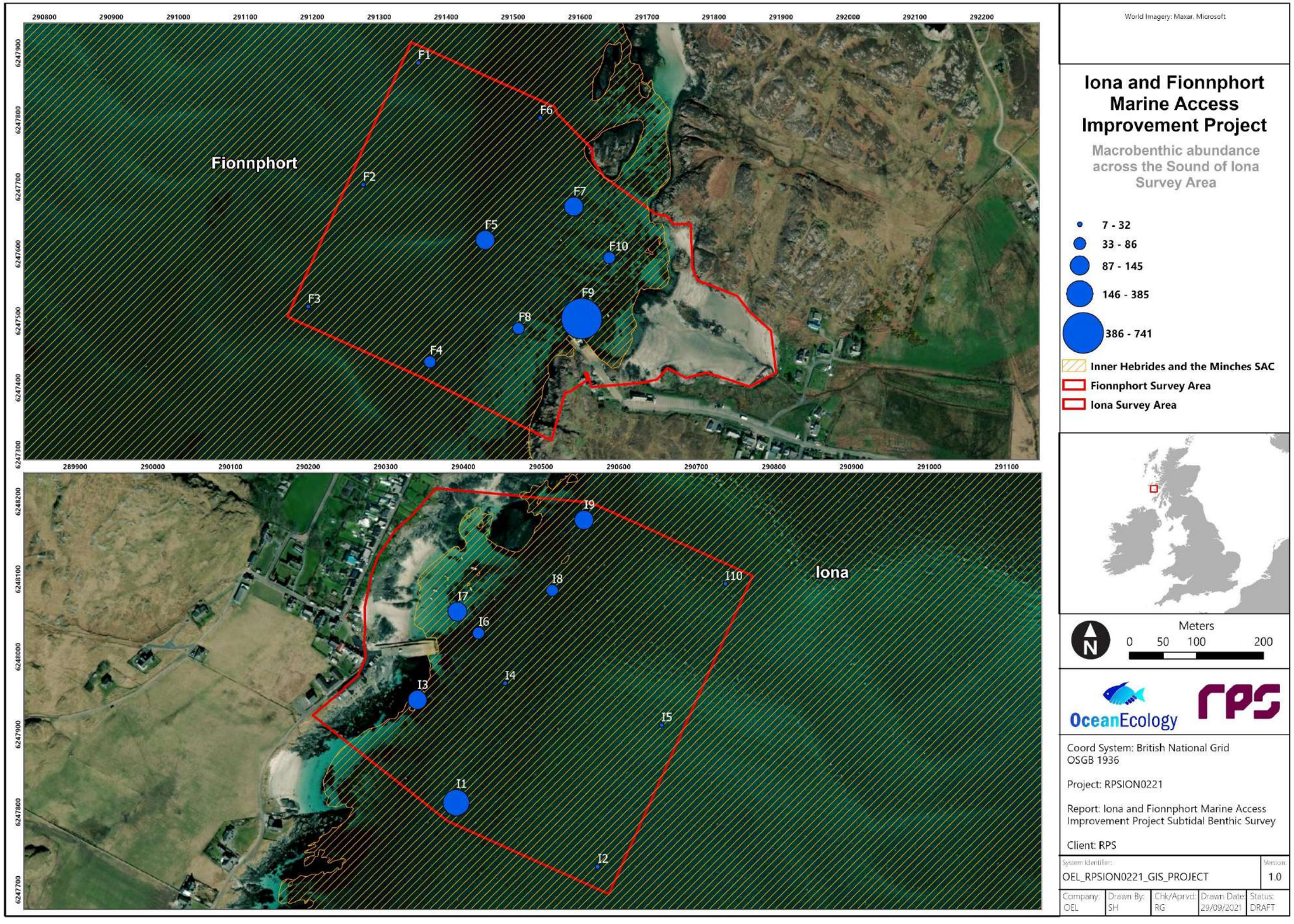

Figure 10 Macrobenthic abundance at stations sampled across the Iona and Fionnphort survey areas.

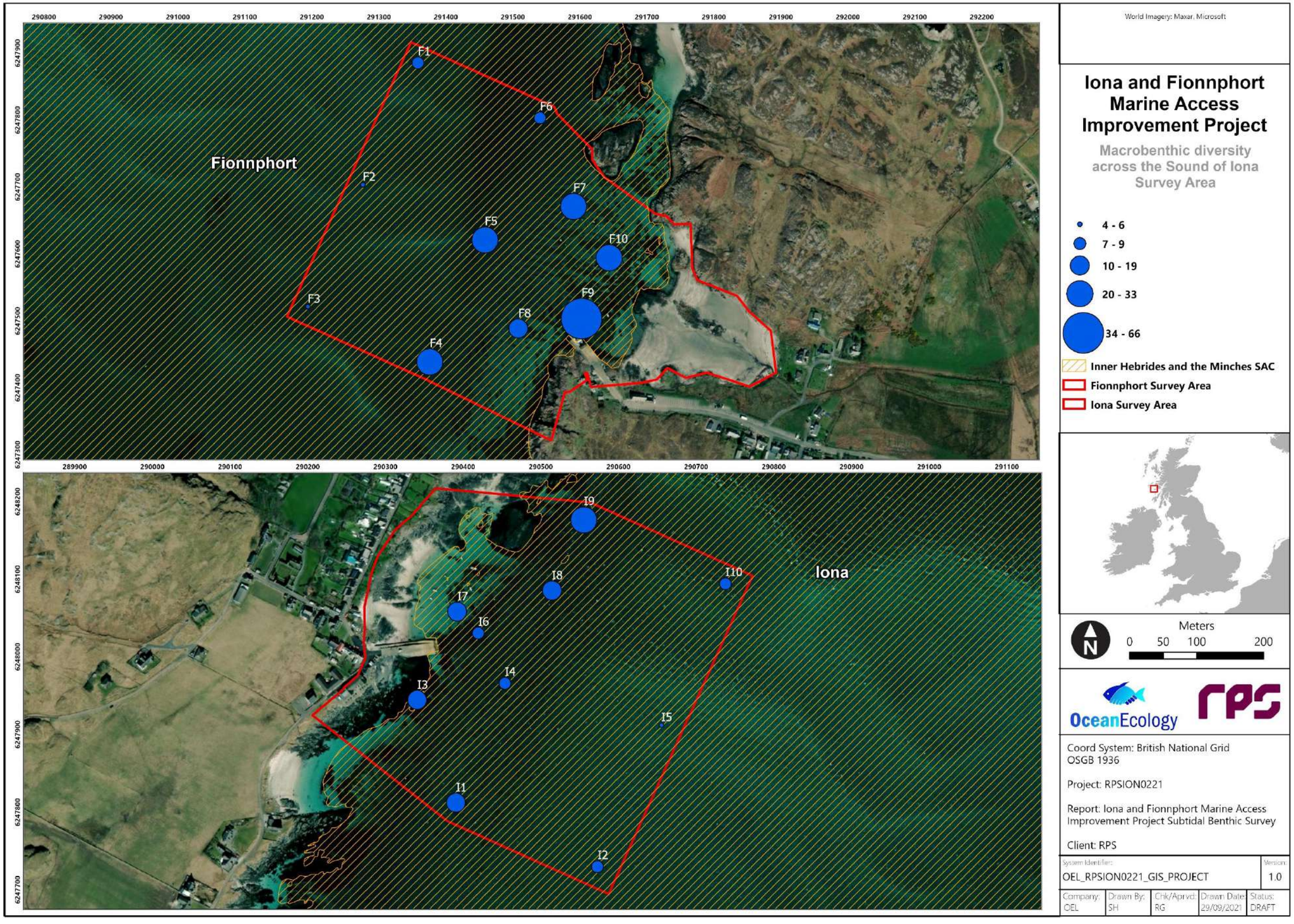

Figure 11 Macrobenthic diversity at stations sampled across the Iona and Fionnphort survey areas.

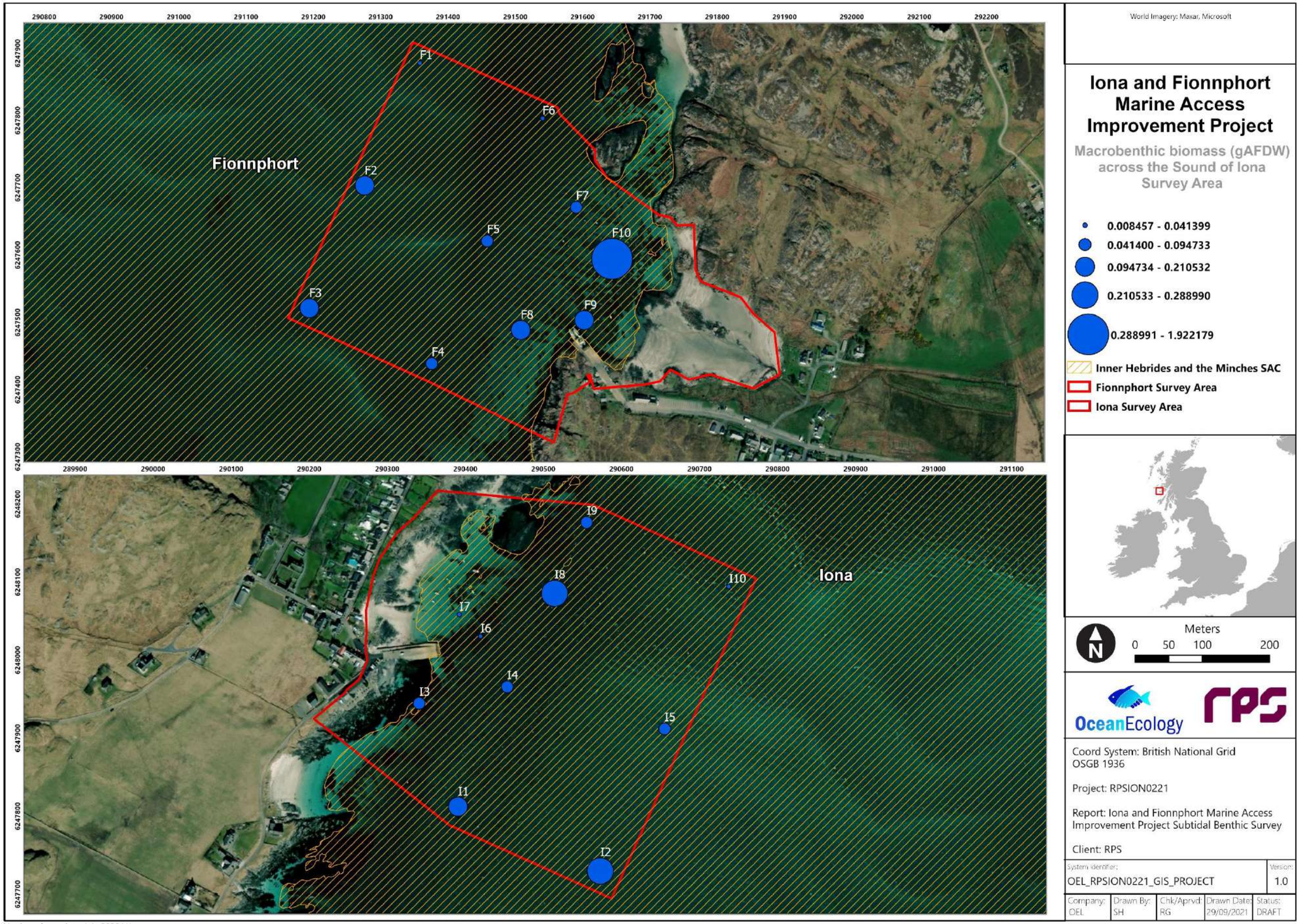

Figure 12 Macrobenthic biomass (gAFDW) at stations sampled within the Iona and Fionnphort survey areas.

4.4.2. Notable Taxa

Three species of interest were identified within the 20 samples which underwent macrobenthic analysis (Table 8). The most abundant of these species, *Crassicorophium crassicorne*, was recorded at only two stations, stations F7 and I8 with 10 and five individuals at each station, respectively. One individual of the economically important shrimp species *Crangon crangon* was identified at Station F9. One ocean quahog of small size, *Arctica islandica*, was identified at Station I7. *A. islandica* is listed on the OSPAR list of Threatened and/ or Declining Species and Habitats, and is also considered a PMF within Scotland.

Table 8 Notable taxa found during the Iona and Fionnphort subtidal benthic survey.

Taxon	Major Group	Designation	N of Individuals
Arctica islandica	Mollusca	OSPAR listed and PMF	1
Crangon crangon	Arthropoda	Economically Important	1
Crassicorophium crassicorne	Arthropoda	Invasive & Non-native	15

4.5. Macrobenthic Faunal Groupings

Multivariate analysis was undertaken on the square-root transformed macrobenthic grab abundance data, to identify spatial distribution patterns in faunal assemblages across the two survey areas 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 sampled stations. The dendrogram resulting from the cluster analysis and associated Type 1 SIMPROF (similarity profile routine) permutation test of all nodes within the dendrogram, identified 5 statistically significantly similar groups ($p > 0.05$). To note that of these 5 groups, station F9 in Fionnphort was an outlier and did not plot close to any of the other sampling locations.

To visualise the relationships between the sampled macrobenthic assemblages, a non-metric multi-dimensional scaling (nMDS) plot was generated on the community abundance data (Figure 13**Error! Reference source not found.**). The nMDS represents the relationships between the communities sampled, based on the distance between sample (station) points. The stress value of the nMDS ordination plot (0.15) indicates that the two-dimensional plot provides an adequate representation of the similarity between stations. The degree of clustering of intra-group sample points demonstrates the level of within group similarity (e.g., points within Macrobenthic Groups D, E and G show distinct clustering), whilst the degree of overlap of inter-group sample points is indicative of the level of similarity between different Macrobenthic Groups (e.g. Macrobenthic Groups A, C and F).

The spatial distribution of the four Macrobenthic Groups and outlier is mapped in Figure 14. SIMPER (similarity percentage analysis) was used to identify the key taxa contributing to the within group similarity (see Appendix IX for SIMPER results).

Macrobenthic Group A - Five stations fell into this group, three located in Iona and two in Fionnphort, in the further offshore area at each site and to the south. The taxon characterising these locations was the sand eel *Ammodytes tobianus* contributing alone to the 48% of the group composition with an average similarity of 30.47 %. Other taxa of notice within this group were the amphipods *Bathyporeia pelagica* and *Pontocrates altamarinus*.

Macrobenthic Group B – Only two stations belonged to this group, F7 and F10, both located close to shore and to the north in Fionnphort. Taxa contributing the most to the group average similarity of 41.24 % were the round worm Nematoda, the white catworm *Nephtys cirrosa,* the sea snail *Retusa obtusa* and the amphipod *Bathyporeia elegans*.

Macrobenthic Group C – Four stations made up this group, with only one station located in Fionnphort. All locations were in proximity of the shore. The characterising taxa for this group were three amphipods *Bathyporeia guilliamsoniana, B. elegans* and *Ampelisca brevicornis* altogether accounting for over 70 % of the group composition with an average similarity of 42.87 %.

Macrobenthic Group D – was the largest group comprising 8 out of the 20 sampling stations. Taxa contributing the most to the group average similarity and composition were Nematoda, *B. guilliamsoniana,* the ribbon worm Nemertea and *N. cirrosa*.

4.5.1. Biotope Assignment

For each of the four Macrobenthic Groups determined using cluster analysis, biotopes were assigned according to the JNCC classification (JNCC, 2015) based upon their faunal and physical characteristics. Correlation of EUNIS/MNCR (Marine Nature Conservation Review) biotopes was undertaken using the JNCC correlation table (JNCC, 2018).

The biotope that most closely aligned with the community observed across the two survey areas was 'A5.233 *Nephtys cirrosa* and *Bathyporeia* spp. in infralittoral sand' for all the macrobenthic groups observed, which is consistent with the survey area being generally composed of sandy sediments, as demonstrated by the PSD data (Figure 3 and Figure 5) and seabed imagery analysis (**Error! Reference source not found.** and Plate 4).

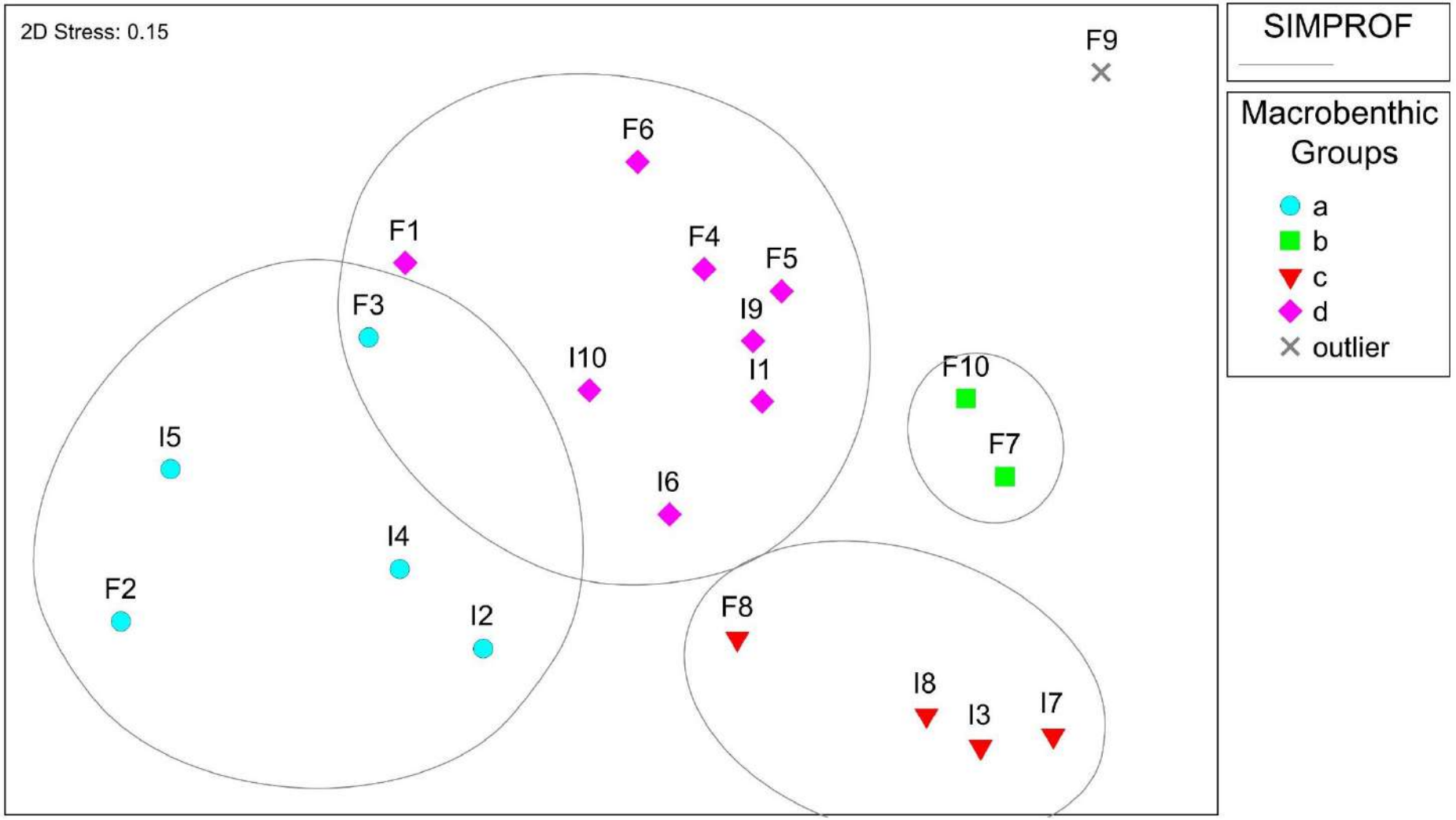

Figure 13 Two-dimensional nMDS ordination of macrobenthic communities sampled across the two survey areas, based on square root transformed and Bray-Curtis similarity abundance data. Macrobenthic Groups were identified based on SIMPROF routine (grey circles).

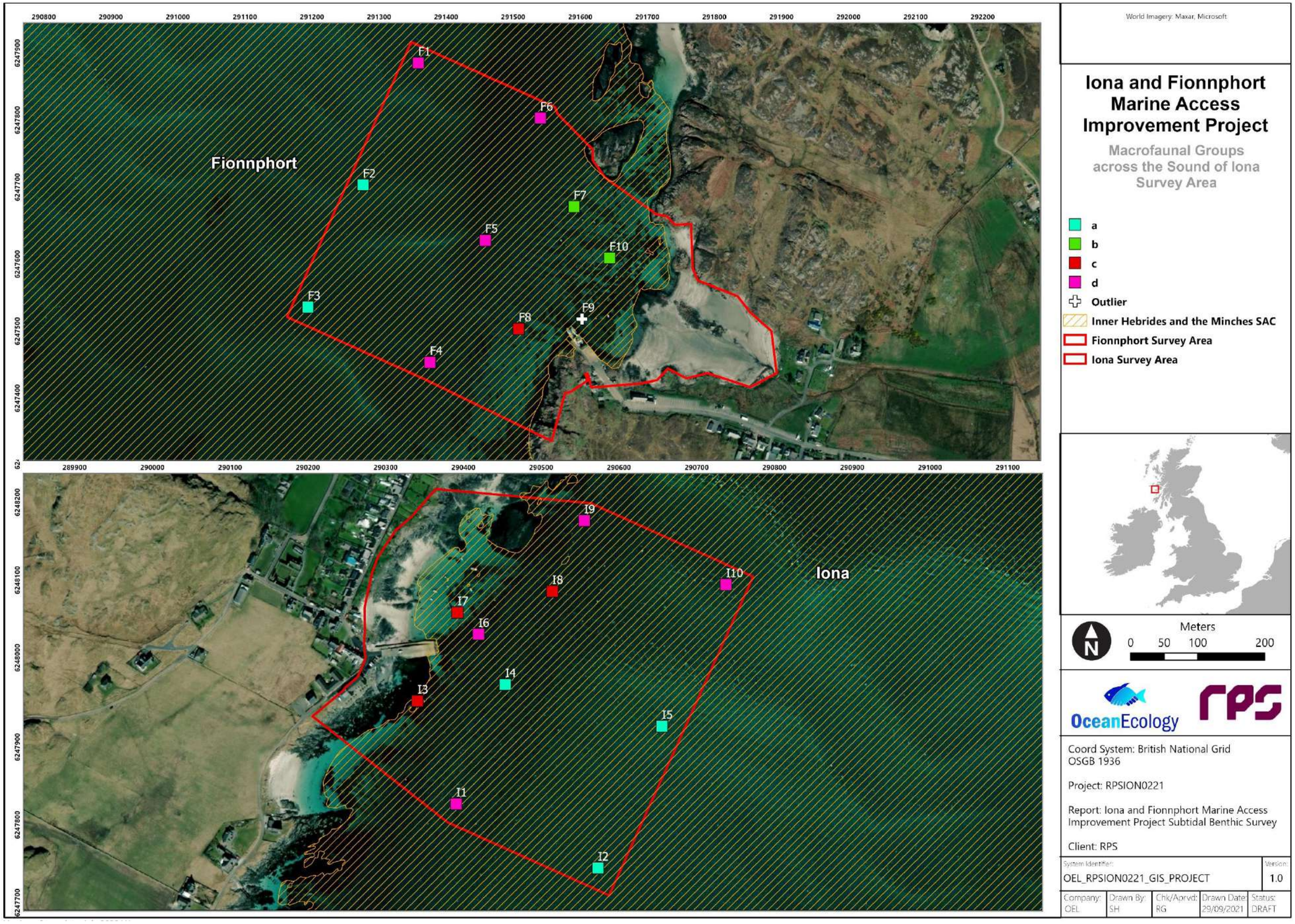

Figure 14 Spatial distribution of Macrobenthic Groups identified for each station across the two survey areas.

4.6. Habitat/ Biotope Mapping

The same five habitats/ biotopes (Table 9) were identified within the Iona and Fionnphort survey areas. The main subtidal habitats identified across the two survey areas were A5.233 '*Nephtys cirrosa* and *Bathyporeia* spp. in infralittoral sand', A5.52 'Kelp and seaweed communities on sublittoral sediment' and A5.5331 '*Zostera marina/angustifolia* beds on lower shore or infralittoral clean or muddy sand' as mapped in Figure 15 and Figure **16**. The EUNIS classification A5.233 was more prevalent within the Fionnphort survey area than the Iona survey area, which had a larger area of EUNIS classification A5.52 (seagrass beds), here classified to EUNIS A5.5331 (Figure 15 and Figure **16**). Note that the habitat mapping presented in Figure 15 and Figure **16** includes the areas extending from MHWS to MLWS which were surveyed during separate intertidal surveys (OEL, 2021).

All habitat / biotope mapping is provided in shapefile (.shp) format as Appendix X.

Table 9 Subtidal EUNIS classifications identified across the two survey areas.

EUNIS Level 4	EUNIS Level 5	EUNIS Description
A3.12	A3.125	Mixed kelps with scour-tolerant and opportunistic foliose red seaweeds on scoured or sand-covered infralittoral rock
A5.13	-	Infralittoral coarse sediment
A5.23	A5.233	*Nephtys cirrosa* and *Bathyporeia* spp. in infralittoral sand
A5.52	-	Kelp and seaweed communities on sublittoral sediment
A5.53	A5.5331	*Zostera marina/angustifolia* beds on lower shore or infralittoral clean or muddy sand

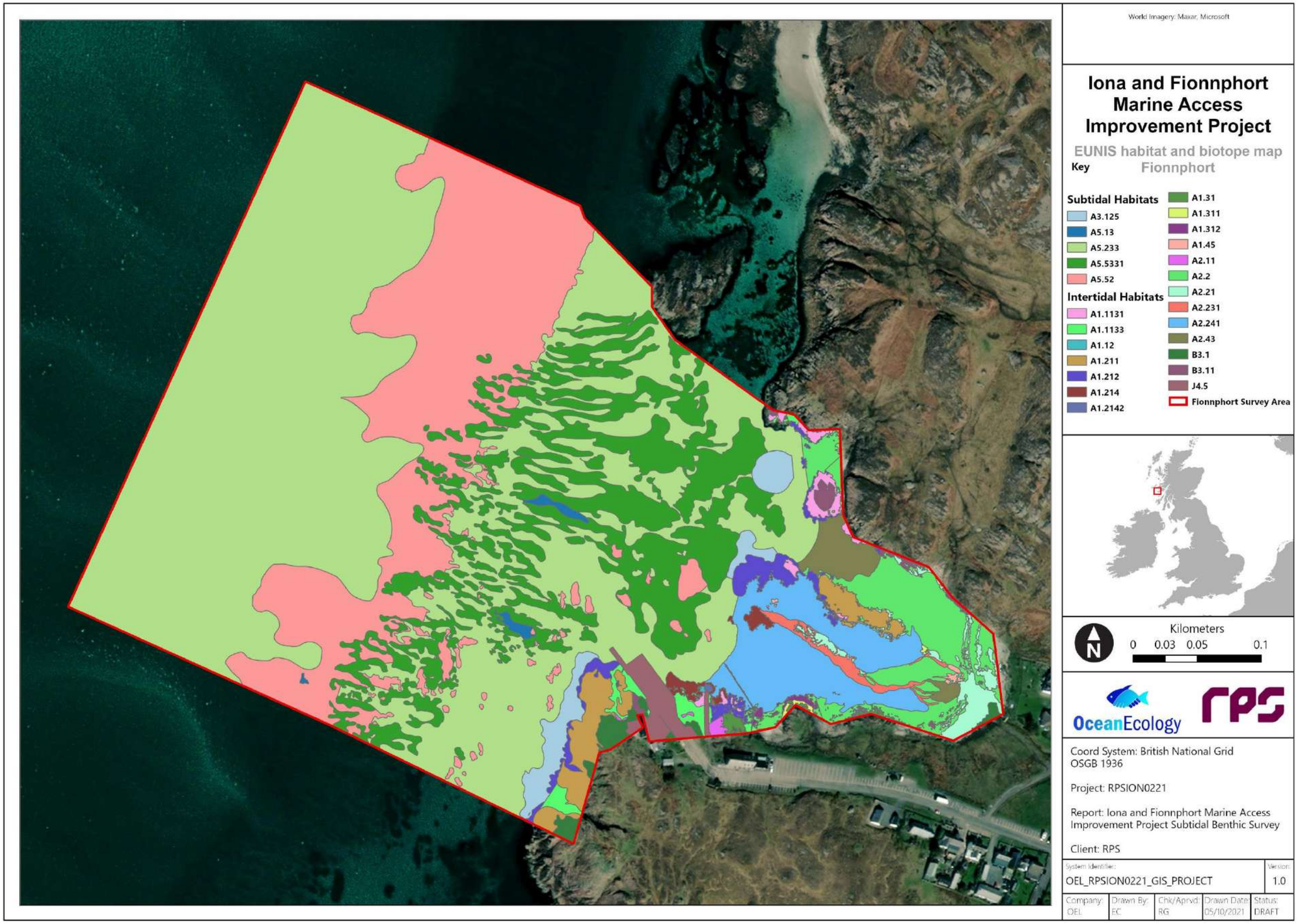

Figure 15 EUNIS habitat / biotope mapping across the subtidal and intertidal zones of the Fionnphort survey area.

Figure 16 EUNIS habitat / biotope mapping across the subtidal and intertidal zones of the Iona survey area.

5. Discussion

A multi-method survey approach involving the collection of seabed imagery and grab samples combined with existing aerial imagery was used here to characterise and map the key benthic habitats present across the subtidal zones of the proposed development areas of the Marine Access Improvement Project.

Sandy sediments dominated both survey areas, with the majority of sediment samples at each site classified as Slightly Gravelly Sand ((g)S). Only one station was classified as anything other than a sand dominated sediment, that being Sandy Gravel (sG) and Station F9. Mud content was consistently low across both survey areas.

The bivalve *Goodallia triangularis* was the most abundant taxa recorded in all macrobenthic samples, however, the most abundant major taxonomic group was Crustacea owing to the consistently high numbers of various amphipod and isopod taxa in samples. The presence of *Nephtys cirrosa* and several species of the genus *Bathyporeia* coupled with the classification of sand dominated sediments throughout the survey area led to the identification of EUNIS biotope A5.233 as the dominant sediment biotope.

Analysis of seabed imagery led to the identification of four further EUNIS habitats and biotopes within the survey area (Table 9). Of the habitats and biotopes identified, the primary classifications accounting for the largest areas were EUNIS classification A5.233 '*Nephtys cirrosa* and *Bathyporeia* spp. in infralittoral sand', A5.52 'Kelp and seaweed communities on sublittoral sediment' and A5.5331 '*Zostera marina/angustifolia* beds on lower shore or infralittoral clean or muddy sand' (Figure 15 and Figure **16**).

Z. marina var. angustifolia beds were known to be present within the broad vicinity of the Sound of Iona survey area (National Marine Plan Interactive (NMPI) - PMFs consultation – July 2018) prior to the completion of this survey however there were no previous records relating to the presence of extensive seagrass beds representative of the PMF 'Seagrass beds' within the two surveys areas as observed during this survey. Thorough analysis of seabed still imagery revealed a total of 11 stations and 15 transects containing areas considered to be representative of the PMF 'Seagrass beds', across both the Iona and Fionnphort survey areas. Areas of dense seagrass coverage (76-100 %) were identified at a total of six stations and 11 transects (Figure 7).

Due to the low winds and excellent underwater visibility on the day of the aerial imagery acquisition (OEL, 2021), the orthomosaic created for the two survey areas could be used to help accurately delineate the boundaries of the seagrass beds. As the orthomosaic coverage extends beyond the subtidal survey areas it appears that the seagrass beds observed are very likely to extend along the coast beyond the areas mapped and potentially along much of the shallow subtidal areas of the Sound of Iona.

In addition to seagrass beds, the PMFs 'Kelp and seaweed communities on sublittoral sediment' and 'Kelp beds' were also observed across both areas and are also likely to extend along much of the shallow subtidal areas of the Sound of Iona.

No live maerl was identified in the seabed imagery or grab samples, however dead maerl was observed in seabed imagery across both survey areas. Maerl beds are known to be present along the west coast of Scotland and north of the Sound of Iona on the west coast of the Isle of Mull and around the Threshnish Isles (Tyler-Walters et al., 2016). It is possible therefore that the observed dead maerl has been transported from one of these known beds, or that there are additional unmapped maerl beds in the general vicinity of the two survey areas.

Broad trends in the distribution of habitats and biotopes were apparent at both survey sites, whereby habitats further offshore were characterised as infralittoral sand biotopes (EUNIS A5.233) with a clear transition into areas dominated by kelp (EUNIS A5.52) closer to the shoreline. Kelp dominated habitats were more prevalent within the Iona survey area and extended all the way to the intertidal zone, concurrent with observations noted in the intertidal habitat assessment (OEL, 2021). At the Fionnphort site, kelp habitats also gave way to the biotope A5.233 closer to the shoreline. Seagrass beds (EUNIS A5.5331) at both survey sites were confined largely to the nearer-shore areas with beds orientated perpendicular to the shoreline limited in extent by the availability of light, extending towards/away from the shore. Seagrass beds were observed covering a greater area across the Fionnphort survey area and were largely present interspersed with areas of the EUNIS biotope A5.233. At the Iona site, seagrass habitats were almost exclusively present in areas of kelp habitat (A5.52), whereby seagrass was observed in the seabed imagery immediately adjacent to kelp beds. Seagrass was only observed in the shallow subtidal zone towards the southern extent of the Iona survey area, and not at all in Fionnphort survey area, which is broadly concurrent with observations made during the intertidal habitat assessment (OEL, 2021).

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