4.9

Rampion 2 WIND FARM

Volume 4, Chapter 9

Benthic Subtidal and Intertidal Ecology Appendices

GoBe wood.

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Rampion 2 WIND FARM

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Ocean Ecology

Marine Surveys, Analysis & Consultancy

Rampion 2 Predictive Seabed Mapping Methods Report

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1. Introduction

1.1. Rampion 2

Rampion Extension Development Limited (hereafter referred to as 'RED') applied to The Crown Estate (TCE) for an extension to the Rampion Offshore Wind Farm (Rampion 1) in 2018 and, following approval under the plan-led Habitats Regulations Assessment (HRA), was awarded development rights for the Rampion Extension Site in 2019. The proposed Rampion 2 Offshore Wind Farm Project (Rampion 2) is located adjacent to Rampion 1 in the English Channel, off the Sussex coast. Rampion 2 is designated as a Nationally Significant Infrastructure Project (NSIP) under Section 15(3) of the Planning Act 2008, thus requiring a Development Consent Order (DCO) accompanied by and Environmental Statement (ES) in accordance with the Environmental Impact Assessment (EIA) Regulations 2017. Rampion 2 is defined as a Schedule 2 project under EIA Regulations 2017.

Rampion 2 comprises both offshore and onshore infrastructures typically associated with an offshore wind farm project. Offshore elements include the seabed area conditionally awarded in 2019 under the TCE wind farm extension process located to the west of Rampion 1, and development within part of the remainder of the original Rampion 1 Round 3 Zone 6 area, to the south east of Rampion 1. The aggregate of these two seabed areas would be optimised to form a single extension development giving rise to a single application for a DCO. Infrastructure include offshore wind turbine generators (WTGs) and associated foundations with an installed capacity of up to 1200 megawatt (MW), inter-array cables, up to three offshore substations and up to four offshore export cables within one cable corridor.

The onshore elements of Rampion 2 comprise a single landfall site at Climping (West Sussex), buried onshore transmission cables in a single corridor approximately 36 kilometre (km) in length, and a new onshore 'satellite' substation located within a 5km radius of the existing National Grid Bolney Substation (Mid Sussex) to which it will be connected.

1.2. Aims and Objectives

Ocean Ecology Limited (OEL) was contracted by GoBe Consultants Ltd (GoBe) / RED to conduct a benthic characterisation of the Rampion 2 survey area to characterise the habitats present within the subtidal zone of the proposed project boundary. Following delays to the subtidal survey due to sustained periods of unsuitable weather, OEL were requested to conduct a predictive modelling exercise using the newly acquired site specific acoustic data and wealth of existing ground-truthing data available to provide full coverage mapping for the survey area. This interim deliverable will be used to inform the project Preliminary Environmental Information Report (PEIR). It is the intention that the results of the ongoing benthic survey will subsequently be fed into the model to produce a final high confidence EUNIS map, which will be available for inclusion into the ES.

1.3. Predictive Habitat Mapping

Predictive habitat mapping is a widely used, automated process of classifying benthic habitat (Degraer *et al*., 2008, McGonigle *et al*., 2009, Brown *et al*., 2011, Stephens and Diesing 2014, Calvert *et al*., 2015, Boswarva *et al*., 2018). It utilises a variety of high-resolution physical variables identified as proxies for habitat and the composition of species and communities of species associated with particular habitats (Brown *et al*., 2011). Thus, promoting wide-scale, relatively fast and cost-effective methods of mapping large areas of the seabed to high degrees of accuracy (Andersen *et al*., 2018). Predictive maps can also act as a baseline in which to develop further comprehensive investigations, further maximising survey time and effort (Wynn *et al*., 2012).

The Maximum Likelihood Classification (MLC) is one commonly used, pixel based, supervised classification technique (Calvert *et al*., 2015, Boswarva *et al*., 2018). It utilises acoustic data and their derivatives to produce class signatures, applying ground-truth data (known also as sea-truth data) to identify or "train" similar regions in acoustic data where no sea-truthing data exists (Calvert *et al*., 2015), thus producing full coverage and cost-effective predictive habitat maps (Che Hasan *et al*., 2014, Calvert *et al*., 2015).

Surfaces derived from bathymetric data can be used to develop a broader picture of the topographic complexity and biological relevant units of the seabed (Brown *et al*., 2011, Costa and Battista 2013). Derivatives such as aspect, slope, and rugosity can be used to describe the seabed in terms of exposure to wave current, energy sediment accretion, and seabed complexity respectively (Rattray *et al*., 2013), whilst topographic roughness is known to influence habitat and colonisation (Wilson *et al*., 2007).

2. Methods

All modelling and modelling processes were conducted in ESRI ArcGIS utilising the Spatial Analyst Extension within a combination of ESRI ArcMap version 10.7 and ESRI ArcPro Version 2.7.

2.1. Ground-truthing

EUNIS classification point data were obtained and collated from various sources:

- Cefas OneBenthic Database (https://openscience.cefas.co.uk/matool_mhtest/)
- EMODnet – EUNIS habitat point observations (https://www.emodnet-seabedhabitats.eu)
- Rampion 2 Particle Size Distribution (PSD) analysis data
- Rampion 1 Offshore Wind Farm benthic ecology baseline characterisation (EMU, 2011)
- Rampion 1 Offshore Wind Farm pre-construction benthic survey report (Natural Power, 2016)

2.1.1. Cefas OneBenthic Database

Using the OneBenthic Database, 203 sediment samples collected from within the Rampion 2 scoping boundary derived from several different survey programs were extracted. To ensure sample data was not truncated prior to analysis, the data was split into 10 subgroups based on the size classification used for the sediment analysis and individually run through Gradistat grain size distribution and statistics package version 9.1 to determine the EUNIS Broadscale Habitat type (BSH).

2.1.2. EMODnet EUNIS habitat point observations

A total of 76 EUNIS classifications were extracted from the EMODnet Seabed Habitats Portal. EUNIS classification descriptions are provided in Appendix A - EUNIS Descriptions.

2.1.3. Rampion 2 PSD Analysis

Broadscale EUNIS classifications were obtained from 11 grab samples collected by OEL as part of the ongoing Rampion 2 benthic survey. The data was run through Gradistat grain size distribution and statistics package version 9.1 to determine the EUNIS BSH type. Note that due to timescales the corresponding macrobenthic data was not available to allow for EUNIS biotope classification.

2.1.4. Rampion 1 OWF

A total of 197 habitat classifications from grab samples and seabed still images collected during two Rampion 1 offshore windfarm surveys were obtained from GoBe. Classifications were first converted from Marine Habitat Classifications for Britain and Ireland (MNCR) format to the EUNIS classification.

2.2. Training and validation

The ground-truth data was divided into four datasets containing EUNIS BSH, Level 4 and Level 5 and All EUNIS classifications combined. A random stratified sampling technique was conducted on each EUNIS classification to ensure sampling incorporated all available classes. Seventy percent of the data from each classification was selected for model training whilst 30 percent was retained for model validation (**Table 1** and Appendix D - Predictive habitat maps displaying training and validation data points). A sense check was conducted on all data, in which data collected from duplicate coordinates were removed.

Table 1 Total data points used to train and validate each predictive map.

EUNIS Level	Training	Validation
All	354	92
BSH	330	128
Level 4	131	48
Level 5	108	46

2.2.1. Confusion matrix

Confusion matrices are calculated to measure map accuracy by highlighting the percentage of pixels classified correctly. They are produced in ArcMap by combining the outputs of each predictive map with its corresponding validation dataset. The resulting integer values are converted to percentages using the expression NT(([values]/[Total]) * 100+0.5.

2.2.2. Cohen's kappa

Cohen's Kappa is a widely applied discrete multivariate technique for assessing the accuracy of habitat mapping predictions. It measures the degree of agreement between variables above that expected by chance alone (Lucieer *et al.*, 2013). The value is interpreted further to identify the level of agreement and percentage of reliable data (Table 2).

It is calculated from the confusion matrix

$$\kappa = \frac{\Pr(a) - \Pr(e)}{1 - \Pr(e)}$$

Where Pr(a) represents the actual observed agreement and Pr(e) represents an agreement by chance.

Table 2 Interpretation of Cohen's Kappa adapted from (Altman 1991, McHugh 2012, Lucieer *et al.*, 2013).

Value of Kappa	Level of agreement	Agreement *	Percent data that are reliable
0 to .20	None	Poor	0 to 4
.20 to .39	Minimal	Fair	4 to 15
.40 to .59	Weak	Moderate	15 to 35

Value of Kappa	Level of agreement	Agreement *	Percent data that are reliable
.60 to .79	Moderate	Good	35 to 63
.80 to .90	Strong	Very good	64 to 81
Above .90	Almost Perfect	Very good	82 to 100

2.3. Physical variables

Acoustic data in the form of Multibeam Eco Sounder (MBES) bathymetry and backscatter were obtained from GoBe in a series of .xyz formatted data files. These files were transformed and mosaiced into two rasters displayed at 1 metre (m) resolution. A Side Scan Sonar (SSS) raster in .tiff format was obtained from GoBe at 0.1m resolution. The backscatter raster (available in Appendix B - Physical Variables) was omitted from the final maps due to strong differences in acoustic signatures between the nearshore and offshore areas, which had the potential to significantly influence the final model predictions.

2.3.1. Bathymetric derivatives

Six derivatives were calculated from the bathymetric raster, these were: Slope, Aspect as Eastness and Northness (in radians), Terrain Ruggedness Index (TRI), Curvature, and Profile Curvature. Each physical variable is displayed in Appendix B - Physical Variables.

2.4. Environmental variables

All environmental variables were downloaded from the EMODnet data portal (https://www.emodnet-seabedhabitats.eu/access-data/download-data/) in .tiff format. This included: kinetic energy at the seabed due to wave energy, light at the seabed, and fraction of light at the seabed. Due to their limited variability across the site the environmental variables were omitted from the final models. An example of each data layer is displayed in Appendix C - Environmental Variables.

2.5. Data transformation

Only the bathymetry, SSS and bathymetric derivatives were selected for the final predictive mapping process. A "Standardise" and "Stretch" function was applied to each variable using the "Transformation" function within the Geomorphometry and Gradient Metrics toolbox (https://evansmurphy.wixsite.com/evansspatial/arcgis-gradient-metrics-toolbox) extension in ArcPRO.

2.6. Principal Components

Principal Component Analysis (PCA) transforms a number of different, but potentially correlated, variables into a smaller number of uncorrelated principal components (Amiri-Simkooei *et al.*, 2011). In doing so, it condenses all information into the first few bands, removing highly correlated information and thus reducing dimensionality without losing data (Costa and Battista 2013). PCA

was conducted on the transformed variables. The resulting outputs produced a series of multiband rasters containing the first three principal components and a statistical text file containing the covariance matrix, correlation matrix, eigenvalues and the percent of accumulated eigenvalues.

2.7. Signature files

Signature files were created in ArcPro from each EUNIS classification dataset and the resulting multiband PCA raster. A signature file is a subset of cells which represent a class or cluster. Signatures incorporate small buffers around sea-truth points, and in doing so assume that the associated habitat within a buffer is the same as the classified data entry (Brown *et al*., 2005).

2.8. Maximum Likelihood Classification

MLC is a widely applied pixel based predictive mapping approach (Brown *et al*., 2005, Ierodiaconou *et al*., 2011, Calvert *et al*., 2015, Boswarva *et al*., 2018) that calculates the probability a given pixel belongs to a specific class, thereby producing a grid of classes in the form of a raster thematic map (Lerodiaconou *et al*., 2011, Micallef *et al*., 2012). MLC was conducted here by combining the variables selected within the multi-band PCA rasters with signature files containing EUNIS classification data. The resulting predictive habitat maps are displayed in **Figure 1** to **Figure 4.**

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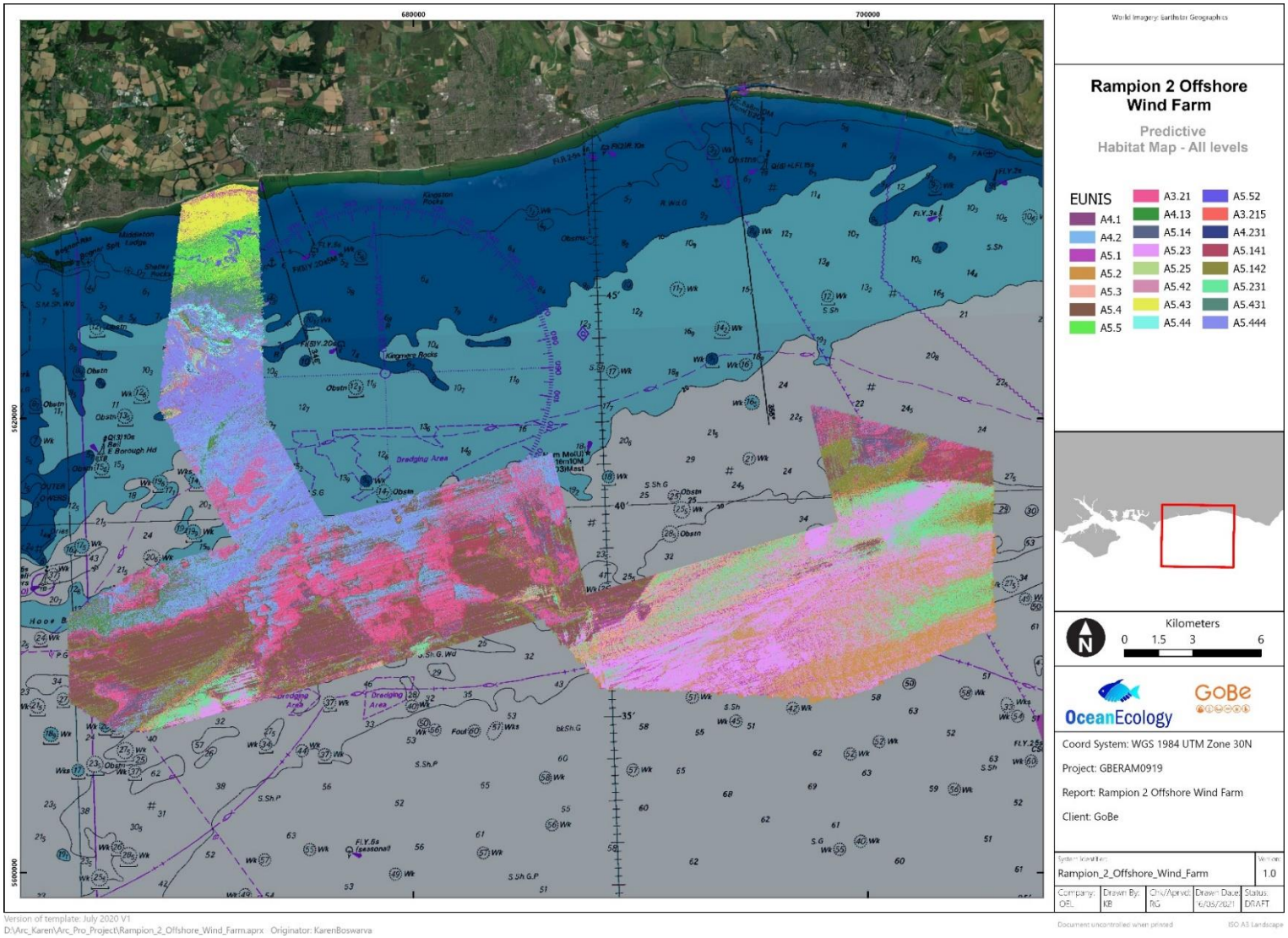

Figure 1 A composite predictive habitat map of the Rampion 2 Offshore Wind Farm area combining BSH, Level 4, and Level 5 EUNIS classifications.

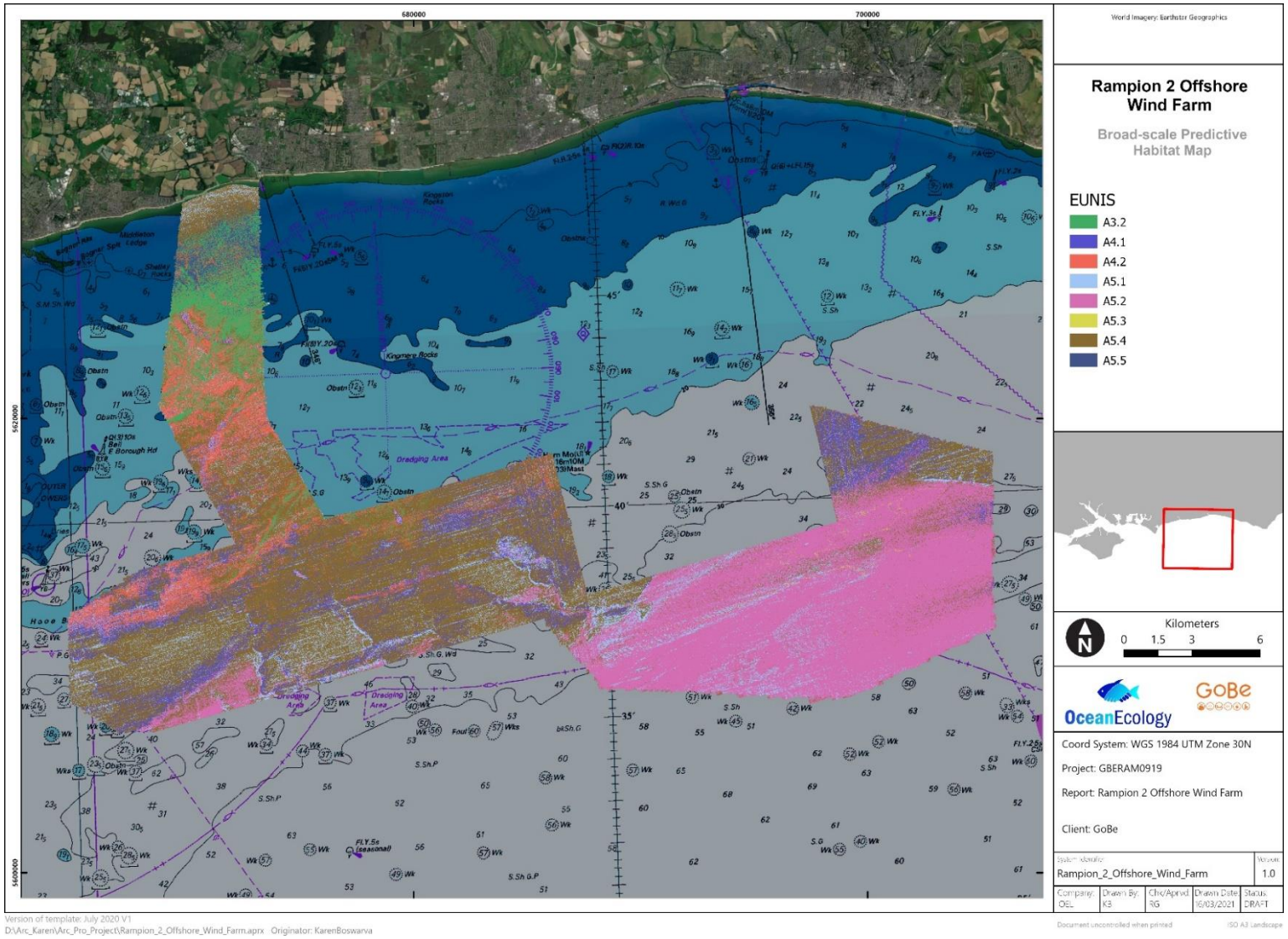

Figure 2 Broadscale predictive habitat map of the Rampion 2 Offshore Wind Farm area.

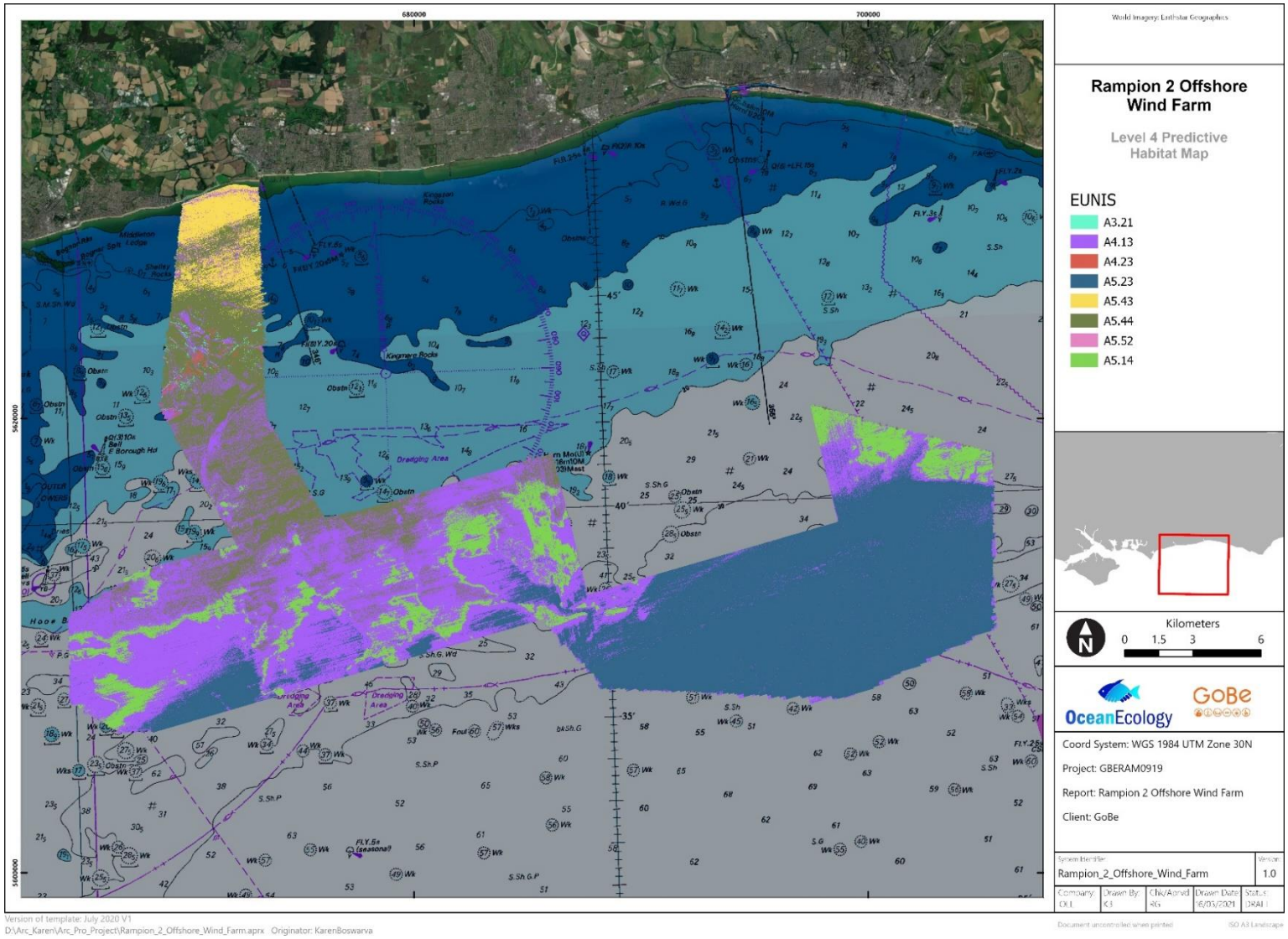

Figure 3 Level 4 predictive habitat map of the Rampion 2 Offshore Wind Farm area.

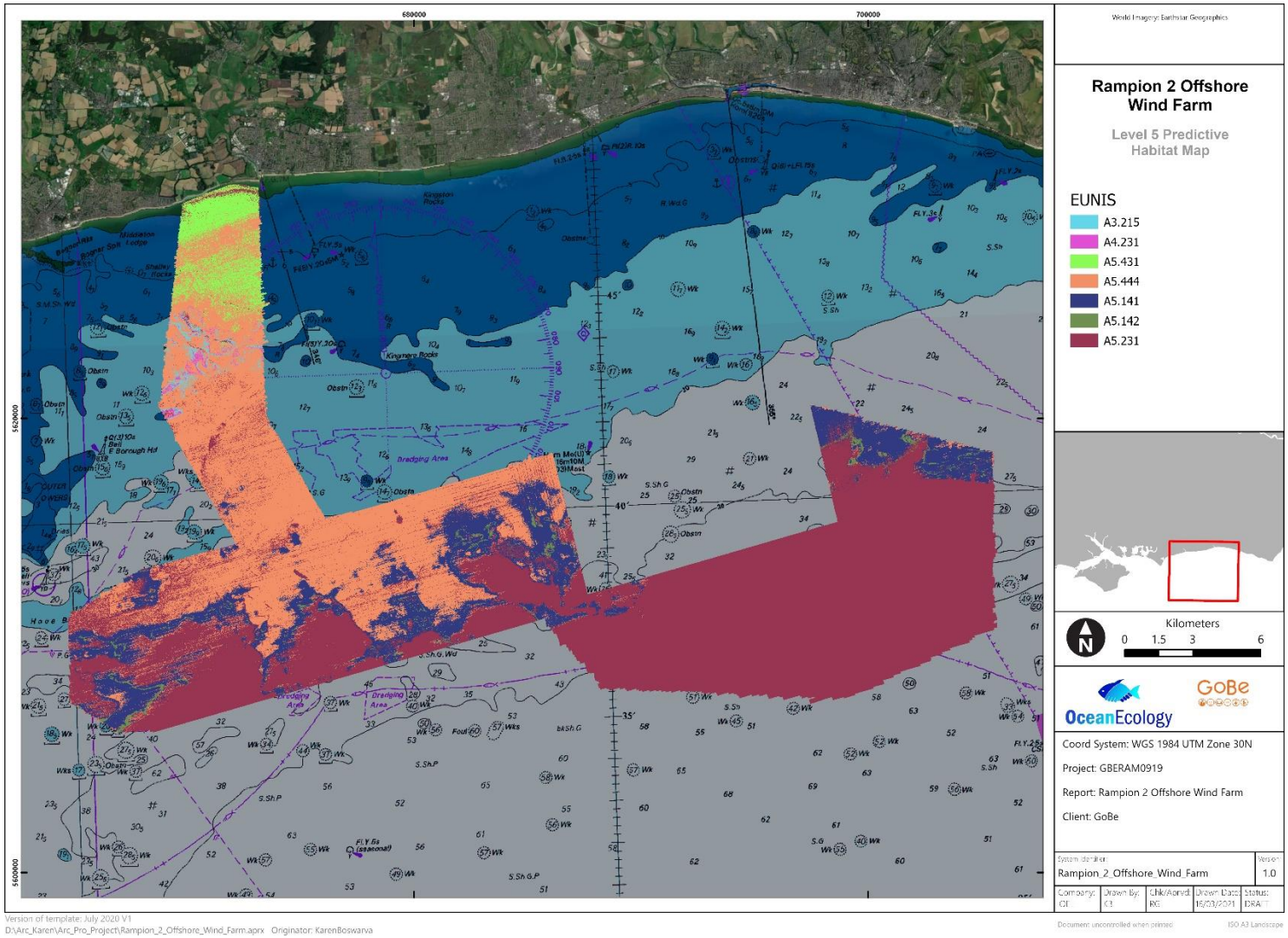

Figure 4 Level 5 predictive habitat map of the Rampion 2 Offshore Wind Farm area.

3. Results

3.1. Predictive habitat/biotope maps

The following tables, **Table 3** to **Table 6** indicate the percentage cover of each EUNIS habitat predicted across the Rampion 2 survey area. The predictive map containing all classifications predominantly comprised of Sublittoral mixed sediments (A5.4) and Infralittoral fine sand (A5.23), this is mirrored in the dominance of A5.4 and Sublittoral sand (A5.2) in the EUNIS BSH predictive map. The Level 4 predictive map was dominated again by A5.23 and also Mixed faunal turf communities on circalittoral rock (A4.13). Whilst the Level 5 predictive map was dominated by Infralittoral mobile clean sand with sparse fauna (A5.231).

Table 3 The number and percentage of pixels classified per EUNIS classification.

EUNIS	Pixels	Percentage
A5.1	4742032	5.3
A5.25	90884	0.1
A3.215	291887	0.3
A4.2	9384946	10.4
A5.4	12471648	13.8
A4.231	22653	0.0
A5.44	576257	0.6
A5.5	1332005	1.5
A5.431	1361360	1.5
A5.2	8553162	9.5
A5.52	188862	0.2
A5.42	52131	0.1
A4.13	2274892	2.5
A5.444	7220945	8.0
A5.43	1558810	1.7
A3.21	9220683	10.2
A5.3	3576479	4.0
A5.142	3631076	4.0
A5.14	1939491	2.2
A5.23	12140803	13.5
A5.231	6213811	6.9
A5.141	3239935	3.6

Table 4 The number and percentage of pixels classified per broad scale habitat EUNIS code.

EUNIS	Pixels	Percentage
A3.2	4446032	4.9
A4.1	8135910	9.0
A4.2	6406370	7.1
A5.1	8499124	9.4
A5.2	27375931	30.4
A5.3	143450	0.2

A5.4	33928940	37.7
A5.3	1148995	1.3

Table 5 The number and percentage of pixels classified per Level 4 EUNIS code.

EUNIS	Pixels	Percentage
A3.21	130345	0.1
A4.13	31805413	35.3
A4.23	170530	0.2
A5.23	32996090	36.6
A5.43	2686030	3.0
A5.44	13507665	15.0
A5.52	35902	0.04

Table 6 The number and percentage of pixels classified per Level 5 EUNIS biotope code.

EUNIS	Pixels	Percentage
A3.215	460188	0.5
A4.231	222063	0.2
A5.431	2741621	3.0
A5.444	25679147	28.5
A5.141	12291105	13.6
A5.142	909288	1.0
A5.231	47781340	53.0

3.2. Model Validation

Model validation is displayed as a series of confusion matrices (**Table 7** to **Table 10**) indicating the percentage of pixels classified correctly and highlighting the miss-classified EUNIS codes, and a Cohen's Kappa score of agreement per predictive map (**Table 11**). Overall, the greatest percentage of correctly classified pixels occurred within sublittoral coarse sediment (A5.1) with 81.5 percent of pixels classified correctly. The greatest percentage of miss-classifications occurred within the map displaying all levels, miss-classification was largely reduced in all single level maps. The Cohen's Kappa scores ranged from non/poor level of agreement (all EUNIS levels) to moderate/good (Level 4 and level 5).

3.2.1. Confusion matrix

Table 7 Confusion matrix for all EUNIS classification levels.

	A5.444	A5.1	A5.4	A5.2	A4.7	A5.141	A4.13	A4.72	A5.3	A5.231
A5.1	9.50	81.50	9.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
A4.2	0.50	83.50	8.50	8.50	0.50	0.50	0.50	0.50	0.50	0.50
A5.4	0.50	53.50	38.50	0.50	7.50	0.50	0.50	0.50	0.50	0.50
A5.2	0.50	33.50	0.50	66.50	0.50	0.50	0.50	0.50	0.50	0.50
A4.13	0.50	100.50	0.50	0.50	0.50h	0.50	0.50	0.50	0.50	0.50
A5.444	16.50	66.50	16.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50

	A5.444	A5.1	A5.4	A5.2	A4.7	A5.141	A4.13	A4.72	A5.3	A5.231
A3.21	0.50	100.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
A5.3	0.50	64.50	0.50	23.50	5.50	0.50	0.50	0.50	0.50	5.50
A5.142	0.50	50.50	50.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
A5.14	0.50	33.50	0.50	0.50	0.50	33.50	33.50	0.50	0.50	0.50
A5.23	0.50	33.50	16.50	33.50	0.50	0.50	0.50	0.50	16.50	0.50
A5.231	0.50	57.50	0.50	14.50	0.50	0.50	0.50	14.50	0.50	14.50
A5.141	0.50	60.50	40.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50

Table 8 Confusion matrix for the EUNIS BSH predictive map.

	A5.4	A5.2	A4.1	A5.1	A4.7	A5.3
A3.2	0.5	0.5	0.5	100.5	0.5	0.5
A4.1	7.5	30.5	15.5	46.5	0.5	0.5
A4.2	37.5	12.5	0.5	50.5	0.5	0.5
A5.1	3.5	11.5	3.5	81.5	0.5	0.5
A5.2	2.5	68.5	0.5	22.5	4.5	2.5
A5.4	27.5	12.5	3.5	57.5	0.5	0.5
A5.5	100.5	0.5	0.5	0.5	0.5	0.5

Table 9 Confusion matrix for the EUNIS Level 4 predictive map.

	A5.43	A5.44	A3.21	A5.14	A4.13	A5.23	A4.72
A4.13	0.5	0.5	33.5	0.5	66.5	0.5	0.5
A5.23	0.5	0.5	0.5	3.5	0.5	89.5	6.5
A5.44	20.5	60.5	0.5	0.5	20.5	0.5	0.5
A5.14	0.5	0.5	0.5	80.5	20.5	0.5	0.5

Table 10 Confusion matrix for the EUNIS Level 5 predictive map.

	A4.139	A5.431	A5.444	A5.141	A5.142	A5.231	A4.721
A5.444	20.5	20.5	60.5	0.5	0.5	0.5	0.5
A5.141	0.5	0.5	0.5	85.5	14.5	0.5	0.5
A5.142	0.5	0.5	0.5	66.5	33.5	0.5	0.5
A5.231	0.5	0.5	0.5	0.5	0.5	96.5	3.5

3.2.2. Cohen's Kappa

Table 11 Results of the Cohen's Kappa

Predictive Model Type	Cohen's Kappa score
All	0.12
Broad scale	0.26
Level 4	0.69
Level 5	0.63

4. Discussion

In general, the resulting maps are all good predictive indicators as to the true characteristics of the seabed. The benefits of producing predictive maps such as these promote wide-scale mapping of the seabed in areas which are relatively data poor when compared with inshore coastal waters. They can act as a baseline for seabed characterisation in which to build a more in-depth picture and assist in selecting appropriate survey designs targeting key areas of interest highlighted by the results. It is expected that further ground truthing information collected as part of the Rampion 2 subtidal benthic survey campaign will, once added into the model, will improve the predictive power of all the maps and increase overall map agreement.

Potential reef habitat is identified from the predictive model as occurring in low density throughout the composite and broad scale maps, particularly in the northwest of the survey area. The SSS backscatter and TRI (Appendix B - Physical Variables) display acoustic signatures indicative of harder sediments such as reef. However, within the Level 4 model, rock classifications are identified as over representative, which is likely a misclassification of mixed and coarse classifications.

The series of models did not predict the presence of species of conservation importance. The A5.431 biotope containing a species of prolific, non-native mollusc *Crepidula fornicata* was identified from within the Level 5 model as dominating the nearshore infralittoral.

The disparity between the confusion matrices and corresponding Cohen's Kappa scores is likely a result of the combined effect of a low abundance and high diversity of validation points over a vast area resulting in low percentages of agreement per EUNIS classification rather than a result of poor predictive power. This is evident in the high percentage of correctly classified validation points generally seen throughout all single level maps.

Seven biotopes were identified as occurring throughout the survey area. It is inherently challenging to assign biological features to physical proxies as they often do not display physical signatures that would differentiate them from higher order classifications. Further, biotopes, (Level 5 classifications) may be localised and species specific. Therefore, care should be taken when analysing the occurrence of biotope information as the extent of biotopes may either be over or underestimated. For example, the biotopes within these predictive maps include; *Flustra foliacea* and *Hydrallmania falcata* on tide-swept circalittoral mixed sediment (A5.444), *Pomatoceros triqueter* with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles (A5.141), *Mediomastus fragilis*, *Lumbrineris* spp. and venerid bivalves in circalittoral coarse sand or gravel (A5.142), Infralittoral mobile clean sand with sparse fauna (A5.231), Sponges and anemones on vertical circalittoral bedrock (A4.139), and *Crepidula fornicata* with ascidians and anemones on infralittoral coarse mixed sediment (A5.431). Further only biotopes identified from existing ground truth data will be present in the resulting map therefore potentially creating an oversimplification of biotopes throughout the survey area. Despite the random stratified sampling of all ground truth data, disparity occurs when

biotopes are both over and underrepresented. For example, the majority of biotope data consisted of A5.231 (72 out of 108 training points) whilst only a single data point of A4.139 was available in which to classify further unknown areas. Further delineation of habitat features is advised in order to increase the quantity of biotope classified data and therefore improve the predictive maps. This is particularly important for identifying further the extent of the prolific non-native species *C. fornicata*.

The physical variables utilised in these predictive maps were selected to best describe the physical features which influence species and communities of species, including depth, slope, aspect, seabed roughness, and seabed profile. There is an exhaustive amount of physical and environmental variables that could also be included in the analyses, in particular Bathymetric Position Index and Vector Ruggedness Measure (both additional derivatives of bathymetry in relation rugosity), and these could be explored further to identify if they can improve the final outputs. Backscatter is a valuable predictive mapping tool and is used widely as a proxy for habitat type as changes in sediment type and their boundaries are often associated with changes in acoustic intensity, with softer sediments displayed as low reflectivity and harder sediments displayed as high reflectivity. Side scan sonar (SSS) offers a similar sediment/habitat proxy as backscatter, however there are inherent flaws which can influence the visual appearance and therefore the interpretation of the resulting acoustic data. SSS often displays varying degrees of shadow as it passes over a 3-dimentional seabed environment, this is particularly apparent in complex rocky environments. In predictive mapping, shadows displaying lower reflectivity than surrounding area have the potential to be classified as a separate feature. The track lines of SSS caused by the equipment's nadir tend to be more visible in SSS and require additional processing to reduce their influence in the predictive mapping process. These nadir marks were visible and caused some influence within the outputs of these maps, however their influence did not over-shadow true features visible in the bathymetry and SSS.

Backscatter was omitted from the final iterations of predictive maps due to the quality of the mosaic having an impact on model outputs. Notably, a sharp decrease in sonar intensity between the nearshore and offshore sections of the data (Appendix B - Physical Variables). This is an anomaly of mosaicking sonar data from multiple sources (for instance, the nearshore and offshore tranches) in ArcPro and could potentially be rectified by either mosaicking and editing xyz data initially in geoprocessing software and exporting as a single data layer, or by producing two predictive maps, one of the nearshore and one of the offshore. The latter has its own limitations as it would require further splitting of ground truth data, resulting in a potential loss of predictive power within either area.

Environmental variables (Appendix C - Environmental Variables) were tested within early models runs; however no environmental layers feature in the final model outputs. This was due to an overall lack of variation in each variable on a survey scale causing a reduction in the

resolution of the corresponding PCA. The limited features of each environmental variable were felt to be captured by the combined influence of the physical variables, notably bathymetry.

4.1. Glossary of terms and abbreviations

Table 12 Glossary of terms and abbreviations

Term (acronym)	Definition
Benthic ecology	Benthic ecology encompasses the study of the organisms living in and on the sea floor, the interactions between them and impacts on the surrounding environment
Biotope	A region of habitat associated with a particular ecological community.
BSH	Broadscale Habitat
Centre for Environment Fisheries and Aquaculture Science (Cefas)	The Government's marine and freshwater science experts, advising the UK government and overseas partners.
DCO	Development Consent Order
Environmental Impact Assessment (EIA)	The process of evaluating the likely significant environmental effects of a proposed project or development over and above the existing circumstances (or 'baseline').
EMODnet	European Marine Observation and Data Network
Environmental Statement (ES)	The written output presenting the full findings of the Environmental Impact Assessment.
EUNIS	European Nature Information System
EUNIS habitat classification	A pan-European system which facilitates the harmonised description and classification of all types of habitat, through the use of criteria for habitat identification
Geographical Information System (GIS)	A system that captures, stores, analyses, manages and presents data linked to location. It links spatial information to a digital database.
GoBe	GoBe Consultants Ltd
HRA	Habitat Regulations Assessment
Intertidal	The area of the shoreline which is covered at high tide and uncovered at low tide.
km	Kilometre
m	Metre

MBES	Multi Beam Echo Sounder
MLC	Maximum Likelihood Scenario
MNCR	Marine Habitat Classifications for Britain and Ireland
MW	Megawatt
NSIP	Nationally Significant Infrastructure Project
OEL	Ocean Ecology Ltd
Offshore	The sea further than two miles from the coast.
Offshore Wind Farm	An offshore wind farm is a group of wind turbines in the same location (offshore) in the sea which are used to produce electricity.
PCA	Principal Component Analysis
PSD	Particle Size Distribution
Preliminary Environmental Information Report (PEIR)	The written output of the Environmental Impact Assessment undertaken to date for the Proposed Development. It is developed to support formal consultation and presents the preliminary findings of the assessment to allow an informed view to be developed of the Proposed Development, the assessment approach that has been undertaken, and the preliminary conclusions on the likely significant effects of the Proposed Development and environmental measures proposed.
Rampion 1	The existing Rampion Offshore Wind Farm located in the English Channel off the south coast of England.
RED	Rampion Extension Development Limited
SSS	Side Scan Sonar
TCE	The Crown Estate
TRI	Terrain Ruggedness Index
WTG	Wind Turbines Generator

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Appendix A - EUNIS Descriptions

EUNIS Level 5 Biotopes:

A3.215: [Sabellaria spinulosa] with kelp and red seaweeds on sand-influenced infralittoral rock
A4.231: Piddocks with a sparse associated fauna in sublittoral very soft chalk or clay
A5.141: [Pomatoceros triqueter] with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles
A5.142: [Mediomastus fragilis], [Lumbrineris] spp. and venerid bivalves in circalittoral coarse sand or gravel
A5.231: Infralittoral mobile clean sand with sparse fauna
A5.431: Crepidula fornicata with ascidians and anenomes on infralittoral coarse mixed sediment
A5.444: [Flustra foliacea] and [Hydrallmania falcata] on tide-swept circalittoral mixed sediment

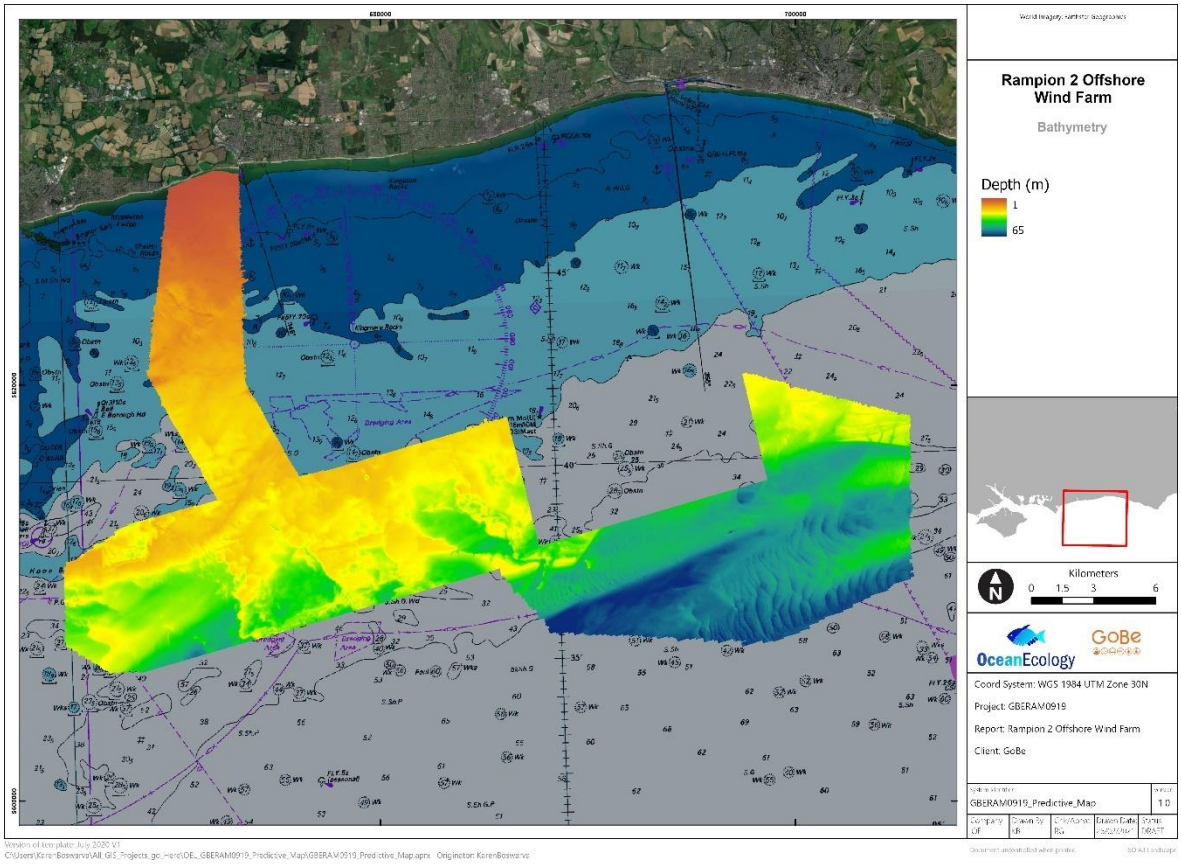
EUNIS Level 4 Biotope Complexes

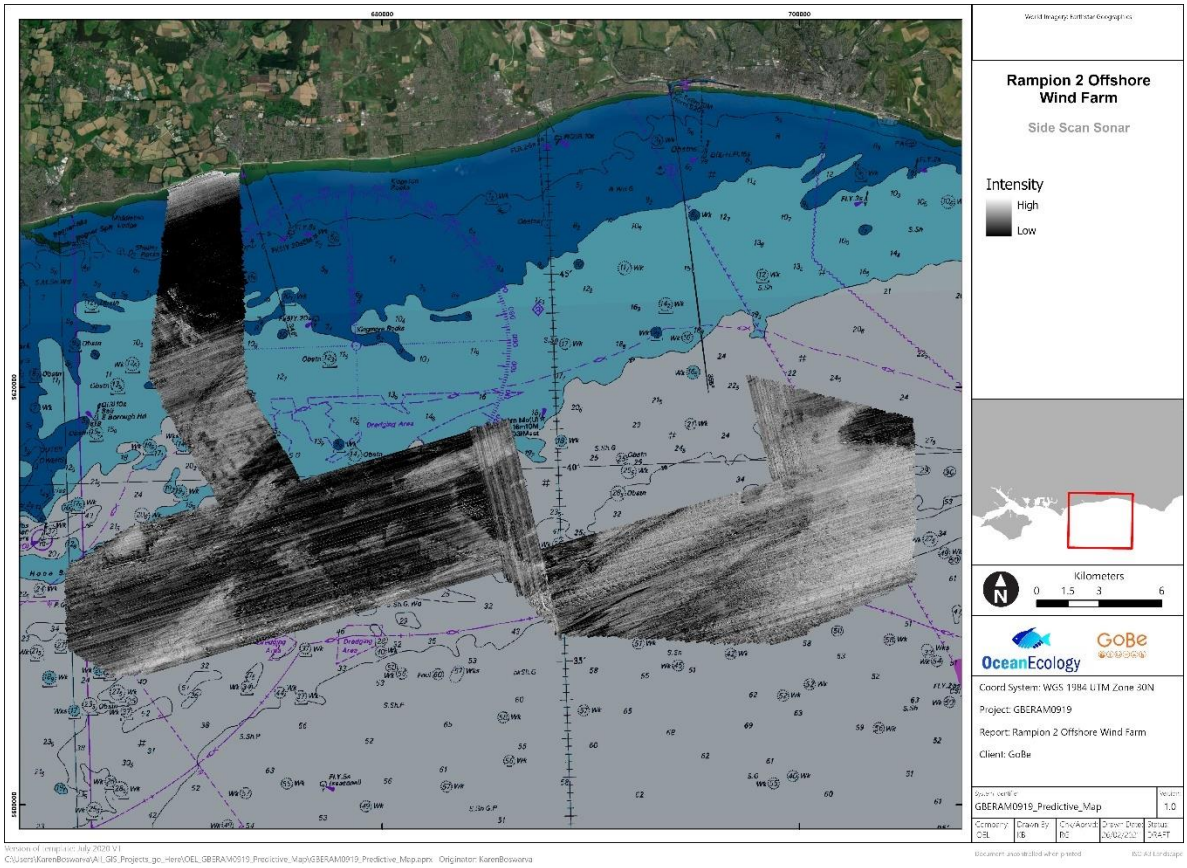
A3.21: Kelp and red seaweeds (moderate energy infralittoral rock)
A4.13: Mixed faunal turf communities on circalittoral rock
A4.23: Communities on soft circalittoral rock
A5.14: Circalittoral coarse sediment
A5.43: Infralittoral mixed sediments
A5.44: Circalittoral mixed sediments
A5.52: Kelp and seaweed communities on sublittoral sediment

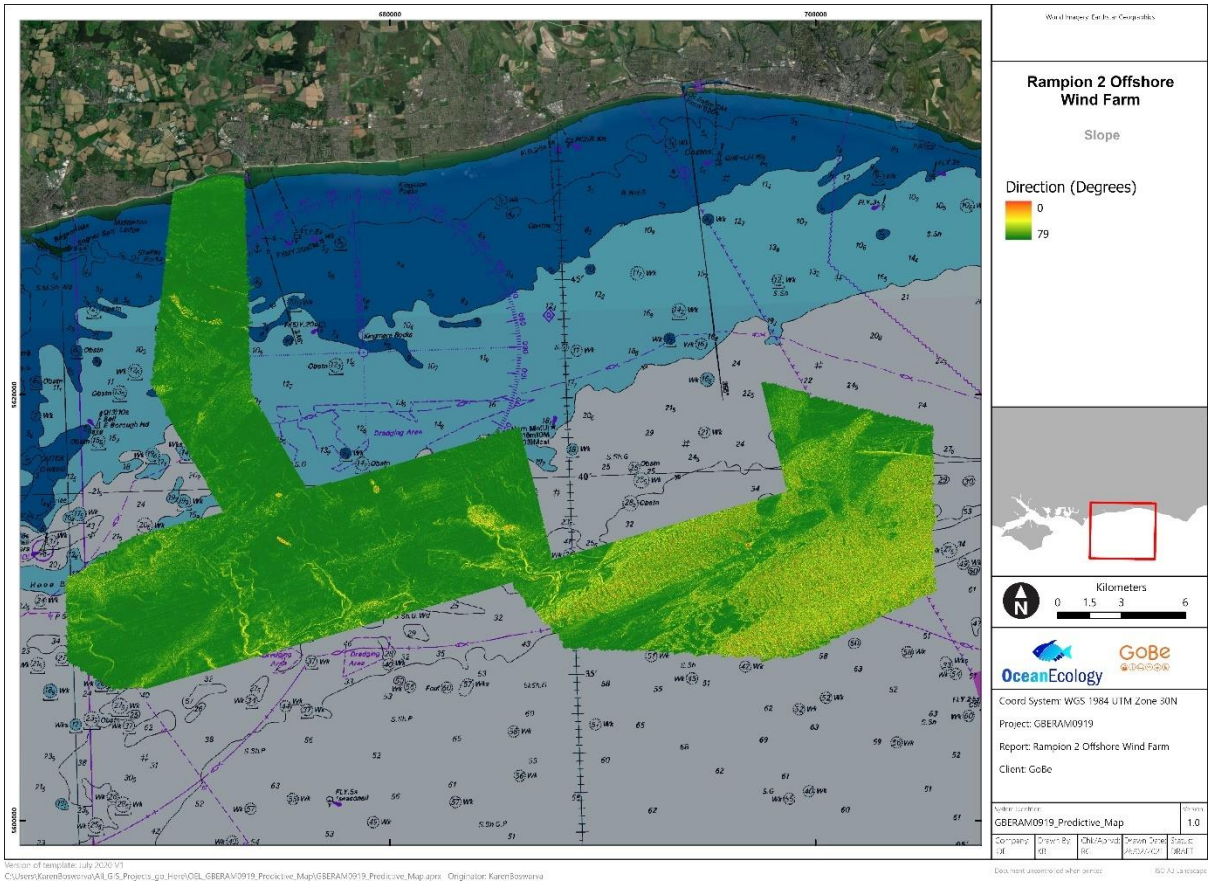
EUNIS Broadscale Habitats

A3.2: Atlantic and Mediterranean moderate energy infralittoral rock
A4.1: Atlantic and Mediterranean high energy circalittoral rock
A4.2: Atlantic and Mediterranean moderate energy circalittoral rock
A5.1: Sublittoral coarse sediment
A5.2: Sublittoral sand
A5.3: Sublittoral mud
A5.4: Sublittoral mixed sediments
A5.5: Sublittoral macrophyte-dominated sediment

Appendix B - Physical Variables



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Direction (Degrees)
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79
Kilometers
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OceanEcology
GoBe
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Client: GoBe
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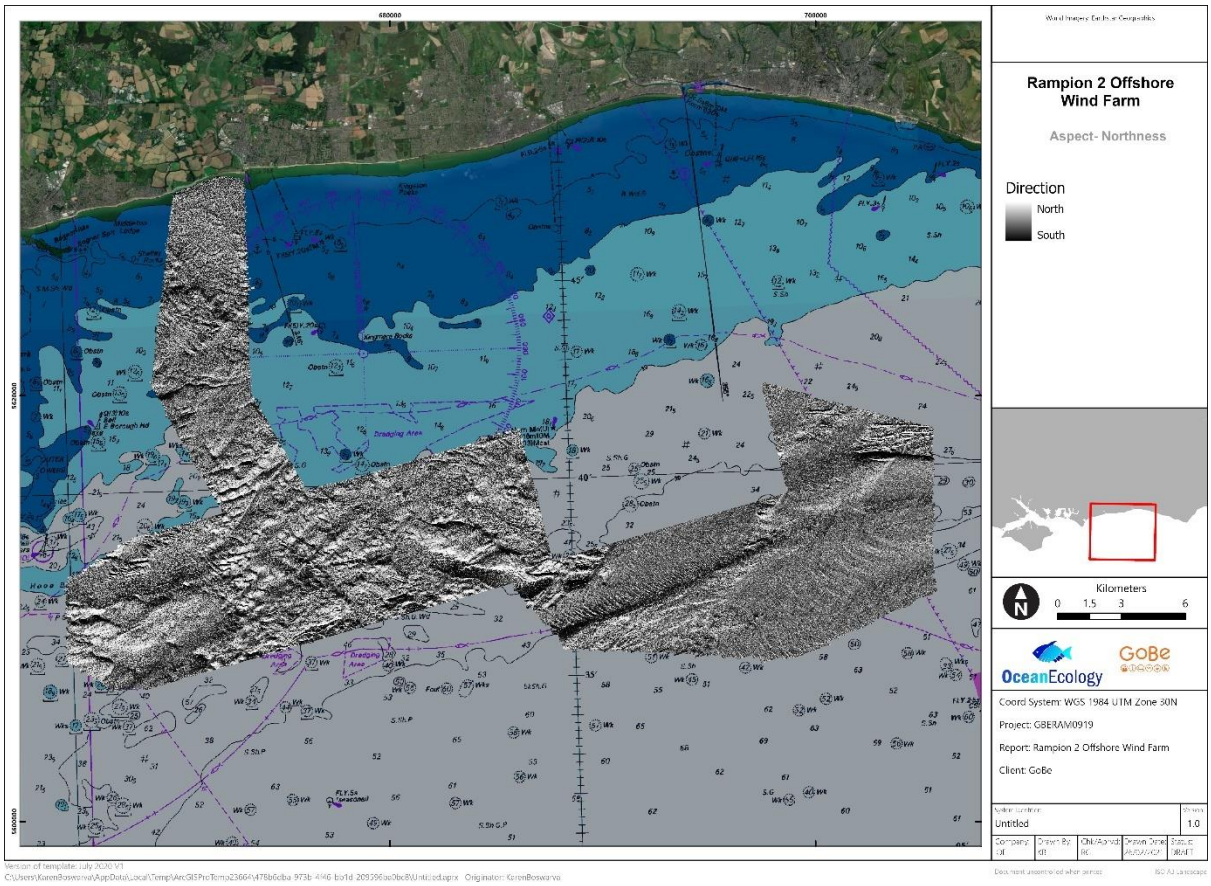
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Direction
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South
Kilometers
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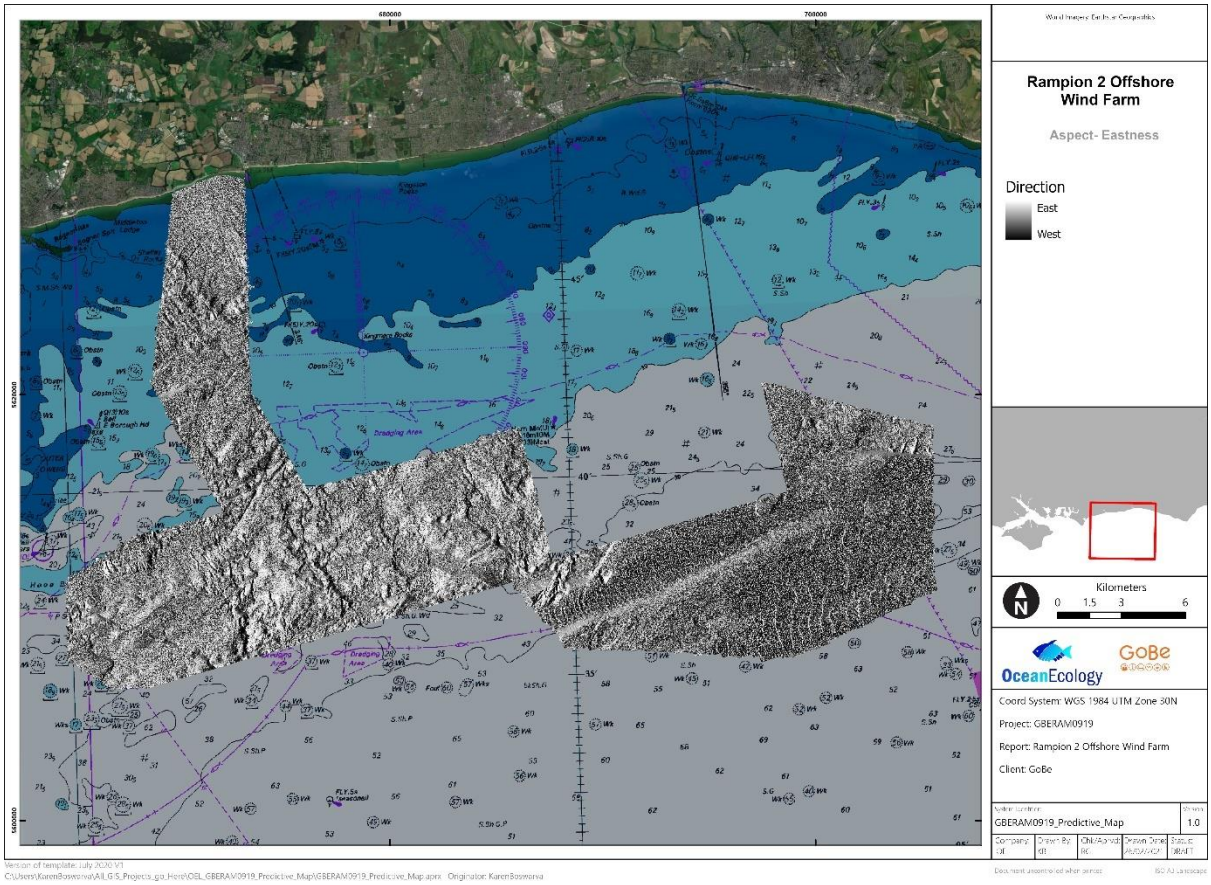
Rampion 2 Offshore Wind Farm
Aspect- Eastness
Direction
East
West
Kilometers
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OceanEcology
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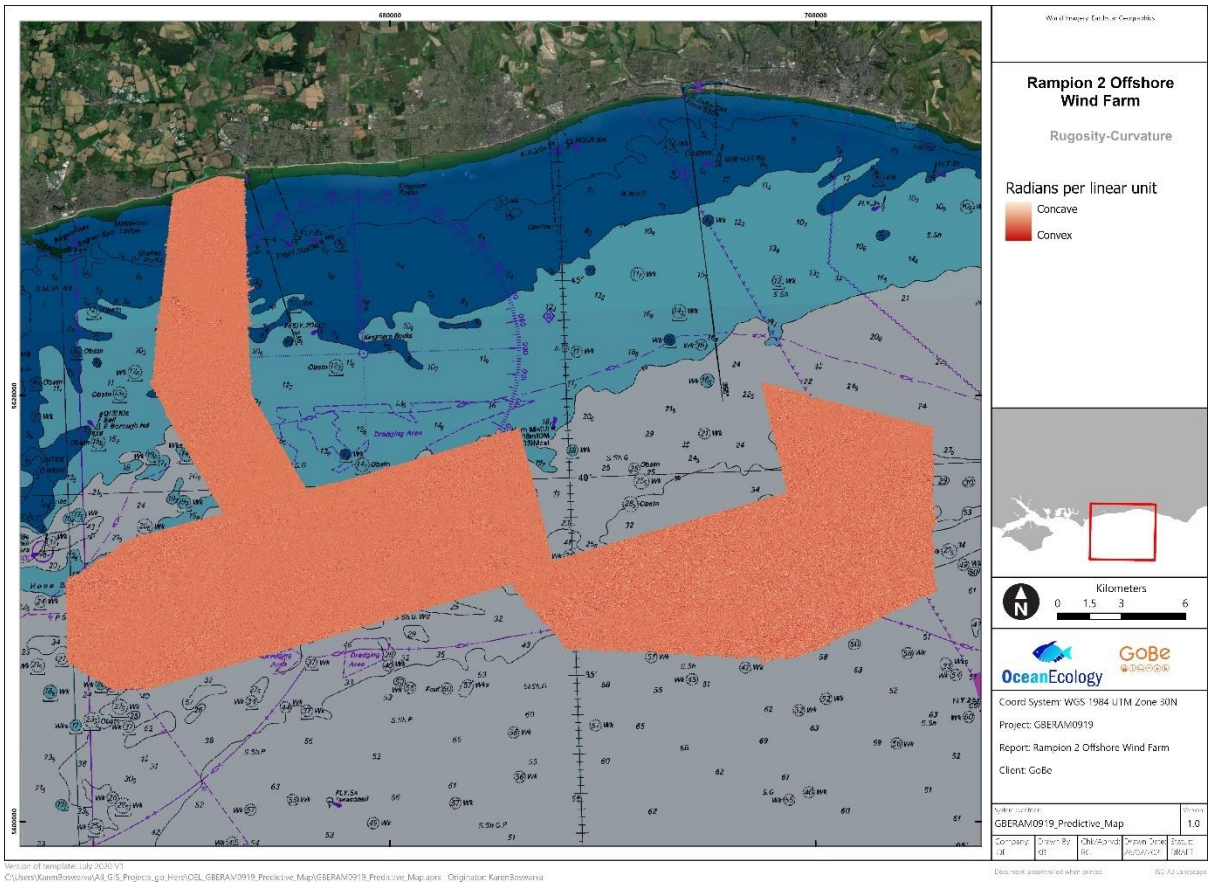
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Rugosity-Curvature
Radians per linear unit
Concave
Convex
Kilometers
0 1.5 3 6
OceanEcology
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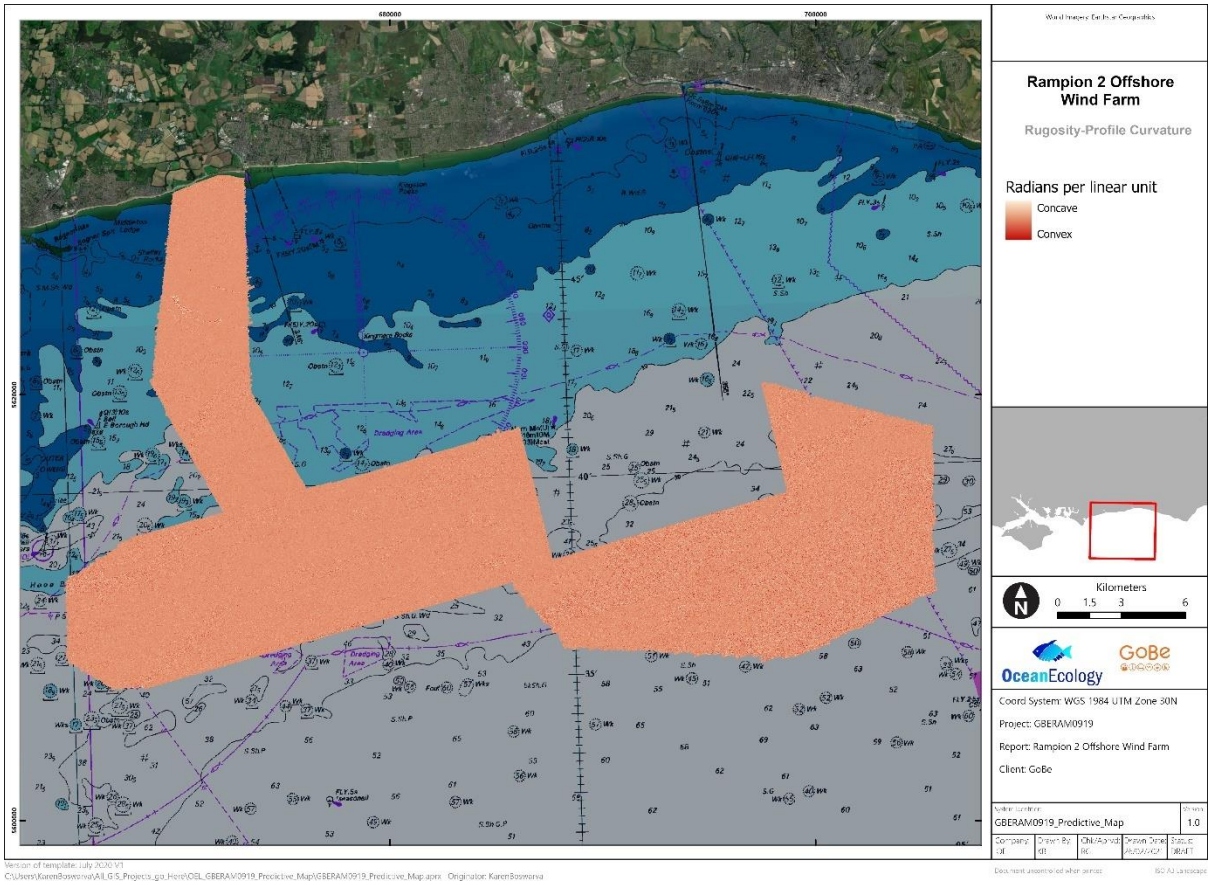
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Rugosity-Profile Curvature
Radians per linear unit
Concave
Convex
Kilometers
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OceanEcology
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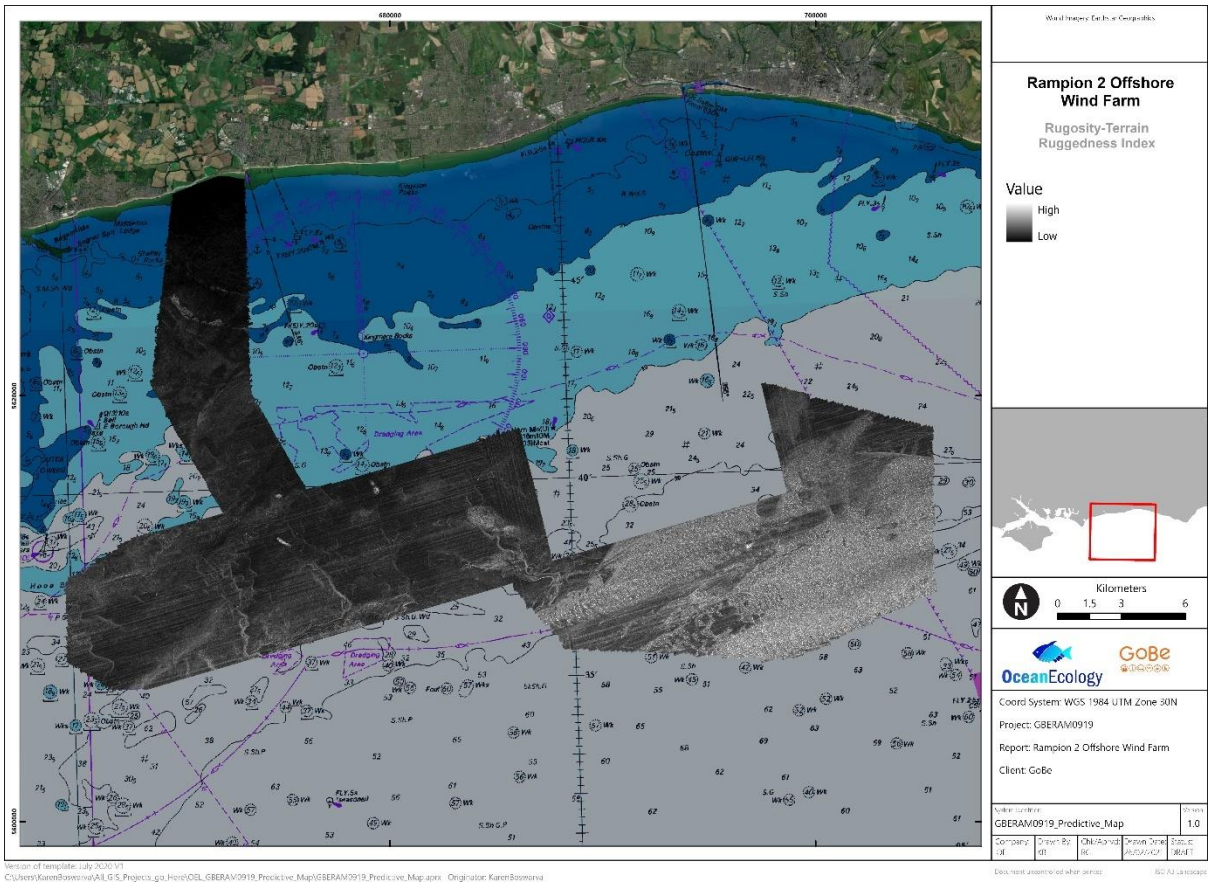
Rampion 2 Offshore Wind Farm
Rugosity-Terrain Ruggedness Index
Value
High
Low
Kilometers
0 1.5 3 6
OceanEcology
GoBe
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Project: GBERAM0919
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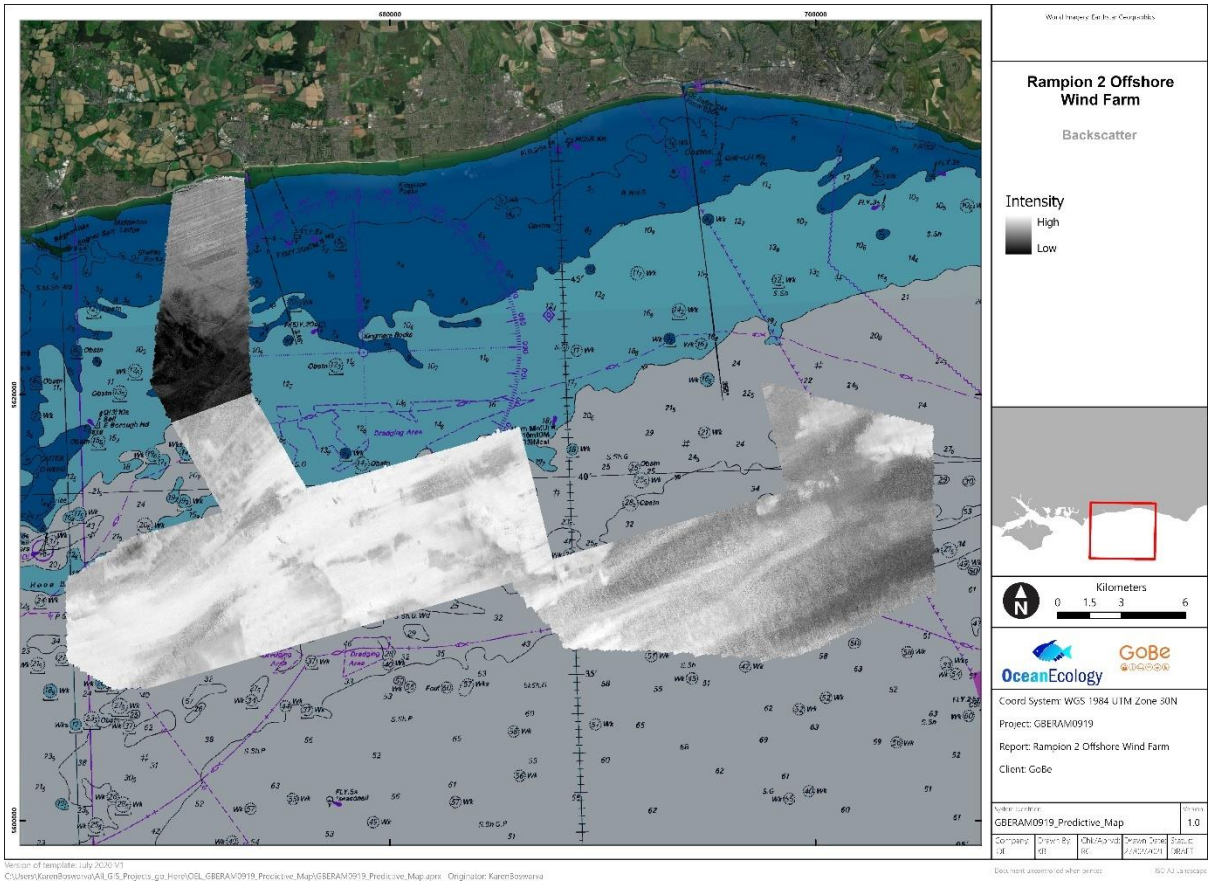
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Backscatter
Intensity
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Low
Kilometers
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GoBe
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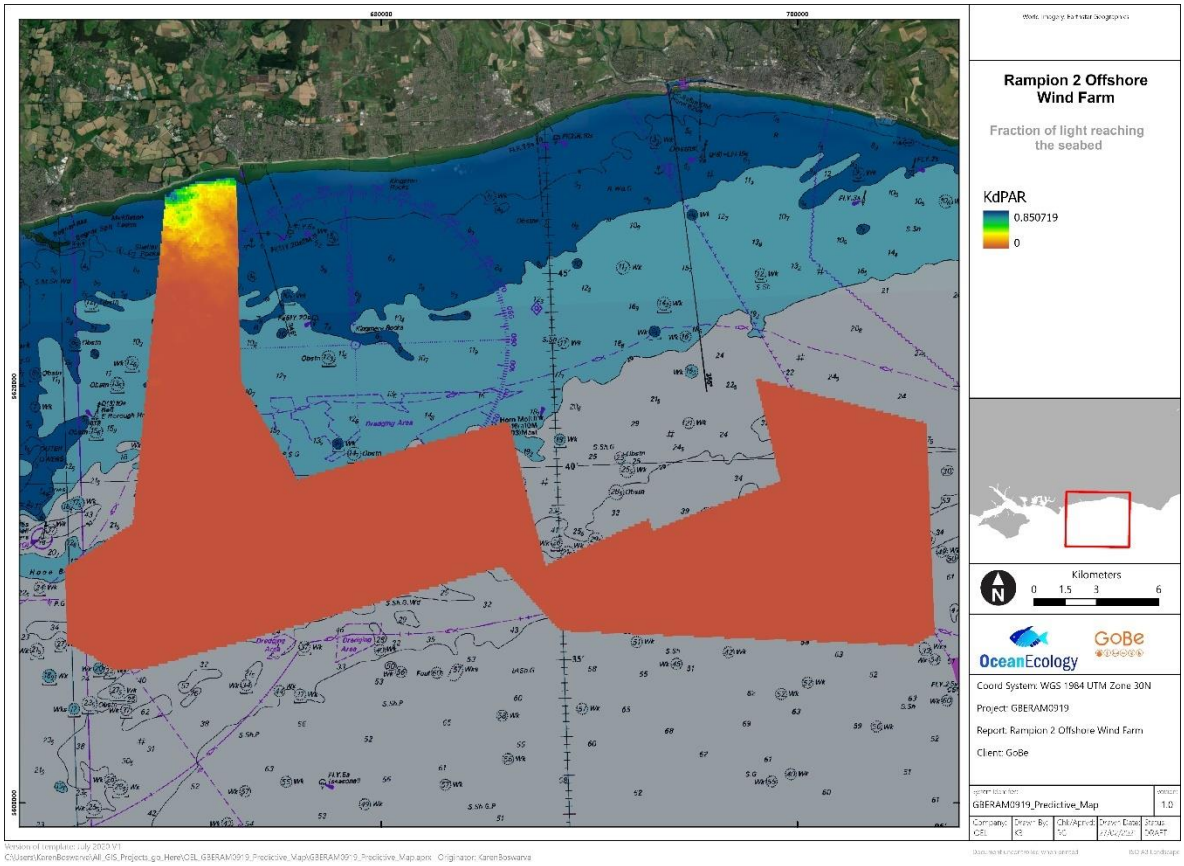
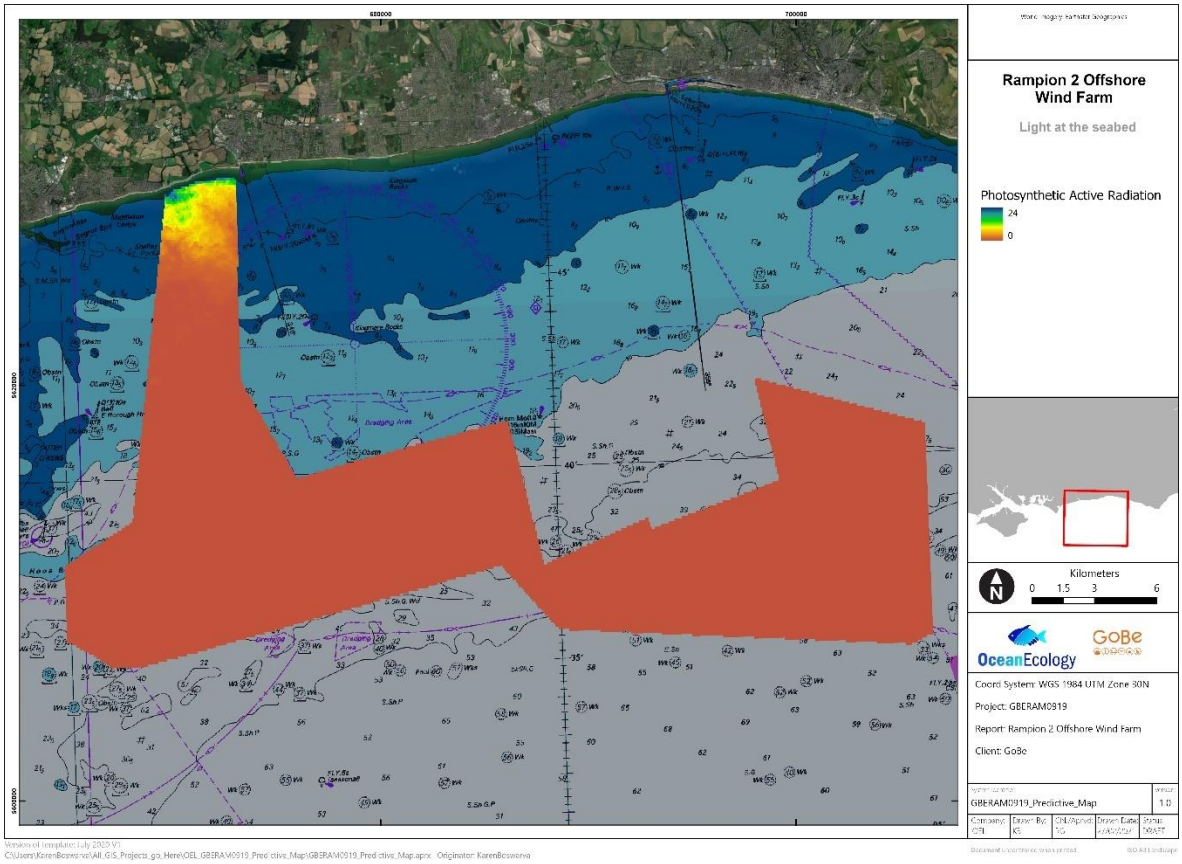
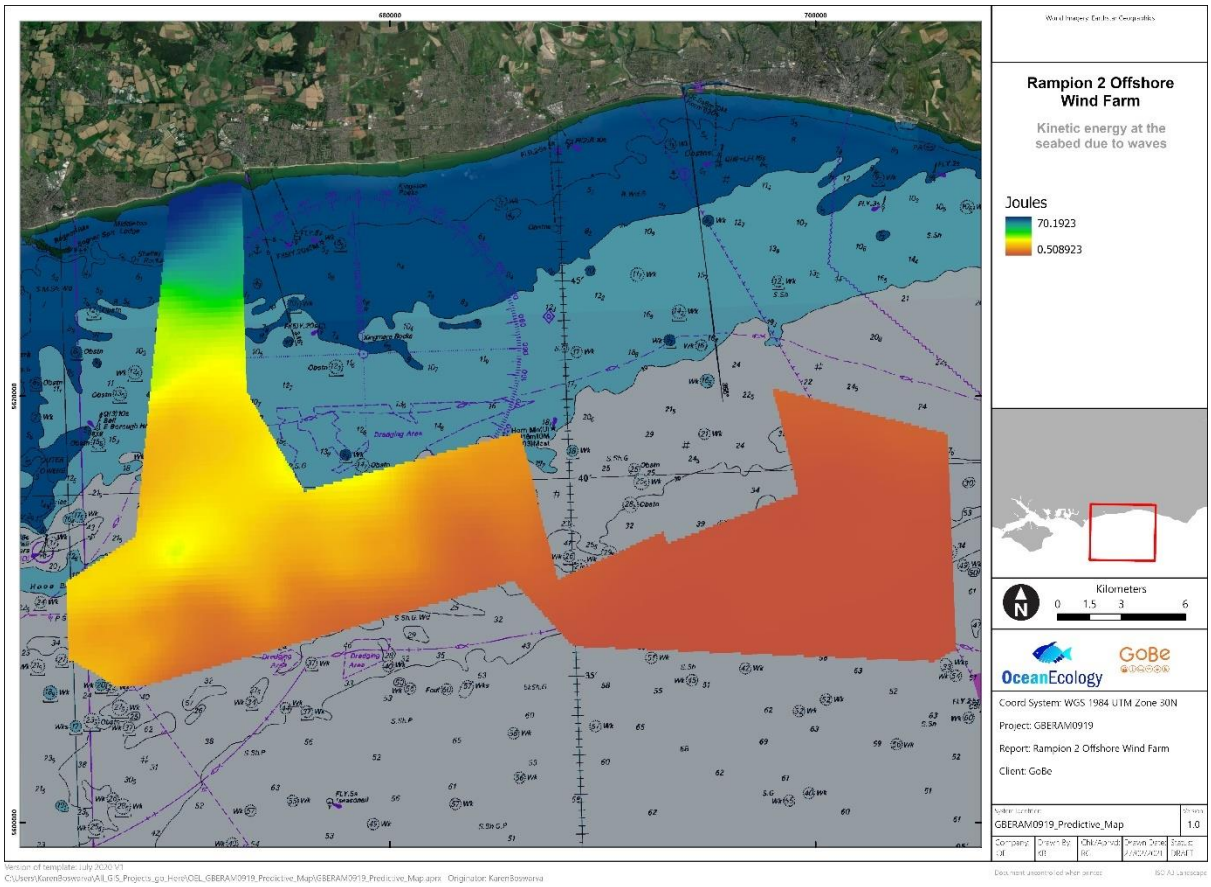
Appendix C - Environmental Variables






Rampion 2 Offshore Wind Farm
Kinetic energy at the seabed due to waves
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0.508923
Kilometers
0 1.5 3 6
OceanEcology
GoBe
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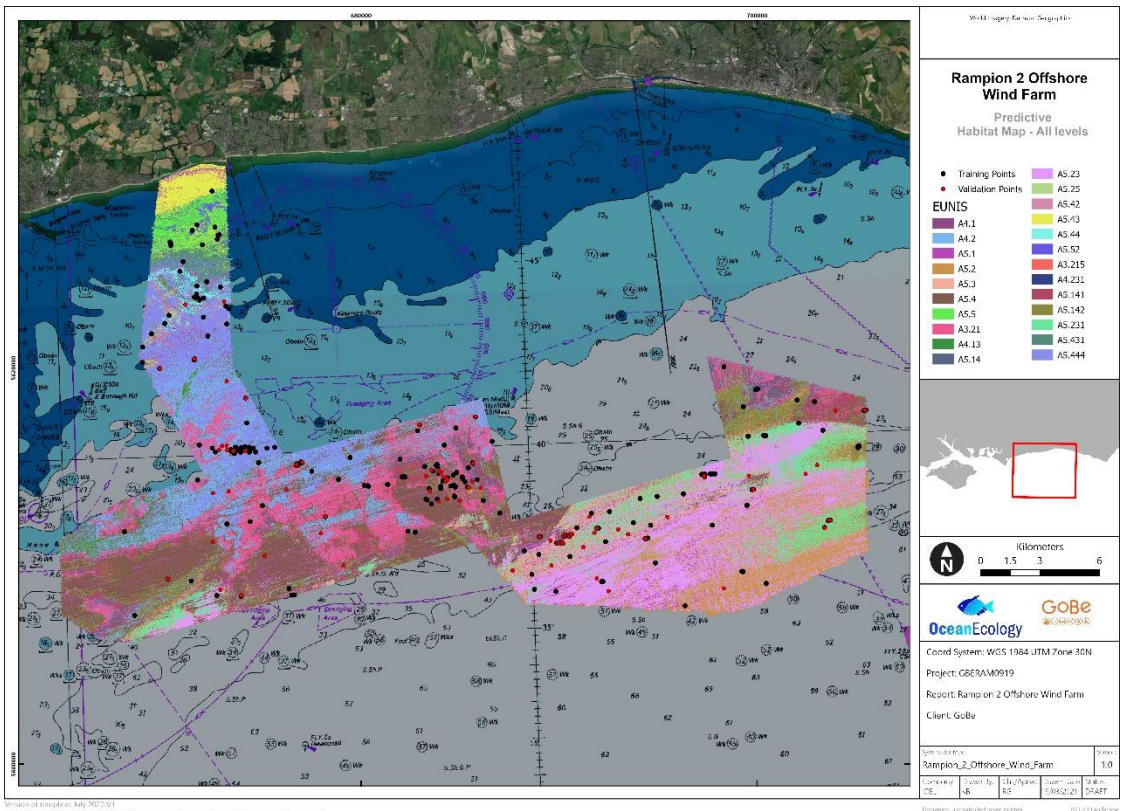
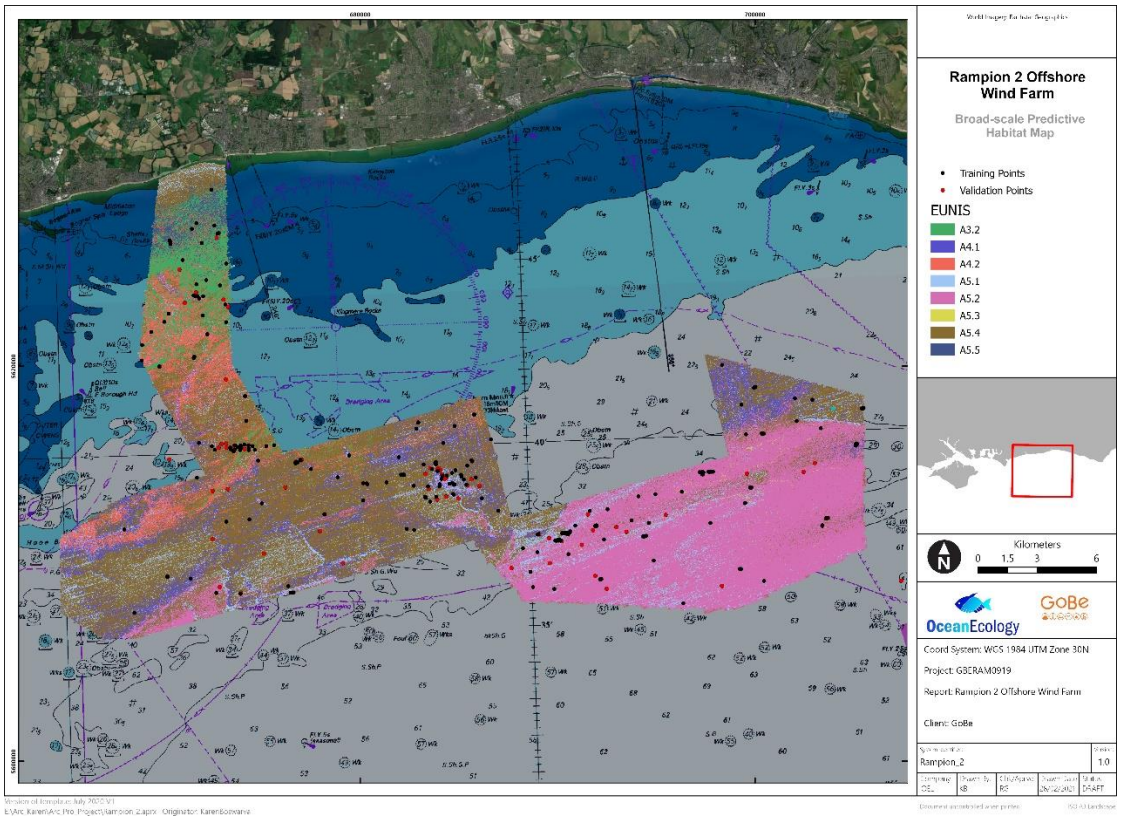
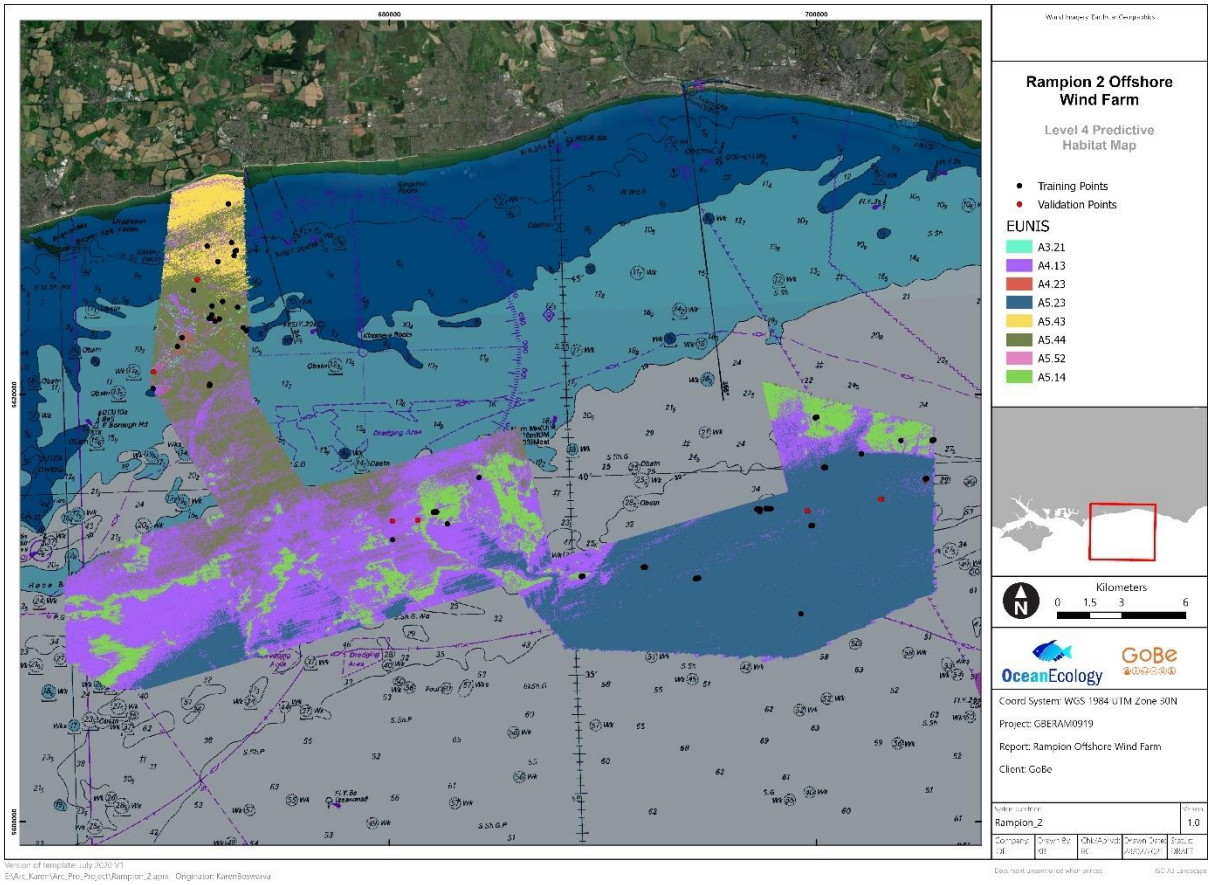
Appendix D - Predictive habitat maps displaying training and validation data points



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Level 4 Predictive Habitat Map
Training Points
Validation Points
EUNIS
A3.21
A4.13
A4.23
A5.23
A5.43
A5.44
A5.52
A5.14
Kilometers
0 1.5 3 6
OceanEcology
GoBe
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Project: GBERAM0919
Report: Rampion Offshore Wind Farm
Client: GoBe
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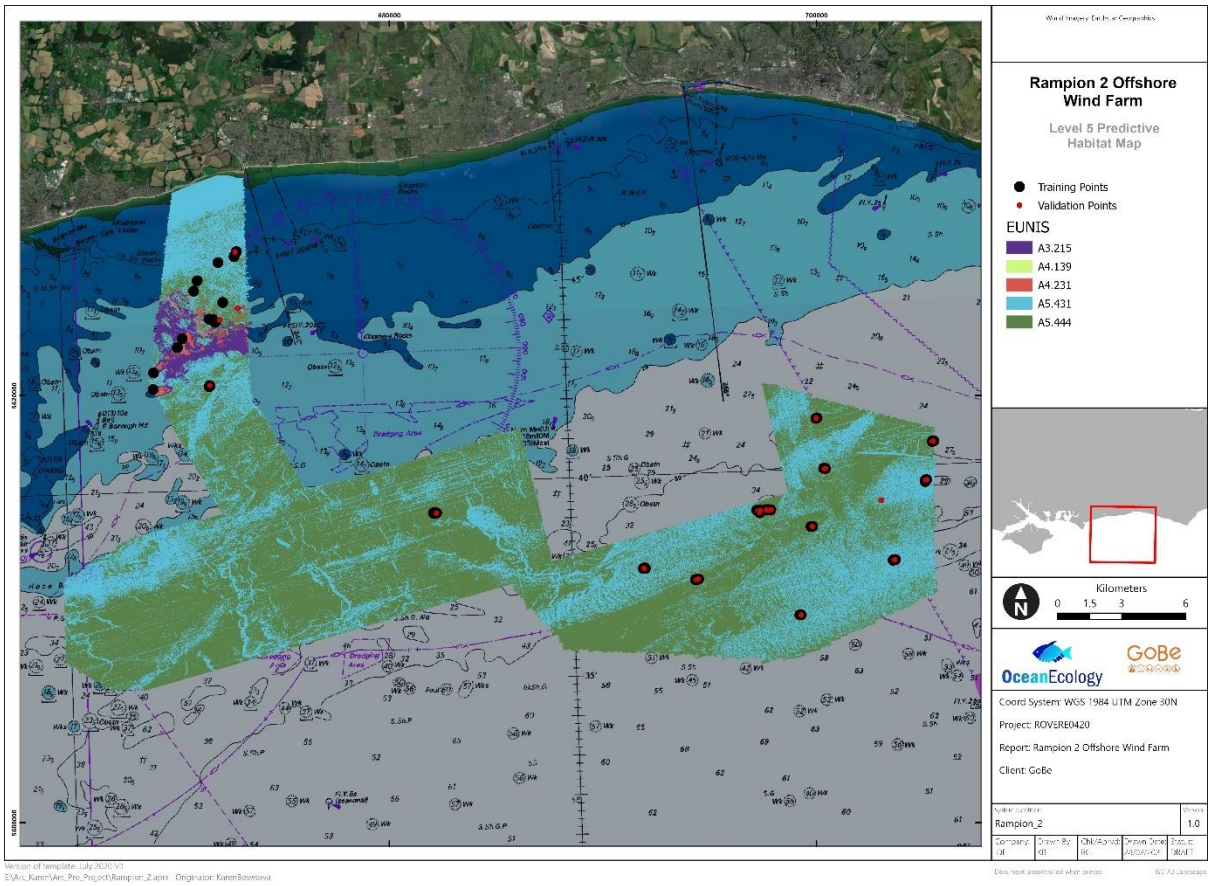
Rampion 2 Offshore Wind Farm
Level 5 Predictive Habitat Map
Training Points
Validation Points
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A4.139
A4.231
A5.431
A5.444
Kilometers
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OceanEcology
GoBe
Coord System: WGS 1984 UTM Zone 30N
Project: ROVERE0420
Report: Rampion 2 Offshore Wind Farm
Client: GoBe
Rampion_2
1.0

4.9.2

Rampion 2 WIND FARM

Volume 4, Appendix 9.2

Intertidal Habitats Survey Report

GoBe wood.

Ocean Ecology

Marine Surveys, Analysis & Consultancy

Rampion 2 Offshore Wind Farm Intertidal Habitats Survey Report 2020

REF: OEL_GBERAM0919_TCR

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Details

Version	Date	Description	Author(s)	Reviewed By	Approved By
V01	04/11/2020	First Draft	Dr Elena Cappelli	Gary Robinson	Ross Griffin
V02	06/12/2020	Updated following client review	Dr Elena Cappelli	Gary Robinson	Ross Griffin

Updates

Section	Description	Page

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1. Non-Technical Summary

1.1.1. This report presents the findings of the intertidal survey conducted between Elmer Beach and the mouth of the River Arun (West Sussex) aimed at establishing the main benthic habitats present in the vicinity of the proposed landfall location of the Rampion 2 Offshore Wind Farm export cable corridor. The survey involved a Phase I walkover accompanied by collection of Unmanned Aerial Vehicle (UAV) aerial imagery and Phase II sampling using cores for soft substrates and quadrat sampling for hard substrates.

1.1.2. The survey area was found to be dominated by sandy sediments in the lower and mid shore supporting mostly polychaetes and amphipods and the upper shore dominated by relatively impoverished shingle and gravel. A typical zonation was observed across the survey area; this included sea kale, *Crambe maritima,* and shingle dominated biotopes in the supralittoral (EUNIS B2.32) and upper shore zones (EUNIS A2.11 and A2.111), and polychaetes / amphipod dominated fine to muddy sands in the mid to lower shore areas (EUNIS A2.21, A2.23 and A2.24). The lower shore was characterised by *Ulva* spp. dominated rockpools (EUNIS A1.45) interspersed with fine sand supporting the polychaete *L. conchilega* (EUNIS A2.245). Of particular note was the presence of interspersed outcropping chalk and clay exposures (EUNIS A1.46) across the upper-mid shore region in the western extent of the survey area.

1.1.3. The rockpool biotope assigned during the survey correlate to Annex I ‘reef’ habitat while the sandy sediment habitats correlate to the Annex I habitat ‘mudflats and sandflats not covered by seawater at low tide’ although it should be noted that the habitats observed are not designated features of Natura 2000 sites. The chalk and clay exposures that were encountered are considered as soft rock and are therefore also representative of Annex I reef habitat. All the above mentioned habitats that fall under Annex I of the EC Habitats Directive are protected here under the Section 41 of the Natural Environment and Rural Communities (NERC) Act 2006 (England).

2. Introduction

2.1. Rampion 2

2.1.1. Rampion Extension Development Limited (RED) applied to The Crown Estate (TCE) for an extension to the Rampion Offshore Wind Farm (Rampion 1) in 2018 and, following approval under the plan-led Habitats Regulations Assessment (HRA), was awarded development rights for the Rampion Extension Site in 2019. The proposed Rampion 2 Offshore Wind Farm Project (Rampion 2) is located adjacent to Rampion 1 in the English Channel, off the Sussex coast. Rampion 2 is designated as a Nationally Significant Infrastructure Project (NSIP) under Section 15(3) of the Planning Act 2008, thus requiring a Development Consent Order (DCO) accompanied by and Environmental Statement (ES) in accordance with the Environmental Impact Assessment (EIA) Regulations 2017. Rampion 2 is defined as a Schedule 2 project under EIA Regulations 2017.

2.1.2. Rampion 2 comprises both offshore and onshore infrastructures typically associated with an offshore wind farm project. Offshore elements include the seabed area conditionally awarded in 2019 under the TCE wind farm extension process located to the west of Rampion 1, and the development within the remainder of the original Rampion 1 Round 3 Zone 6 area, to the south east of Rampion 1. The aggregate of these two seabed areas would be optimised to form a single extension development giving rise to a single application for a DCO. Infrastructures include offshore wind turbine generators (WTGs) and associated foundations with an installed capacity of up to 1200 megawatts (MW), inter-array cables, up to three offshore substations and up to four offshore export cables within one cable corridor.

2.1.3. The onshore elements of Rampion 2 comprise a single landfall site at Climping (West Sussex), buried onshore transmission cables in a single corridor approximately 36 kilometres (km) in length, and a new onshore ‘satellite’ substation located within a 5km radius of the existing Bolney Substation (Mid Sussex) to which it will be connected (**Figure 1**).

2.2. Project Background

2.2.1. Ocean Ecology Limited (OEL) were commissioned by RED’s EIA consultants, GoBe Consultants Ltd (GoBe)), to undertake an intertidal Phase I walkover survey and Phase II sampling survey (quadrats and cores) of the intertidal section of the proposed Rampion 2 cable corridor (**Figure 1**) to a) establish the main benthic habitats present and b) characterise the associated marine biological communities. The Rampion 2 cable corridor extends approximately 3.5km from Elmer Beach to the mouth of the River Arun (West Sussex).

2.2.2. This report provides a summary of the survey methodologies employed and a description of the habitats encountered during the survey. Habitats were determined through Unmanned Aerial Vehicle (UAV) imagery, walkover interpretation and quadrat and core sampling allowing for the determination of EUNIS habitats and biotopes (where possible) and subsequent creation of full coverage mapping across the survey area.

2.3. Current Understanding

2.3.1. The Rampion 2 intertidal survey area includes the Climping Beach Site of Special Scientific Interest (SSSI) to the east, which in turn comprises the West Beach Local Nature Reserve (LNR) that covers the beach and riverbank on the west side of the mouth of the river Arun at Littlehampton (West Sussex) (**Figure 1**).

2.3.2. Existing intertidal habitat mapping (MagicMap) suggests the biotopes present within the Climping Beach SSSI and the surrounding area primarily consist of intertidal sand and gravel. The eastern part of the survey area is thought to be dominated by finer sand (EUNIS A2.2). Coarser sediments, including gravel and cobbles (EUNIS A2.1) are thought to be the most abundant habitats present in the central areas and to the west. Occasional rocky areas (EUNIS A1) are thought to occur, particularly around coastal defence structures.

2.3.3. Natural Environment and Rural Communities (NERC) Act (2006) Section 41 Habitats of Principal importance are present along the top of the shore, particularly within the Climping Beach SSSI. These include:

- Coastal Vegetated Shingle (EUNIS B2); and
- Coastal Sand Dunes (EUNIS B1).

2.3.4. These habitats are recorded as being particularly prevalent in the eastern part of the survey area but also extending west along the coastline.

Climping Beach Site of Special Scientific Interest (SSSI)

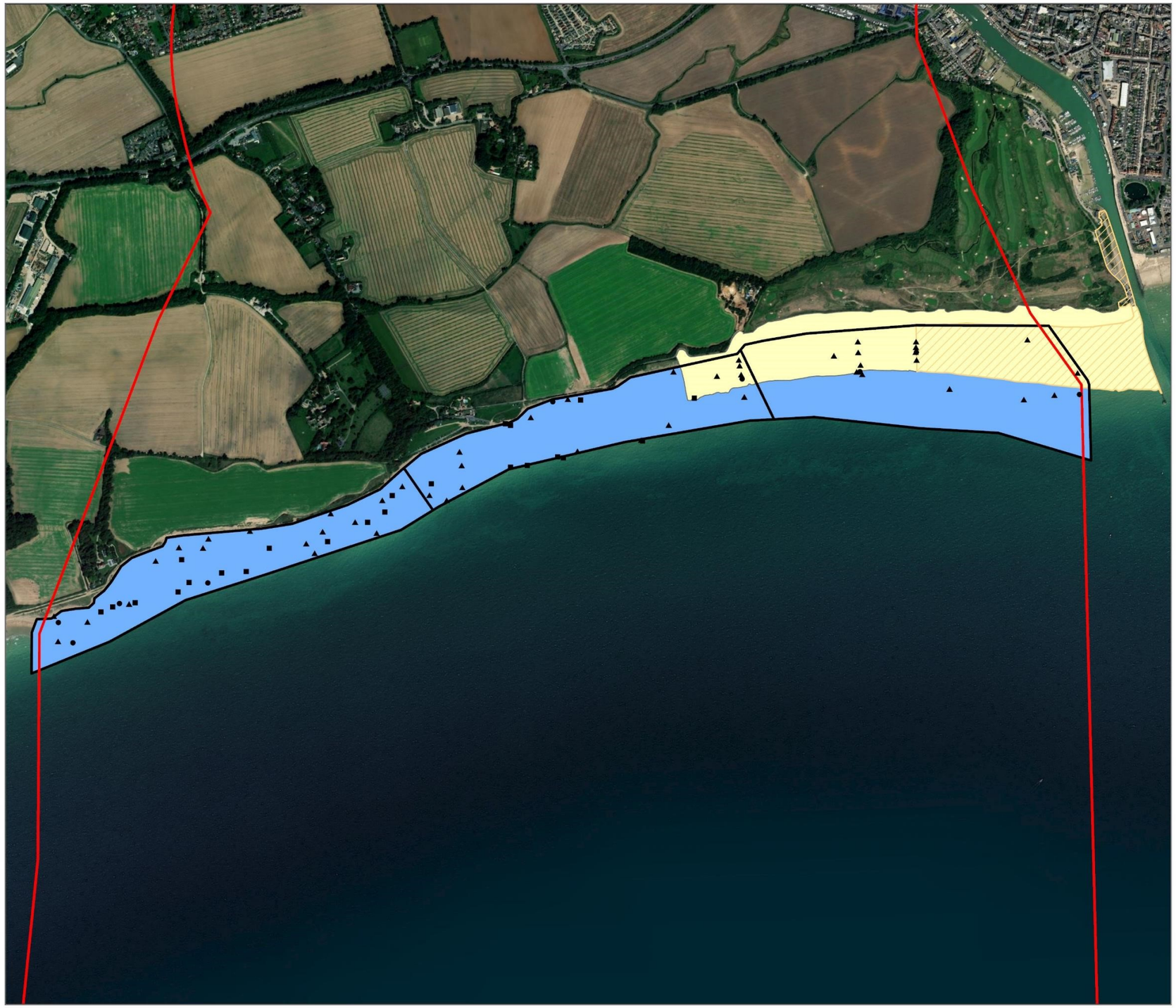
2.3.5. Climping Beach SSSI extends from the breakwater at the eastern end of West Beach to approximately half-way along the survey area (**Figure 1**). The site is a stretch of coast with a vegetated shingle beach, behind which is a mature sand dune system. The intertidal zone consists of soft muds and sands which support large populations of marine invertebrates that are an important food source for wintering birds. In particular up to 300 sanderling (*Calidris alba*) have been recorded from this site in winter; a figure which represents 1 percent of the West European population of this bird which breeds in the high Arctic and flies south to winter on sandy coasts and estuaries. Other overwintering birds found to utilise

this site include grey plover (*Pluvialis squatarola*) and oystercatcher (*Haematopus ostralegus*).

West Beach Local Nature Reserve (LNR)

2.3.6. The West Beach LNR is part of the Climping Beach SSSI and was declared by Arun District Council in 1995 (**Figure 1**). It includes sand dunes, vegetated shingle, sand flats and a small patch of saltmarsh. The dunes are part of one of only two sand dune systems in West Sussex. The sand lizard (*Lacerta agilis*) protected under the Wildlife and Countryside Act 1984 and four nationally scarce burrowing bees and wasps occur in the dunes. The vegetated shingle, though locally common, is internationally rare, and is used by a Red Data Book ant species *Myrmica specioides*. The sand flats host large numbers of migratory waders in the winter months.

Figure 1 Intertidal survey area for the proposed Rampion 2 export cable corridor landfall.



World Imagery: Maxar, Microsoft

Rampion 2 Offshore Wind Farm Intertidal Survey 2020

Intertidal Survey Area

Key

- Target Notes
- 0.01 m2 Core
- 0.25 m2 Quadrat
- Rampion 2 red line boundary
- West Beach Local Nature Reserve
- Climping Beach SSSI
- Intertidal Survey Area

N

Kilometers

0 0.13 0.25 0.5

OceanEcology GoBe

Coord System: WGS 1984

Project: GBERAM0919

Report: Rampion 2 Offshore Wind Farm Intertidal Biotope Mapping

Client: GoBe

System Identifier:	Version:
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Company:	Drawn By:	Chk/Aprvd:	Drawn Date:	Status:
OEL	EC	GR	20/11/2020	DRAFT

Version of template: July 2020 V1

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ISO A3 Landscape

3. Methods

3.1. Survey Design

3.1.1. The intertidal survey covered the entirety of the proposed Rampion 2 cable corridor intertidal survey area, in addition to a 25 m buffer, from Mean Low Water Springs (MLWS) to Mean High Water Springs (MHWS). A UAV survey was undertaken to collect high resolution imagery across the survey area at low water. Additionally, a total of 23 quadrats and 10 core locations (sampled in duplicate) were selected across the survey area to further supplement the Phase I walkover survey and UAV imagery and inform detailed biotope mapping.

3.2. Survey Methods

Phase I Walkover Survey

3.2.1. The Phase I intertidal survey was undertaken during spring tides using ESRI ArcCollector on a Global Positioning System (GPS) enabled tablet device in line with 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 (Natural Resources Wales (NRW) 2019a; 2019b). During the walkover survey, EUNIS classifications were assigned in consideration of the latest Joint Nature Conservation Committee (JNCC) guidance (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 ArcCollector. A detailed intertidal survey log and field notes are provided in Appendix I.

3.2.2. Representative examples of each habitat / biotope encountered were photographed. Additionally, the distribution of any features of conservation interest were recorded using photographs and GPS fixes where encountered. The presence of any invasive non-native species (for example, *Crepidula fornicata*) was also noted and their location recorded. Other information recorded included general site conditions, sediment surface features (for example, *Lanice conchilega* tube aggregations), sediment type and characteristics, topography and anthropogenic pressures.

UAV Mapping

3.2.3. The UAV mapping was carried out in line with JNCC guidance for use of UAVs in marine benthic monitoring (Crabb *et al*. 2019). All flights were conducted by OELs Qualified UAV Pilots (RPQs) under its Permission for Commercial

Operations (PfCO) (CAA ID: 2654) granted by the Civil Aviation Authority (CAA)[1]. The UAV used was a DJI Phantom 4 multi-rotor quadcopter. The flight(s) were pre-planned using in Drone Deploy software to achieve an orthomosaic Ground-Sampling Distance (GSD) of 1-3 centimetres (cm)/pixel (px) with an accuracy[2] of 5-10 metres (m).

Target Notes

3.2.4. Target notes were taken at any notable change in habitat / substrate and identified the presence of any notable features (for example, intertidal rockpools). These were accompanied by GPS fixes and close-up photographs of each feature along with general site photographs.

Phase II Sampling

3.2.5. ESRI ArcCollector was used on a GPS enabled tablet device to navigate between core and quadrat sampling stations located across areas of soft and hard substrate throughout the survey area.

Quadrat Sampling

3.2.6. Areas representative of each key hard substrate habitat at different tidal heights were assessed by recording the epibiotal taxa present in randomly placed 0.25 square metres (m^2) (0.5m x 0.5m) quadrats. Identification was taken to species level where possible and undertaken in the field. Any cryptic taxa that were not identified in the field were retained and identified in the laboratory.

3.2.7. At each quadrat location the substrate was subject to a visual inspection and observations of colour, smell, texture and presence of surface features (accretions, algae, fauna, etc.) recorded. A high-resolution photograph was taken directly above the quadrat (in plan view) for subsequent analysis, and a further four photographs were taken in a north, east, south and west orientation.

Core Sampling

3.2.8. Areas representative of each key soft substrate habitat at different tidal heights were assessed by collecting 0.01m^2 duplicate hand core samples to a depth of 15cm. The first core sample was used to characterise the macrobenthic communities present and the second for Particle Size Distribution analysis (PSD)

1.1.1. _____

1 Ocean Ecology's UAV aerial survey operations comply with all UK legislation regarding commercial use of Small Unmanned Aerial Systems (sUAS). This requires that Ocean Ecology hold a CAA PfCO, Liability Insurance, a CAA approved Operational Manual and Qualified UAV Pilots (RPQs).

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

to characterise the physical nature of the sediments. Five photographs were also taken at each soft sediment station: the first directly above the sediment (in plan view) and the following four in a north, east, south and west orientation.

3.3. Analysis

Macrobenthic Analysis

3.3.1. All macrobenthic analyses were carried out by in-house marine taxonomists at OEL's NE Atlantic Marine Biological Analytical Quality Control (NMBAQC) scheme participating laboratory in line the NMBAQC Processing Requirement Protocol (PRP) (Worsfold & Hall 2010). On arrival to OEL's laboratory, all macrobenthic samples were logged in and entered into OEL's cloud-based marine ecological database 'ABACUS'.

3.3.2. For each sample, the excess formalin was drained off into a labelled container over a 0.5 millimetre (mm) mesh sieve in a well-ventilated area. The samples were then re-sieved over a 0.5mm 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 0.5 mesh sieve, transferred into a Nalgene and preserved in 70 percent Industrial Denatured Alcohol (IDA).

3.3.3. All macrobenthos present was identified to species level, where possible, by trained benthic taxonomists using the most up to date taxonomic literature and checks against existing reference collections. Nomenclature used the most up to date taxonomic classifications provided on the World Register of Marine Species (WoRMS) and results with accompanying metadata provided in Marine Environmental Data and Information Network (MEDIN) compliant format.

Particle Size Distribution (PSD) Analysis

3.3.4. PSD analysis of separate sediment samples was undertaken by in-house laboratory technicians at OEL's NMBAQC participating laboratory in line with NMBAQC best practice guidance (Mason 2016).

3.3.5. Frozen sediment samples were first transferred to a drying oven and thawed at 80 degrees Celsius (°C) for at least 6 hours prior to visual assessment of sediment type. Before any further processing (for example, sieving or sub-sample removal), samples were mixed thoroughly with a spatula and all conspicuous fauna (>1mm) 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. 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 Phi (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 1**.

Table 1. 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

3.3.6. The sample was then transferred onto the coarsest sieve at the top of the sieve stack and shaken for a standardised period of 20 minutes. The sieve stack was checked to ensure the components of the sample had been fractioned as far down the sieve stack as their diameter would allow. A further 10 minutes of shaking was undertaken if there was evidence that particles had not been properly sorted.

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

3.3.8. 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.

3.3.9. Sediment were described by their size class based on the Wentworth classification system (Wentworth 1922) (**Table 2**). 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).

Table 2. Classification used for defining sediment type based on the Wentworth Classification System (Wentworth 1922). µm = micrometre.

Wentworth Scale	**Phi Units (φ)**	**Sediment Types**
>64mm	<-6	Cobble and boulders
32 to 64mm	-5 to -6	Pebble
16 to 32mm	-4 to -5	Pebble

Wentworth Scale	Phi Units (φ)	Sediment Types
8 to 16mm	-3 to -4	Pebble
4 to 8mm	-3 to -2	Pebble
2 to 4mm	-2 to -1	Granule
1 to 2mm	-1 to 0	Very coarse sand
0.5 to 1mm	0 to 1	Coarse sand
250 to 500µm	01-Feb	Medium sand
125 to 250µm	02-Mar	Fine sand
63 to 125µm	03-Apr	Very fine sand
31.25 to 63µm	04-May	Very coarse silt
15.63 to 31.25µm	05-Jun	Coarse silt
7.813 to 15.63µm	06-Jul	Medium silt
3.91 to 7.81µm	7 – 8	Fine silt
1.95 to 3.91µm	08-Sep	Very fine silt
<1.95µm	<9	Clay

UAV Imagery Analysis

3.3.10. Following initial screening to remove any erroneous images, all images collected during the UAV mapping flights were ‘stitched’ together to generate orthomosaic and Digital Elevation Model (DEM) outputs for the intertidal survey area using Drone Deploy software. The outputs were then used as base maps in Geographical Information System (GIS) to facilitate subsequent habitat / biotope mapping by visual interrogation and delineation of boundaries.

EUNIS Classification Mapping

3.3.11. EUNIS habitats and biotopes were identified in line with JNCC guidance on assigning benthic biotopes (Parry 2019) to allow the communities to be mapped and allow comparison with existing data. All habitat / biotope determination was undertaken through consideration of the following:

- existing habitat mapping (derived from European Marine Observation and Data Network (EMODnet));

- UAV imagery interpretation;
- review and interpretation of target field notes and quadrat imagery;
- PSD analysis results (textual groups, sediment percent contribution and mean grain size) (for determination of Broad Scale Habitat (BSH);
- macrobenthic analysis results (presence and absence of key taxa and abundance of dominant taxa);
- general site imagery.

4. Results

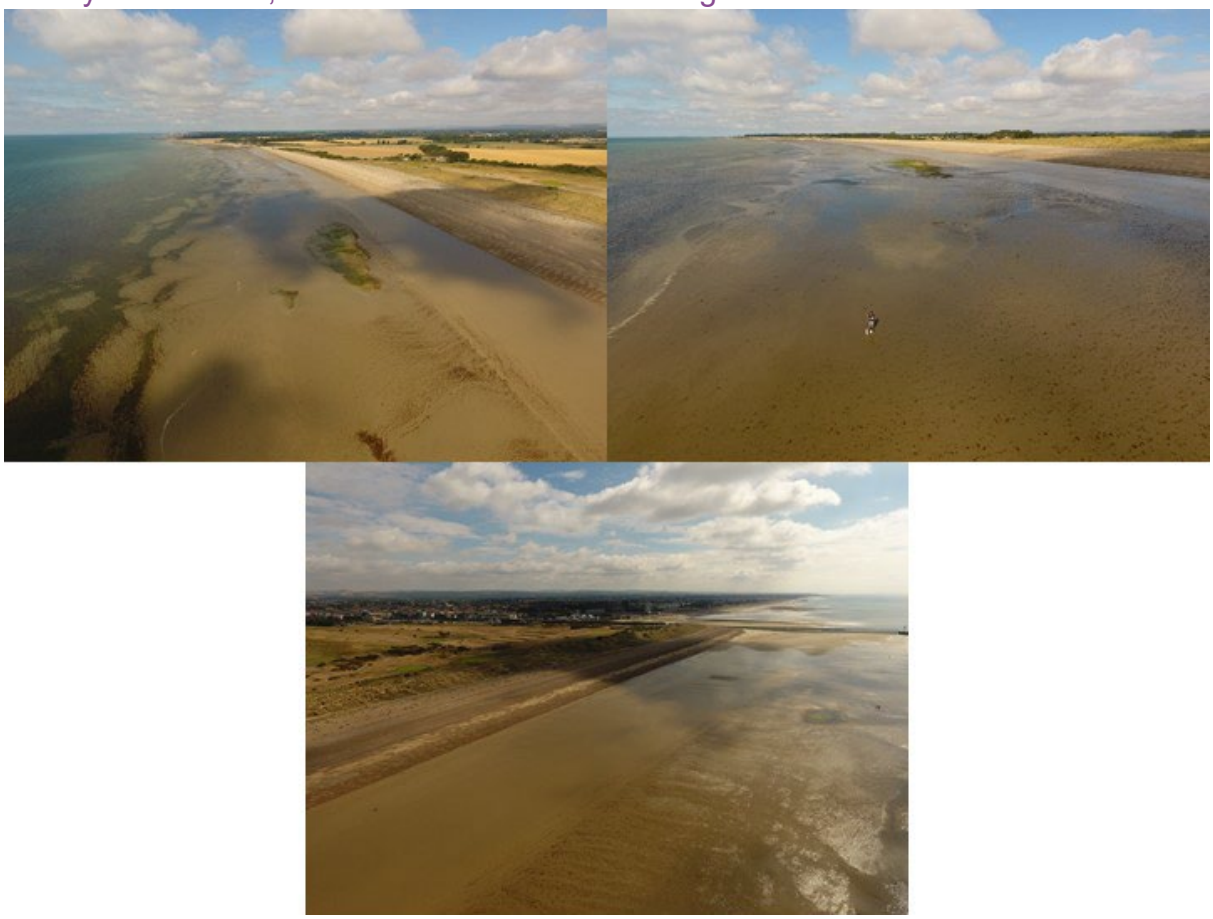
4.1. Survey Progress

4.1.1. The intertidal survey was undertaken during spring tides on 24 July 2020. **Table 3** provides a summary of the sampling undertaken and information collected during the survey. **Plate 1** provides an overview of the intertidal survey area, as captured during additional UAV site imagery collection.

Table 3 Summary of sampling undertaken and information collected during the intertidal survey.

Sampling	Intertidal Survey Area
Quadrats	23
Sediment Cores	10 sites, 20 cores: 2 duplicate cores per site
Target Notes	50
UAV imagery	1263 high resolution images

Plate 1 Top left: western extent looking towards Atherington; Top right: middle survey area extent; Bottom: eastern extent looking east towards the River Arun.



4.2. UAV Survey

4.2.1. UAV mapping of the proposed Rampion 2 cable corridor survey area was undertaken over a 90-minute period around low water on 24 July 2020. The survey was split into three independent flights to cover the west, east and central extent of the survey with a total flight duration across all three flights of 83 minutes. Flight height was maintained at 70 m for all areas and weather conditions (for example, wind / precipitation) remained favourable for data collection throughout.

4.2.2. The UAV survey successfully captured over 1,263 high-resolution nadir images across a coverage area of 804,405m^2 to produce a high resolution orthomosaic model (GSD = 2.83cm/px) and DEM (GSD = 11.33cm/px) (**Figure 2** to **Figure 4**) with an average RMSE accuracy level of 1.8m. Example aerial images are provided as **Plate 2**.

Plate 2 Left: Upper shore shingle grading into sand dune habitat; Right: Chalk and clay exposures on the mid shore.

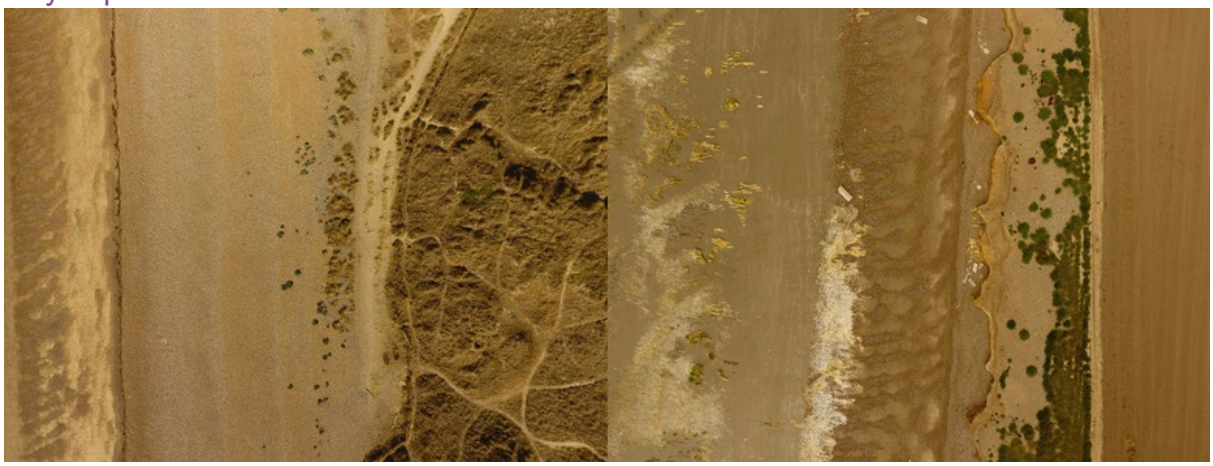


Figure 2 UAV orthomosaic and Digital Elevation Model (DEM) data collected during the intertidal survey for the proposed Rampion 2 export cable corridor landfall (East Zone).

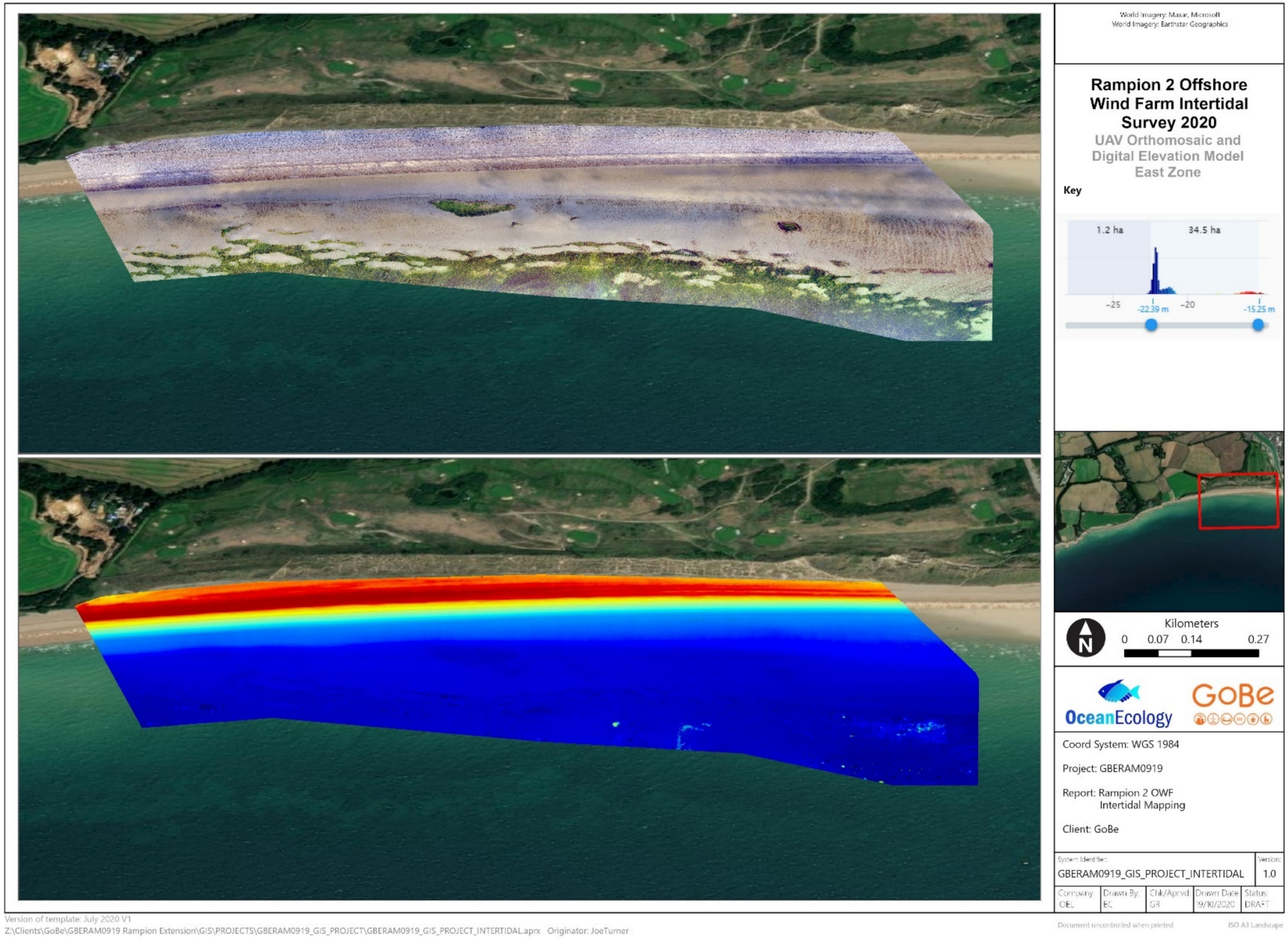


Figure 3 UAV orthomosaic and Digital Elevation Model (DEM) data collected during the intertidal survey for the proposed Rampion 2 export cable corridor landfall (Middle Zone).

Figure 4 UAV orthomosaic and Digital Elevation Model (DEM) data collected during the intertidal survey for the proposed Rampion 2 export cable corridor (West Zone).

4.3. Phase II Sampling

Sediment Cores

4.3.1. In total, 10 sediment cores were analysed for full particle size classification to support the determination of EUNIS habitats and biotopes. The raw data is provided in Appendix III with summary sediment statistics in Appendix IV.

Sediment Type

4.3.2. Sediment types, as classified using the Folk Triangle (Folk 1954), for each of the cores sampled across the Rampion 2 intertidal survey area are presented in **Figure 5**. Each Folk classification was converted to BSH type (EUNIS Level 3) using the adapted Folk triangle (Long 2006).

4.3.3. Sediments showed a clear gradient across the survey area with coarse sediments characterising the upper shore and sand predominant in the mid to lower shore. **Figure 5** shows that the sediments sampled across the Rampion 2 survey area consisted of Sandy Gravel, Gravelly Sand, and Gravel (BSH A2.1), as well as Slightly Gravelly Sand and Sand (BSH A2.2).

4.3.4. The sediments recorded grouped into two broad main categories based on their sorting: six cores were classified as poorly and very poorly sorted sediments while four were classified as moderately to well sorted sediments. This reflects the same zonation seen before with coarser and generally poorly sorted sediments in the upper shore and sorted sediments further down the shore.

Sediment composition

4.3.5. Percentage contribution of gravel (> 2mm), sand (0.63mm to 2mm) and mud (< 63µm) is presented in **Figure 6** for each of the ten sediment cores collected. Percentage contribution of sand was greatest across the survey area with sand being the dominant sediment fraction in seven cores. In cores 4, 6 and 9, all collected in the upper shore, gravel was the dominant sediment fraction. The mean (± Standard Error (SE)) proportion of sand across all stations was 70.0 ± 9.3 percent, while mean (± SE) gravel content was 27.7 ± 9.8 percent and mean (± SE) mud content was 2.3 ± 0.005 percent. Mean grain size ranged between 123.8 and 14331.8µm with larger grain sizes in cores sampled in the upper shore compared to cores collected from the mid to lower shore.

Figure 5 Folk (Folk 1954) triangle classifications of sediment gravel percentage and sand to mud ratio of sediment cores collected during the Rampion 2 intertidal survey, overlain by the modified Folk triangle for determination of mobile sediment BSHs under the EUNIS habitat classification system (adapted from Long 2006).

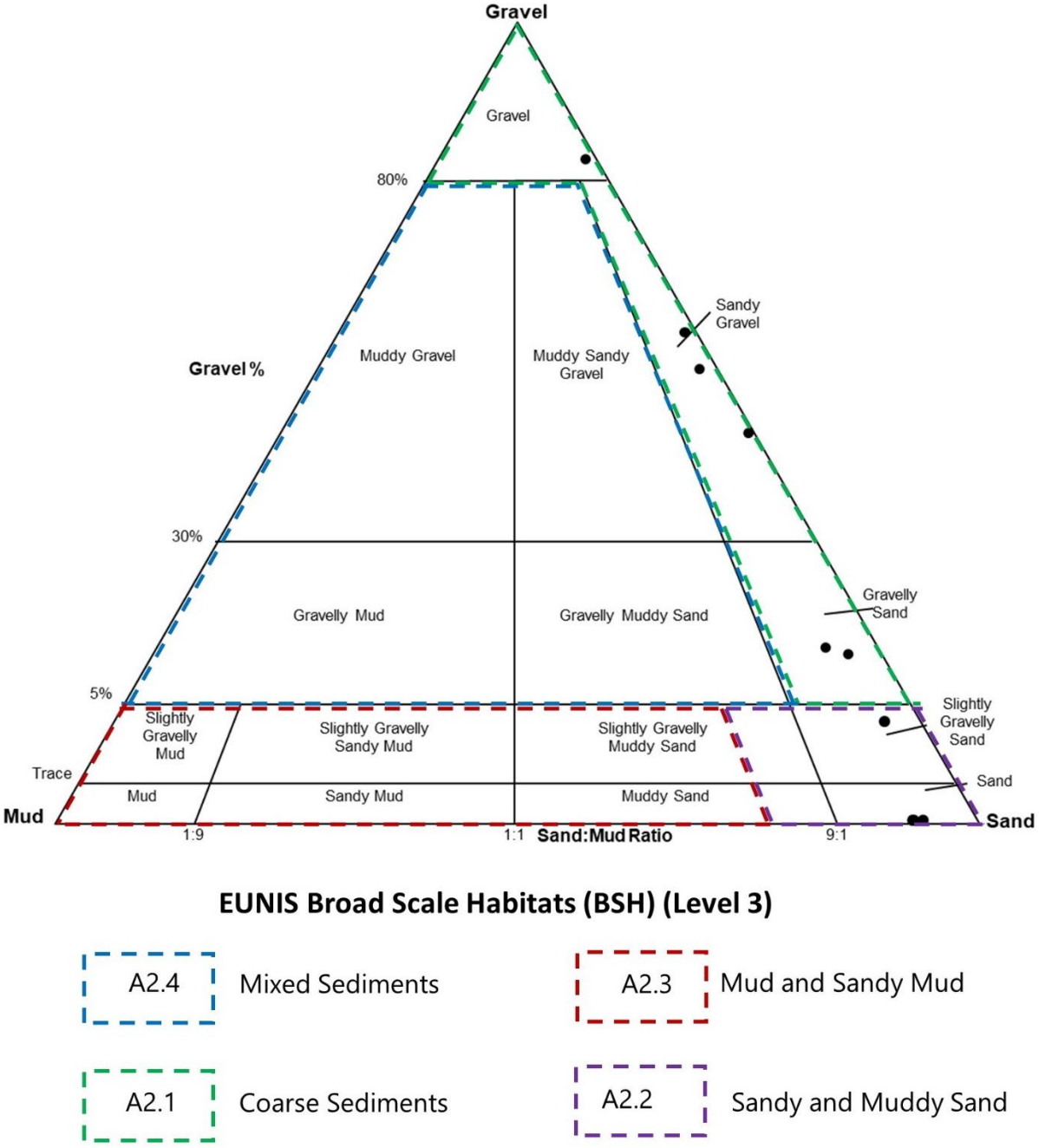
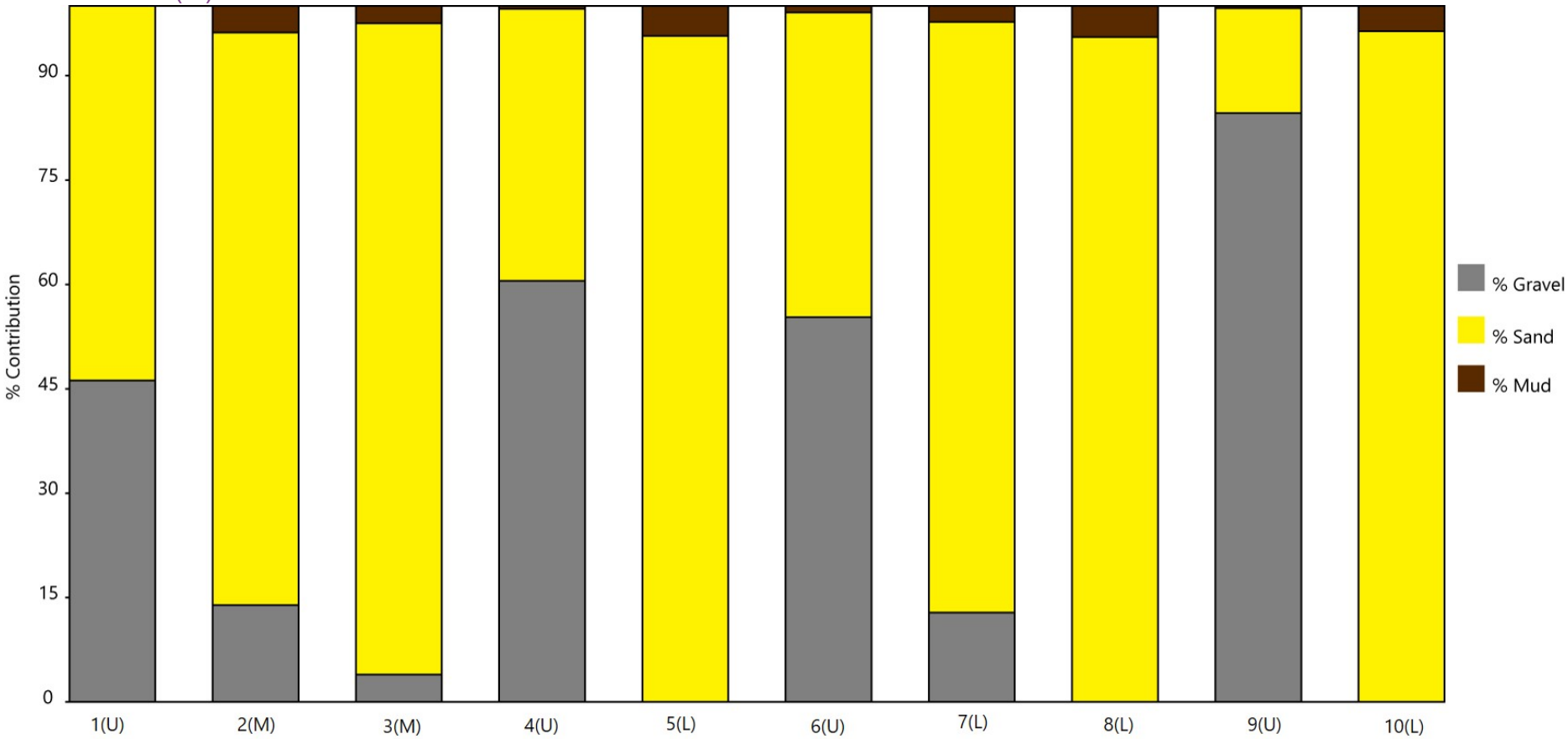


Figure 6 Sediment contribution (percentage gravel, sand and mud) for each core collected during the Rampion 2 intertidal survey. Cores marked with (U) were collected from the upper shore, with (L) from the lower shore and the remaining were sampled from the mid shore (M).



Macrobenthos

Macrobenthic Composition

4.3.7. The full abundance matrix is provided in Appendix V presenting the abundance of each taxon. The biomass (gAFDW – Ash Free Dry Weight) of each major taxonomic group (Annelida, Crustacea, Mollusca, Echinodermata and Miscellaneous) in each core is presented in Appendix VI.

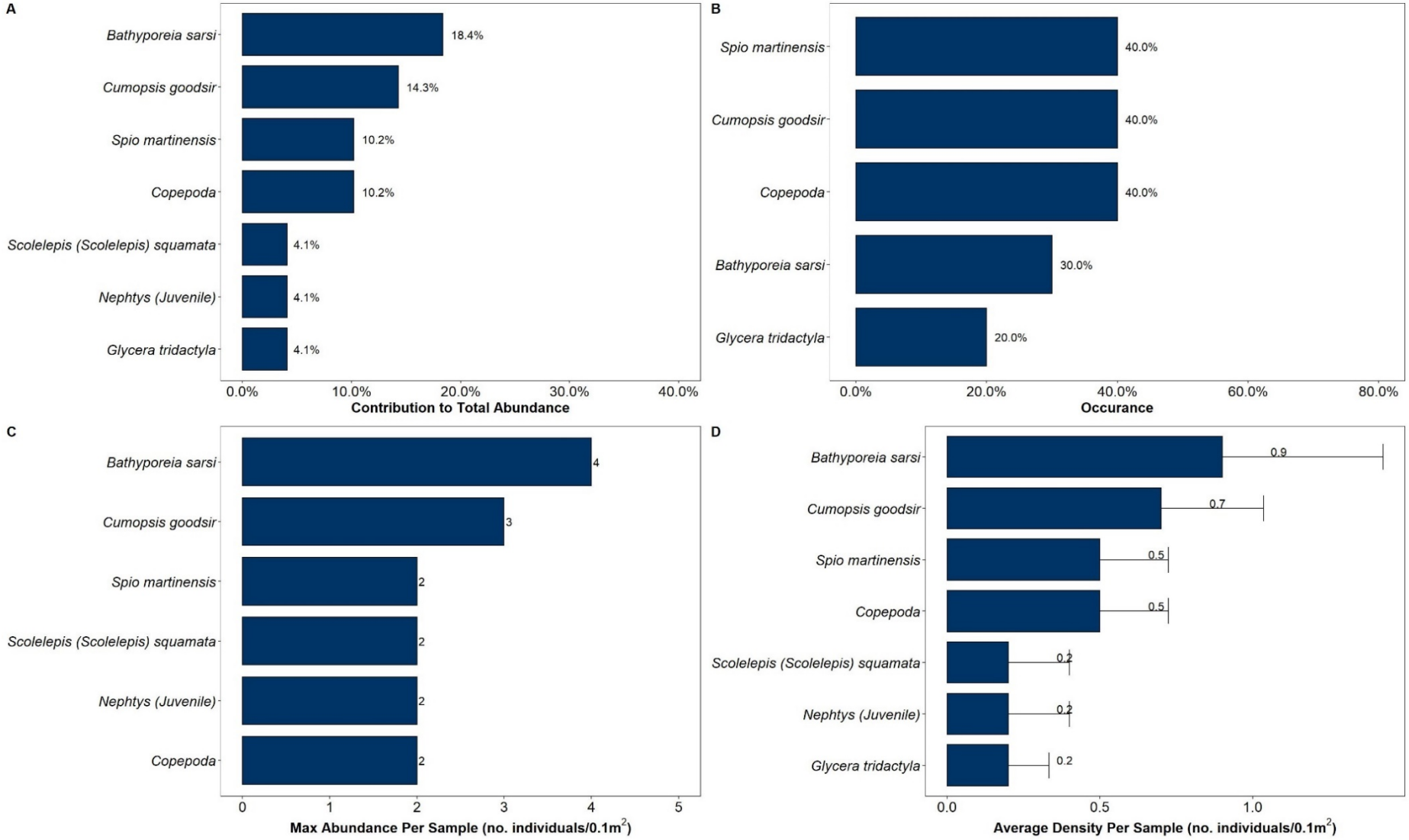
4.3.8. The macrobenthic infaunal assemblage identified across the Rampion 2 survey area consisted of a total of 49 individuals from a total of 24 taxa, including 5 taxa of algae with four belonging to the phylum Rhodophyta and one to the phylum Chlorophyta. Mean (± SE) abundance per sample was 0.2 ± 0.07 with a mean (± SE) biomass per sample of 0.0004 ± 0.0001 gAFDW.

4.3.9. As shown in **Figure 7**, the amphipod *Bathyporeia sarsi* was the most abundant and frequent taxon sampled accounting for 18.4 percent of all individuals recorded and occurring in 40 percent of the cores. Additionally, it also accounted for the maximum abundance in a single sample (**Figure 7**). Other key taxa were the polychaete *Spio martinensis* and the crustacean *Cumopsis goodsir* also occurring in 40 percent of the cores, albeit in lower numbers than *B. sarsi* (**Figure 7**). The core with the highest diversity was core 10 (collected from the lower shore of the far eastern area) with 18 individuals from a total of 15 different taxa.

4.3.10. The overall macrobenthic composition dominated by the presence of polychaetes and crustaceans was deemed to be representative of the biotope *'Polychaete / amphipod-dominated fine sand shores'"* (A2.23) also consistent with fine sand being the dominant sediment fraction (**Figure 6**).

4.3.11. Biomass results ranged between 0.0006 and 0.0060 gAFDW per sample, with the highest value found in sediment core 5 (collected from the lower shore in the western area). Two major taxonomic groups contributed to the 97.7 percent of the total biomass, with Annelida contributing to the 84.7 percent and Crustacea to the 13 percent.

Figure 7 Top 5 species of macrobenthic taxa recorded across the intertidal survey area for the Rampion 2 export cable corridor landfall.



4.4. Habitat / Biotope Mapping

4.4.1. There was a total of 9 unique biotopes (EUNIS level 5 or above) from a total of nine BSH (**Table 4**) as mapped in **Figures 8** to **10**.

4.4.2. The majority of the survey area at the proposed Rampion 2 cable corridor location was characterised by littoral sand and muddy sand (A2.2). This dominant habitat was fringed by littoral coarse sediment (A2.1) along the upper shore and by chalk cobbles often covered in mixed algae in the lower shore (A1.4) (**Table 4** and **Figures 8** to **10**).

4.4.3. The extreme upper shore of the eastern section of the survey area was characterised by shingle with sea kale *Crambe maritima* (B2.32) giving way to a steep bank of shingle (pebbles) and gravel representative of the biotope A2.11 (**Figure 8**). A narrow strandline habitat (A2.21) was present within the transition zone between A2.11 and a sandier area characterised by polychaete/amphipod- dominated fine sand shores (A2.23). The mid shore area was generally dominated by fine sand representative of the biotope A2.23 interspersed with muddy sand supporting the sandworm *Arenicola marina* and representative of the biotope A2.24. The lower shore was a mosaic of littoral rocks and sandy sediments consisting of chalk pebbles as well as bored chalk often covered in green and red seaweeds (A1.45) with small patches of fine rippled sand supporting the polychaete *Lanice conchilega* (A2.245) (**Figure 8**).

4.4.4. The middle section of the survey area showed a zonation similar to that of the east zone but with no *C. marina* and a much narrower shingle bank in the upper shore (A2.11) (**Figure 9**). The mid shore was similarly dominated by fine and muddy sands representative of the biotopes A2.2, A2.23 and A2.24; however, outcropping chalk and clay exposures (A1.46) were also observed in the upper shore.

4.4.5. The western area had coarser sediments in the upper shore grading into fine sand / muddy sand in the mid shore (**Figure 10**). A larger area of chalk outcrops was present in the upper and mid shore area as well as a number of rockpools characterised by the presence of green and red seaweeds (A1.45). The lower shore was fringed with more littoral rocks consisting of chalk pebbles covered in *Ulva* spp. The area to the west of Climping beach was also interspersed with various artificial defences including rock armour groynes running parallel to the shore with barnacles (Balanoidea) on the lower two metres and bare rock above. Wooden groin structures running down the shore were either covered in *Ulva* sp. and *Fucus spiralis* or Balanoidea (**Figure 10**).

4.4.6. A summary of EUNIS classifications recorded during the Phase I walkover survey is provided in Appendix II along with supporting example photographs.

Table 4 Key biotopes recorded during the intertidal survey of the proposed Rampion 2 cable corridor.

EUNIS BSH	EUNIS Code	EUNIS Description
A1.4 – Features of Littoral Rock	A1.45	Ephemeral green or red seaweeds (freshwater or sand-influenced) on non-mobile substrata
	A1.46	Hydrolittoral soft rock
A2.1 - Littoral Coarse Sediment	A2.11	Shingle (pebble) and gravel shores
	A2.111	Barren littoral shingle
A2.2 – Littoral Sand and Muddy Sand	A2.21	Strandline
	A2.23	Polychaete / amphipod-dominated fine sand shores
	A2.24	Polychaete / bivalve-dominated muddy sand shores
	A2.245	[*Lanice conchilega*] in littoral sand
B2.3 - Upper shingle beaches with open vegetation	B2.32	Channel [*Crambe marina*] communities

Figure 1 EUNIS habitat and biotope mapping and sampling locations visited during the intertidal survey for the proposed Rampion 2 export cable corridor landfall (East Zone).

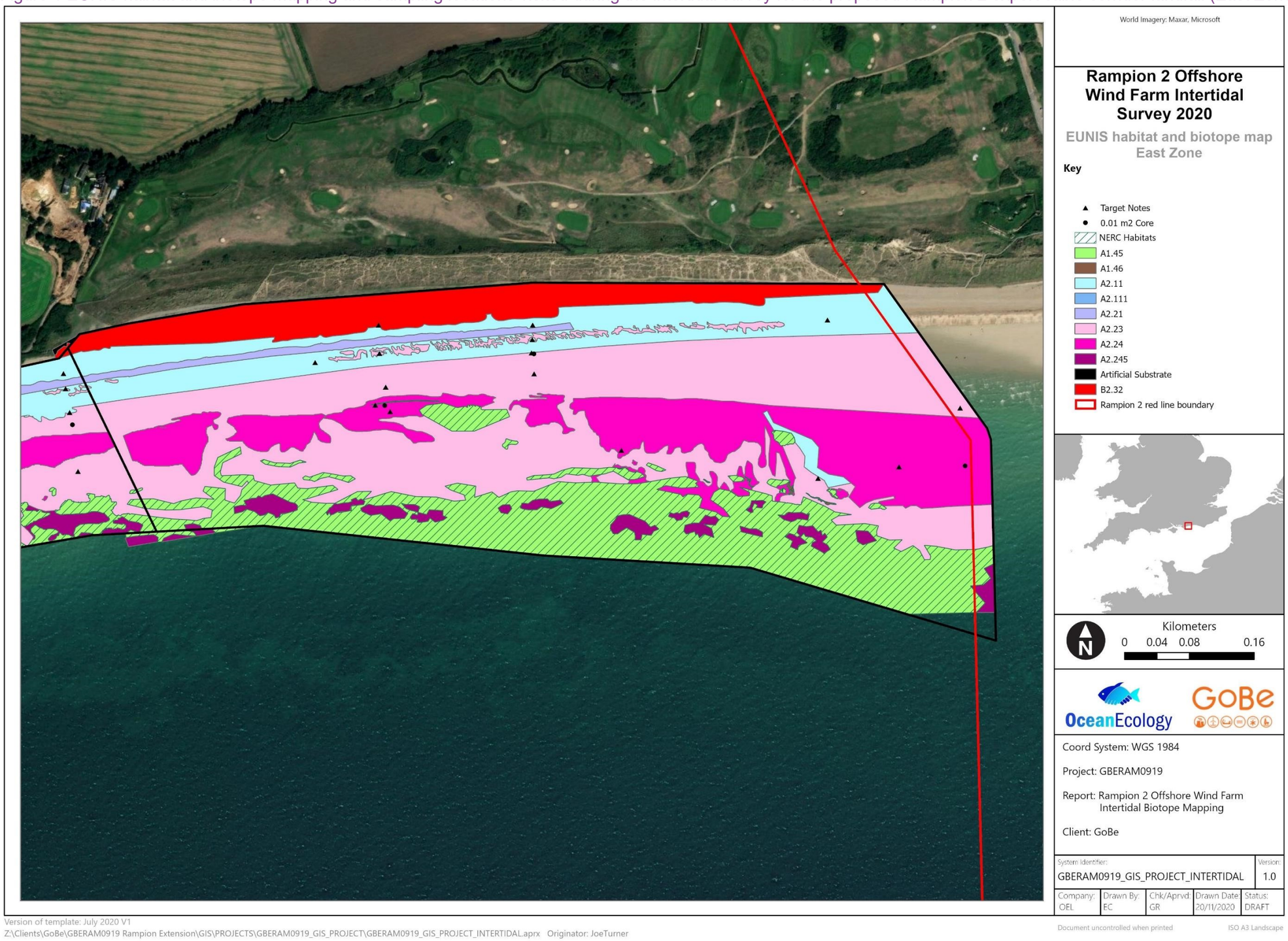


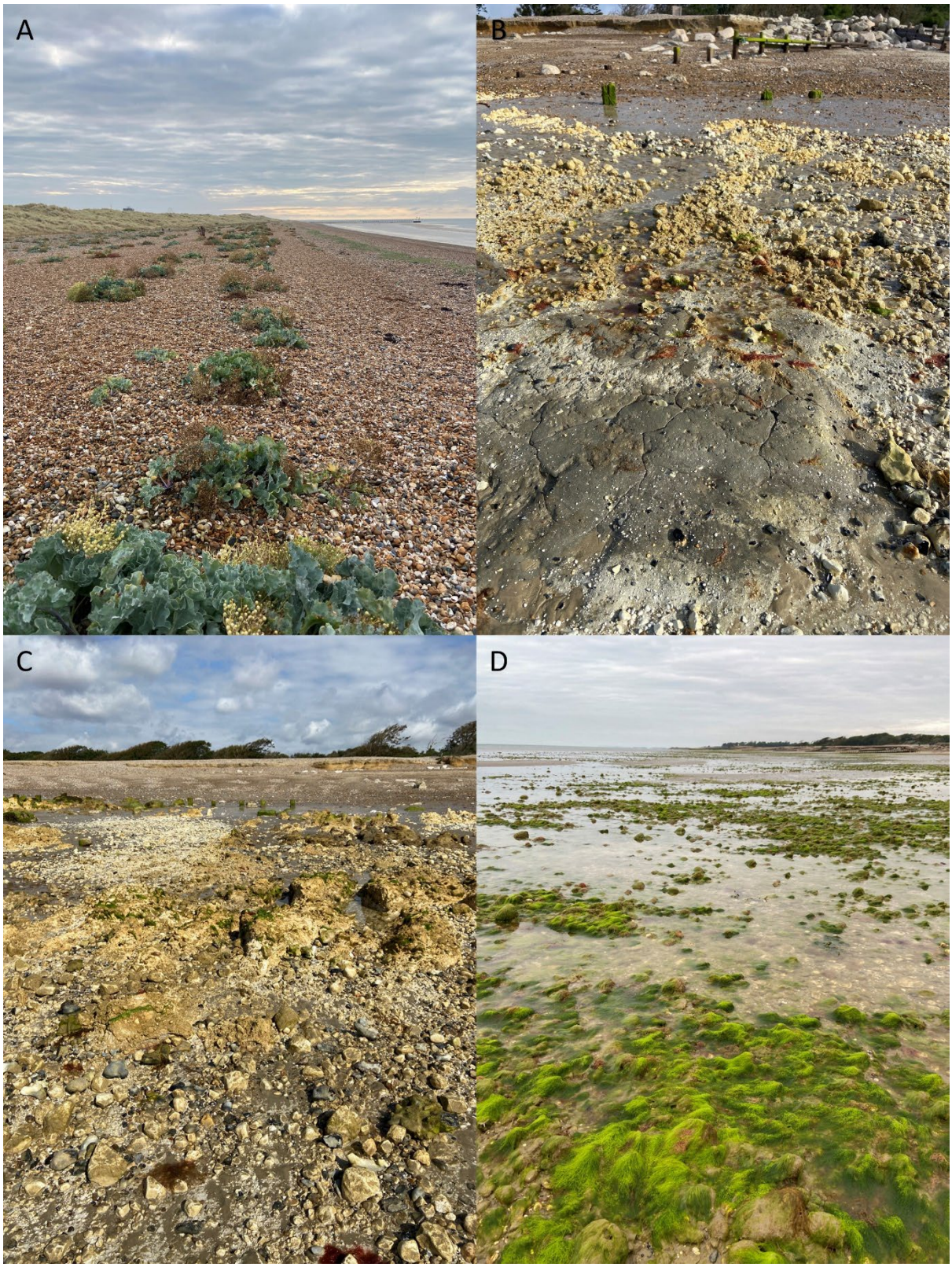
Figure 2 EUNIS habitat and biotope mapping and sampling locations visited during the intertidal survey for the proposed Rampion 2 export cable corridor landfall (Middle Zone).

Figure 3 EUNIS habitat and biotope mapping and sampling locations visited during the intertidal survey for the proposed Rampion 2 export cable corridor landfall (West Zone).

4.5. Features of Interest

4.5.1. Areas of rock noted across the intertidal survey area was almost entirely made up of rockpools dominated by chalk cobbles and bored chalk covered in green seaweeds (**Plate 3**); these were deemed to be representative of the biotope A1.45. These features of littoral rock correlate to habitats that fall under Annex I of the EC Habitats Directive but are protected here under NERC Act 2006 (herein referred to as NERC habitats) while the sandy sediment habitats correlate to the Annex I habitat 'mudflats and sandflats not covered by seawater at low tide' but are protected under the NERC Act 2006. Significant portions of the upper and middle shore were dominated by chalk outcrops and clay exposures (A1.46), especially to the west of the survey area (**Plate 3**) also representative of NERC habitats.

Plate 2. A) Channel *Crambe maritima* communities. B) Clay exposures with chalk cobbles and pebbles. C) Chalk outcrops and cobbles. D) Intertidal rockpool with green and red seaweed.



5. Discussion

5.1.1. This report presents the findings of the intertidal survey conducted between Elmer Beach and the mouth of the River Arun (West Sussex) and aimed at establishing the main benthic habitats present in the general vicinity of the proposed landfall location of the Rampion 2 export cable corridor. The survey involved Phase I walkover surveying to map the habitats present accompanied by Phase II sampling using cores for soft substrates and quadrat sampling for hard substrates to a) establish the main benthic habitats present and b) characterise the associated marine biological communities.

5.1.2. The Rampion 2 intertidal survey area was found to be dominated by sandy shores in the mid to lower shore, supporting a number of marine invertebrates mostly belonging to two major taxonomic groups: Annelida and Crustacea. Clear zonation was observed across the survey area, the full range of which was more evident in the eastern reaches of the site. This included *C. maritima* and shingle dominated biotopes in the supralittoral (B2.32) and upper shore zones (A2.11 and A2.111), and polychaete / amphipod dominated fine sands in the mid to lower shore areas (A2.21, A2.23 and A2.24) interspersed with seaweed dominated rock pools (A1.45). The lower shore was characterised by green and red seaweed dominated rock (A1.45) with chalk cobbles as well as bored chalk often interspersed with fine sands supporting the polychaete *L. conchilega* (A2.245). The upper-mid shore in the west zone of the survey area was characterised by patches of hydrolittoral soft rock (A1.46) comprising a mosaic of exposed clay and chalk.

5.1.3. Rockpools were ubiquitous across the survey area in the lower shore and all littoral rock habitats / biotopes encountered during the survey (A1.45 and A1.46) correlate to NERC habitats while the sandy substrates (A2.23 and A2.24) correlate to the Annex I habitat ‘mudflats and sandflats not covered by seawater at low tide’ but are protected here under NERC Act 2006.

5.2. Glossary of terms and abbreviations

Table 5 Glossary of terms and abbreviations

Term (acronym)	Definition
Benthic ecology	Benthic ecology encompasses the study of the organisms living in and on the sea floor, the interactions between them and impacts on the surrounding environment
Biotope	A region of habitat associated with a particular ecological community.
BSH	Broadscale Habitat
CAA	Civil Aviation Authority
cm	Centimetre
°C	Degrees Celsius
Crustacea	Arthropod of the large, mainly aquatic group Crustacea, such as a crab, lobster, shrimp, or barnacle
DCO	Development Consent Order
DEM	Digital Elevation Model
Environmental Impact Assessment (EIA)	The process of evaluating the likely significant environmental effects of a proposed project or development over and above the existing circumstances (or 'baseline').
EMODnet	European Marine Observation and Data Network
Environmental Statement (ES)	The written output presenting the full findings of the Environmental Impact Assessment.
EUNIS	European Nature Information System
EUNIS habitat classification	A pan-European system which facilitates the harmonised description and classification of all types of habitat, through the use of criteria for habitat identification
FOCI	Features of Conservation Interest
gAFDW	grams Ash Free Dry Weight
Geographical Information System (GIS)	A system that captures, stores, analyses, manages and presents data linked to location. It links spatial information to a digital database.

Term (acronym)	Definition
GoBe	GoBe Consultants Ltd
GPS	Global Positioning System
GSD	Ground-Sampling Distance
HRA	Habitat Regulations Assessment
IDA	Industrial Denatured Alcohol
Intertidal	The area of the shoreline which is covered at high tide and uncovered at low tide.
Joint Nature Conservation Committee (JNCC)	JNCC is the public body that advises the UK Government and devolved administrations on UK-wide and international nature conservation.
km	Kilometre
LNR	Local Nature Reserve
m	Metre
m^2	Square Metre
MEDIN	Marine Environmental Data and Information Network
MHWS	Mean High Water Springs
MLWS	Mean Low Water Springs
mm	Millimetre
MNCR	Marine Habitat Classification for Britain and Ireland
MW	Megawatt
NERC	Natural Environment and Rural Communities
NMBAQC	National Marine Biological Quality Control
NRW	Natural Resources Wales
NSIP	Nationally Significant Infrastructure Project
OEL	Ocean Ecology Ltd
Offshore	The sea further than two miles from the coast.

Term (acronym)	Definition
Offshore Wind Farm	An offshore wind farm is a group of wind turbines in the same location (offshore) in the sea which are used to produce electricity.
PfCO	Permission for Commercial Operations
φ	Phi
PSA	Particle Size Analysis
PSD	Particle Size Distribution
PRP	Processing Requirement Protocol
px	Pixel
Rampion 1	The existing Rampion Offshore Wind Farm located in the English Channel off the south coast of England.
RED	Rampion Extension Development Limited
RMSE	Root Mean Square Errors
RPQs	Qualified UAV Pilots
SE	Standard Error
SSSI	Site of Special Scientific Interest
sUAS	Small Unmanned Aerial Systems
TCE	The Crown Estate
UAV	Unmanned Aerial Vehicle
WoRMS	World Register of Marine Species
WTGs	Wind Turbines Generators

6. References

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4.9.3

Rampion 2 WIND FARM

Volume 4, Appendix 9.3

Subtidal Benthic Characterisation Survey Report

GoBe wood.

Ocean Ecology

Marine Surveys, Analysis & Consultancy

Rampion 2 Offshore Wind Farm Subtidal Benthic Characterisation Survey Report

REF: OEL_GBERAM0919_SYR_V01

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Details

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Updates

Section	Description	Page

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1. Introduction

1.1. Project Overview

Rampion Extension Development Limited (RED) has applied for development consent to develop a new offshore wind project (Rampion 2) adjacent to the existing Rampion Offshore Wind Farm (**Figure 1**). Rampion was developed following the United Kingdom Round 3 offshore wind development programme run by The Crown Estate (TCE) in 2009. It is located within the English Channel, off the south coast of England within the Round 3 Zone 6 area.

RWE applied to TCE for an extension to the Rampion Wind Farm in 2018 and following approval under the plan-led Habitats Regulations Assessment (HRA), was awarded development rights for the Rampion Extension Site in 2019. It is one of seven extension proposals that passed TCE's plan led HRA process and is required to connect into the onshore transmission or distribution networks at an existing substation 'node'.

Rampion 2 comprises both the seabed area conditionally awarded under the TCE Round 3 extension process and development within the remainder of the original Round 3 Zone 6 area. The aggregate of these two seabed areas would be optimised to form a single extension development giving rise to a single application for a Development Consent.

RED's Environmental Impact Assessment (EIA) consultants (Wood Environment & Infrastructure Solutions UK Ltd (Wood) and GoBe Consultants Ltd (GoBe)) are coordinating the Rampion 2 EIA and are responsible for producing the Scoping Report, Preliminary Environmental Information Report (PEIR), Environmental Statement (ES) and Non-Technical Summary (NTS) for a Development Consent Order (DCO) application to the Planning Inspectorate (PINS). As part of this process, a series of onshore and offshore surveys are being undertaken to gather baseline datasets relating to a series of onshore and offshore disciplines ranging from air quality to benthic ecology.

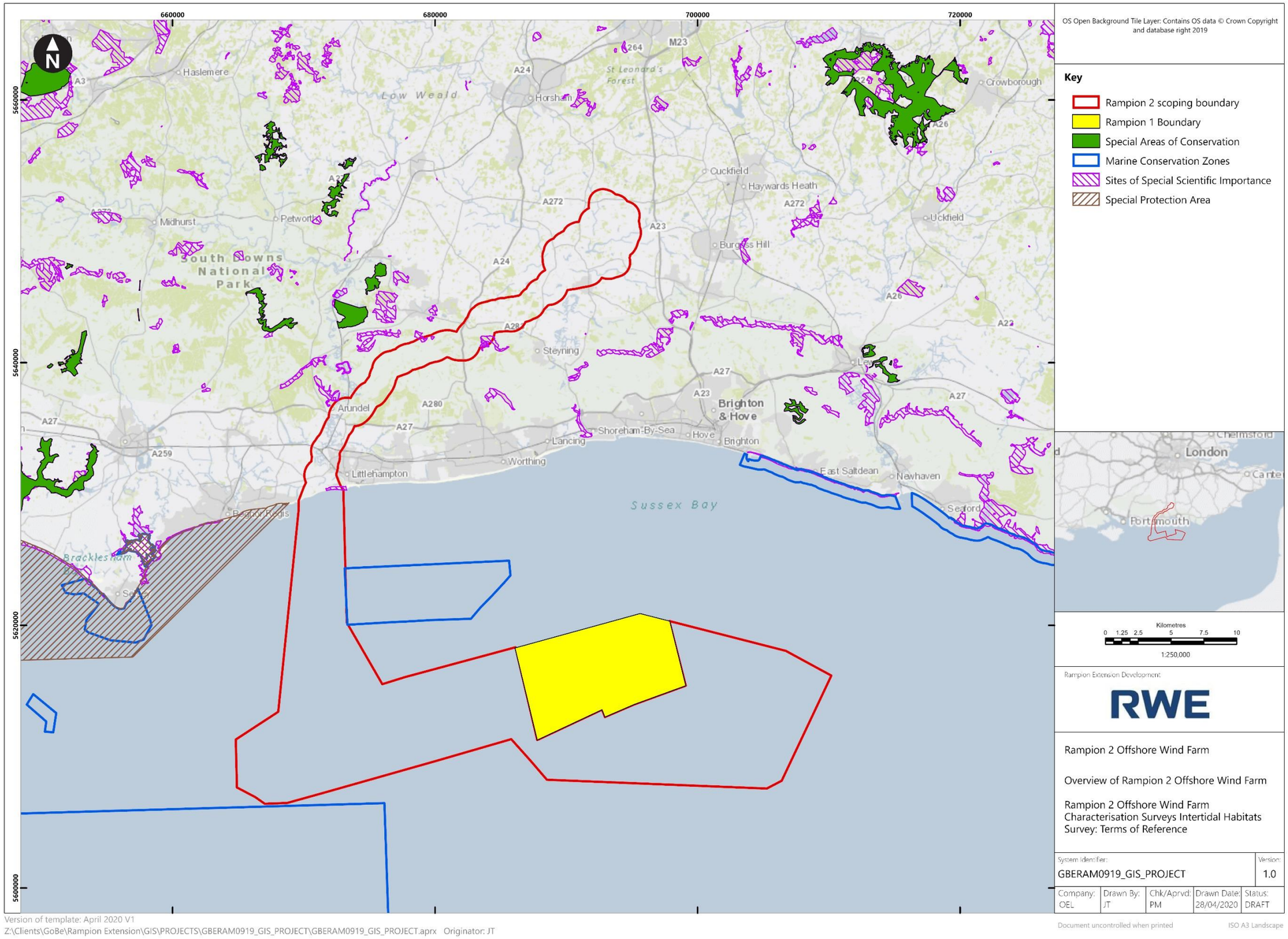

Figure 1 Overview of the Rampion 2 offshore wind farm Development Boundary.

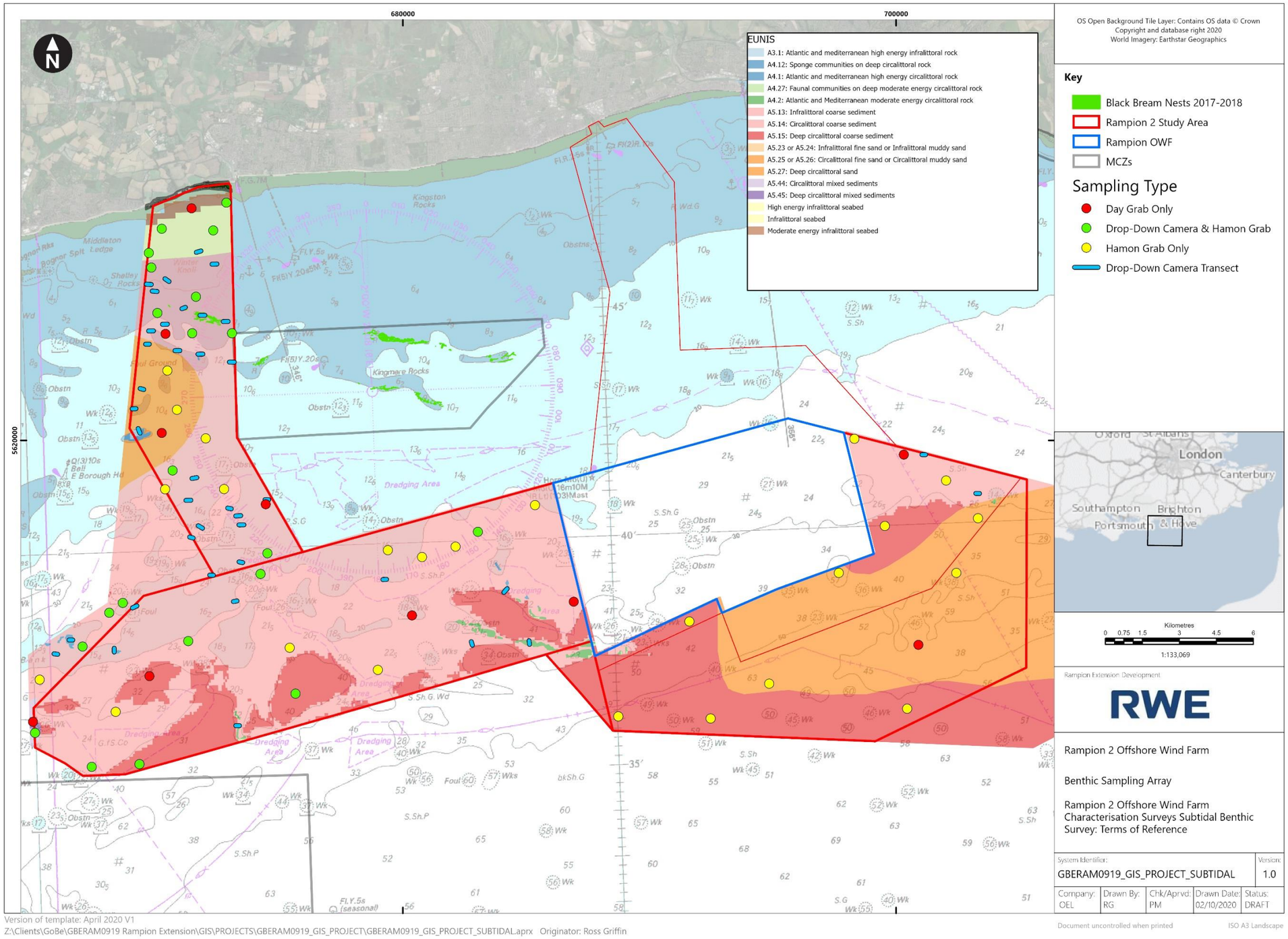

Figure 2 Proposed Rampion 2 subtidal benthic habitat sampling array

2. Survey Design

2.1. Sampling Rationale

The benthic subtidal survey array was designed to provide adequate coverage of all areas of the Rampion 2 export cable corridor and array areas where previous sampling coverage was deemed to be limited whilst ensuring representative examples of all sediment types and potential features of conservation importance were targeted. This was set out in a Terms of Reference (ToR) (OEL_GBERAM0919_TOR_SUB) signed off by the Marine Management Organisation (MMO) prior to the survey. The key principles underpinning the survey design were to therefore:

- provide adequate spatial coverage of the Rampion 2 export cable corridor and array areas;
- ensure representative sampling of all main sediment types was undertaken; and
- ensure representative examples of all potential features of conservation interest (FOCI) (including Annex I reefs and black bream nest sites) were adequately ground-truthed.

2.2. Sampling Strategy

Table 1 sets out the final sample stations signed off by the MMO across the subtidal survey area based on the rationale outlined in **Section 2.1** and presented in **Figure 2**.

Table 1 Final agreed sampling strategy.

DDV Transects	DDV Stations	Hamon Grabs	Day Grab
39	21	45	10

3. Methods

3.1. Survey Vessels

All work was conducted aboard Ocean Ecology Limited's (OEL) dedicated 10.4 metre (m) Marine and Coastal Agency (MCA) Category 2 coded survey vessel 'Seren Las' (**Plate 1**). The vessel was equipped with a Hemisphere V104s Global Positioning System (GPS) Compass system that provided an accurate offset position of the sampling equipment when deployed from the stern A frame. This provided a GPS feed to a dedicated survey navigation PC operating EIVA NaviPac and TimeZero Navigator v3 marine navigation with routing module and SeaTraceR Class B Automatic Identification System (AIS).

Plate 1 Nearshore survey vessel 'Seren Las'.

3.2. Geodetic Parameters

All coordinates were based on World Geodetic System 1984 (WGS 1984) with projected grid coordinates based on Universal Transverse Mercator (UTM) zone 31N with a Central Meridian of 03 degrees (˚)E. A summary of geodetic and projection parameters is provided in **Table 2**.

Table 2 Geodetic parameters used for the nearshore benthic survey.

Local geodetic Datum Parameters	
Datum	World Geodetic System 1984 (WGS 1984)
Spheroid	WGS 1984
Project Projection Parameters	
Grid Projection	Universal Transverse Mercator, Northern Hemisphere
UTM Zone	31 N
Central Meridian	03˚ 00′ 00″ East
Latitude of Origin	00˚ 00′ 00″ North
False Easting	500000.0 m
False Northing	0 m

Scale factor on Central Meridian	0.9996
Units	Metres

3.3. Survey Equipment

3.3.1. Subsea Positioning

Due to the shallow water depths, an offset position of the sampling equipment was used to determine the position of the sampling equipment on the seabed when deployed from the stern A frame of Seren Las.

3.3.2. Drop-Down Camera Systems

Seabed imagery (simultaneous video and stills) was collected using a high-definition optical camera system (**Plate 2**). The imagery was collected using OEL's ROVTech subsea camera system providing 1080p High Definition (HD) video and 20 Megapixel (MP) stills imagery. Due to greater turbidity in the shallower nearshore areas, the camera was mounted in a Clear Liquid Optical Chamber (CLOC) filled with fresh water to ensure imagery of suitable quality was obtained (Jones *et al.,* 2020). Lighting from two light-emitting diode (LED) strip lamps and two lasers separated by 10 centimetre (cm) were projected into the field of view for illumination and scaling.

3.3.3. Drop-Down Camera Sampling

All seabed imagery was collected in consideration of the Joint Nature Conservation Committee (JNCC) epibiota remote monitoring operational guidelines (Hitchin *et al.,* 2015). Along the transects, images were taken every ~10m and more often when features of interest were encountered. At each screening Drop Down Video (DDV) location, a minimum of 60 seconds of video footage and five seabed still images (of between 0.5 square metre (m^2) to $1m^2$ of seabed coverage depending on visibility) were obtained. All video footage was reviewed *in situ* by OEL's environmental scientists.

The camera system was deployed as follows:

- the vessel approached the target location, and the deck personnel were alerted to prepare lifting equipment, camera, and umbilical when on position.
- the camera umbilical was run through a block on the A frame.
- the camera was raised using the A frame winch and lowered into the water column to within 5 m of the seabed.
- video recording was then started, and the camera lowered until gently landing on the seabed.
- the camera was then kept on the seabed to wait for any suspended sediments in the field of view to disperse before a still image was taken.
- the camera was then raised from the seabed and was moved along the transect at a speed of 0.3 to 0.5 knots. Where possible the seabed was kept in view throughout.

- following the capture of the final image, the camera was lifted, video recording was stopped, and the camera was retrieved to the surface.
- the winch operator then took the tension on the wire and the deck crew ensured the camera umbilical was free for recovery.
- the vessel skipper then confirmed sea conditions were suitable for retrieval and the camera system was recovered aboard.
- the camera frame was then lowered onto the deck and the tension released.

Plate 2 Left: OEL's ROVTech camera system equipped with CLOC. Right: OEL's ROVTech camera system topside computer control station.

3.3.4. Benthic Grab Sampling

A 0.1m^2 mini-Hamon grab (**Plate 3**) was used to obtain macrobenthic and sediment samples (particle size analysis (PSA)) at each of the proposed grab sampling locations. Grab sampling was conducted in line with v08 of the Regional Seabed Monitoring Programme (RSMP) Protocol for Sample Collection and Processing (Cooper and Mason, 2019) (Ware *et al.*, 2011). A 0.1m^2 Day grab was used to collect sediment samples for subsequent chemical contaminant analysis (heavy metals (HM), and Hydrocarbons (HC)). Where coarser sediment was identified during the camera survey, the mini-Hamon grab was used to obtain chemical samples.

3.3.5. Sample Collection

The grab was deployed from the hydraulic 'A' frame on the aft deck of Seren Las and lowered to the seabed. Detailed field notes were taken including station number, fix number, number of attempts, sample volume, sediment type, conspicuous fauna, any sign of protected features and water depth.

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

- the sample was less than 5 litres (L) for instance, the sample represents less than half the 10L capacity of the grab used.
- the jaws failed to close completely or were jammed open by an obstruction, allowing fines to pass through (washout or partial washout).
- the sample was taken at an unacceptable distance from the target location (beyond 20m).
- there was obvious contamination of the sample from survey equipment, paint chips etc.

Where a suitable sample was not collected after three attempts, the sample location was moved up to 50m away. Where samples of less than 5L were continually achieved, these samples were assessed on-site to establish if the sample volume was acceptable to allow subsequent analysis. No pooling of samples took place.

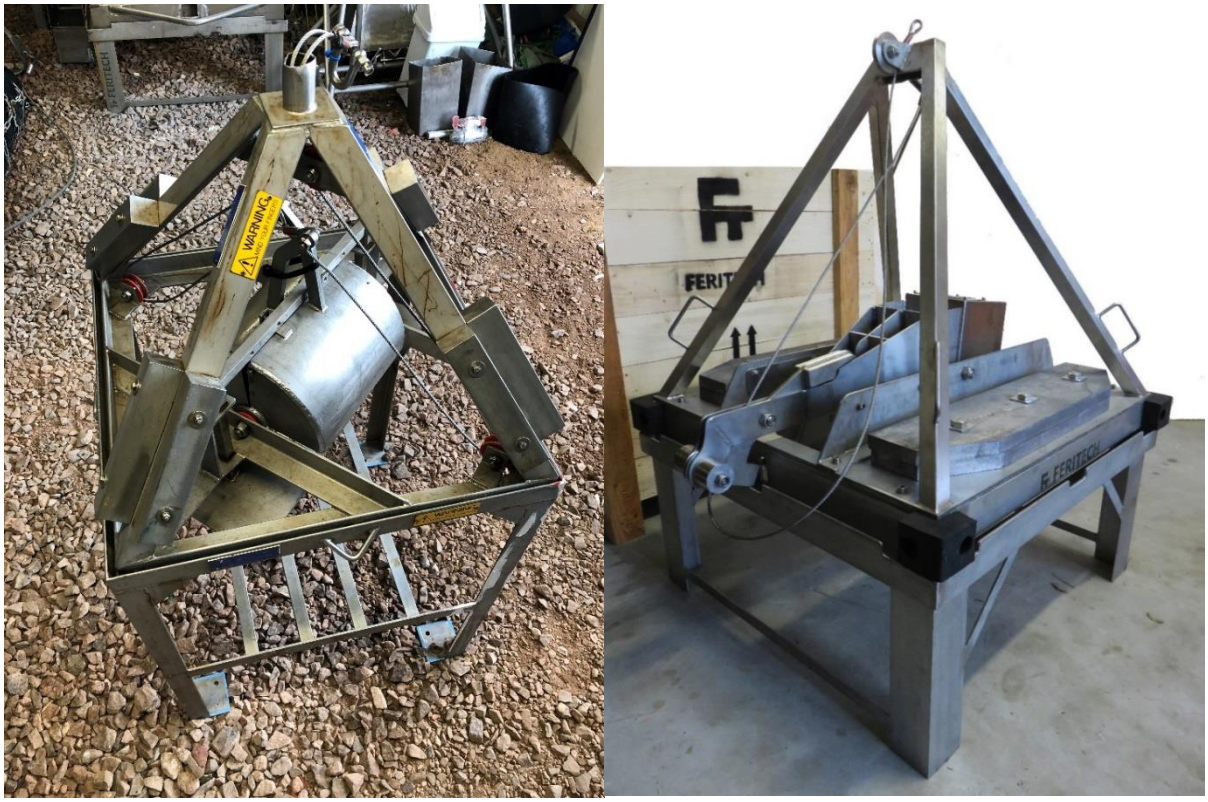

Plate 3 Left: OEL's 0.1m^2 Day Grab. Right: OEL's 0.1m^2 mini-Hamon grab.

3.3.6. Mini-Hamon Grab Sample Processing

Initial mini-Hamon grab sample processing was undertaken onboard the survey vessel in line with the following methodology:

- initial visual assessment of sample size and acceptability made.
- photograph of the sample with station details and scale bar taken.

- 10 percent of the sample removed for Particle Size Distribution (PSD) analysis and transferred to a labelled tray.
- remaining sample emptied onto 1.0 mm sieve net laid over 4.0 mm sieve table and washed through using gentle rinsing with seawater hose.
- remaining sample for faunal sorting and identification backwashed into a suitable sized sample container and diluted 10 percent formalin solution added to fix the sample prior to laboratory analysis.
- sample containers clearly labelled internally and externally with date, sample ID and project name.

3.3.7. Day Grab Sample Processing

Initial Day grab sample processing was undertaken onboard the survey vessel in line with the following methodology:

- Assessment of sample size and acceptability made.
- Photograph of drained sample showing undisturbed sediment surface with station details and scale bar taken.

Subsamples were then taken from the surface of the sample while retained in the grab (not decanted) as follows:

Two replicate samples for HC and Organics (TOC and TOM) analysis were collected using a metal scoop to a nominal depth of 2cm. The samples were preserved in 120 millilitres (ml) amber glass jars and stored frozen (<-18 degrees Celsius (°C)).

A single replicate sample for HM analysis was collected using a plastic scoop to a nominal depth of 2 cm. The samples were preserved in 500 ml plastic tubs and stored frozen (<-18°C).

4. Results

4.1. Survey Progress

The nearshore sampling was conducted aboard the Seren Las between 7 December 2020 and 28 February 2021. The vessel mobilised on 6 December 2020 and operated out of Newhaven maria and Littlehampton harbour. The vessel was demobilised in Newhaven marina on the 28 February 2021.

A summary of the sampling undertaken is detailed in **Table 3**.

4.2. Seabed Imagery

A total of 39 camera transects and 23 DDV locations were sampled throughout the duration of the survey programme resulting in the collection of 1,252 still images and approximately 188 Gigabyte (GB) of HD video.

Full sample logs are presented in Appendix I and II. Example imagery is presented in **Section 4.4**. The full catalogue of seabed imagery will be provided upon completion of the detailed imagery analysis and submission of the technical report.

4.3. Benthic Grab Sampling

A total of 33 successful PSD/macrobenthic samples were collected during the survey. PSD/macrobenthic samples were unable to be obtained from 12 stations during the survey. These failed samples occurred due to the coarse sediment (pebbles / cobbles / bedrock) present at the target location.

A total of seven successful chemical samples (HM and HC) were collected. Chemical samples were unable to be obtained from eight stations during the survey due to the coarse sediment (pebbles / cobbles / bedrock) present at the target location.

Full sample logs are presented in Appendix III. Example photographs of grab samples are presented in **Plate 4**. The full catalogue of grab sample photographs will be provided upon completion of the detailed imagery analysis and submission of the technical report.

Plate 4 Example photographs of; unreleased Day grab sample (top left), failed Day grab attempt (top right), released Hamon grab sample (bottom left), sieved Hamon grab sample (bottom right).

Table 3 Sampling summary.

Date	Activity	DDV Transects Completed	DDV Stations Completed	Hamon Grabs Completed	Chemical Sampling Completed
06/12/20	Equipment and personnel mobilised onto the vessel at Newhaven marina.	0	0	0	0
07/12/20	Vessel departed Newhaven Marina at 0730 hrs and arrived on site 0840 hrs. 10 contaminant stations complete including 6 stations that had to be abandoned after four failed attempts due to hard ground. Sampling finished at 1415hrs and transit back to Newhaven.	0	0	12	0
08/12/20		0	0	0	10
04/02/20	Equipment and personnel re-mobilised onto the vessel at Newhaven marina.	0	0	0	0
05/02/20	Vessel departed Newhaven Marina at 0610 hrs and arrived on site 0855 hrs. A total of 3 drop-down camera stations and 9 transects were completed by 1600. The vessel then transited to Littlehampton and was alongside at 1715 hrs.	9	3	0	0
06/02/20	Vessel departed Littlehampton at 0545 hrs and arrived on site at 0700 hrs. A total of 11 drop-down camera stations and 7 transects were completed by 1530 hrs. The vessel then transited to Newhaven and was alongside at 1730 hrs.	7	11	0	0
21/02/20	Equipment and personnel re-mobilised onto the vessel at Newhaven marina.	0	0	0	0
22/02/20	Vessel departed Newhaven at 06:15 hrs and arrived on site at 08:20 hrs. Camera sampling continued throughout the day with a total of 3 drop-down stations and 11 camera transects completed. The vessel left the site at darkness and arrived alongside in Littlehampton at 18:00 hrs.	11	3	0	0
24/02/10	Equipment and personnel re-mobilised onto the vessel at Littlehampton harbour.	0	0	0	0
25/02/20	Vessel re-fuelled at 09:30 and departed Littlehampton at 10:30 hrs, after waiting for the residual swell to calm down. Vessel began camera sampling at 11:00 hrs and completed a total of 5 drop-downs and 7 transects throughout the day until darkness. Vessel left the site at 17:30 and was alongside in Littlehampton at 19:10 hrs.	7	5	0	0
26/02/20	Vessel departed Littlehampton at 07:30 hrs. Vessel arrived at camera station 1 at 07:50 hrs to re-try the drop-down due to zero visibility experienced yesterday. Conditions were still the same and there was zero visibility. Vessel then transited offshore and continued camera sampling, completing all stations	5	1	0	1

Date	Activity	DDV Transects Completed	DDV Stations Completed	Hamon Grabs Completed	Chemical Sampling Completed
	by 13:30 hrs. The vessel was then re-configured for grab sampling operations. One grab station was completed before the vessel headed to Newhaven. The vessel was alongside in Newhaven 17:30 hrs.				
27/02/20	Vessel departed Newhaven at 06:00 hrs and arrived on site at 07:40 hrs. The first grab sample was collected at 07:45 hrs and sampling continued throughout the day. All remaining grab stations were completed. A total of 22 PSA and macrofaunal samples were collected. As well as 2 chemical sampling stations. A total of 9 PSA/Macrofaunal and 2 chemical sampling stations were abandoned after 4 unsuccessful attempts. Vessel was alongside in Newhaven 19:00 hrs.	0	0	31	4
28/02/20	Survey personnel arrived at the vessel at 09:00 hrs and demobilised the Hamon grab, and all samples collected. Personnel arrived at the OEL premises at 15:00 hrs and samples were logged in and stored.	0	0	0	0
	Total	**39**	**23**	**43**	**15**

4.4. Survey Findings

Two DDV stations and four additional chemical sampling stations were added to the original scope on the 2 February 2021. Two Hamon grab stations were removed from the scope on the 25 February 2021 due to coarse ground not suitable for grab sampling being identified during the camera survey. An additional chemical sampling station was added on the 26 February.

Table 4 Summary of final samples collected.

DDV Transects	DDV Stations	Hamon Grabs	Chemical Sampling Stations
39	23	43	15

4.4.1. Seabed Habitats

The preliminary results indicate coarse, mixed sediments across most of the Rampion 2 survey area. Examples of these sediment habitats encountered are shown in Plate 5 below. A detailed European Nature Information System (EUNIS) habitat map will be produced for the survey area following completion of the analysis of all seabed imagery and grab samples collected during the survey.

4.4.2. Notable Features

Potential Annex I bedrock and stony reefs, supporting diverse floral and faunal communities, were present along 31 transects and 10 DDV stations (

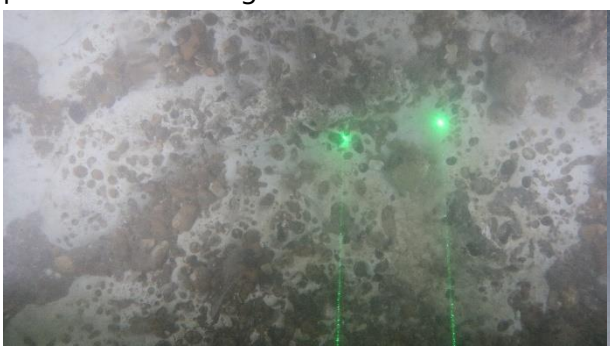

Plate 6). Chalk bedrock reef structures were present at transects T02, T04, T06, T07 and DDV stations 04 and 032. Except for T024 (**Plate 7**), there was no obvious evidence of any significant biogenic reef noted during *in situ* review of the seabed footage or during processing of the sediment samples in the field. Some localised *Sabellaria spinulosa* tube aggregations were recorded in several still images at transects T018, T027, T036, and T_038, and DDV station 02.

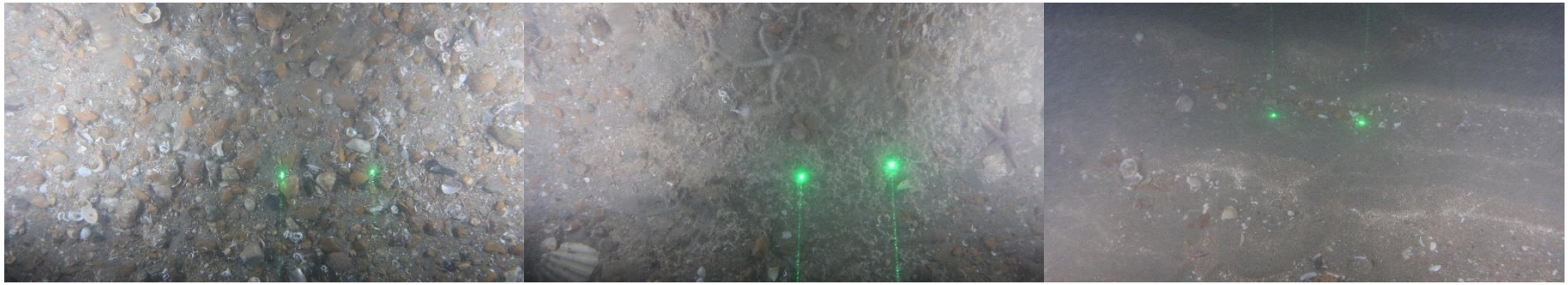

Plate 5 Examples of representative sediment habitats recorded across the survey area.

Plate 6 Example of potential bedrock (including chalk) and stony reefs observed during the survey.

Plate 7 Examples of *S. spinulosa* tube aggregations at T024.

4.5. Glossary and abbreviations

Table 5 Glossary of terms and abbreviations

Term (acronym)	Definition
AIS	Automatic Identification System
Benthic ecology	Benthic ecology encompasses the study of the organisms living in and on the sea floor, the interactions between them and impacts on the surrounding environment
CLOC	Clear Liquid Optical Chamber
cm	Centimetre
°C	Degree Celsius
°	Degree
DCO	Development Consent Order
DDV	Drop Down Video
Environmental Impact Assessment (EIA)	The process of evaluating the likely significant environmental effects of a proposed project or development over and above the existing circumstances (or 'baseline').
Environmental Statement (ES)	The written output presenting the full findings of the Environmental Impact Assessment.
EUNIS	European Nature Information System
EUNIS habitat classification	A pan-European system which facilitates the harmonised description and classification of all types of habitat, through the use of criteria for habitat identification
FOCI	Features of Conservation Interest
GB	Gigabyte
Geographical Information System (GIS)	A system that captures, stores, analyses, manages and presents data linked to location. It links spatial information to a digital database.
GoBe	GoBe Consultants Ltd
GPS	Global Positioning System
HC	Hydrocarbons
HD	High Definition
HM	Heavy Metals

HRA	Habitat Regulations Assessment
Intertidal	The area of the shoreline which is covered at high tide and uncovered at low tide.
Joint Nature Conservation Committee (JNCC)	JNCC is the public body that advises the UK Government and devolved administrations on UK-wide and international nature conservation.
km	Kilometre
L	Litres
LED	Light-Emitting Diode
m	Metre
m^2	Square Metre
Marine Management Organisation (MMO)	MMO is an executive non-departmental public body, sponsored by the Department for Environment, Food & Rural Affairs. MMO license, regulate and plan marine activities in the seas around England so that they're carried out in a sustainable way
MCA	Marine and Coastal Agency
ml	Millilitres
mm	Millimetre
MP	Megapixel
NTS	Non-Technical Summary
OEL	Ocean Ecology Ltd
Offshore	The sea further than two miles from the coast.
Offshore Wind Farm	An offshore wind farm is a group of wind turbines in the same location (offshore) in the sea which are used to produce electricity.
Planning Inspectorate (PINS)	The Planning Inspectorate deals with planning appeals, national infrastructure planning applications, examinations of local plans and other planning-related and specialist casework in England and Wales.
PSA	Particle Size Analysis
PSD	Particle Size Distribution
Preliminary Environmental	The written output of the Environmental Impact Assessment undertaken to date for the Proposed Development. It is

Information Report (PEIR)	developed to support formal consultation and presents the preliminary findings of the assessment to allow an informed view to be developed of the Proposed Development, the assessment approach that has been undertaken, and the preliminary conclusions on the likely significant effects of the Proposed Development and environmental measures proposed.
Rampion 1	The existing Rampion Offshore Wind Farm located in the English Channel off the south coast of England.
RED	Rampion Extension Development Limited
RSMP	Regional Seabed Monitoring Programme
TCE	The Crown Estate
ToR	Terms of Reference
UTM	Universal Transverse Mercator
WGS 1984	World Geodetic System 1984
Wood	Wood Environment & Infrastructure Solutions UK Ltd
WTG	Wind Turbines Generator

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