

Kingmere Marine Conservation Zone (MCZ) Characterisation Report 2018

MPA Monitoring Programme

January 2026

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Foreword

Marine Conservation Zones (MCZs) are designated under the Marine and Coastal Access Act (2009). Section 124 of this act sets a requirement for the Department for Environment, Farming and Rural Affairs (Defra) is required to provide a report to Parliament every six years that includes an assessment of the degree to which the conservation objectives set for MCZs are being achieved.

In order to fulfil its obligations, Defra has directed the Statutory Nature Conservation Bodies (SNCBs) to carry out a programme of MPA monitoring to support reporting under section 124 as well as wider assessment and reporting of the marine environment, such as progress toward achieving Good Environmental Status (GES) under the UK Marine Strategy (UKMS), or the Environmental Targets (Marine Protected Areas) Regulations 2023. Natural England is the Statutory Nature Conservation Body (SNCB) responsible for marine nature conservation between 0 and 12 nm from the English coastline. Natural England utilise the data from MPA monitoring reports in conjunction with other evidence (such as information on activities, pressures, historical data, and survey data collected by other organisations and to meet different obligations) to meet assessment and reporting obligations. The data from this report will be used by Natural England to assess the condition of designated features within the site, to inform and maintain up to date site-specific conservation advice.

Natural England commission a range of reports from external contractors to provide evidence and advice to assist us in delivering our duties. The views in this report are those of the authors and do not necessarily represent those of Natural England.

Executive Summary

Under the UK Marine & Coastal Access Act (2009), Defra is required to provide a report to Parliament every six years that includes an assessment of the degree to which the conservation objectives set for Marine Protected Areas (MPAs) are being achieved.

This monitoring report, informed by data acquired during a dedicated survey carried out at the Kingmere Marine Conservation Zone (MCZ) during 2018, will form part of the ongoing time series data and evidence programme for this Marine Protected Area (MPA). Kingmere MCZ is an inshore site, located in the English Channel off the West Sussex coast to the south of Littlehampton and Worthing. The site, which covers 47.84 km², protects two habitat Features of Conservation Interest (FOCI), namely 'Moderate energy infralittoral rock with thin mixed sediments' and 'Subtidal chalk', and one species FOCI; Black seabream (*Spondyllosoma cantharus*).

Acoustic data from the United Kingdom Hydrographic Office (UKHO), alongside sediment particle size and imagery footage captured during the 2018 survey at Kingmere, were used to create a revised Broadscale Habitat (BSH) map for the site. Two BSHs were identified: the sedimentary habitat 'A5.1 Subtidal coarse sediment' was the most widespread (covering 93.9% of the site) and the hard substratum 'A3.2 Moderate energy infralittoral rock' which accounted for 6.1% of the site, chiefly as a narrow, east-west band across the MCZ. An additional map was also produced, reclassifying some of the sedimentary areas (based on interpretation of the underlying geology) as Moderate energy infralittoral rock and thin mixed sediments, and highlighting areas of the habitat FOCI Subtidal chalk.

The coarse nature of the sediments at Kingmere impacted the capacity of the 2018 grab survey to comprehensively characterise the infaunal communities. Data from the nine (out of 16) successful mini Hamon grabs revealed that assemblages from the two sedimentary BSHs (as governed by their sediment particle size distributions): 'A5.1 Subtidal coarse sediment' and 'A5.4 Subtidal mixed sediments' (which was not discerned by the mapping approaches) were comparable. Similarly, six univariate metrics of community structure, and biomass, were equivalent between these two BSHs.

While the video footage from the 2018 drop down video (DDV) was of insufficient quality for analyses, 380 still images of the 446 classed as 'good' quality (from a total of 632) were analysed and revealed three biotopes within the 'A3.2 Moderate energy infralittoral rock' BSH: 'A3.215 Dense foliose red seaweeds on silty moderately exposed infralittoral rock'; 'A3.225 Filamentous red seaweeds, sponges and *Balanus crenatus* on tide-swept variable-salinity infralittoral rock', and 'A3.24 Faunal communities on moderate energy infralittoral rock'.

The improved understanding of the ecological characteristics of the Kingmere MCZ, based on these outcomes, are discussed in a broader context, including how they may be used to facilitate future management of the MCZ. We also advocate that

future monitoring efforts should contemplate adopting approaches to enable the depth of sediment layers overlying bedrock across the site to be quantified; capturing incidental visual footage during grabbing approaches; and if monitoring infaunal assemblages remains an objective, to consider the use of a larger grab type capable of sampling the coarse sediments which prevail. Grabbing should only be targeted in areas where evidence (from acoustic approaches or otherwise) suggests the depth of sediment is sufficient.

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Abbreviations

ANOSIM	Analysis of Similarity
BGS	British Geological Society
BSH	Broadscale Habitats
Cefas	Centre for Environment, Fisheries and Aquaculture Science
DDV	Drop-down Video
Defra	Department for Environment, Food and Rural Affairs
EA	Environment Agency
EUNIS	European Nature Information System
FOCI	Feature of Conservation Interest
FPV	Fisheries Patrol Vessel
GES	Good Environmental Status
GMA	General Management Approach
IFCA	Inshore Fisheries and Conservation Authority
JNCC	Joint Nature Conservation Committee
NMBAQC	North East Atlantic Marine Biological Analytical Quality Control Scheme
MBES	Multibeam echosounder
MCZ	Marine Conservation Zone
MESH	Mapping European Seabed Habitats
MPA	Marine Protected Area
MSFD	Marine Strategy Framework Directive
NE	Natural England
NIS	Non-Indigenous Species
nMDS	Non-metric Multidimensional Scaling
OBIA	Object-Based Image Analysis
OSPAR	The Convention for the Protection of the Marine Environment of the North-East Atlantic
PSA	Particle Size Analysis
ROG	Recommended Operating Guidelines
RV	Research Vessel
SAC	Special Area of Conservation

SACO	Supplementary Advice on Conservation Objectives
SAD	Site Assessment Document
SIMPER	Similarity Percentages analysis
SIMPROF	Similarity Profile
SNCB	Statutory Nature Conservation Body
SNCI	Site of Nature Conservation Interest
SSS	Sidescan sonar
SV	Survey Vessel
UKHO	United Kingdom Hydrographic Office

1 Introduction

Under the Marine and Coastal Access Act (2009), Defra is required to provide a report to Parliament every six years that includes an assessment of the degree to which the conservation objectives set for Marine Conservation Zones (MCZ) are being achieved.

This monitoring report primarily explores data acquired from the first dedicated monitoring survey of Kingmere MCZ, which will form the initial point in a monitoring time series against which feature condition can be assessed in the future. The specific aims of the report are discussed in more detail in Section 1.3.

This report does not aim to assess the condition of the designated features. Statutory Nature Conservation Bodies (SNCBs) use evidence from Marine Protected Areas (MPA) monitoring reports in conjunction with other available evidence (e.g., activities, pressures, historical data, survey data collected from other organisations or collected to address different drivers) to make assessments on the condition of designated features within an MPA.

1.1 Site overview

The Kingmere MCZ is located in the English Channel off the West Sussex coast, four miles to the south of Littlehampton and Worthing, and protects a seabed area of 47.84 km² (Figure 1; Table 1). The site was designated in 2013 due to the presence of excellent examples of rocky habitats and subtidal chalk outcropping reef systems¹. The site was included in the network because of its contribution to Ecological Network Guidance (ENG) criteria to Broadscale Habitats, and its added ecological importance. For a detailed site description see 'Balanced Seas Marine Conservation Zone Project Final Recommendations' (Balanced Seas, 2011).

The rocky sandstone and boulder habitats found across the Kingmere MCZ represent excellent examples of rocky habitats and subtidal chalk outcropping reef systems. These are important for biodiversity as they support a wide range of marine life, such as algae, sea squirts and sponges. The MCZ contains two marine Sites of Nature Conservation Interest (SNCI) known as Kingmere Rocks and Worthing Lumps. SNCI are non-statutory sites identified for their local conservation and geological values.

Within this site the moderate energy infralittoral rock is covered with a thin veneer of mixed sediments. This creates a complex mosaic of habitats that are particularly important to the black seabream, a fish species that is also protected by this site. Indeed, Kingmere MCZ is one of the most well-known spawning sites for the black seabream (*Spondyllosoma cantharus*) in the UK as the rocky habitats and chalk

¹ [The Kingmere Marine Conservation Zone Designation Order 2013 \(legislation.gov.uk\)](https://www.legislation.gov.uk)

outcrops provide ideal nesting grounds. Black seabream is a species FOCI for the site (Table 1).

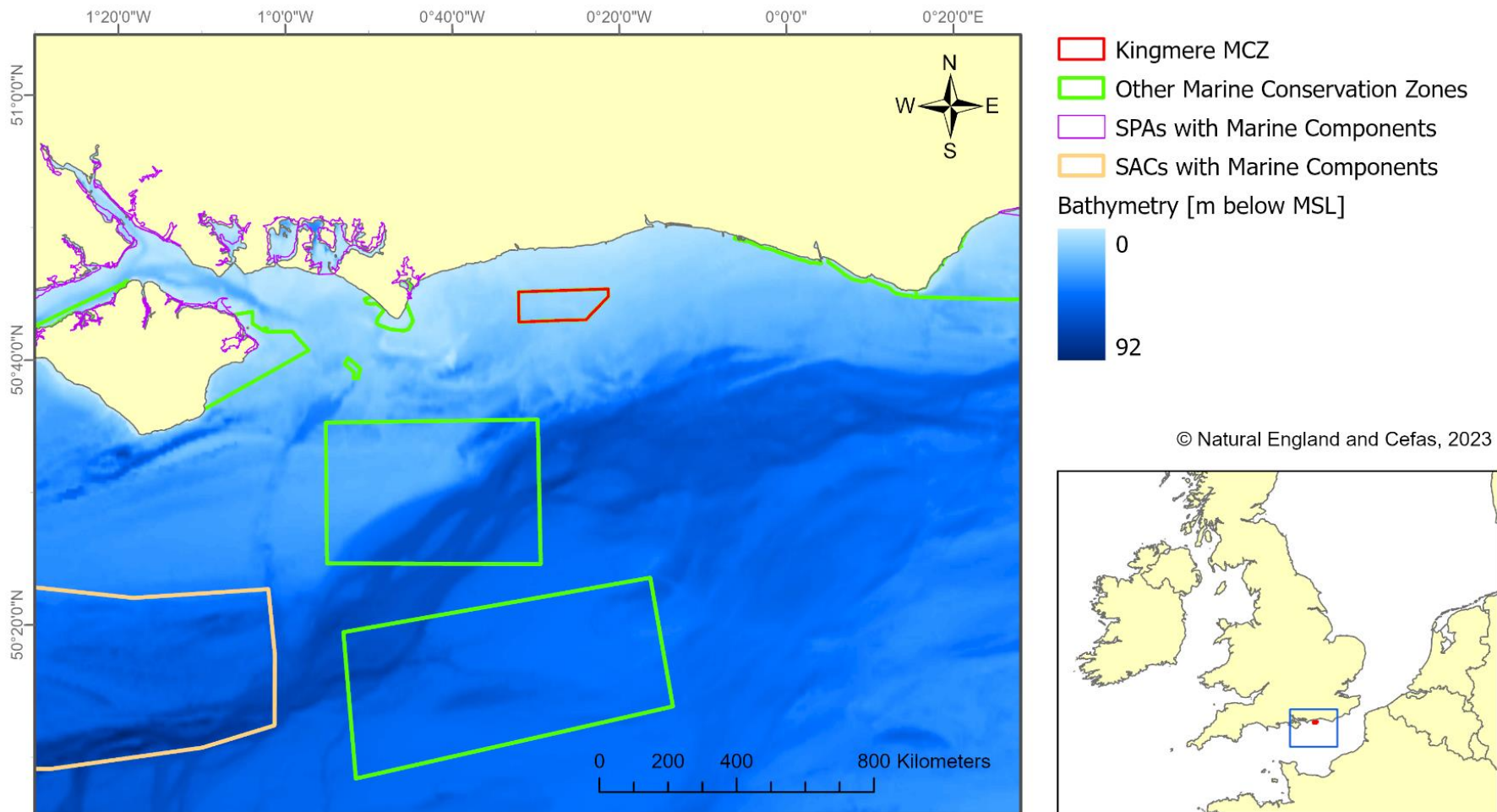


Figure 1. Location of the Kingmere MCZ in the context of Marine Protected Areas proximal to the site. Bathymetry is from the General Bathymetric Chart of the Oceans (GEBCO, 2022). © Natural England and Cefas, 2023.

Table 1. Kingmere MCZ site overview. © Natural England and Cefas, 2023.

Key Information	
Charting Progress 2 Region	Eastern English Channel
Spatial area (km ²)	47
Water depth range (m)	5 – 19 m
Broadscale Habitat (BSH) Features Present	Designated?
Moderate energy infralittoral rock and thin mixed sediment	✓
Subtidal chalk	✓
Species FOCI Present	Designated?
Black seabream (<i>Spondyliosoma cantharus</i>)	✓

1.2 Existing data and habitat maps

Acoustic data and tidal modelling

A full seabed coverage sidescan sonar (SSS) survey of the Kingmere MCZ was undertaken by the Sussex Inshore Fisheries and Conservation Authority (IFCA), in partnership with Cefas, onboard Fisheries Patrol Vessel (FPV) *Watchful* in May 2014 (Figure 2). A 4800MP SSS with a 200 m swath was used.

Subsequently, in May 2015, Multibeam echosounder (MBES) bathymetry data were collected by Fugro EMU Ltd, onboard the RV *Discovery* in accordance with Fugro EMU's standard procedures, using a Kongsberg EM2040 dual head MBES (Fugro EMU Limited, Area 435/396 Monitoring report, 2015). The data were processed in accordance with Fugro EMU's standard procedures with final bathymetry data resolved at 1 m cell size. The MBES data were acquired for five blocks within the MCZ boundary (Figure 2).

To understand the supporting processes for the Kingmere MCZ, maximum (peak ebb and peak flood) tidal current velocities (m s⁻¹) at the seabed were predicted using a tidal model built for the site. The depth-averaged model was nested within a larger English Channel model (which extends into the Bristol Channel) and has been built using an unstructured triangular mesh, using the software Telemac2D (v7p1). Further details on the tidal model can be accessed in 'Annex 2. Sampling, data acquisition and analyses'.

Habitat maps

A site assessment document (SAD) habitat map (Figure 3) was produced for Kingmere MCZ using modelled data from the UKSeaMap 2010 v5 (McBreen and others, 2011). For further detail see *Balanced Seas* (2011).

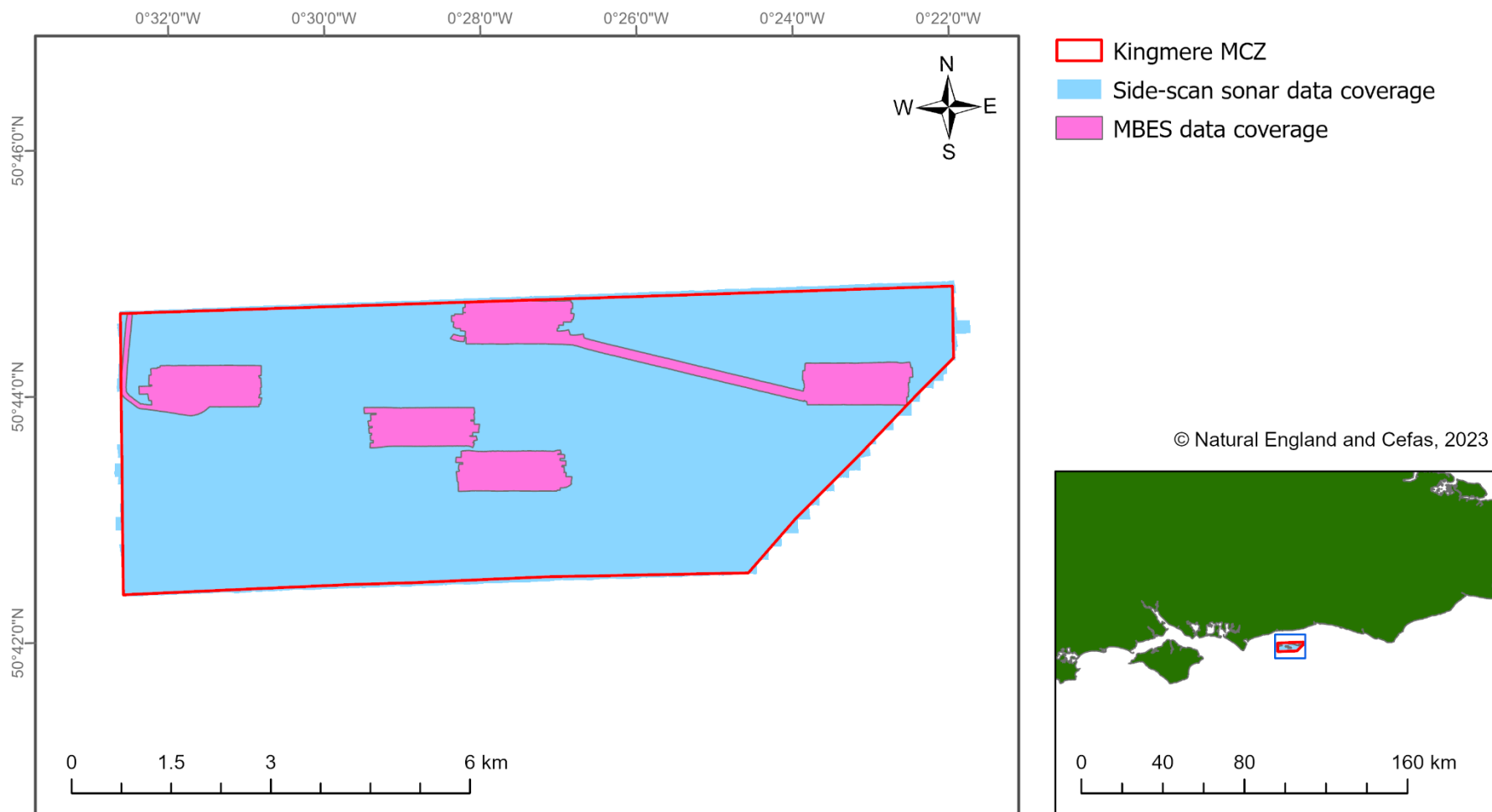


Figure 2. Extent of side-scan sonar (SSS) and multibeam echo sounder (MBES) and data within the Kingmere MCZ. Data were collected in 2014 by Sussex Inshore Fisheries and Conservation Authority and in 2015 by Fugro EMU Ltd. respectively.

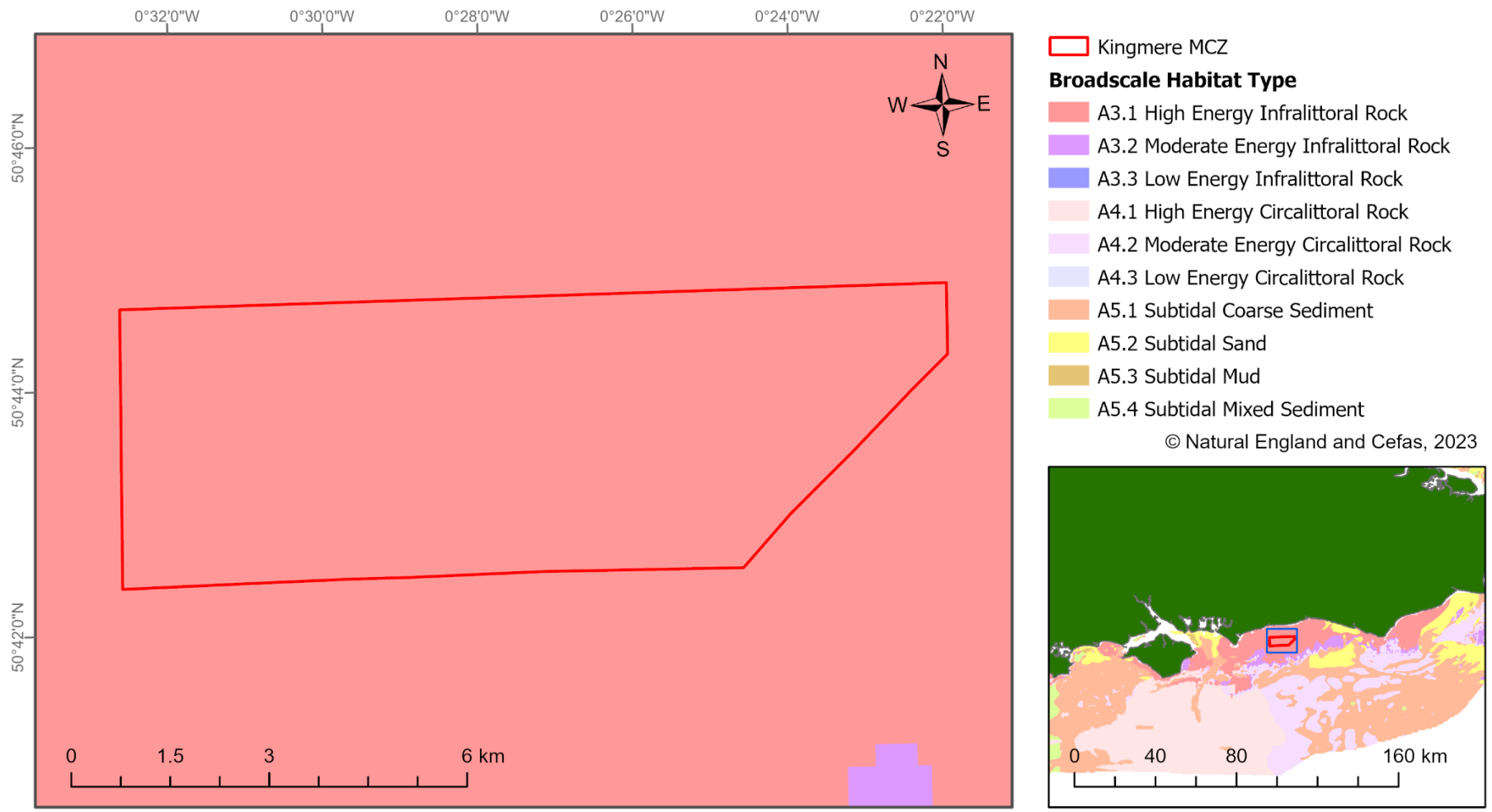


Figure 3. Original habitat map for Kingmere MCZ from the Site Assessment Document.

Grab and video sampling

Grab samples were collected from within the Kingmere MCZ in February 2012 onboard *Sea Vigil* (Godsell and others, 2013). A total of 30 stations were selected across the site using a 1.5 km grid spread across the predicted 'High energy infralittoral rock' BSH in the SAD (Figure 3). Stations located within black seabream nesting areas, Subtidal chalk habitat and lobster grounds were selected for camera work only. All stations were surveyed using video, with suitable (sedimentary) sites then being selected for grab sampling. Video footage, using a drop-down camera following the Mapping European Seabed Habitats (MESH) Recommended Operating Guidelines (ROG) for underwater video and photographic imaging techniques (Coggan and others, 2007), was successfully collected at all 30 planned stations. A single successful grab sample (mini Hamon grab) was sampled from of a total of 15 planned stations (Godsell and others, 2013).

1.3 Aims and objectives

High-level conservation objectives

Site-specific conservation objectives serve as benchmarks against which to monitor and assess the efficacy of management measures in maintaining a designated feature in, or restoring it to, 'favourable condition'.

As detailed in the Kingmere MCZ designation order¹, the conservation objectives for the site are that the designated features:

- a) So far as already in favourable condition, remain in such condition; and
- b) So far as not already in favourable condition, be brought into such condition, and remain in such condition.

Report aims and objectives

The primary aim of this characterisation report is to explore and describe the attributes of the designated features within the Kingmere MCZ, to enable future assessment and monitoring of feature condition. The results presented, based on the outcomes of a dedicated survey of the site during 2018, will be used to develop recommendations for future monitoring, including specific metrics which may indicate whether the condition of the feature has been maintained, is improving, or is in decline.

The objectives of this monitoring report and the associated outputs are provided in Table 2. To achieve report objective 1, selected Feature Attributes and supporting

processes of the designated features are described (as defined in Supplementary Advice on Conservation Objectives²; see Table 2

¹[The Kingmere Marine Conservation Zone Designation Order 2013 \(legislation.gov.uk\)](https://www.legislation.gov.uk)

²[Designated Sites View \(naturalengland.org.uk\)](https://naturalengland.org.uk)

Table 2. Report objectives and outputs for the Kingmere MCZ report, 2018. © Natural England and Cefas, 2023.

Objective		Feature Attribute*	Features / Entire MCZ	Proposed Output
Objective 1	Provide a description of the extent³, distribution and structural attributes of the designated features within the site (see Table 2 for more detail), to enable subsequent condition monitoring and assessment;	Extent and distribution	Moderate energy infralittoral rock and thin mixed sediment Subtidal chalk	Generate a habitat map to determine the extent of designated feature BSH and habitat FOCI within the MCZ.
		Physical structure	Moderate energy infralittoral rock and thin mixed sediment Subtidal chalk	Discuss the physical structure of the rock habitats, as determined using imagery and acoustic data.
		Sediment composition and distribution	Moderate energy infralittoral rock and thin mixed sediment	Discuss the composition and distribution of sediments across the MCZ, with reference to the BSH classes and habitat map.
		Presence and spatial distribution of biological communities Presence and abundance of key	Moderate energy infralittoral rock and thin mixed sediment Subtidal chalk	Conduct qualitative descriptive analysis, and where appropriate, multivariate analysis of infaunal and epifaunal data to: <ul style="list-style-type: none"> - Identify patterns in biological assemblages - Assign biotopes (where possible)

³ Note that where current habitat maps are not available, extent will be described within the limits of available data.

Objective	Feature Attribute*	Features / Entire MCZ	Proposed Output
	structural and influential species Species composition of component communities		- Identify, if possible, apparent key structural and influential species.
Presence and distribution of the species FOCI	Black seabream	Entire MCZ	Map location of active / recent nesting activity – observations from video to be presented in Results section. In Discussion section, draw in qualitative observations / locations of nesting observed into context of revised habitat map and potentially in a brief qualitative ‘Black seabream annex’ draw in observations and conclusions from wider black bream reporting from NE / Sussex IFCA.
Extent of supporting habitats for species FOCI	Black seabream	Entire MCZ	Map location of active / recent nesting activity – observations from video to be presented in Results section. In Discussion section, draw in qualitative observations / locations of nesting observed into context of revised habitat map and potentially in a brief qualitative ‘Black seabream annex’ draw in observations and conclusions from wider black bream reporting from NE / Sussex IFCA.
Supporting processes: energy and exposure		Entire MCZ	Explore and discuss what data sources are available for both physical processes and physio chemical water

Objective	Feature Attribute*	Features / Entire MCZ	Proposed Output
			column. As an example, extract Telemac tidal model for site. Future recommendations regarding supporting processes, e.g., requirements of sediment transport modelling, to be presented in Discussion section.
Objective 2	Note observations of any habitat or species FOCI not covered by Designation Order as features of the site.	Entire MCZ	Sub-section in Results.
Objective 3	Present evidence relating to non-indigenous species (Descriptor 2) and marine litter (Descriptor 10), to satisfy requirements of the MSFD.	Entire MCZ	Sub-section in Results
Objective 4	Record any anthropogenic activities or pressures encountered during the dedicated monitoring survey.	Entire MCZ	Sub-section in Results
Objective 5	Provide practical recommendations for appropriate future monitoring approaches for the designated features (e.g., metric selection, survey design, data collection approaches) with a discussion of their requirements.	Entire MCZ	Discussion section

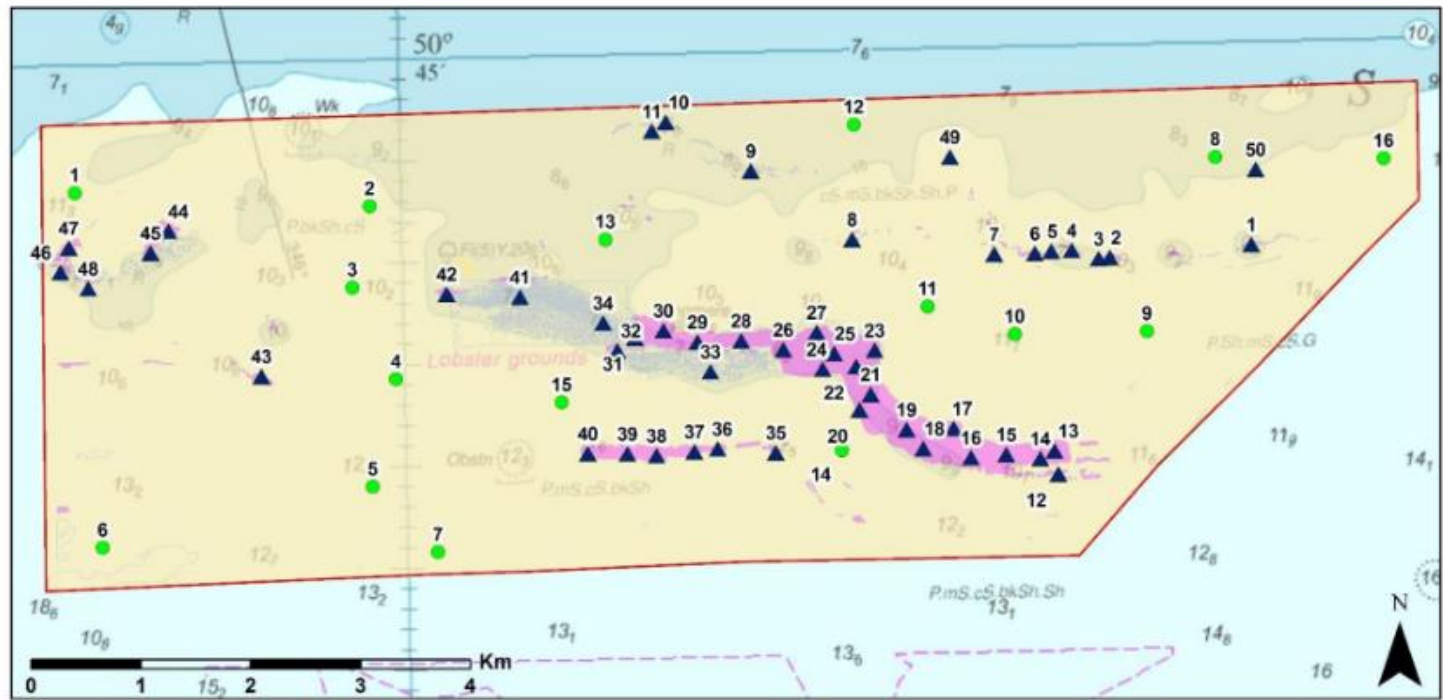
* As defined in Supplementary Advice on Conservation Objectives (SACO) for the Kingmere MCZ. [[Designated Sites View \(naturalengland.org.uk\)](http://naturalengland.org.uk)]

2 Methods

2.1 Survey design

Between 19th and 24th June 2018, a dedicated survey was conducted at the Kingmere MCZ onboard the Survey Vessel (SV) *Solent Guardian*. The 2018 survey comprised both drop-down video (DDV) camera and grab sampling approaches (Godsell, 2019). The DDV survey design was stratified based on the interpreted habitat map produced following the MCZ verification survey. Fifty DDV stations targeted areas predicted to be 'A3.2 Moderate energy infralittoral rock' to provide information on feature distribution and community structure (Figure 4). Following advice from the Sussex IFCA the survey was conducted during the latter half of June to avoid the high density of potting undertaken in the planned DDV survey areas and to coincide with the end of the Bream Management Season (1st April to the 30th June) (Godsell, 2019), although this was later updated in March 2021 to March to July (inclusive).

Sixteen mini-Hamon grab (0.1 m²) stations were selected (Figure 4) for the 2018 survey also based on the interpreted habitat map to target areas of 'A5 Subtidal sediment' (Figure 4).



Kingmere MCZ 2018 Survey Plan

- ▲ target camera stations
 - target grab stations
 - Kingmere MCZ Boundary
- Broadscale Habitat Types**
- A5 Subtidal sediment
 - A4.2 Moderate A3.2 gy infralittoral rock

Figure 4. Location of the camera and grab stations for the 2018 Kingmere MCZ survey, plotted over interpreted Broadscale Habitat map. Image taken from Godsell (2019).

2.2 Data acquisition, preparation, and analysis

Creation of a revised broadscale habitat map (BSH) for Kingmere

The 2018 survey at the Kingmere MCZ did not acquire any acoustic SSS or MBES data. The revised BSH map for the site within this report was based the following data sources:

- Bathymetric data acquired from the UKHO Marine Data Portal⁴;
- Sidescan sonar data collected by Southern IFCA in 2014; and
- Data on the underlying geology from the British Geological Society (BGS) Offshore GeolIndex⁵.

The acquisition of these data, and how they were used to derive a BSH map for the site, is described in detail in 'Annex 2.2 Acoustic data (for habitat mapping)'.

Seabed imagery

The DDV camera approach conducted during the 2018 survey was in accordance with the MESH 'recommended operating guidelines (ROG) for underwater video and photographic imaging techniques' (Coggan and others, 2007). The Subsea Technology & Rentals (STR) SeaSpyder camera system was deployed from the stern of the SV *Solent Guardian* and real time navigation data acquisition and manual position fixing when the gear contacted the seabed was captured via Trimble® HYDROpro™ software. Images of the seabed were captured approximately every 10 to 15 m over a distance of > 150 m. Extra photographs were taken in heterogeneous areas of BSH and if particular habitat/species FOCI were observed. If a BSH habitat boundary was detected towards the end of a tow, the camera deployment was extended to confirm the change. All 50 planned stations (Figure 4) were successfully sampled using the DDV approach (Table 3). Further details regarding the video imagery set up and approaches can be accessed in 'Annex 2.3 Seabed imagery'.

Grab sampling

A mini-Hamon grab (0.1 m²) was deployed from the stern gantry of the vessel to collect sediment from the seabed, as described by Ware and Kenny (2011). Sampling positions were recorded (fixed) using Hydropro data acquisition software when the gear contacted the seabed. From each grab sample, a 500 ml sub-sample was taken and stored at -20°C prior to determining the particle size distribution. Sediment samples were processed following the recommended methodology of the North East Atlantic Marine Biological Analytical Quality Control (NMBAQC) scheme (Mason, 2011). The less than 1 mm sediment fraction was analysed using laser

⁴ <https://data.admiralty.co.uk/portal/apps/sites/#/marine-data-portal>

⁵ <https://www.bgs.ac.uk/map-viewers/geoindex-offshore/>

diffraction and the greater than 1 mm fraction was dried, sieved and weighed at 0.5 phi (ϕ) intervals. Sediment distribution data were merged and used to classify samples into BSH. The faunal fraction was sieved over a 1 mm mesh, photographed, then fixed in buffered 4% formaldehyde. Faunal samples were processed to extract all fauna present in each sample. Fauna were identified to the lowest taxonomic level possible, enumerated and weighed (blotted wet weight) to the nearest 0.0001 g following the recommendations of the NMBAQC scheme (Worsfold and others, 2010).

The success of viable grab samples varied across the survey area. Samples for both macrofaunal and particle size analyses (PSA) were successfully collected at nine stations, while the quantity of sediment collected was only sufficient for PSA at a further six stations (Table 3). One further station yielded only sediment ‘discards’ due to sample volume and therefore no viable sample. The limited number of successful grab samples acquired for macrofauna will inevitably impact on the capacity to provide an assessment of the infaunal assemblages associated with the sedimentary regions and this will be highlighted, where relevant, within the results section.

Table 3. Summary of samples collected during the 2018 Kingmere Marine Conservation Zone monitoring (MCZ) survey, June 2018. © Natural England and Cefas, 2023.

Equipment	Data type	No. samples
DDV	Video and still images	50
Mini-Hamon grab	Macrofaunal and PSA	9
Mini-Hamon grab	PSA only	6

Note, metadata can be obtained from Godsell (2019)

The infaunal dataset was initially reviewed to ensure consistent nomenclature using the WORMS ‘match taxa’ tool, then community structure analysed using PRIMER v7 (Clarke and Gorley, 2015). Details regarding the various steps and PRIMER routines used can be accessed in ‘Annex 2.4 Grab sampling Annex 2. Sampling, data acquisition and analyses’. Several univariate metrics of community structure considered relevant to describe the basic assemblage attributes were generated using the DIVERSE routine in PRIMER v7 for each sample (together with total biomass to reflect assemblage function).

3 Results

3.1 Supporting processes: energy and exposure (report objective 1)

Modelled peak flood tidal current magnitudes (observed during the maximum flood tide) within Kingmere MCZ vary between 0.72 m s⁻¹ and 0.91 m s⁻¹ (Figure 5). Tidal magnitudes observed during maximum ebb tidal flow vary between 0.77 m s⁻¹ and

0.90 m s⁻¹ (Figure 6). The highest magnitudes at both peak ebb and peak flood tides are observed to the south of the site. Tidal current directions at peak ebb and peak flood vary significantly across the site with a net westward flow during the flood tide and a net eastward transport during ebb. This is congruent for this part of the English Channel.

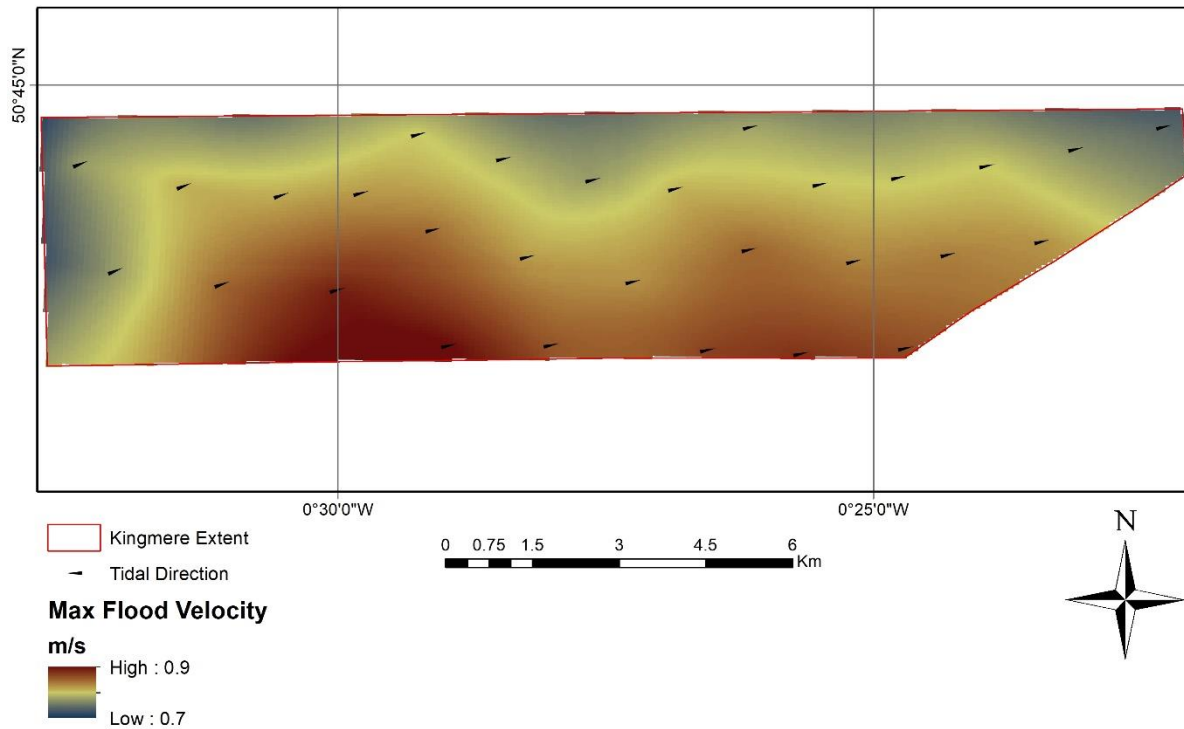


Figure 5. Direction and magnitude of peak tidal flood flow within the Kingmere MCZ. © Natural England and Cefas 2023.

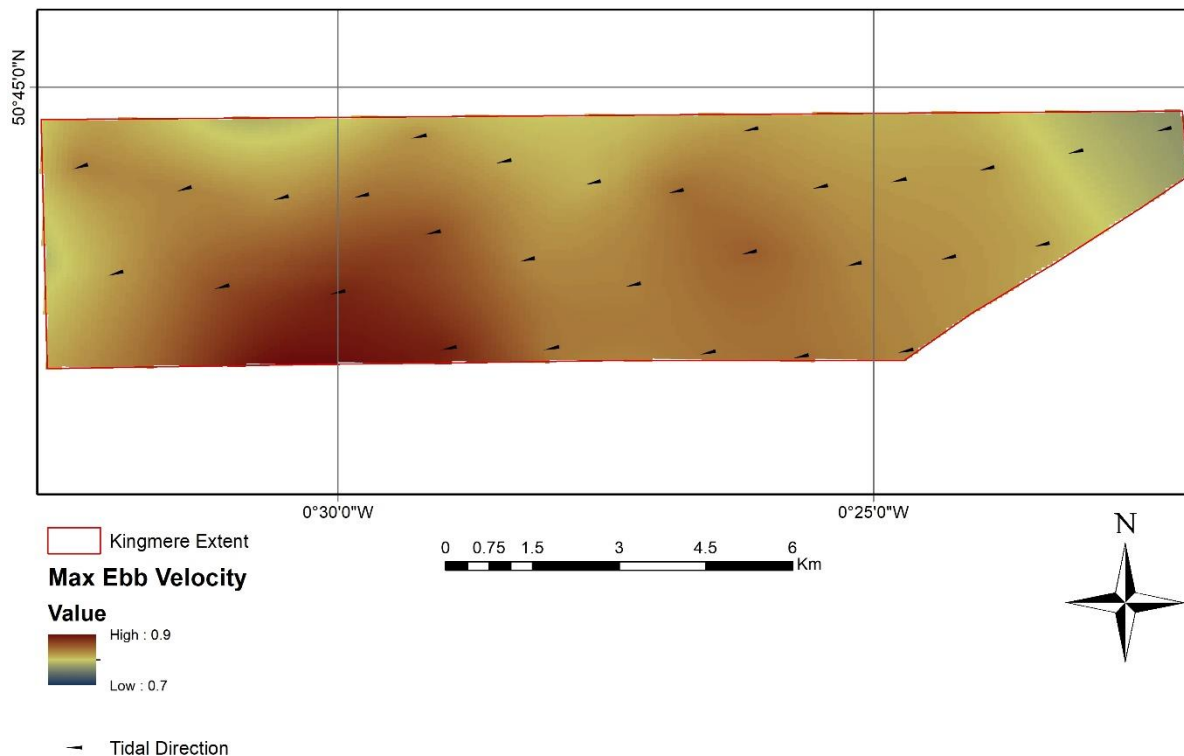


Figure 6. Direction and magnitude of peak tidal ebb flow within the Kingmere MCZ. © Natural England and Cefas 2023.

3.2 Particle size analysis (PSA) (report objective 1)

The PSA data from the 15 successful grab samples taken across Kingmere during the 2018 survey reveal that the sediments, where sampled, comprise predominantly of gravel and sand, with a silt/clay content of less than 5% at all but two stations (Figure 7). The relative dominance of gravel and sand varied between stations, with the maximum gravel and sand content at any station being 89.8% and 73.5% respectively. All samples were poorly sorted (most were bimodal or trimodal) and classed as either ‘A5.1 Subtidal coarse sediment’ (12 stations) or ‘A5.4 Subtidal mixed sediments’ (three stations) (Figure 7). The three stations which contained the slightly higher proportions of silt/clay and were classed as ‘A5.4 Subtidal mixed sediments’ are located along the southern boundary of the site (one station) and towards the eastern limit (two stations) of the site (Figure 8, Figure 9).

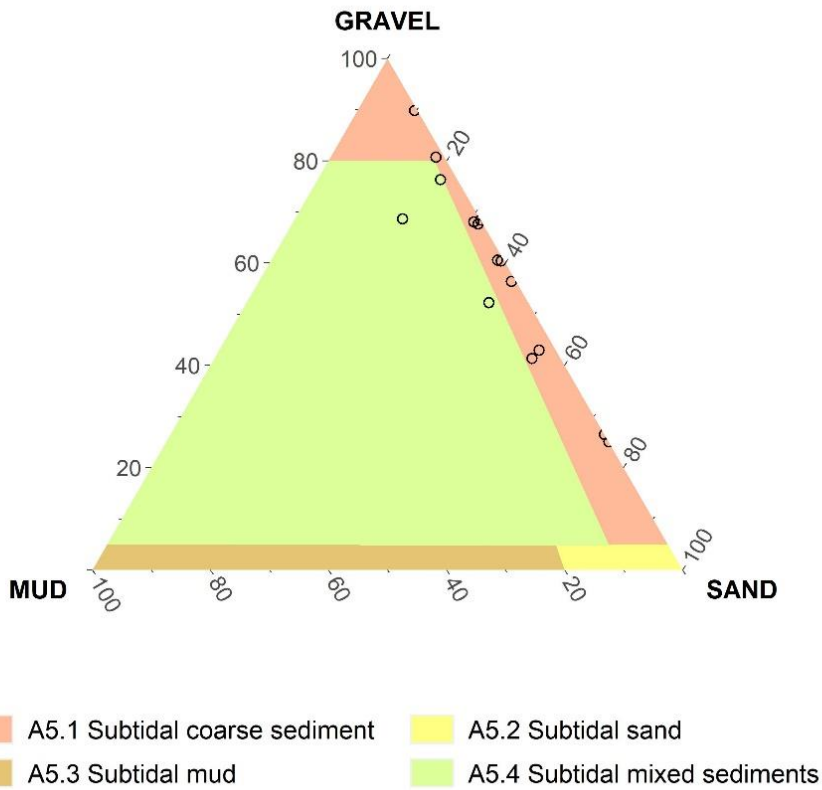
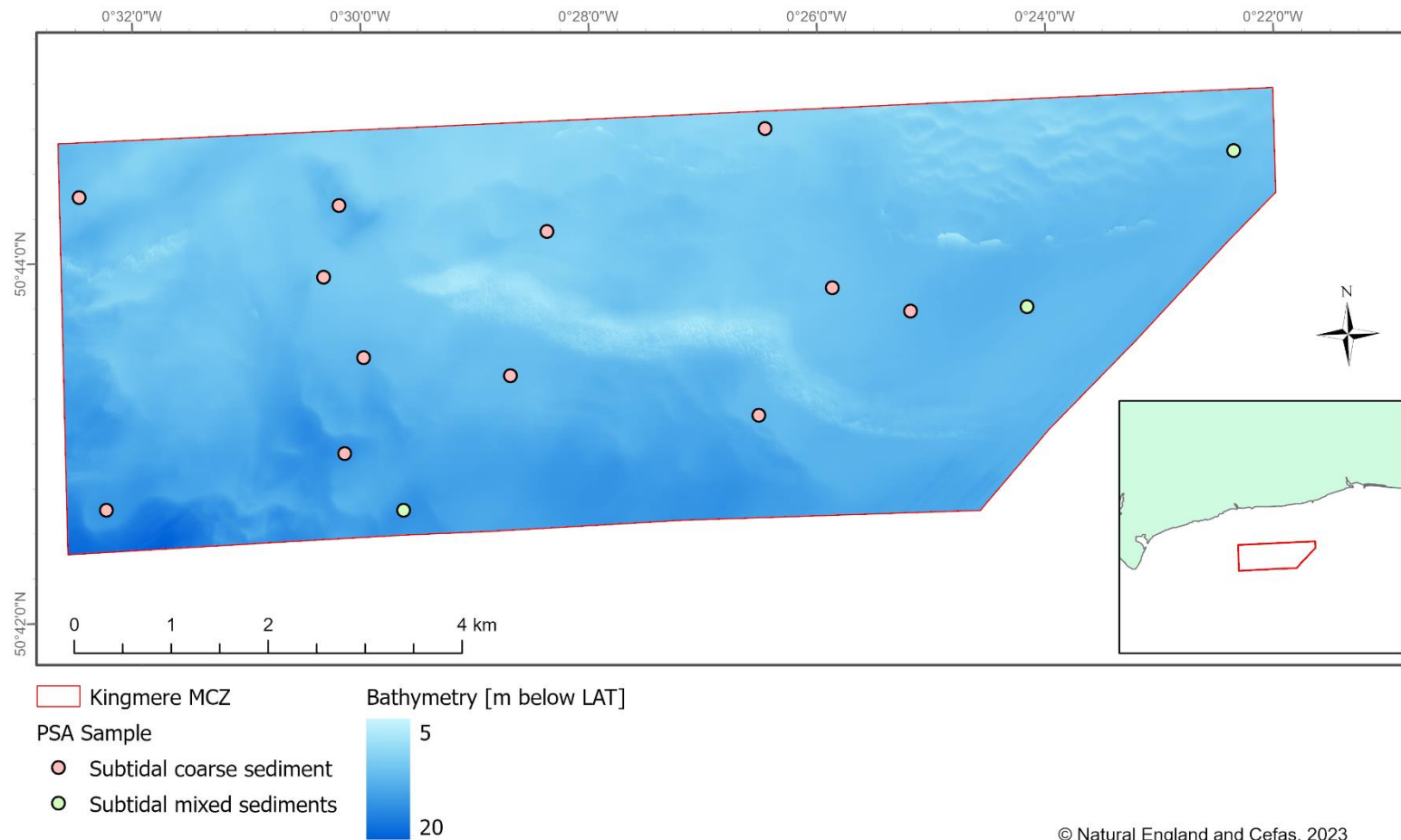
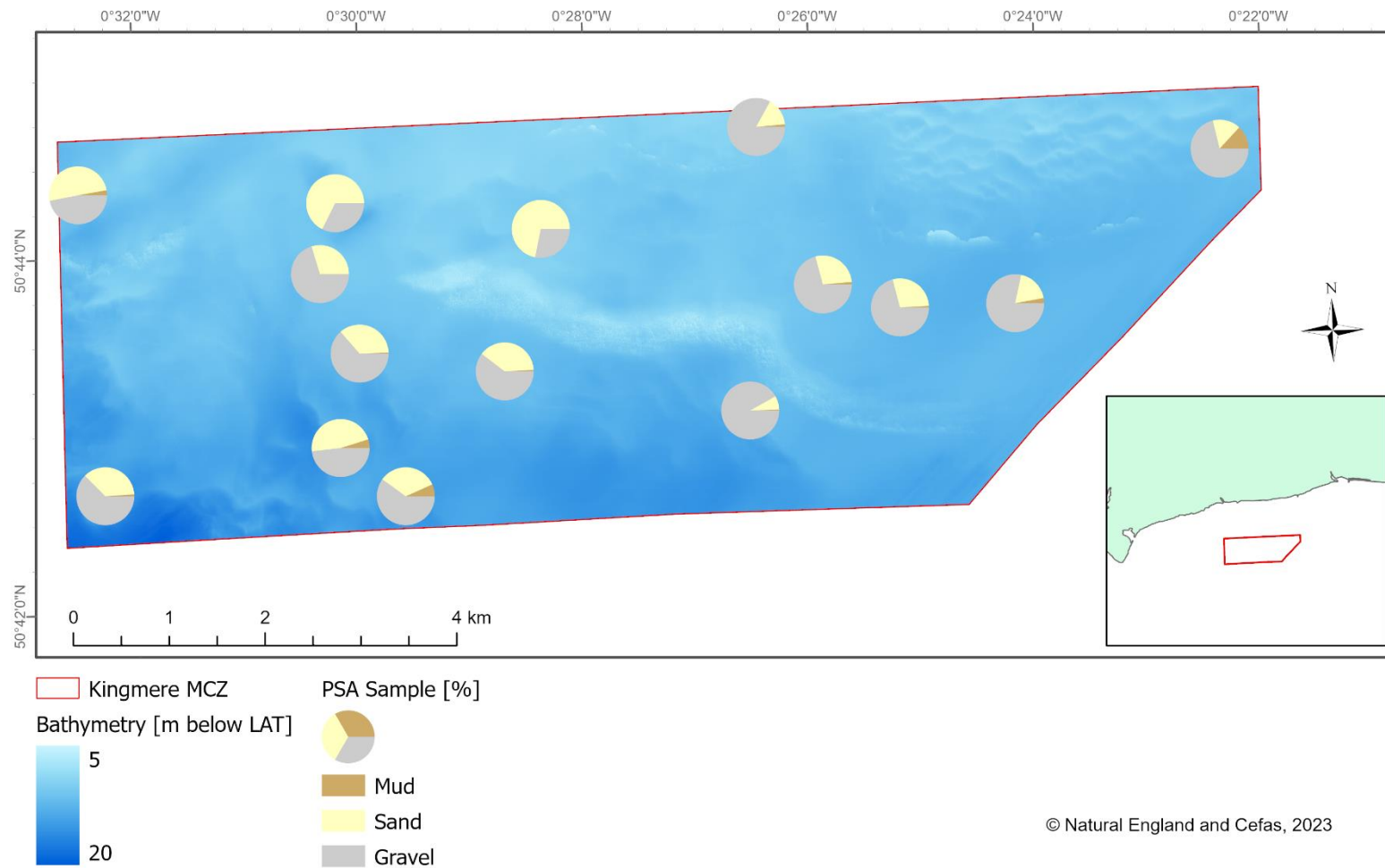


Figure 7. Classification of particle size distribution (half phi) data for each sediment sample from the 2018 Kingmere MCZ survey. Each sample (circles) is located in one of the sediment Broadscale Habitats (coloured areas) plotted on a true scale subdivision of the Folk triangle into the simplified classification for UKSeaMap (Long, 2006; Folk, 1954). © Natural England and Cefas, 2023.



© Natural England and Cefas, 2023

Figure 8. Map of the successful grabs for Particle Size Analysis (PSA) during the 2018 Kingmere survey, classified by broadscale habitat. Basemap shows bathymetry from the UKHO (2022). © Natural England and Cefas, 2023.



© Natural England and Cefas, 2023

Figure 9. Map of the successful grabs for Particle Size Analysis (PSA) during the 2018 Kingmere survey. Stations are represented as pie charts showing the relative proportions of gravel, sand and silt/clay. Basemap shows bathymetry from the UKHO (2022). © Natural England and Cefas, 2023.

3.3 Broadscale Habitats (BSH) (report objective 1)

3.3.1 Revised habitat maps

Based on the acoustic data acquired from the UKHO, together with groundtruthed data captured by the DDV and grab approaches of the 2018 survey (see 'Annex 2.2 Acoustic data (for habitat mapping)' for details), two separate maps were produced for the site, each based on a different habitat classification. The first map (Figure 10) representing the conventional BSH map, displays the surficial sediments and rock, but does not consider the thickness of the sediment layers. The second map (Figure 11) reclassifies some of the sedimentary areas (based on interpretation of the underlying geology) as Moderate energy infralittoral rock and thin mixed sediments, and includes confidence scores for this habitat's prediction (see 'Annex 2.2 Acoustic data (for habitat mapping)'). This map also highlights the BSHs, including the areas of Subtidal chalk.

Across the site, two BSHs were identified through the habitat mapping approach. The sedimentary habitat 'A5.1 Subtidal coarse sediment' was the most widespread (Figure 10) covering 93.9% of the Kingmere MCZ (Table 4). The other BSH, occupying 6.1% of the site (Table 4) was the hard substrate 'A3.2 Moderate energy infralittoral rock' which occurs as a narrow band crossing the site from east to west (Figure 10).

The BSH 'A5.1 Subtidal coarse sediment' was characterised by gravelly sandy sediments with little to no silt/clay content (Figure 9). The relative proportion of sand to gravel increased to the west of the site with the gravelliest sediments found in the east of the site. A depression in the north of the site was found to have a higher proportion of sand relative to the surrounding stations. When this area was previously sampled in 2012, the sample was classified as 'A5.2 Subtidal sand'. Evidence of sand waves within the depression were evident from the bathymetric derivatives created during the mapping procedure (see 'Annex 2.2 Acoustic data (for habitat mapping)').

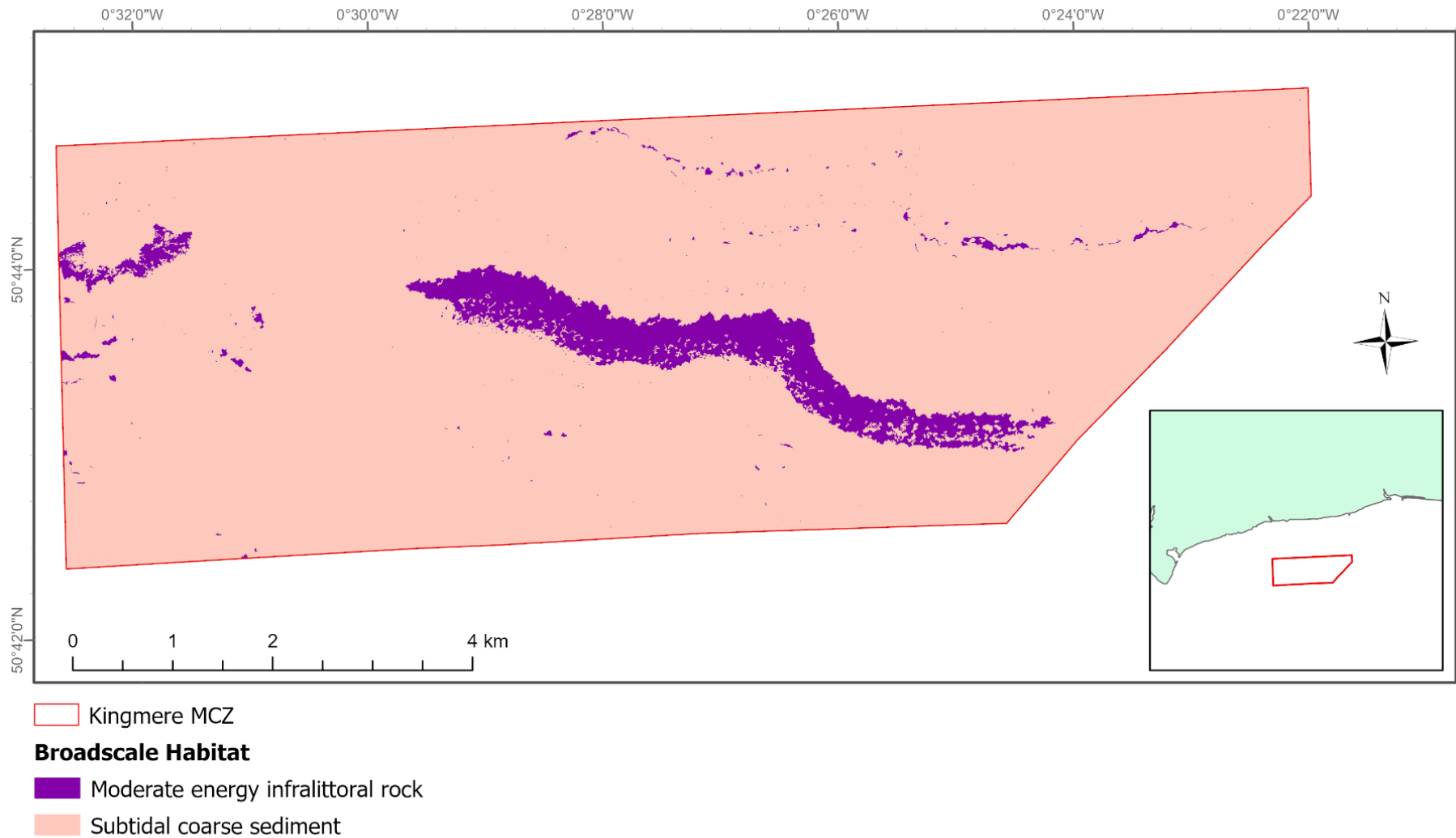
The narrow, east to west ribbon of 'A3.2 Moderate energy infralittoral rock' is characterised by high relief boulders elevating several metres above the surrounding seabed. This area, known as the Kingmere Rocks, consists of sandstone boulders surrounded by coarse and mixed sediments. The shape of the outcropping follows the underlying geological formations of the site. The underlying geology influences much of the sediment morphology of the site to the north and the south of the central outcropping. This is highly evident from the bathymetric derivatives which were created during the mapping process. 'A3.2 Moderate energy infralittoral rock' is also evident in the western part of the MCZ (Figure 10).

Table 4. Spatial extent of the Broadscale Habitats within the Kingmere MCZ. © Natural England and Cefas, 2023.

Broadscale Habitat (BSH)	Area [km ²]	Proportion of the site (%)
A5.1 Subtidal coarse sediment	44.82	93.9
A3.2 Moderate energy infralittoral rock	2.93	6.1

Confidence Score

The confidence in the resulting habitat map, based on the MESH confidence Assessment Tool, ranged from 83 to 88 (Figure 12). The lower scores associated with the sedimentary habitats are associated with the lack of associated observation data. Additional imagery collected in these areas could increase the confidence in this area. Both scores can be considered good, however, some caveats should be considered (see Section 4).



© Natural England and Cefas, 2023

Figure 10. Updated Broadscale Habitat map for the Kingmere MCZ. Derived from bathymetric and backscatter data collected in 2018 for the UKHO and ground-truthed with the 2018 grab PSA and imagery data. © Natural England and Cefas, 2023.

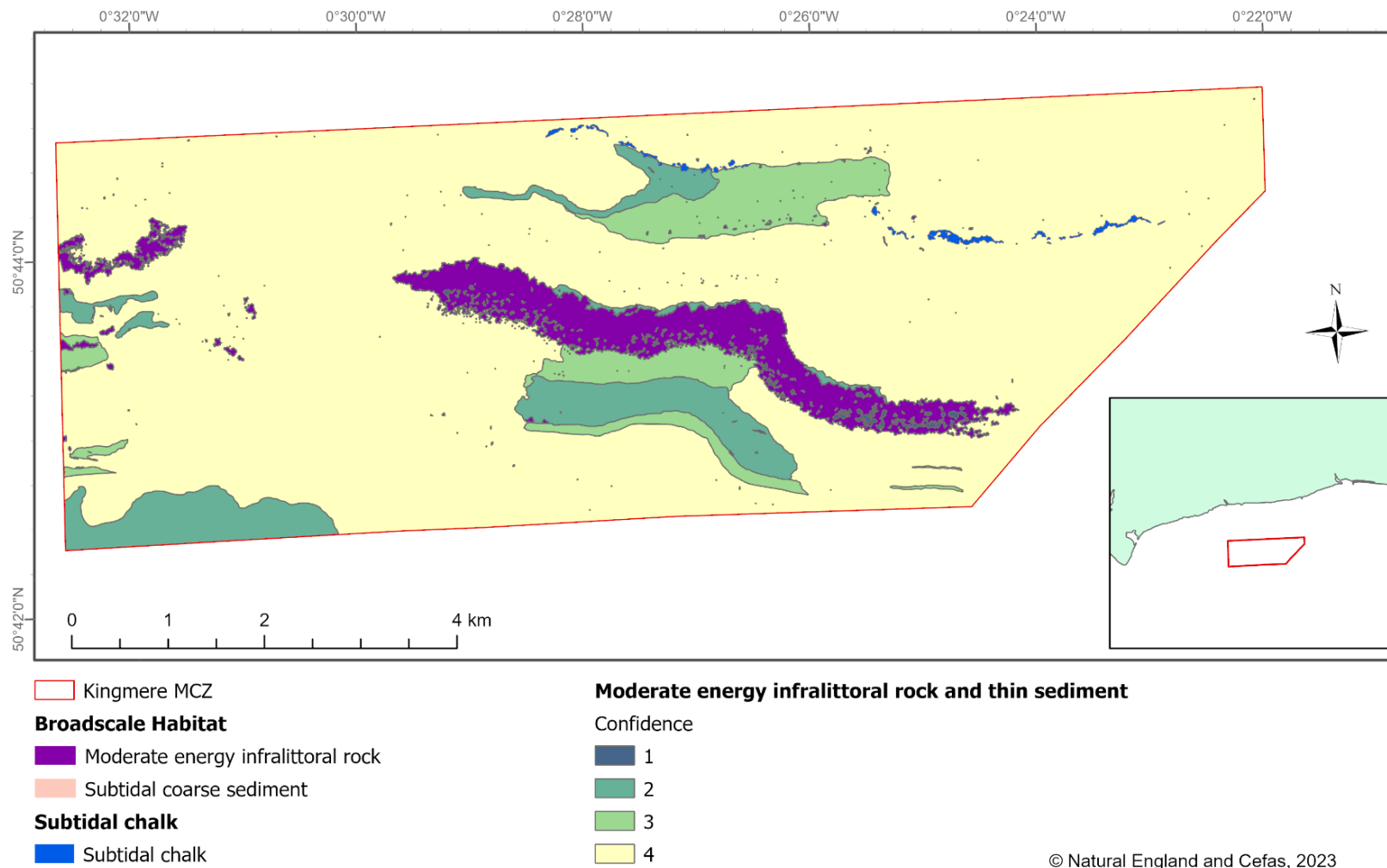


Figure 11. Habitat FOCI and confidence in the Moderate energy infralittoral rock with thin mixed sediment habitat across the Kingmere MCZ. Confidence levels (MESH confidence assessment method) for the mapping from 1 (high) to 4 (low) are presented. © Natural England and Cefas, 2023.

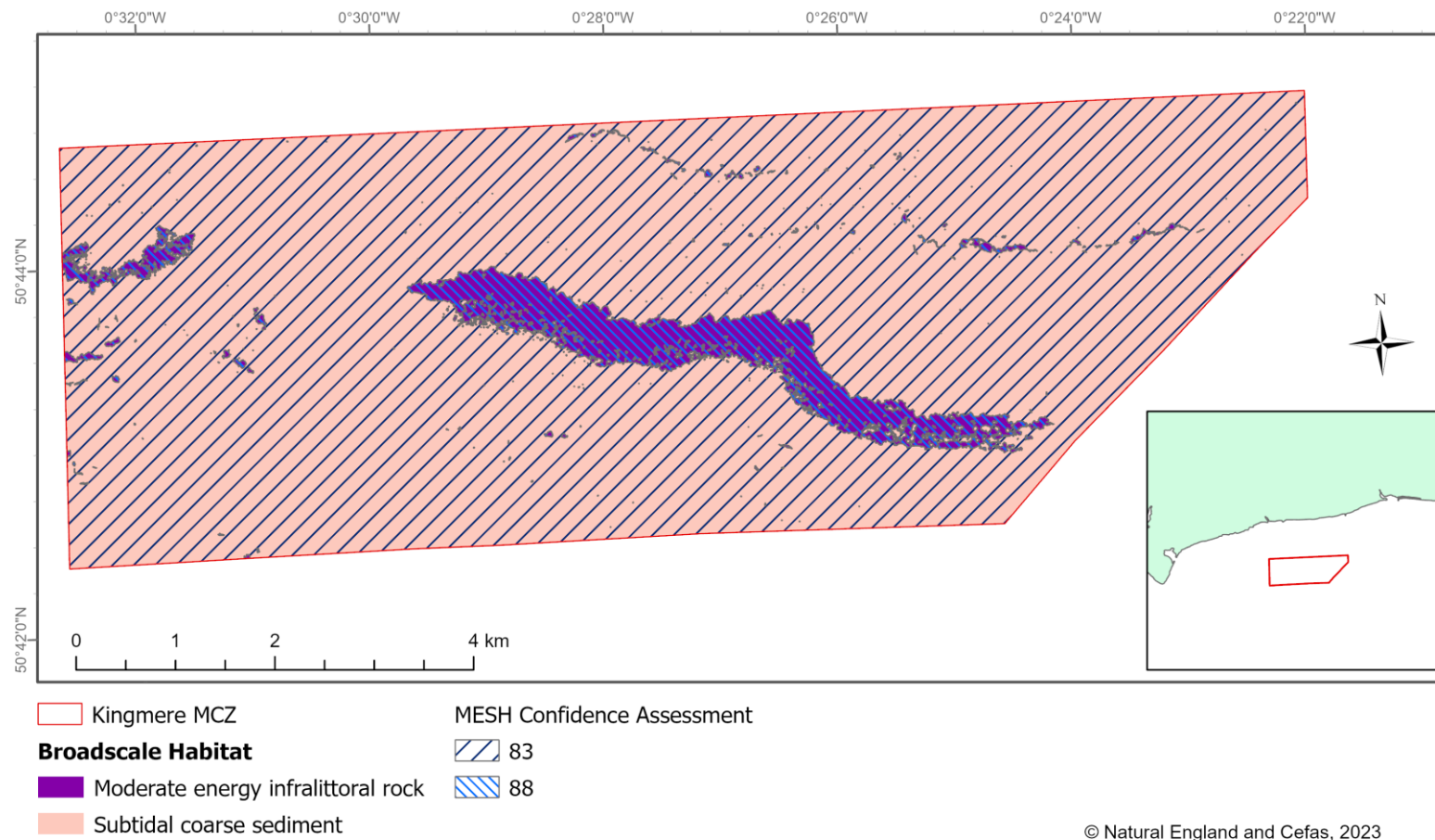


Figure 12. MESH Confidence scores associated with the BSH habitat map created for the Kingmere MCZ. © Natural England and Cefas, 2023.

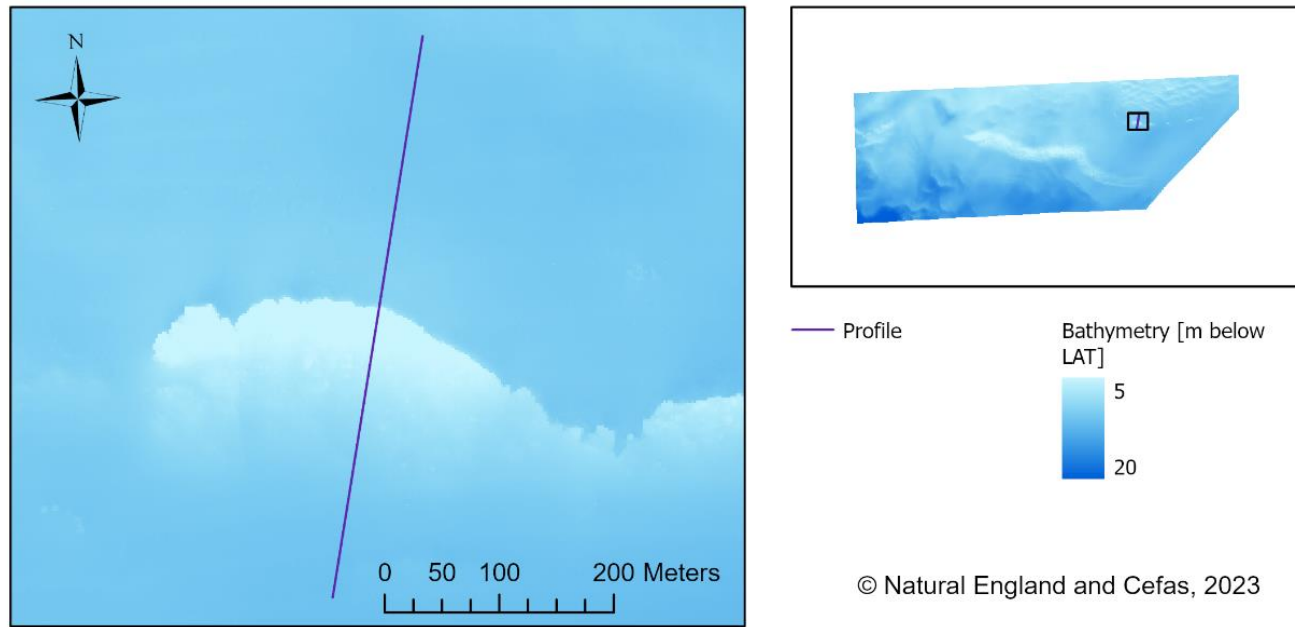
3.3.2 Moderate energy infralittoral rock and thin sediments

The habitat 'A3.9 Moderate energy infralittoral rock and thin sediments' (James and others, 2007) was mapped across the site. Based on the acoustic data, this habitat displays characteristics of both sedimentary and rock substrates with clear geomorphological shapes, however, grab and DDV data indicate sediment as the dominant substrate. The areas mapped as 'A3.9 Moderate energy infralittoral rock and thin sediments' were each given a confidence score, with the criteria set out in 'Annex 2.2 Acoustic data (for habitat mapping)'. Areas scoring a confidence score of 1 (the highest confidence) were found immediately between the areas of outcropping sandstone rock across the centre of the site (Figure 11). Areas with a confidence score of 2 displayed the characteristics of underlying rock layer but without any outcropping rock. The largest area with this level of confidence was found to the south of the main area of outcropping rock, south of the Kingmere Rocks, but also at the southwest corner of the Kingmere MCZ (Figure 11). Other areas with this confidence score were found to the north of the main outcropping rock and to the west of the site near a smaller area of outcropping sandstone.

Areas with a confidence score of 3 tended to be those with a reduced rock morphology whilst still maintaining evidence of outcropping and boulders. These areas were found adjacent to areas of confidence score 2 and areas of outcropping rock (Figure 11). The remainder of the site was given a confidence score of 4.

3.3.3 Subtidal chalk

Areas of the Subtidal chalk BSH were identified following methods set out in 'Annex 2.2 Acoustic data (for habitat mapping)'. The Subtidal chalk within the Kingmere MCZ showed a distinctly different morphological characteristic to the outcropping sandstone found elsewhere within the MCZ (Figure 11). The surfaces of the Subtidal chalk features had a lower relief and rugosity compared to the sandstone, with the boundary of the Subtidal chalk characterised by a cliff-like feature of several meters high. This observation was confirmed by the video data collected in 2018 and a more detailed assessment of the bathymetry from a region within the 'Worthing Lumps', towards the east of the MCZ (Figure 13). The outcropping Subtidal chalk was found across the north of the site, in a more-or-less east to west band (Figure 13), with the cliff-like feature facing northwards.



© Natural England and Cefas, 2023

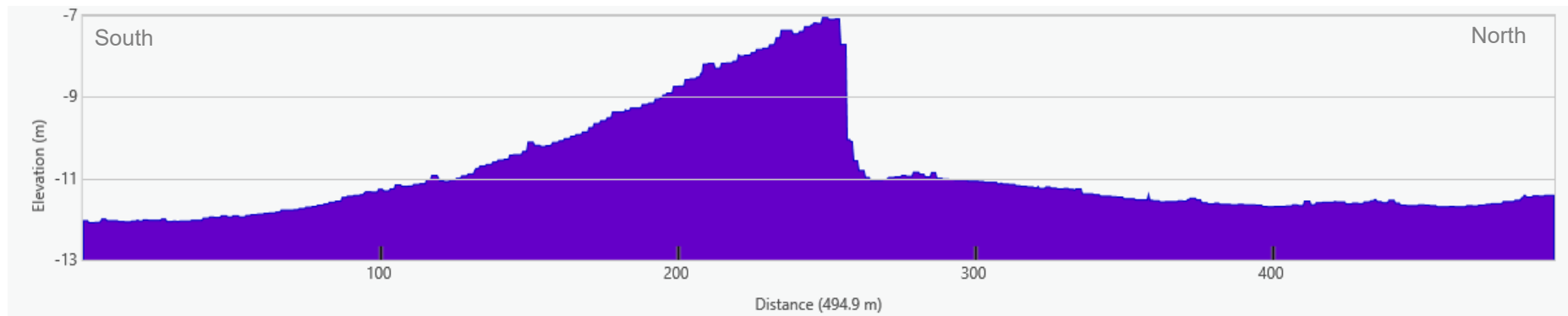


Figure 13. Cross section of outcropping Subtidal chalk at the Kingmere MCZ showing the relatively smooth surfaces and cliff-like feature along its northern boundary. © Natural England and Cefas, 2023.

3.4 Infaunal community analyses

The limited success of sediment sampling at this site, due to the mosaic nature of the coarse sediment over bedrock, resulted in limited utility of the grab data to characterise the site's infaunal assemblages. In total, nine infaunal samples were successfully collected and their PSA data classified these as 'A5.1 Subtidal coarse sediment' (six stations) and 'A5.4 Subtidal mixed sediment' (three stations). Sample volumes were small (range = 3.4 L to 8.0 L, mean = 4.6 L) due to the challenging substratum present.

Following truncation of the 2018 abundance data ('Annex 2.4 Grab sampling'), the infaunal dataset from the nine mini Hamon grab samples collected contained 132 taxa. This included 60 annelid, 17 arthropod, 16 molluscan, 11 bryozoan and nine cnidarian taxa (86% of the total). Other phyla (n = 7) accounted for the remaining 14% of taxa.

The most abundant taxon overall was the polychaete worm, *Spirobranchus lamarcki*, with 99 individuals collected across the MCZ: it was present at six of the nine stations with a maximum abundance of 41 individuals per grab. Almost as abundant was the polychaete *Sabellaria spinulosa* with 89 individuals recorded across five stations. The distribution of *S. spinulosa* however was highly skewed with 73 individuals observed at one station, the remaining four stations having a maximum of 9 individuals. The most ubiquitous taxa were the polychaete *Glycera lapidum* (agg.), Nemertea (Ribbon worm) and the bryozoan *Electra pilosa*, which were each sampled at seven of the nine stations.

Four bivalve molluscs accounted for 34% of the total biomass recorded from the nine stations, these were *Spisula elliptica* (16%), *Moerella donacina* (7%), *Abra alba* (6%) and *Nucula hanleyi* (5%). Four further taxa, the decapod crustacean *Upogebia deltaura* (9%), the polychaetes *Thelepus setosus* (8%) and *Sabellaria spinulosa* (6%), and the echinoderm *Ophiothrix fragilis* (3%), accounted for a further 26% of total biomass.

To assess variation in benthic community composition the infaunal abundance and biomass datasets were imported into the statistical package PRIMER (version 7; Clarke and Gorley (2015); see 'Annex 2.4 Grab sampling' for further details). Diversity metrics were calculated for the nine samples collected; these generally show that the three samples classified as 'A5.4 Subtidal mixed sediments' have a higher diversity than the six 'A5.1 Subtidal coarse sediment' samples (Figure 14). Partly due to the low number of samples, the 95% confidence intervals overlap, with the exception of Pielou's evenness (J'), indicating there are no significant differences for these metrics between the two BSHs.

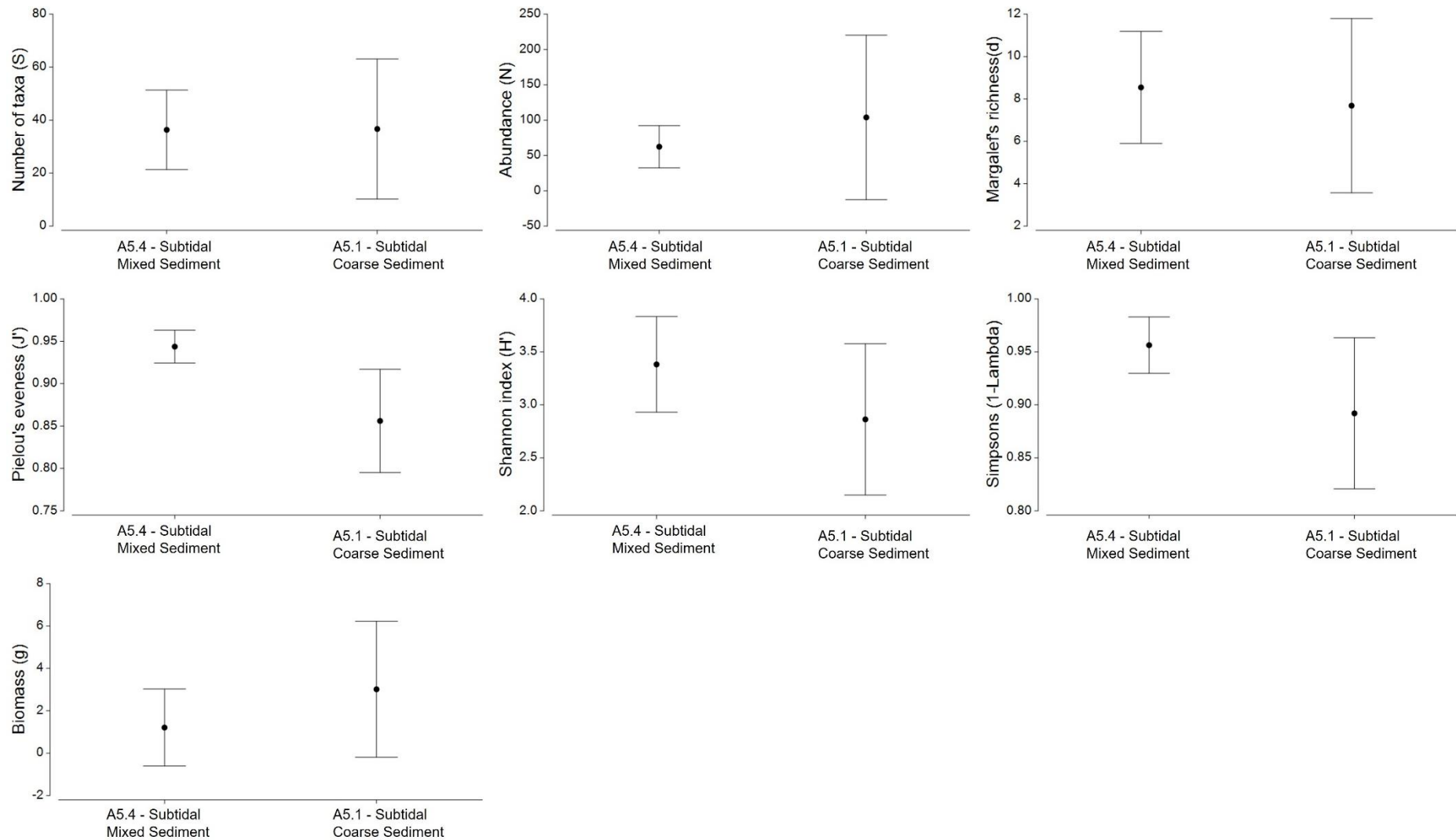


Figure 14. Mean values (\pm 95% C.I.) of the infaunal diversity metrics (N , H' , d , S , J' and $1-lambda$) and total wet biomass (g) of the two sediment Broadscale Habitats (BSH) at Kingmere MCZ, based on the mini Hamon grab sample data collected in 2018 ($n = 3$ and 6 ; 'A5.4 Subtidal mixed sediments' and 'A5.1 Subtidal coarse sediment' respectively). © Natural England and Cefas, 2023.

Multivariate comparison of infaunal assemblages between the two BSHs was carried out using PRIMER's Analysis of Similarity (ANOSIM) routine on Bray-Curtis similarities calculated from square root-transformed abundance data ('Annex 2.4 Grab sampling'). The routine indicated that assemblages did not differ significantly between BSHs (ANOSIM, $R = -0.037$, $p = 0.452$), suggesting no relationship between community composition and BSH type. The infaunal assemblages clustered into four statistically distinct groups using the non-hierarchical k-means clustering method ($R = 0.935$, $p = 0.001$). Samples clustered together within and between BSHs with cluster A comprising samples from both BSHs (Figure 15). The characterising species from Similarity of Percentages (SIMPER) analysis for the cluster groups 'A' and 'D' can be found in 'Annex 3. Ancillary infaunal and epifaunal outputs'. Cluster groups 'B' and 'C' were represented by single samples, therefore SIMPER analysis was not possible.

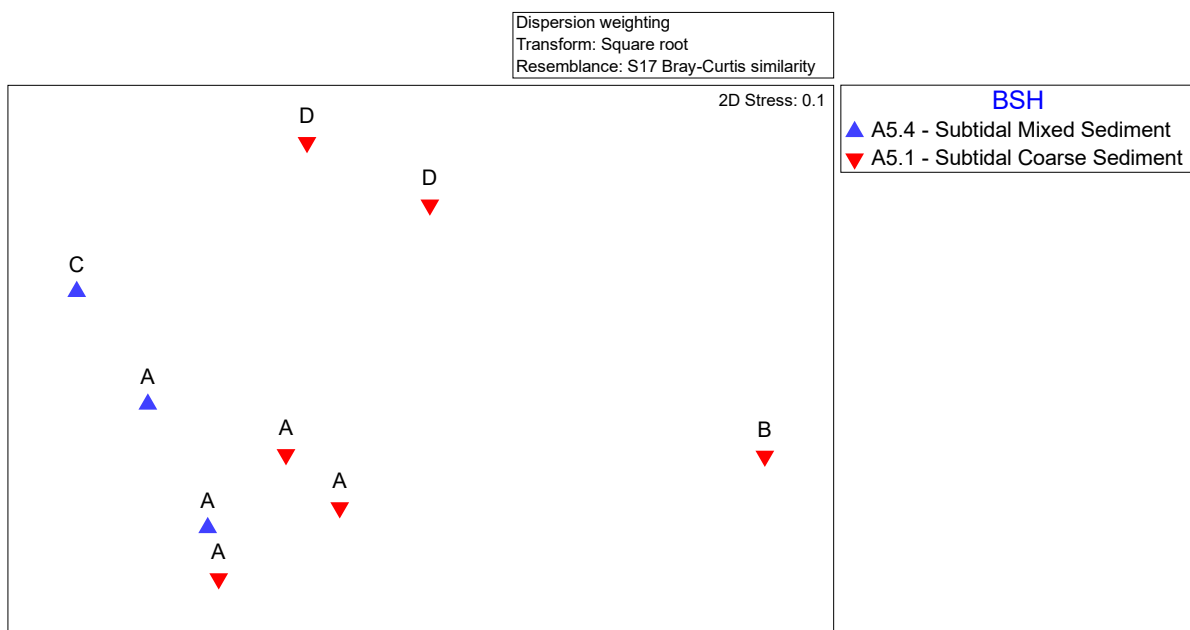


Figure 15. Non-metric MDS (nMDS) of the k-means infaunal cluster groups and Broadscale Habitats (BSH) for Kingmere MCZ, based on the 2018 mini Hamon grab sample data. © Natural England and Cefas, 2023.

‘A5.1 Subtidal coarse sediment’

The BSH ‘A5.1 Subtidal coarse sediment’ was the most common BSH, as governed by the PSA data, identified for six of the nine samples from the 2018 survey. The most abundant taxa within this BSH were the polychaetes *S. spinulosa* (average abundance of 14.5 individuals per 0.1 m²) and *S. lamarcki* (13.8 per 0.1 m²). Average within-group similarity was 21.0%. SIMPER analysis identified the characterising taxa to be the polychaete worms *Syllis garciai* (accounting for 8.5% of the within BSH similarity), *Nephtys cirrosa* (6.8% contribution), *G. lapidum* (agg.; 5.9% contribution), and Nemertea (6.1% contribution). The full SIMPER outputs are

presented in 'Annex 3. Ancillary infaunal and epifaunal outputs'. The k-means cluster groups, 'B' and 'D' are fully represented by samples from this BSH whilst cluster group 'A' contains three samples from this BSH (Figure 15).

'A5.4 Subtidal mixed sediments'

The 'A5.4 Subtidal mixed sediments' BSH was identified in three of the nine samples acquired during the 2018 Kingmere MCZ grab survey. These samples were not dominated by any particular taxon. All taxa were generally present in low numbers in the three grabs, with the polychaete worm *S. lamarcki* being the most abundant (average abundance of 5.3 individuals per 0.1 m²).

Average within-group similarity of 'A5.4 Subtidal mixed sediments' BSH samples was 36.6%. The characterising taxa were Nemertea (12.3% contribution), and the polychaete worms *G. lapidum* (agg; 9.2% contribution), *Polycirrus* sp. (9.1% contribution), and *Pista mediterranea* (8.13% contribution). 'Annex 3. Ancillary infaunal and epifaunal outputs' presents the full SIMPER outputs. The k-means cluster group 'C' is fully represented by samples from this BSH whilst cluster group 'A' contains two samples from this BSH (Figure 15).

3.5 Epifaunal community analysis

A total of 50 camera deployments were conducted across the Kingmere MCZ during the 2018 survey. The underwater video data was classified as 'poor' or 'zero' visibility, precluding their use for epifaunal analysis. Of the 632 still images acquired from the 50 deployments, 71% were classed as 'good' quality, 18% 'poor', 9% 'very poor' and 2% 'not usable for any purpose' (no visibility). Only 'good' quality imagery data, 446 images in total, were used in the epifaunal community assessment (Turner and others, 2016) and these allowed 49 of the 50 stations sampled to be analysed (i.e., all images at one station were classed as 'poor' or worse).

For this report, the term 'epifauna'/'epifaunal' refers to all epibenthic biota recorded from the imagery survey, including 47 macroalgal taxa. While the latter are flora, as opposed to fauna, they are nonetheless often important taxa in characterising epibenthic assemblages.

Following truncation of the epifaunal data based on the 'good' quality still images, 37 epifauna taxa remained. This included 7 molluscan, 6 cnidarian, 6 sponge, 4 crustacean and 4 bryozoan taxa (73% of the total). Other phyla (n = 5) accounted for the remaining 27% of total taxa. The most frequently observed epifaunal taxon across the Kingmere MCZ was the polychaete worm c.f. *Spirobranchus* sp., present in 84% of images analysed. Almost as ubiquitous was the epifaunal group known collectively as 'Faunal turf' which was present in 83% of images. The next three most observed epifaunal taxa were macroalgae, namely, 'Macroalgae > Encrusting > Red > Calcareous' present in 51% of the images analysed, 'Macroalgae > Brown' in 51% and 'Macroalgae > Red' in 21% of the still images.

To assess variation in epifaunal community composition, the epifaunal abundance and percentage cover data were imported into the statistical package PRIMER. Epifaunal counts and percentage cover were combined by presenting both as a standardised relative abundance (see 'Annex 2.3 Seabed imagery' for details). Whilst this standardised combined dataset enabled both count and cover data to be used in the same analysis, the resulting abundance values should only be interpreted as proportional values relative to this specific dataset. Resulting abundance values (and index values derived using the abundance data) should therefore not be directly compared to those from other datasets. Stills were then summed according to BSH within each station with a total area of 1 m² set as a minimum threshold (calculated from still image field of view). This total spatial area sampled threshold reduced the number of viable stations from 49 to 42 and the number of 'good' quality stills used from 446 to 380.

Two main BSHs were observed across the 42 stations analysed; 'A5.1 Subtidal coarse sediment' and 'A3.2 Moderate energy infralittoral rock'. The BSH 'A3.2 Moderate energy infralittoral rock' had higher values for three of the six diversity metrics of community structure, i.e., Number of taxa (S), Abundance (S) and Shannon's index (H'), than 'A5.1 Subtidal coarse sediment' (Figure 16). The remaining three diversity metrics (Margalef's richness (d), Pielou's evenness (J'), Simpson's (1-Lambda)) showed no significant difference between the two BSHs. The large 95% confidence intervals associated with mean values of the majority of diversity metrics (Figure 16) is likely reflect the sediment veneers covering hard rock substrata making sediment BSHs difficult to separate from rock BSHs.

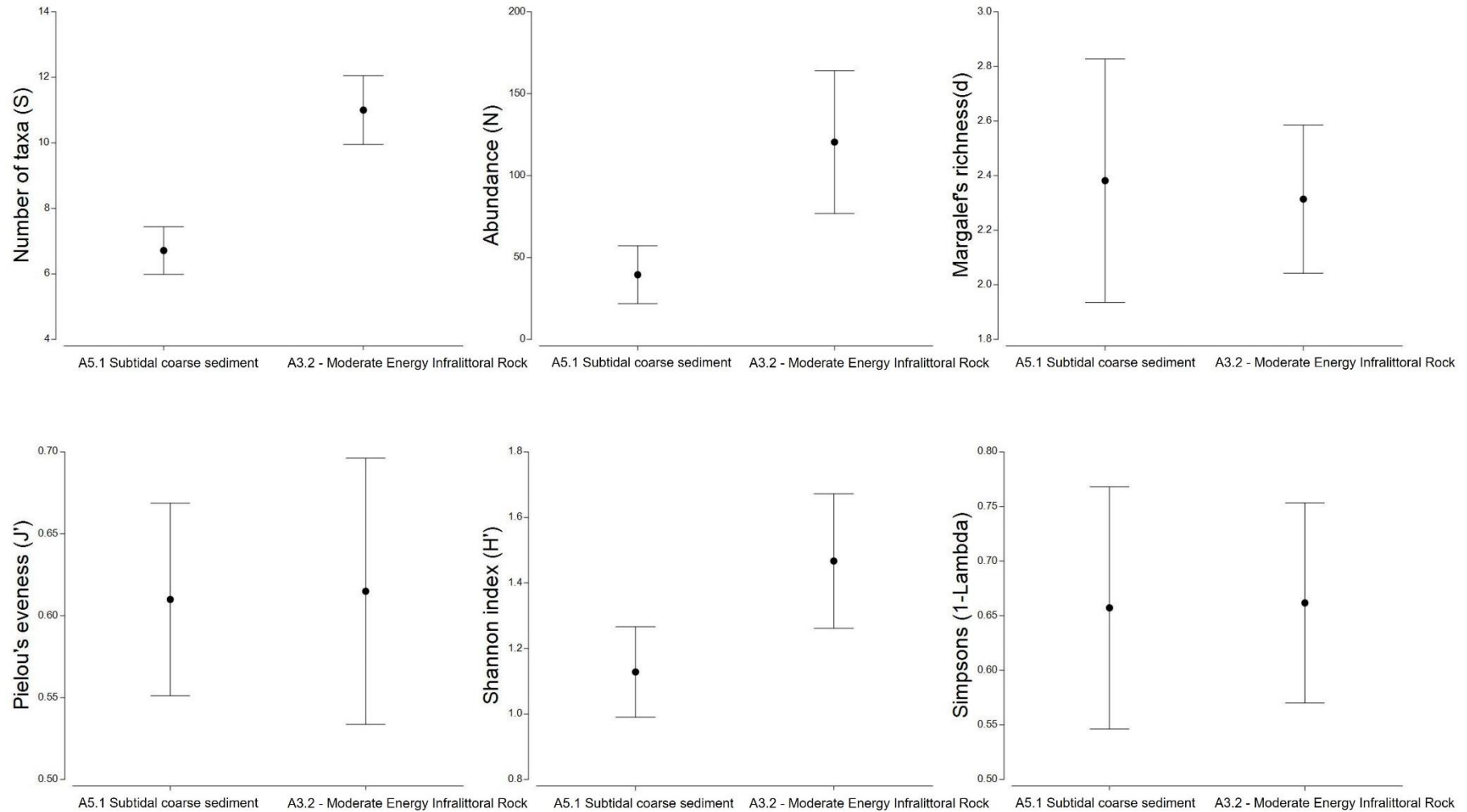


Figure 16. Mean values (\pm 95% C.I.) of the epifaunal diversity metrics (N, H', d, S, J' and 1-lambda) of the two main BSHs observed at Kingmere MCZ based on the still images acquired during 2018. © Natural England and Cefas, 2023.

Comparison of the multivariate structure of epifaunal assemblages associated with the two BSHs was carried out using PRIMER's ANOSIM routine on Bray Curtis similarities calculated from square root-transformed abundance data (see 'Annex 2. Epifaunal data preparation' for details). The results indicated that the assemblages differed significantly between BSHs (ANOSIM, $R = 0.368$, $p = 0.001$), suggesting there is a relationship between community composition and BSH type although it should be noted that the ANOSIM test statistic R value was low, reflecting some overlap between the BSHs.

Non-hierarchical k-means clustering was used to identify six statistically distinct groups of epifaunal assemblages ($R = 0.844$, $p = 0.050$). Non-metric multidimensional scaling (nMDS) shows samples clustered according to BSH with no overlap (Figure 17) although the high stress value (0.22) of the 2D plot implies that the ordination should be interpreted with some caution. The two BSHs mostly contain distinct cluster groups with cluster group A being restricted to 'A3.2 Moderate energy infralittoral rock' and groups B, D and E observed only in 'A5.1 Subtidal coarse sediment'. Groups C and F however, which each comprise relatively few samples (five and three respectively), were found in both BSHs. The characterising species from the SIMPER analysis of the cluster groups can be found in 'Annex 3. Ancillary infaunal and epifaunal outputs'. No spatial pattern in epifaunal cluster groups was observed across the Kingmere MCZ (Figure 18).

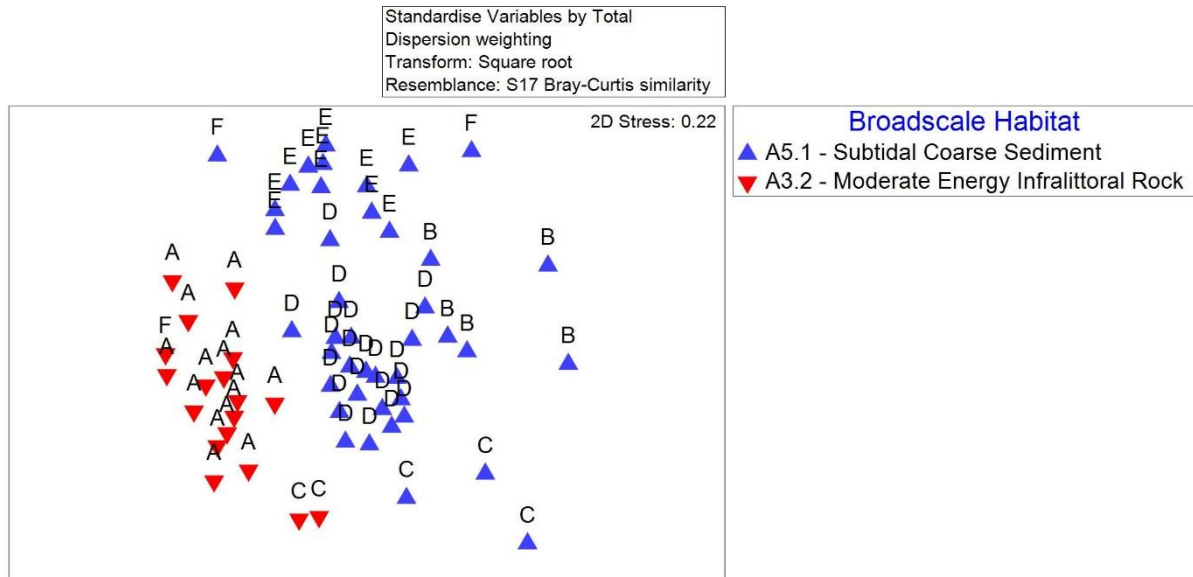


Figure 17. Non-metric MDS (nMDS) of the k-means epifaunal cluster groups and Broadscale Habitats (BSH) for the Kingmere MCZ, based on the 2018 drop-down video imagery data. © Natural England and Cefas, 2023.

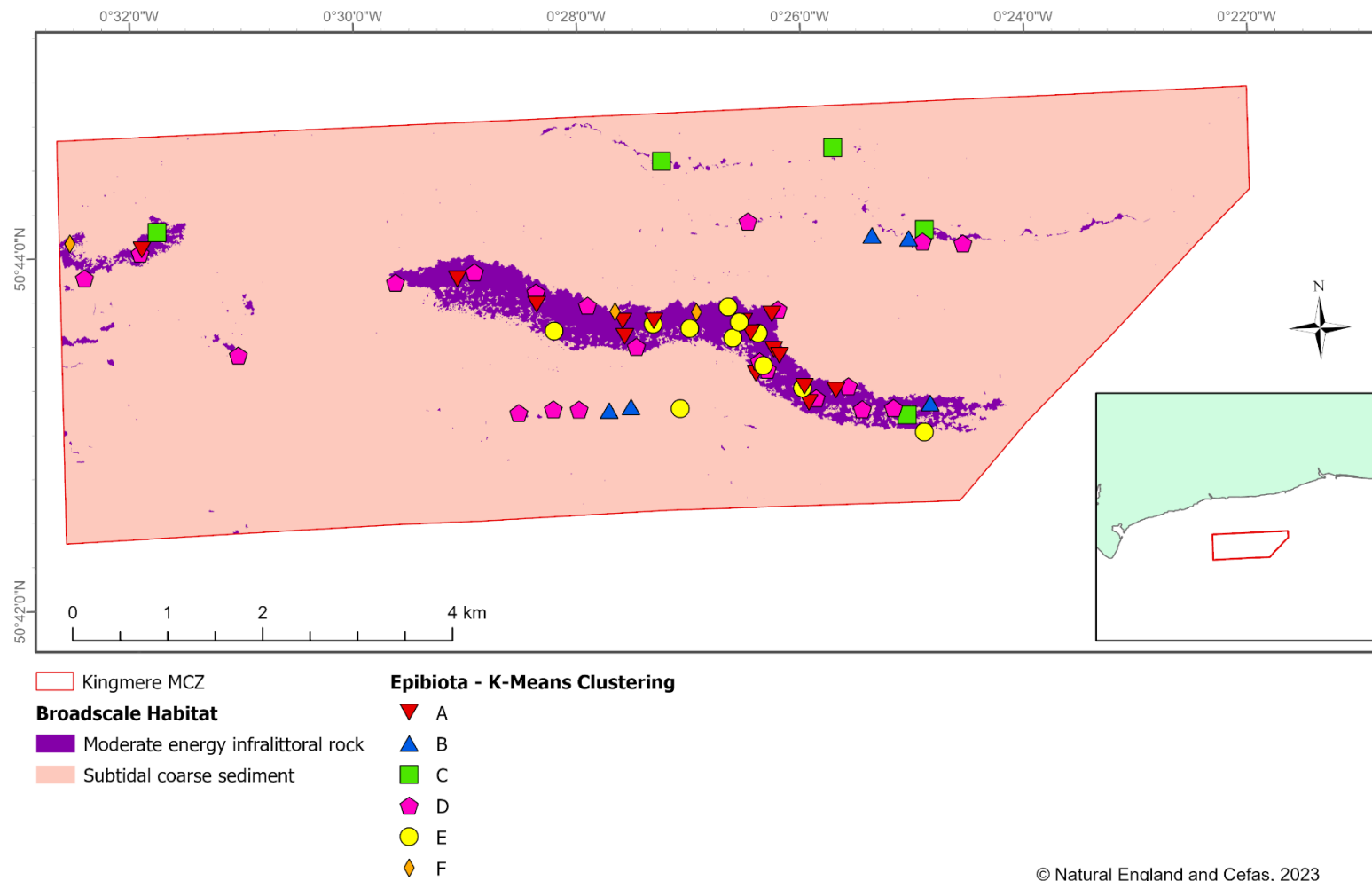


Figure 18. Epifaunal groups determined by k-means clustering of the still image data collected across the Kingmere MCZ in 2018. Basemap shows the revised BSH map created for the site. © Natural England and Cefas, 2023.

‘A3.2 Moderate energy infralittoral rock’

The BSH ‘A3.2 Moderate energy infralittoral rock’ (Figure 19) was recorded in 207 stills (33% of total analysed) from the 2018 survey of the Kingmere MCZ. Average within-group similarity calculated using SIMPER was 52.9%, indicating samples displayed a good degree of similarity. The main characterising taxa were the ‘Faunal turf’ group, ‘Bryozoa > Soft > Dendroid’ and ‘Macroalgae > Red’, with similarity contributions of 28.6%, 14.2% and 11.2% respectively (see ‘Annex 3. Ancillary infaunal and epifaunal outputs’).

A3.2 Moderate energy infralittoral rock

(n = 207)

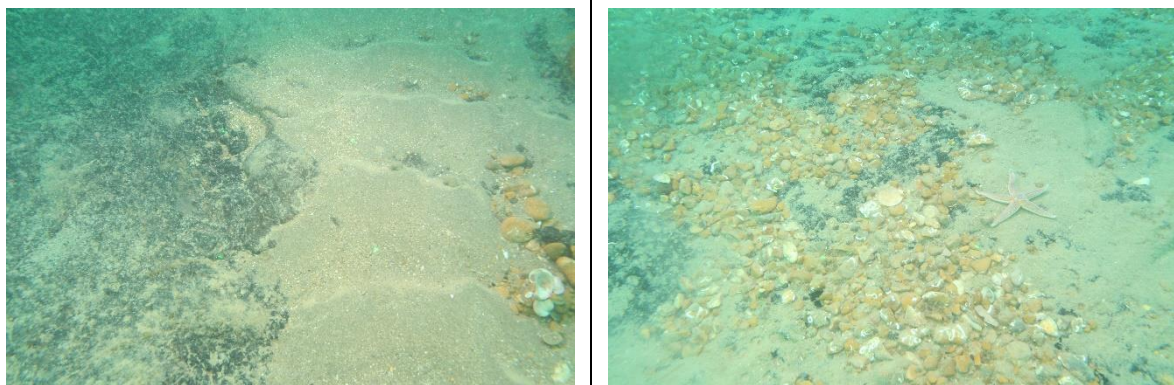


Figure 19. Digital still images of ‘A3.2 Moderate energy infralittoral rock’ BSH acquired during the Kingmere MCZ survey, 2018. © Environmental Agency and Natural England (2018).

‘A5.2 Subtidal sand’

The BSH ‘A5.2 Subtidal sand’ was only recorded in eight stills (1% of total analysed) across the survey. This BSH was characterised by very sparse visible epifauna which included the ‘Faunal turf’ group (Figure 20).

A5.2 Sublittoral sand

(n = 8)



Figure 20. Digital still images of 'A5.2 Sublittoral sand' BSH acquired during the Kingmere MCZ survey, 2018. © Environmental Agency and Natural England (2018).

'A5.1 Subtidal coarse sediment'

The BSH 'A5.1 Subtidal coarse sediment' was observed in 403 (63%) of the 632 images taken from the 2018 survey (Figure 21). The average within-group similarity for this BSH was 43.5% indicating some similarities between the assemblages within the group, but with some differences. The main characterising taxa accounting for 78.2% of the similarity were 'Faunal turf', 'Worms > Polychaetes > Tube worms > Serpulidae > cf. *Spirobranchus* sp.' and 'Echinoderms > Sea stars > cf. *Asterias rubens* > *Asterias rubens*'.

A5.1 Subtidal coarse sediment

(n = 403)



Figure 21. Digital still images of 'A5.1 Subtidal coarse sediment' BSH acquired during the Kingmere MCZ survey, 2018. © Environmental Agency and Natural England (2018).

3.6 Biotopes

Three European Nature Information System (EUNIS) level 4/5 habitats were assigned to images which corresponded to the 'A3.2 Moderate energy infralittoral rock' BSH (Figure 22). These were 'A3.215 Dense foliose red seaweeds on silty moderately exposed infralittoral rock' assigned to 69 images (11% of total), 'A3.225 Filamentous red seaweeds, sponges and *Balanus crenatus* on tide-swept variable-salinity infralittoral rock' assigned to five images (<1% of total) and 'A3.24 Faunal communities on moderate energy infralittoral rock' assigned to 17 images (3%). These represent closest matches of EUNIS biotopes to the observed the faunal groupings. Biotope derivation was not conducted for 'A5.1 Subtidal coarse sediment' due to the absence of infaunal data.

Derivation of biotopes is a highly subjective process and the observed faunal assemblages generally unlikely to match exactly to the biotope classifications. Apparent changes between biotopes over time should therefore be interpreted with extreme caution. Such changes should not be assumed to indicate a change in condition, or trigger changes to management measures or conservation advice without additional robust evidence.



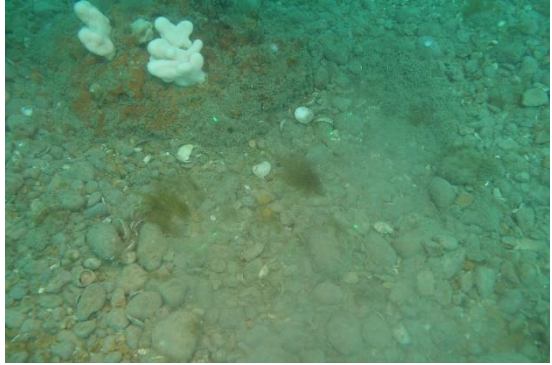
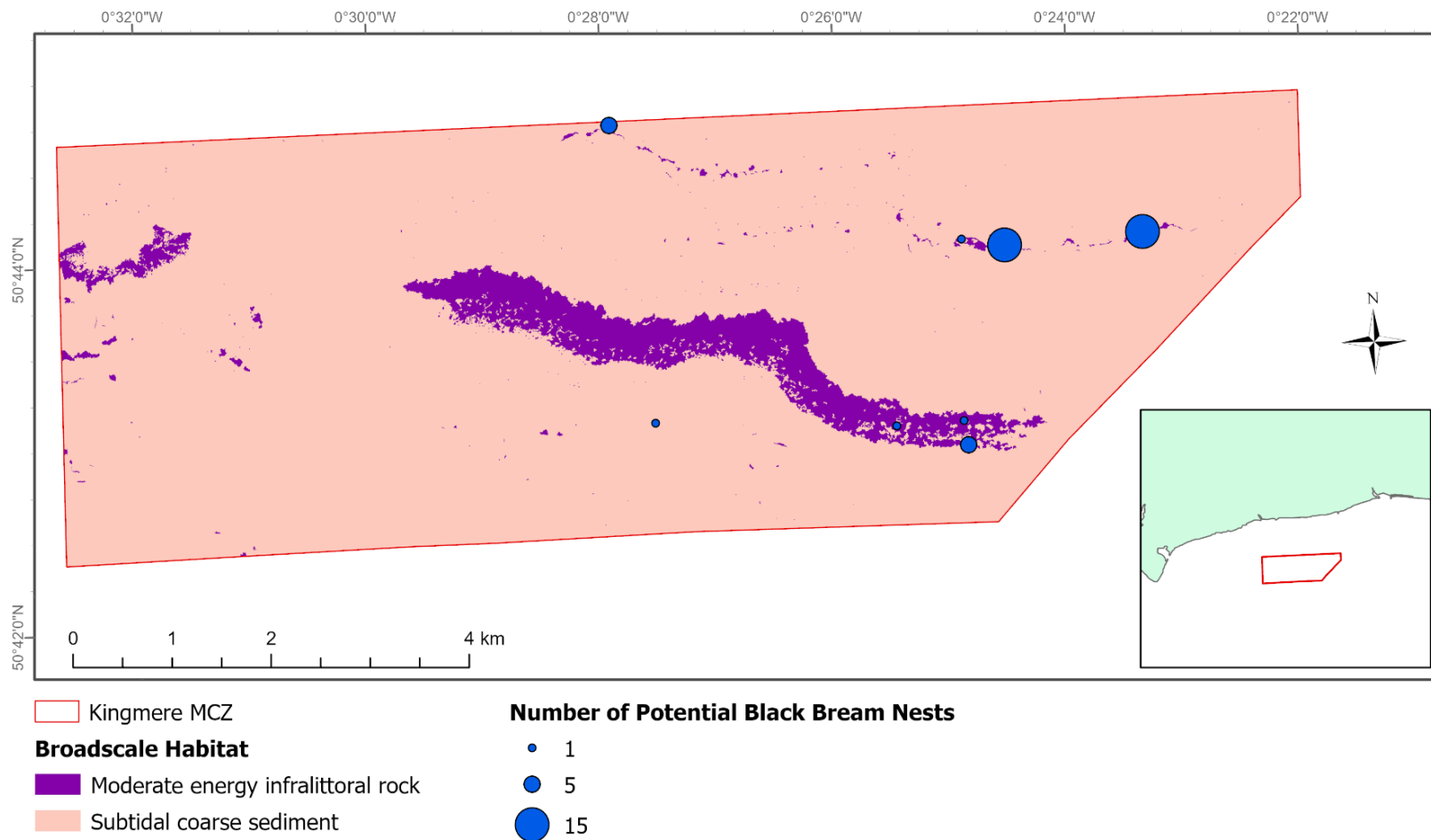
<p>A3.215 Dense foliose red seaweeds on silty moderately exposed infralittoral rock (n = 69)</p>	<p>A3.225 Filamentous red seaweeds, sponges and <i>Balanus crenatus</i> on tide-swept variable-salinity infralittoral rock (n = 5)</p>
	
<p>A3.24 – Faunal communities on moderate energy infralittoral rock (n = 116)</p>	
	

Figure 22. Digital still images of the three biotopes recorded within ‘A3.2 Moderate energy infralittoral rock’ BSH acquired during the Kingmere MCZ survey, 2018. ‘n’ denotes the number of stills for which each biotope was depicted. © Environmental Agency and Natural England (2018).

3.7 Habitat Features of Conservation Importance (FOCI) (reporting objective 1)

Designated habitat FOCI

Though the imagery survey was not designed to identify and thus map black seabream nests, several potential active/recent nests were recorded from the DDV video transects conducted during the 2018 survey across the Kingmere MCZ. The potential nests were observed at eight of the DDV transects with two transects evidencing 15 nests, and the remaining six transects showing between one and three potential nests to be present. Figure 23 shows the location and density of the nests: an example ‘potential’ black seabream nest can be seen in Figure 24.



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Figure 23. Stations sampled during the Kingmere 2018 drop-down video survey where potential Black seabream nests could be observed. Basemap shows the revised BSH map for the MCZ. © Natural England and Cefas, 2023.

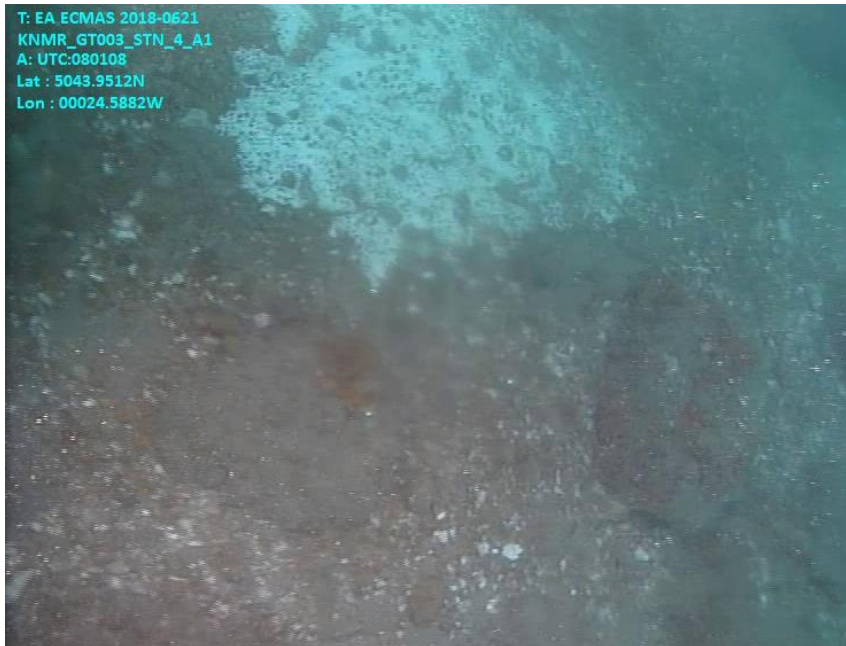


Figure 24. Video frame grab of a potential Black seabream nest (station GT003), evidenced as area where sediment has been removed showing bare rock exposed. Imagery acquired during the Kingmere MCZ drop-down video survey in 2018. © Environmental Agency and Natural England (2018).

Undesignated habitat FOCI

No undesignated habitat FOCI were recorded during the Kingmere MCZ survey conducted in 2018.

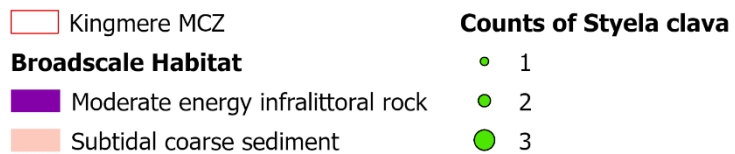
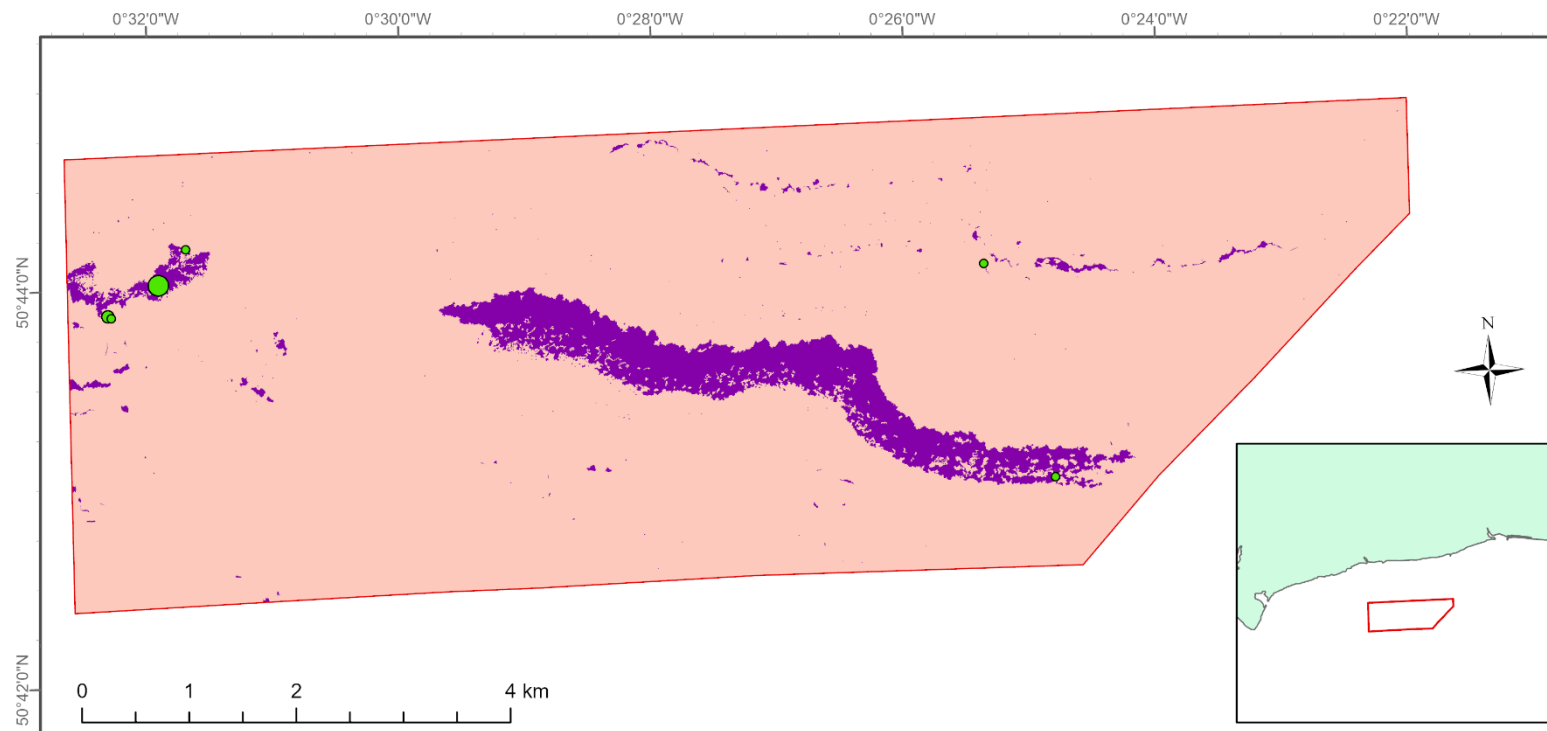
3.8 Species FOCI (reporting objective 2)

Designated species FOCI

This survey did not set out to observe black seabream, the designated species FOCI for the Kingmere MCZ.

3.9 Non-indigenous species (NIS) (reporting objective 3)

The leathery sea squirt (*Styela clava*) was observed in six still images across four DDV stations during the Kingmere MCZ survey in 2018, with counts ranging from 1 to 3 individuals per image (Figure 25). No NIS were observed from the data acquired through the sediment grab sampling.



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Figure 25. Occurrences of the leathery sea squirt *Styela clava*, a non-indigenous species (NIS), per still image at the four stations where it was observed during the Kingmere MCZ drop-down video survey in 2018. Basemap shows the revised Broadscale Habitat map for the MCZ. © Natural England and Cefas, 2023.

3.10 Marine litter (reporting objective 3)

Marine litter (classified as detailed in 'Annex 5. Marine litter categories') was observed in one of the grabs and in six of the DDV transects conducted across the Kingmere MCZ in 2018 (Figure 26). Five of the litter items observed from the survey imagery were rope, the lengths of which could not be determined as none were seen in their entirety, but all were several meters in length. The final litter item observed from the imagery was a large crab/lobster pot (size category F; see 'Annex 5. Marine litter categories'). Paint flecks were also found within one of the sediment samples from the survey and were recorded as 'A14 other' ('Annex 5. Marine litter categories').

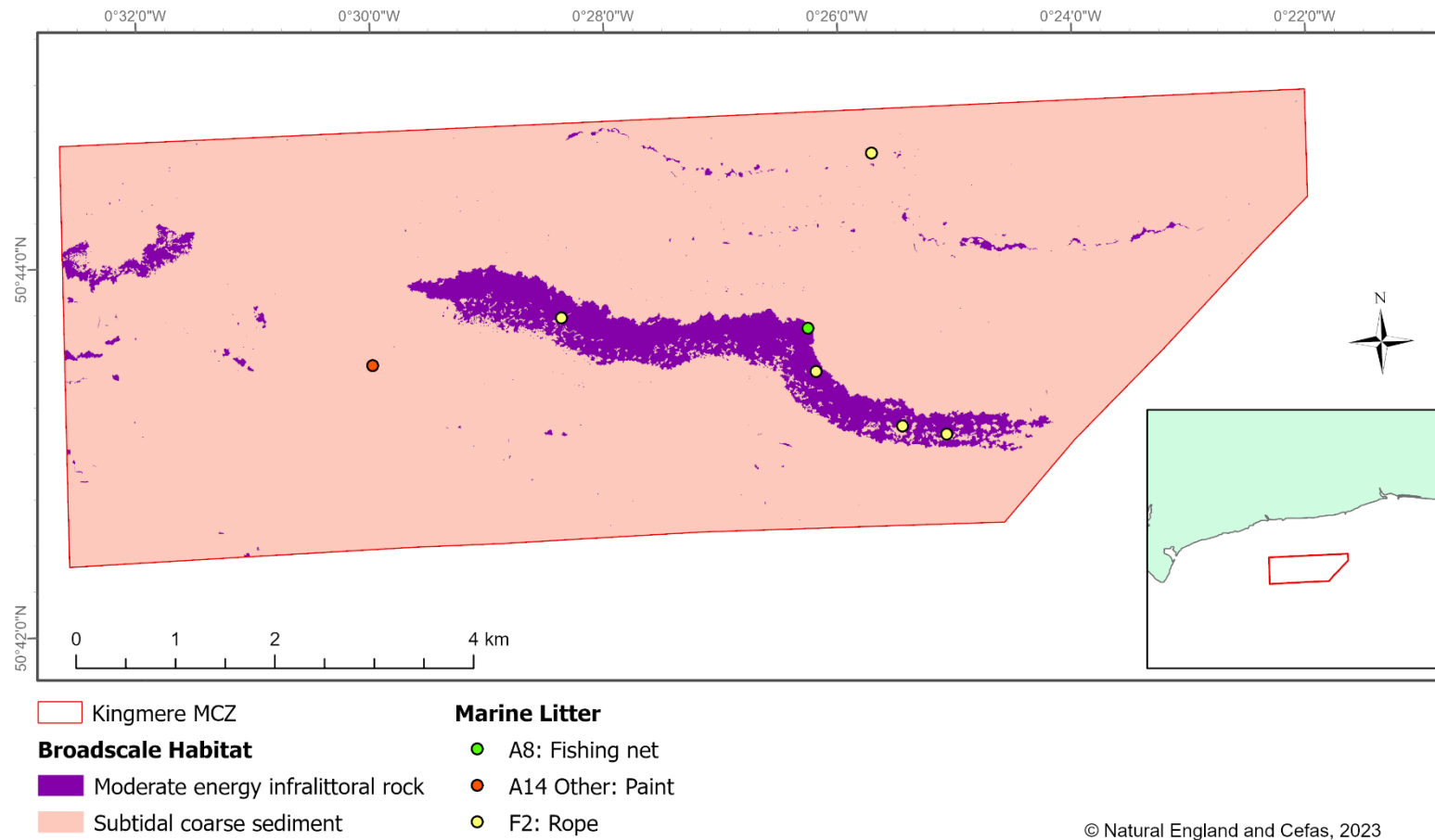


Figure 26. Updated (2022) habitat map for the Kingmere MCZ with litter occurrences during the 2018 survey. © Natural England and Cefas, 2023.

3.11 Observed anthropogenic activities and pressures (reporting objective 4).

Aside from the large crab/lobster pot (see Section 3.1), no evidence of anthropogenic activities or pressures were observed during the 2018 survey or from the data collected.

4 Discussion

The 2018 seabed survey at the Kingmere MCZ, adopting a combined approach of sediment grab and DDV techniques, acquired important physical and biological data which, together, have not only enabled a greater understanding of the ecological features within and across the site, but have also allowed the production of a revised habitat map. This progressed knowledge of the MCZ will ultimately be of great applied utility for the assessment and future management of the site. Here we discuss the findings of the data and place them in a wider context with regards to future management of the site.

4.1 'Moderate energy infralittoral rock with thin mixed sediment' habitat

The mapping of the habitat 'Moderate energy infralittoral rock with thin mixed sediment' within the Kingmere MCZ was undertaken using the best available evidence. This included information taken from the 2018 grab samples and DDV footage, acoustic data from the UKHO, and best available geological data (BGS, 2022). Areas with a high predicted confidence in the habitat were found in several regions across the site (Figure 11). The remainder of the site, excluding the areas of outcropping rock, were also classified as 'Moderate energy infralittoral rock with thin mixed sediment' but with a low confidence score.

In previous studies, the habitat 'Rock with thin sediment' was designated to areas where the sediment layer was less than 1.5 m thick (James and others, 2007). The habitat classification was first proposed to aid mapping seabed habitats of the English Channel in a joint project between Cefas, JNCC, BGS and Marine Ecological Surveys Ltd (now part of the Gardline Group). The team adapted the EUNIS classification scheme to account for what was witnessed from seabed imagery and acoustic data. In other mapping efforts across the English Channel, large areas were showing morphological features reminiscent of 'Rock' where the imagery and grab data were depicting sediment (James and others, 2007; Diesing and others, 2009; Coggan and others, 2009). In consequence, the team introduced a new interim substrate class 'Rock with thin sediment' and several associated habitats and biotopes to encompass energy, light and sediment regimes.

The ecological and functional characteristics of this habitat are likely to be strongly influenced by the depth of the sediment. For example, one of the key attributes of the habitat is the presence of sessile organisms which typically attach to hard substrates, but these are observed in the 'Rock with thin sediment' habitat where, according to the video data, appear to be sedimentary habitats. It is likely that sessile organisms would only exist in very thin sediment layers, while areas of deeper sediment layers are much more likely to behave functionally as sedimentary habitats. Therefore, the importance of the 'Rock with thin sediment' habitat is likely to be

directly related to the depth of sediment with shallower sediments (e.g., 0 to 10 cm) being more characteristic of it than deeper sediments (>10 cm).

In previous studies, sub-bottom profiling data were used to identify areas where the underlying rock reached the seabed surface (James and others, 2007; Diesing and others, 2009; Coggan and others, 2009). Combining this information with imagery and grab data of sedimentary habitats allowed a reasonable confidence to be placed on the classifications. For the current mapping project, little to no sub-bottom data were available for the site, so the depth of the rock layer below the sedimentary habitats could not be defined. Thus, the 'Rock with thin sediment' habitat was mapped based on the morphology of the seabed taken from the MBES data. Where the seabed morphology typically resembled rocky substrates, the seabed was reclassified. A confidence score based on the influence of the underlying rock and the proximity to exposed bedrock was used to delineate the different areas.

As indicated from the maps created here (Figure 11), it is likely that the 'Moderate energy infralittoral rock with thin mixed sediment' spans the entire MCZ. In the areas classified with a confidence score of 4, little to no evidence of underlying geology can be seen from the acoustic data. This habitat has been shown to be very extensive in the northern English Channel (James and others, 2007) but has not previously been the focus of surveys so close inshore as the Kingmere MCZ. Data from a single seabed core (gravity corer) collected in 1983 in the far southeast of the site indicated that the sediment layer overlying the siltstone was 16 cm deep, well within the threshold of 1.5 m deep set out by James and others (2007). This core was taken in an area which showed only a slight indication of underlying geology based on the recent acoustic data from UKHO. This implies that sediment layers are very thin even in areas where rock-like morphology is not apparent or that there has been significant change in sediment depths over the past 40 years. Future core sampling in the area would provide the data to elucidate this.

4.2 Infaunal and epifaunal assemblages within the Kingmere MCZ

The Kingmere MCZ is not an amenable site for which the infaunal assemblages may be sampled and described using routine grabbing approaches. As has been evidenced by the data presented herein, the site varyingly comprises outcropping rock (in specific areas) and sediment layers of varying thickness over rock. Where sediment is present, it is generally coarse (with a predominant gravel component) or mixed at a small number of locations. The 16 grab stations of the 2018 survey across the Kingmere MCZ were targeted at the areas predicted to be of a sedimentary nature and yielded only nine successful samples for macrofaunal assessment. Furthermore, the resulting sediment volume of the majority of these accepted samples were below the generally accepted 5 L threshold. Thus, describing the infaunal assemblages of the MCZ and assessing their ecological status is problematic, and based on the evidence here, focussing on this biological component of the seabed is unlikely to be a viable option for future management of

the site. The limited grab success and small volumes will inherently result in a high between-station variability in metrics of community structure (as was supported here; Figure 14) with a resulting low statistical power to confidently detect a temporal change in any selected metrics.

The DDV element of the 2018 survey at the Kingmere MCZ essentially targeted the areas predicted to represent the 'A3.2 Moderate energy infralittoral rock' to provide a greater understanding of feature distribution and its associated community structure. The video footage was regarded as being of too limited quality to provide meaningful and reliable data in this respect but, despite a significant proportion (29%) of the 632 still images being classed as unacceptable for faunal assessment, a sufficient number of 'good' quality still images were captured to allow epifaunal analysis of 42 of the 50 sampled stations. These data facilitated the mapping of the site, providing important groundtruthing information for verifying the acoustic data regarding the presence of outcropping rock and geological typology, and to the presence and general characteristics of sediment in other areas. The still images also revealed the presence of three biotopes within the 'A3.2 Moderate energy infralittoral rock' BSH, namely 'A3.215 Dense foliose red seaweeds on silty moderately exposed infralittoral rock', 'A3.225 Filamentous red seaweeds, sponges and *Balanus crenatus* on tide-swept variable-salinity infralittoral rock', and 'A3.24 Faunal communities on moderate energy infralittoral rock'.

4.3 Black seabream nest distribution

While the 2018 survey across the Kingmere MCZ did not objectively set out to identify black seabream nests, several potential active/recent nests were recorded through the DDV video transects conducted. Potential nests were witnessed in eight video transects with two transects evidencing 15 nests, with six transects showing between one and three potential nests. The Kingmere MCZ is an important area for black seabream, as evidenced by the fact that the species represents a designated habitat FOCI at the site (Table 1). Current Sussex IFCA management measures for the Kingmere MCZ include spatial and temporal restrictions of commercial and recreational fishing activities, the most stringent measure being a ban on all fishing activities during the black seabream breeding season (1st April to 30th June inclusive) in an area (termed 'zone 1'; Figure 27) where the majority of nests are located. The 2018 survey was conducted at a time of year where nests are not at their most prominent and the DDV stations were not targeted at the potential Black seabream nest areas. However, it is interesting to compare where the nests were observed, together with where they are normally observed through more targeted black seabream nest monitoring undertaken by the IFCA, with the revised habitat map created here. It is apparent that this fish species relies on the regions where outcropping rocks occur for nesting, as evidenced by their potential sightings in the 2018 survey (Figure 23) which closely correspond with mapped areas of 'A3.2 Moderate energy infralittoral rock' habitat. All the potential nests observed in the

2018 imagery data coincided with the management zones 1 (in the northern and north-eastern part of the site) and 2 (south of zone 1) (Figure 27), which represent the most important areas of the MCZ for black seabream nests. It is expected that these anecdotal data, together with the improved understanding of the ecological features and the nature and spatial distribution of the sediment and rock features of the site, will assist in the planning and interpretation of the ongoing black seabream nest monitoring conducted by the Sussex IFCA.

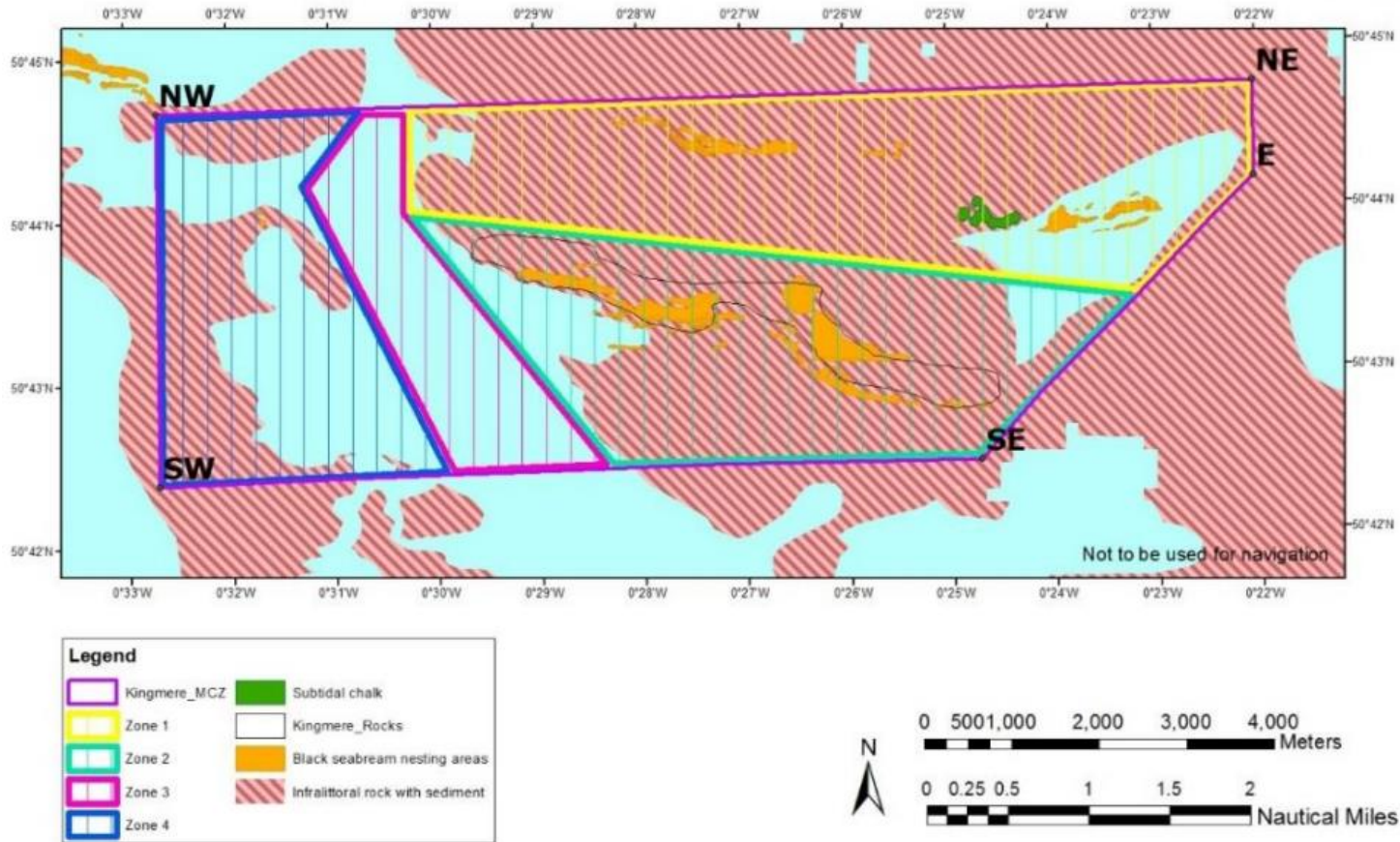


Figure 27. Kingmere Marine Conservation Zone, illustrating extent of area and management zones 1-4. Boundaries projected on 2015 site conservation feature data. Image taken from the Sussex Inshore Fisheries and Conservation Authority (IFCA) website [accessed 9/12/2022].

5 Recommendations for future monitoring

On the basis that future sampling and/or monitoring will be conducted to build upon the knowledge already established for the Kingmere MCZ and further support its management, we provide some recommendations which may be considered in the planning of such survey. The relevance of these recommendations will inherently be governed by the actual objectives of future surveys which, at the time of writing, are not known.

5.1 Operational and survey strategy

- The collection of geophysical data could be complimented by collecting core samples (gravity or piston corer) from across the site could be used to create an interpolated bedrock depth layer across the site. The cores could either be used to groundtruth the geophysical data or to determine sediment depths in particular places.
- Additional geophysical data in the form of shallow sub-bottom profiling data could be collected in transects across the site. The instrument should be relatively high frequency (such as a 'chirp' or 'sparker') to ensure the resolution is sufficient to pick up the thin sediment layer overlying the sandstone/siltstone found across the site.
- To facilitate the DDV approach and enhance the potential for increasing the proportion of usable still images (and video footage) for analyses, future surveys should ensure that they are conducted during periods when bottom visibility is likely to be at its highest. This might be during neap tides and/or during periods of clement weather or sea conditions.
- Based on the experience of the 2018 survey and the resulting sampling success, future surveys should carefully consider the requirement for assessing the infaunal assemblages of the sedimentary habitats of the Kingmere MCZ. If it is deemed to be a vital component as part of the site's management, then consideration of alternative sampling gear should be undertaken. It is likely that a Hamon grab, i.e., seabed sampling area of 0.25 m² as opposed to the 0.1 m² of the mini Hamon grab used in 2018, would provide a more reliable approach. However, the implications of the lack of direct comparability of the resulting data from the larger grab (resulting from the larger sampling area and deeper penetration; Boyd and others, 2006) with that which already exists for Kingmere (and generally all other MCZs) should be considered from the outset. Additionally, this larger grab is likely to limit the pool of potential vessels which might be capable of safe deployment and recovery: this will have practical and logistical implications for routine monitoring of the site using this larger grab type. Grabbing should ideally only

be targeted in areas of the site which have been evidenced to exhibit sediment of sufficient depth for grab penetration.

- Any future grabbing surveys of the Kingmere MCZ should additionally collect imagery data, potentially by adopting a 'Ham-Cam' set-up whereby a video camera is attached to the frame of a mini Hamon grab to capture the nature of the bed on landing. This relatively easily captured footage can be used to acquire information on the nature of the seabed at stations where not only the grab fails to sample (where it would provide the only data in those instances) but additional, *in situ* data to augment the infaunal and/or PSA acquired at successful stations. The imagery data this set-up acquires is inherently going to be spatially limited and cannot be seen to substitute drop camera transect approaches. Furthermore, the quality of data acquired will similarly be governed by the same environmental factors (e.g., bottom turbidity and suspended solids) which affect the quality of images captured using drop cameras.

5.2 Analysis and interpretation

- Further information on sediment depths across the site is needed to better understand the way the habitat functions across the site and through ongoing monitoring of sediment depths would provide data regarding the temporal mobility of this habitat.
- The Kingmere MCZ is the subject of targeted sampling and/or monitoring through other initiatives. For example, the Sussex IFCA undertakes monitoring of Black seabream nests using camera approaches while acoustic data acquisition is conducted by stakeholders within the aggregate sector. Future assessment and management of the site might benefit from a greater coordination of not only survey approaches (relevance to Section 5.1 above) but also from a greater appraisal of these disparate data types.

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Annex 1. Glossary

Definitions signified by an asterisk (*) have been sourced from Natural England and JNCC Ecological Network Guidance (Natural England and Joint Nature Conservation Committee, 2010).

Assemblage	A collection of plants and/or animals characteristically associated with a particular environment that can be used as an indicator of that environment. The term has a neutral connotation and does not imply any specific relationship between the component organisms, whereas terms such as 'community' imply interactions (Allaby, 2015).
Benthic	A description for animals, plants and habitats associated with the seabed. All plants and animals that live in, on or near the seabed are benthos (e.g. sponges, crabs, seagrass beds).*
Biotope	The physical habitat with its associated, distinctive biological communities. A biotope is the smallest unit of a habitat that can be delineated conveniently and is characterised by the community of plants and animals living there.*
Broadscale Habitats	Habitats which have been broadly categorised based on a shared set of ecological requirements, aligning with level 3 of the EUNIS habitat classification. Examples of Broadscale Habitats are protected across the MCZ network.
Community	A general term applied to any grouping of populations of different organisms found living together in a particular environment; essentially the biotic component of an ecosystem. The organisms interact and give the community a structure (Allaby, 2015).
Conservation Objective	A statement of the nature conservation aspirations for the feature(s) of interest within a site, and an assessment of those human pressures likely to affect the feature(s).*
Epifauna	Fauna living on the seabed surface.
EUNIS	European Nature Information System. A European habitat classification system, covering all types of habitats from natural to artificial, terrestrial to freshwater and marine.*
Favourable Condition	When the ecological condition of a species or habitat is in line with the conservation objectives for that feature. The term 'favourable' encompasses a range of ecological conditions depending on the objectives for individual features.*

Feature	A species, habitat, geological or geomorphological entity for which an MPA is identified and managed.*
Feature Attributes	Ecological characteristics defined for each feature within site-specific Supplementary Advice on Conservation Objectives (SACO). Feature Attributes are monitored to determine whether condition is favourable.
Features of Conservation Importance (FOCI)	Habitats and species that are rare, threatened or declining in Secretary of State waters.*
Habitats of Conservation Importance (HOICI)	Habitats that are rare, threatened, or declining in Secretary of State waters.*
Infauna	Fauna living within the seabed sediment.
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. JNCC has responsibility for nature conservation in the offshore marine environment, which begins at the edge of territorial waters and extends to the UK Continental Shelf (UKCS).
Marine Strategy Framework Directive (MSFD)	The MSFD (EC Directive 2008/56/EC) aims to achieve Good Environmental Status (GES) of EU marine waters and to protect the resource base upon which marine-related economic and social activities depend.
Marine Conservation Zone (MCZ)	MPAs designated under the Marine and Coastal Access Act (2009). MCZs protect nationally important marine wildlife, habitats, geology and geomorphology, and can be designated anywhere in English and Welsh inshore and UK offshore waters.*
Marine Protected Area (MPA)	A generic term to cover all marine areas that are 'A clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values' (Dudley, 2008).*
Natural England	The statutory conservation advisor to Government, with a remit for England out to 12 nautical miles offshore.
Non-indigenous Species	A species that has been introduced directly or indirectly by human agency (deliberately or otherwise) to an area where it has not occurred in historical times and which is separate from

and lies outside the area where natural range extension could be expected (Eno and others, 1997).*

Pressure	The mechanism through which an activity has an effect on any part of the ecosystem (e.g. physical abrasion caused by trawling). Pressures can be physical, chemical or biological, and the same pressure can be caused by a number of different activities (Robinson and others, 2008).*
Species of Conservation Importance (SOCI)	Habitats and species that are rare, threatened or declining in Secretary of State waters.*
Supplementary Advice on Conservation Objectives (SACO)	Site-specific advice providing more detailed information on the ecological characteristics or 'attributes' of the site's designated feature(s). This advice is issued by Natural England and/or JNCC.

Annex 2. Sampling, data acquisition and analyses

2.1 Tidal modelling (for supporting processes)

The tidal model referenced in Section 1.2 has a domain which extends 48.01°N to 52.48°N and 2.23°E to 9.51°W. The unstructured mesh was discretised with 292, 630 nodes and 571, 260 elements. The mesh has a resolution of approximately 3 km along the open boundary. In the area of interest, the resolution was refined to approximately 25 m. Bathymetry for the model was sourced from the Defra Digital Elevation Model (Astrium, 2011). The resolution of the dataset is 1 arc second (~30 m). The hydrodynamics were forced along the open boundaries using 11 tidal constituents (M2, S2, N2, K2, K1, O1, P1, Q1, M4, MS4 and MN4) from the OSU TPXO European Shelf 1/30° regional model. After a spin up period of 5 days, the model was run for 30 days to cover a full spring-neap cycle.

2.2 Acoustic data (for habitat mapping)

Multibeam echosounder (bathymetry) data

Bathymetric datasets spanning the complete Kingmere MCZ were downloaded from the UKHO Marine Data Portal⁶ as .bag files, at a resolution of 2 m (Table 5). The bathymetry data were converted to floating point geotiffs before being merged to a new raster. The data was then clipped to the extent of the Kingmere MCZ.

Table 5. Bathymetric datasets used for habitat mapping the Kingmere MCZ. © Natural England and Cefas, 2023.

Name	Year	Resolution
HI1561 Sussex West Bay	2018	2 m x 2 m
HI1498 Eastern Approach to Solent	2018	2 m x 2 m

To aid the mapping of the different features within the site, several different derivative layers were calculated from the bathymetric data (Table 6). These layers aid in the identification of geomorphological features which underpin a number of different habitats. All derivatives were calculated using SAGA-GIS toolbox within QGIS.

⁶ <https://data.admiralty.co.uk/portal/apps/sites/#!/marine-data-portal>

Table 6. Bathymetric derivatives calculated from the combined data. © Natural England and Cefas, 2023.

Layer Name	Detail
Bathymetric Position Index	Bathymetric position index (Lundblad and others, 2006); radii of 3 and 20 cells.
Aspect	Identifies the direction of maximum rate of change in depth from each cell.
Ruggedness	The difference between a central cell and the mean of its eight neighbours (Wilson and others, 2007)
Slope	The slope in degrees using the maximum change in elevation of each cell and its 8 neighbours.

MBES backscatter data

Beam intensity, or backscatter, is the amount of return energy received by the transceiver from each bathymetric measurement. The amount of return energy gives an indication of the amount of energy which is absorbed or scattered by the seabed. The intensity of the backscatter measurement can then be used to estimate the small-scale roughness (grain size) and the intrinsic nature of the seabed (hard or soft). This makes it a powerful tool for being able to identify areas of different substrate which are not apparent from the bathymetric data.

MBES data from the 2018 HI1561 Sussex West Bay survey was processed from the raw .all files using QPS FMGT. The backscatter mosaic was output as a 2 m by 2 m floating point geotiff. Throughout this report 'Acoustic data' is used as a collective term to refer to the bathymetry, bathymetric derivatives and backscatter data.

Object based image analysis

The Kingmere MCZ was mapped using object-based image analysis (OBIA). Object-based image analysis (OBIA) is a method of mapping based on computer vision which aims to delineate real-world items from remote sensing data and combine image processing and geographical information services (GIS) to use the spectral and contextual information in an integrated approach (Blaschke, 2010). In its simplest form OBIA involves the segmentation of the remote sensing data into objects which are then classified, either manually or using a classification algorithm (Archer-Rand and others, 2021).

Segmentation

Segmentation divides the image into objects, based on their spectral and spatial characteristics. The resulting objects can be characterised by their various features such as layer values (mean, standard deviation, skewness, etc.), geometry (extent, shape, etc.) and texture. The input layers used were the primary acoustic data layers (bathymetry and backscatter strength) and their derivatives (Table 6). The initial

segmentation was conducted using the multi-resolution segmentation algorithm in eCognition (Trimble, 2023). This is an optimisation procedure that starts with an individual pixel and consecutively merges it with neighbouring pixels to form an object. The process continues until a threshold value (determined by the operator) for a scale parameter determining the variability allowed in the objects is reached. The goal of the segmentation is to create meaningful objects that represent areas of homogeneous values in the map image. The size of the objects is influenced by the scale parameter and the heterogeneity of the image. For a fixed value of the scale parameter, a homogeneous area of seabed will have larger objects than a heterogeneous area. Likewise, for a fixed seabed heterogeneity, larger values of the scale parameter produce larger objects than smaller values. For the Kingmere MCZ the initial segmentation was carried out at a scale parameter of 10.

Broadscale Habitat Mapping

Broadscale Habitats identified from the video data and the PSA samples were mapped across the site initially. This was done in two stages; with the areas of rock being identified first, followed by the classification of the sedimentary habitats.

Rock Mapping

Rocky areas across the site were mapped using information collated from the still images data. Locations of the still images were overlain onto the segmented acoustic data. Where an image which was classified as rock intersected an “object”, that object was then classified as rock. For comparison with sedimentary areas, objects coincident with PSA samples were given “sediment” statistics based on the mean and standard deviation for each acoustic layer calculated for the classified objects (rock and sediment) and exported from eCognition. Box plots were created from the data outputs to identify thresholds to split the data between rock and sedimentary (Figure 28). From the box plot a threshold of 1.4 was identified which successfully divided the objects between sedimentary and rock habitats. This threshold was applied to remaining objects across the site. The finalised ‘Rock’ layer was output from eCognition as a Shapefile. This layer was reclassified as ‘A3.2 Moderate energy infralittoral rock’ based on the observations from the video and still image data.

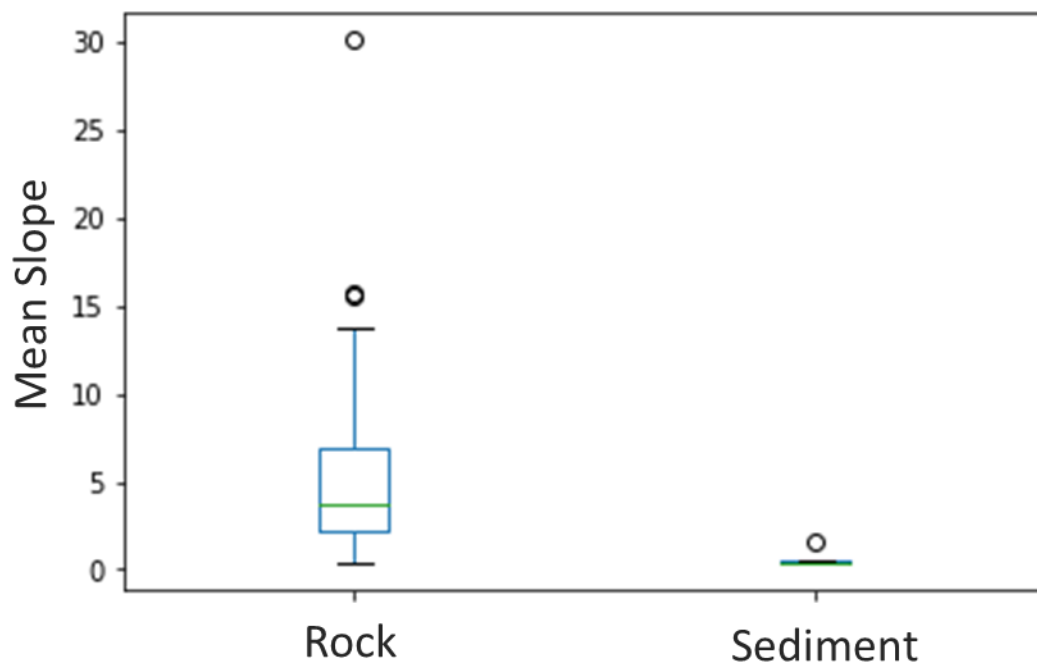


Figure 28. Boxplot showing the sample values of the derivative layer mean slope (y axis) for object mean backscatter based on the acoustic data for the Kingmere MCZ. © Natural England and Cefas, 2023.

Sedimentary habitats

Variations in the sedimentary habitats were mapped using the data from the PSA samples which were collected across the site. The majority of PSA samples (13 of 15 samples; 87%) belonged to a single broadscale habitat 'A5.4 Subtidal coarse sediment'. The remaining two samples belonged to the habitat 'A5.1 Subtidal mixed sediments'. No difference between the two different habitat classes could be distinguished from the bathymetric derivatives of the backscatter data. Therefore, all the sedimentary habitats across the Kingmere site were classified as 'A5.4 Subtidal coarse sediment'.

A3.9 Moderate energy infralittoral rock and thin mixed sediment

The biotope A3.9 Moderate energy infralittoral rock and thin mixed sediment is a relatively complex habitat to map due to its mixed characteristics. This is especially true when it comes to groundtruthing data. Imagery data can confirm the presence of the overlying sediment type and can sometimes indicate where species are present which are associated with rock. However, it is almost impossible to gauge the depth of the sediment layers from the imagery data. Some of the metadata associated with the collection of the PSA samples can indicate where the sediment layer is particularly shallow. Where only small sample volumes were retrieved and there is no evidence of grab wash-out (where a cobble has become stuck in the jaws), then

this may be an indication of a shallow layer of sediment. Sediment volumes were mapped across the site (Figure 29).

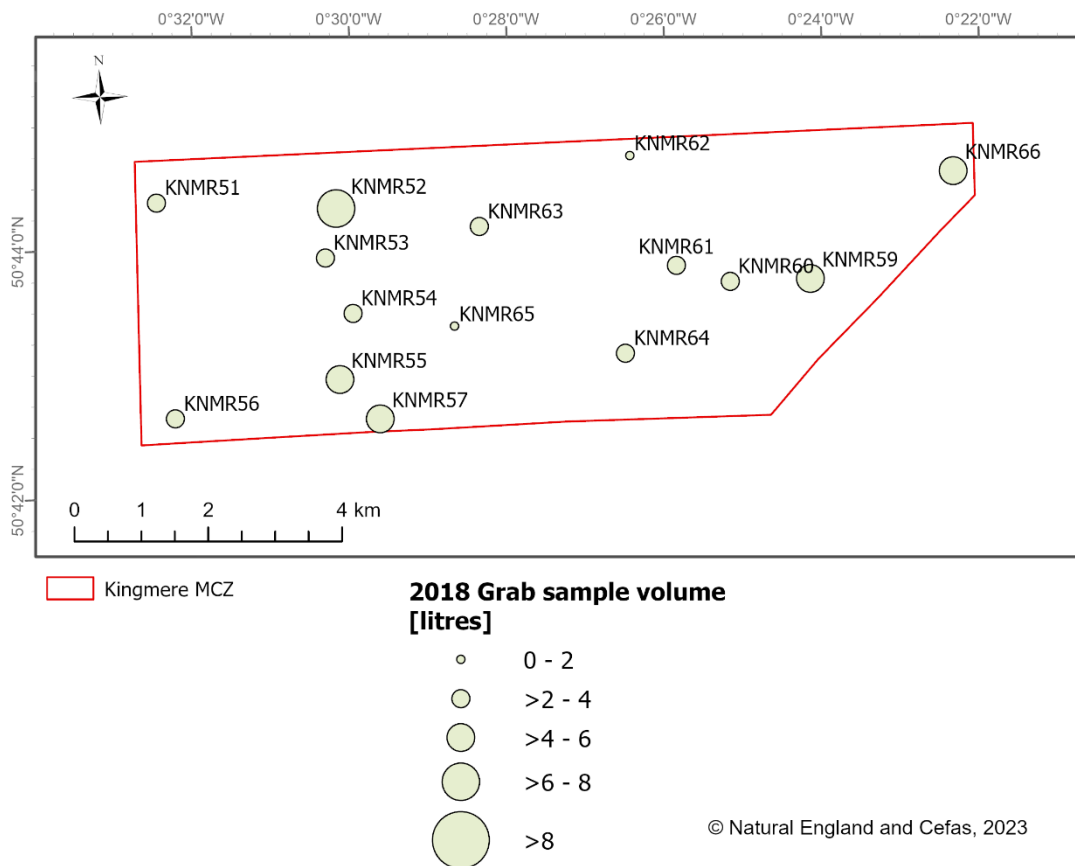


Figure 29. Volumes recorded from the mini Hamon grab samples collected during the Kingmere MCZ survey in 2018. © Natural England and Cefas, 2023.

Legacy sub-bottom profile data was downloaded from the BGS data portal (LINK). One line of data tracked into the MCZ boundary but did not cross the whole site. Unfortunately, upon inspection of the data, the end of line data had a significant amount of interference making it impossible to interpret where the rock bedding planes reach the surface.

Shallow geological formations of rock can have a strong influence on the morphology of the overlying sediments with this being more pronounced where the sediment layer is especially thin. This influence can be seen visually on the bathymetry data (Figure 30) and can be enhanced using some of the bathymetric derivatives. These morphological features are especially apparent on the larger scale derivatives such as the BPI at a radii of 20.

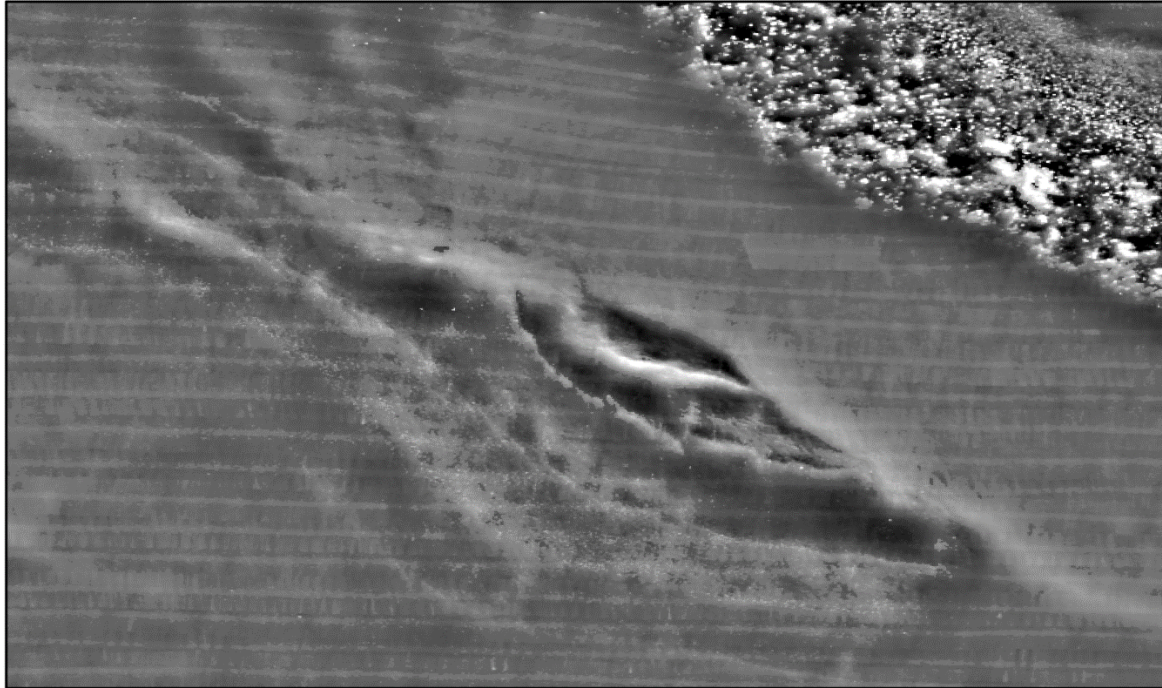


Figure 30. Example of the bathymetric derivative BPI20 showing morphological features influenced by underlying geology. © Natural England and Cefas, 2023.

Areas were delineated based on the apparent influence of the underlying geology. Each area was given a confidence score based on the criteria set out in Table 7.

Table 7. Confidence scores given to areas delineated as infralittoral rock and thin mixed sediments. © Natural England and Cefas, 2023.

Score	Rationale
1	Areas of sediment mapped immediately between areas of exposed rock. Sediment shows strong influence of underlying rock substrate and is likely to be very thin.
2	No evidence of exposed rock but a strong influence on sediment morphology from underlying geology. The shape of the underlying rock is clearly visible on the bathymetry and bathymetric derivatives.
3	Some/light influence of underlying geology on sediment morphology. Likely to be a thicker sediment layer than areas which scored 1 and 2.
4	Little to no evidence of geology influencing morphology. Historical maps and modelling information indicate rock formation being close to surface.

Subtidal Chalk

Subtidal chalk was mapped across the site based on the observations of chalk in the imagery data collected in the previous surveys. The imagery classified as Subtidal chalk coincided with distinct flat areas of outcropping rock which were different in form to the outcropping sandstone rocks found in the central areas of the site. Areas classified as ‘A3.2 Moderate energy infralittoral rock’ during the broadscale habitat mapping which also had the distinct flat top shape were reclassified as ‘Subtidal chalk’.

Broadscale Habitat Map Accuracy

The technical quality of the updated habitat map was assessed using the MESH confidence Assessment Tool, originally developed by an international consortium of marine scientists working on the MESH (Mapping European Seabed Habitats) project. This tool considers the provenance of the data used to make a biotope/habitat map, including the techniques and technology used to characterise the physical and biological environment and the expertise of the people who had made the map. In its original implementation, it was used to make an auditable judgement of the confidence that could be placed in a range of existing, local biotope maps that had been developed using different techniques and data inputs. It was then used in compiling a full coverage map for north-west Europe. Where two of the original maps overlapped, the map with the highest MESH confidence score would take precedence in the compiled map.

Subsequent to the MESH project, the confidence assessment tool has been applied to provide a benchmark score that reflects the technical quality of newly developed habitat/biotope maps. Both physical and biological survey data are required to achieve the top mark of 100 but, as the current MCZ exercise requires the mapping of BSHs as opposed to biotopes, it excludes the need for biological data. In the absence of biological data, the maximum score attainable for a purely physical map is 88. In applying the tool to the current work, none of the weighting options were altered; that is, the tool was applied in its standard form, as downloaded from the internet.

2.3 Seabed imagery

Drop down video camera equipment was deployed in accordance with the MESH 'recommended operating guidelines (ROG) for underwater video and photographic imaging techniques' (Coggan and others, 2007). The Subsea Technology & Rentals (STR) SeaSpyder camera system was deployed from the stern of the survey vessel. Real time navigation data acquisition and manual position fixing when the gear contacted the seabed was captured via Trimble® HYDROpro™ software and logged by the survey officer. The mid-point of the vessel's stern gantry was used as the default offset for position fixing. Video files and digital still images were transmitted via the sea cable to be captured and saved directly to a computer in the survey cabin. The video footage was annotated with time and position using a GPS (SIMRAD MX512 DGPS) referenced video overlay (uncorrected position data). Images of the seabed were captured approximately every 10 to 15 m over a distance of >150 m. Extra photographs were taken in heterogeneous areas of BSH and if particular habitat/species FOCI were observed. If a BSH habitat boundary was detected towards the end of a tow, the camera deployment was extended to confirm the change. The drop frame depth was controlled via a winch operator receiving instructions from the survey cabin. Further information regarding the camera, the camera set up, underwater video procedure and underwater visibility scale used for

the 2018 survey at Kingmere MCZ can be obtained in Godsell (2019). During each drop camera deployment, a member of the survey team continuously monitored the real-time video feed, recording general station notes, underwater visibility, habitat information and fauna observations.

Epifaunal data preparation

A modified version of the CATAMI scheme of standardised terminology for annotating benthic substrates and biota in marine imagery was used to classify images (Althaus and others, 2015). The CATAMI classification scheme was designed to allow imagery from a range of sources (including video and digital still images), with varying resolution, and across marine habitats from shallow waters to abyssal depths, to be classified using the same set of consistent identifiers (Althaus and others, 2015). The scheme was designed to avoid duplication of categories and to allow all sensing techniques to result in the same classifications, while allowing the resolution and quality of imagery to define the level in the hierarchy to be used. The scheme was designed to be flexible enough that it can be modified when new information is presented but also be stable enough that it can support ongoing use. Changes and additions are allowed but should be clearly documented and related back to earlier categories.

With CATAMI, the data were:

- 1) consistently truncated to the lowest level of the scheme;
- 2) Hydrozoa were split into 'branched' (e.g. *Abietinaria* sp.) and 'feather' (e.g. *Aglaophenia* sp.) categories;
- 3) all fish were removed, and;
- 4) taxa occurring in very few images and with uncertain identification were removed from the dataset.

Table 8. List of truncated taxa showing which have been removed from the analyses and which have been combined with other records for the epifaunal point data from the still imagery. © Natural England and Cefas, 2023.

Taxon	Taxon Truncation action
Biota > Cnidaria > True anemones	Removed
Biota > Echinoderms > Sea stars	Removed
Biota > Fishes > Bony fishes	Removed
Biota > Fishes > Bony fishes > cf. <i>Callionymus</i> sp.	Removed
Biota > Molluscs > Gastropods	Removed
Biota > Worms > Polychaetes > Other polychaetes	Removed
Biota > Worms > Polychaetes > Tube worms > Sabellidae	Removed

Table 9. List of truncated taxa showing which have been removed from the analyses and which have been combined with other records for the epifaunal percentage cover data from the still imagery. © Natural England and Cefas, 2023.

Taxon	Taxon Truncation action
Biota > Bryozoa > Hard > Encrusting > Orange	Biota > Bryozoa > Hard > Encrusting
Biota > Bryozoa > Hard > Encrusting > Purple	Biota > Bryozoa > Hard > Encrusting
Biota > Bryozoa > Hard > Encrusting > Red	Biota > Bryozoa > Hard > Encrusting
Biota > Bryozoa > Soft > Foliaceous > cf. <i>Flustra foliacea</i>	Biota > Bryozoa > Soft > Foliaceous > cf. <i>Flustra foliacea</i>
Biota > Bryozoa > Soft > Foliaceous > cf. <i>Flustra foliacea</i> > <i>Flustra foliacea</i>	Biota > Bryozoa > Soft > Foliaceous > cf. <i>Flustra foliacea</i>
Biota > Macroalgae > Erect coarse branching > Brown	Biota > Macroalgae > Brown
Biota > Macroalgae > Filamentous / filiform > Brown	Biota > Macroalgae > Brown
Biota > Macroalgae > Frondose > Brown	Biota > Macroalgae > Brown
Biota > Macroalgae > Erect coarse branching > Red	Biota > Macroalgae > Red
Biota > Macroalgae > Erect fine branching > Red	Biota > Macroalgae > Red
Biota > Macroalgae > Frondose > Red	Biota > Macroalgae > Red
Biota > Sponges > Crusts > Encrusting > Sp_Cr_Enc_Brown	Biota > Sponges > Crusts > Encrusting
Biota > Sponges > Crusts > Encrusting > Sp_Cr_Enc_Green	Biota > Sponges > Crusts > Encrusting
Biota > Sponges > Crusts > Encrusting > Sp_Cr_Enc_Grey	Biota > Sponges > Crusts > Encrusting
Biota > Sponges > Crusts > Encrusting > Sp_Cr_Enc_Orange	Biota > Sponges > Crusts > Encrusting
Biota > Sponges > Crusts > Encrusting > Sp_Cr_Enc_Red	Biota > Sponges > Crusts > Encrusting
Biota > Sponges > Crusts > Encrusting > Sp_Cr_Enc_Yellow	Biota > Sponges > Crusts > Encrusting
Biota > Sponges > Crusts > Encrusting > cf. <i>Hemimycale columella</i>	Biota > Sponges > Crusts > Encrusting

Taxon	Taxon Truncation action
Biota > Sponges > Massive forms > Simple > Sp_M_S_Brown	Biota > Sponges > Massive forms > Simple
Biota > Sponges > Massive forms > Simple > Sp_M_S_Cream	Biota > Sponges > Massive forms > Simple
Biota > Sponges > Massive forms > Simple > Sp_M_S_Green	Biota > Sponges > Massive forms > Simple
Biota > Sponges > Massive forms > Simple > Sp_M_S_Grey	Biota > Sponges > Massive forms > Simple
Biota > Sponges > Massive forms > Simple > Sp_M_S_Orange	Biota > Sponges > Massive forms > Simple
Biota > Sponges > Massive forms > Simple > Sp_M_S_Peach	Biota > Sponges > Massive forms > Simple
Biota > Sponges > Massive forms > Simple > Sp_M_S_Pink	Biota > Sponges > Massive forms > Simple
Biota > Sponges > Massive forms > Simple > Sp_M_S_Red	Biota > Sponges > Massive forms > Simple
Biota > Sponges > Massive forms > Simple > Sp_M_S_White	Biota > Sponges > Massive forms > Simple
Biota > Sponges > Massive forms > Simple > Sp_M_S_Yellow	Biota > Sponges > Massive forms > Simple
Biota > Sponges > Massive forms > Simple > cf. <i>Amphilectus fucorum</i>	Biota > Sponges > Massive forms > Simple

2.4 Grab sampling

A Mini-Hamon grab (Figure 31), with a sampling area of 0.1 m², was deployed from the stern gantry of the vessel to collect sediment from the seabed, as described by Ware and Kenny (2011). Sampling positions were recorded (fixed) using Hydropro data acquisition software when the gear contacted the seabed, with the mid-point of the vessel's stern gantry being used as the default offset for position fixing.

Once recovered, the sample was emptied into a suitable container, photographed, and the sample volume measured. A minimum of three attempts was made at each station to obtain a valid grab sample before the station was abandoned. A sample volume of five litres was required to qualify as a valid sample. Samples of less than five litres were ordinarily discarded. However, when it was difficult to obtain a valid sample, a sample with less than five litres of material was retained at the discretion of the lead scientist if it was deemed representative of the habitat. For valid samples, a small scoop was used to remove a sub-sample (approx. 0.5 L) of sediment for particle size analysis (PSA). The remaining sample was washed over a 1.0 mm sieve to retain the faunal fraction (Figure 31), photographed, and preserved with a buffered 4% formaldehyde solution for transfer ashore to a specialist laboratory for analysis.

If the volume of sediment collected was insufficient for faunal analysis in each grab attempt made at a particular station, a photograph was taken and, if possible, material removed for PSA. The station was then abandoned.



Figure 31. Mini-Hamon grab (left), and equipment for sieving benthic fauna samples (right). Images taken from Godsell (2019).

Preliminary sediment descriptions were recorded for each sample collected. For consistency across all the MCZ benthic habitat surveys, these were based on a pictorial field guide produced by Cefas marine sedimentologists, a modified Folk seabed sediment classification system (Long, 2006) (Figure 32) and the Wentworth

scale. These preliminary descriptions aid in the classification of sediment BSHs once results of PSA are available.

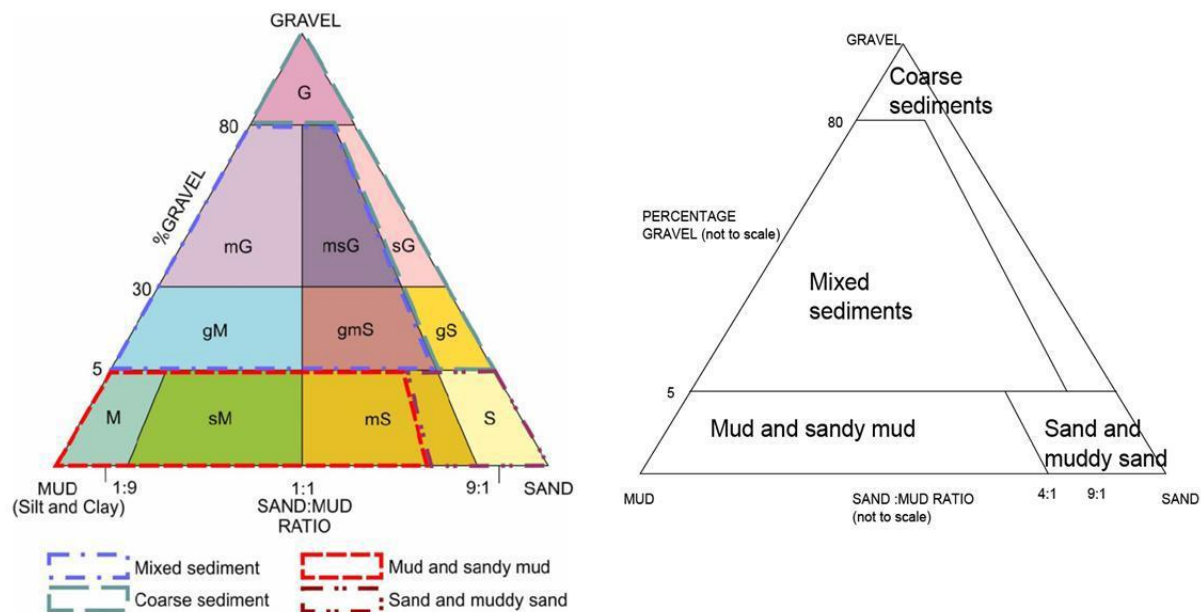


Figure 32. Simplified sediment classification of the Folk triangle for UK SeaMap (Long, 2006). Images taken from Godsell (2019).

Sediment particle size distribution

Sediment particle size distribution data (half phi classes) were grouped into the percentage contribution of gravel, sand and mud derived from the classification proposed by Folk (1954). In addition, each sample was assigned to one of four sediment Broadscale Habitats using a modified version of the classification model produced during the Mapping European Seabed Habitats (MESH) project (Long, 2006) (Figure 32).

Infaunal data preparation

Raw taxon abundance and biomass matrices can often contain entries that include the same taxa recorded differently, erroneously or differentiated according to unorthodox, subjective criteria. Therefore, ahead of analysis, data should be checked and truncated to ensure that each row represents a legitimate taxon, and that they are consistently recorded within the dataset. An artificially inflated taxon list (i.e., one that has not had spurious entries removed) risks distorting the interpretation of patterns contained within the sampled assemblage. Often, some taxa have to be merged to a level in the taxonomic hierarchy that is higher than the level at which they were identified. In such situations, a compromise must be reached between the level of information lost by discarding recorded detail on a taxon's identity, and the potential for error in analyses, results and interpretation, if that detail is retained.

Details of the data preparation and truncation protocols applied to the infaunal datasets acquired at Kingmere MCZ ahead of the analyses reported here are provided below:

- The infaunal dataset was reviewed to ensure consistent nomenclature using the WoRMS 'match taxa' tool.
- Where there are records of one named species together with records of members of the same genus (but the latter not identified to species level) the entries are merged and the resulting entry retains only the name of the genus.
- Taxa are often assigned as 'juveniles' during the identification stage with little evidence for their actual reproductive natural history (with the exception of some well-studied molluscs and commercial species). Many truncation methods involve the removal of all 'juveniles'. However, a decision must be made on whether removal of all juveniles from the dataset is appropriate or whether they should be combined with the adults of the same species where present. Species labelled as 'juvenile' were combined with the associated species (adult) level identification, when present. However, where no corresponding adults of that species were present in the sample, the 'juvenile' label was removed and the entry treated as an adult.
- Records of eggs were removed.
- Records of fish species were removed.

Table 10. List of truncated taxa which have been removed, changed or merged from the 2018 abundance and biomass data matrices. © Natural England and Cefas, 2023.

Taxon	Qualifier	Truncation action
<i>Glycera</i>	Juvenile	Changed to <i>Glycera lapidum</i> (agg) following audit recommendations
<i>Nephtys</i>	Juvenile	Removed
Lumbrineridae	Aggregate	Changed to <i>Lumbrineris cingulata</i> (agg) following audit recommendations
<i>Spio gonocephala</i>		Changed to <i>Spio</i> as single record
<i>Caulleriella bioculata/viridis</i>		Changed to <i>Caulleriella bioculata</i>
<i>Leiochone johnstoni</i>		Changed to <i>Leiochone</i> as single record
Ampharetidae		Removed
Terebellidae		Removed
<i>Polycirrus norvegicus</i>	Juvenile	Changed to <i>Polycirrus</i> following audit recommendations
<i>Jasmineira elegans</i>		Changed to <i>Jasmineira</i> following audit recommendations
<i>Spirobranchus</i>		Changed to Serpulidae following audit recommendations
<i>Maera</i>		Changed to <i>Maera grossimana</i> following audit recommendations
Paguridae	Juvenile	Removed
Polyplacophora	Juvenile	Removed
Gastropoda		Changed to <i>Tornus subcarinatus</i> following audit recommendations
Gastropoda	Eggs	Removed
Bivalvia		Removed
<i>Spisula</i>	Juvenile	Removed
<i>Ophiura albida</i>		Changed to <i>Ophiura</i> as single record
Callionymidae		Removed
Pisces		Removed
Annelida_fragments		Removed

Numerical and statistical analyses

The infaunal and epifaunal species abundance-by-taxon matrices were then truncated according to the truncation steps described above. The 'indicators' and 'sum' functions in PRIMER v7 were then used to allow grouping of the data for analyses.

Bray-Curtis similarity matrices were produced from the square root-transformed data for both samples and variables within PRIMER v7 (Clarke and Gorley, 2015) following a review of the resulting shade plots of other, less suitable, abundance data transformations. Infaunal assemblage groups were derived using a non-hierarchical K-means clustering' method. This method determines the optimum number of groups

using the Analysis of Similarity (ANOSIM) R statistic and the Similarity Profile (SIMPROF) algorithm to test whether a suitable number of groups had been reached (with a minimum of two and a maximum of 20 groups). This non-hierarchical clustering approach enables samples to be reallocated at latter points in the clustering process without becoming isolated as similarity measures are developed during algorithm computation (Clarke and others, 2016). Non-metric multidimensional scaling ordinations (nMDS) were produced to illustrate differences in assemblage structure within and between group classifications. The ANOSIM routine was used to determine any significant differences in infaunal assemblage composition between groups and the Similarity Percentage (SIMPER) routine was used to determine within- and among-group similarity (Clarke and Gorley, 2015).

Several univariate metrics of community structure, considered relevant to describe the basic assemblage attributes, were generated using the DIVERSE routine in PRIMER v7 for each sample (together with total biomass to reflect assemblage function):

- Number of taxa (*S*): number of taxa present in a sample.
- Abundance (*N*): the total number of individuals of enumerable taxa. Colonial taxa are recorded as present and subsequently assigned an abundance of 1.
- Margalef's richness index (*d*): a measure of the number of species present for a given number of individuals in a sample; high values indicate high diversity.
- Pielou's evenness (*J'*): quantifies how evenly the individuals in a sample are distributed, *J'* ranges from zero (uneven distribution or dominance of a taxon) to one (even distribution of individuals across taxa, less dominance by a taxon).
- Shannon-Wiener index (*H'*): measures the uncertainty in predicting the identity of the next species in a sample, with high values indicating a high biodiversity.
- Simpson's index ($1-\lambda$): the probability of choosing two individuals from a sample that are different species (0 = minimum diversity; 1 = maximum diversity). In this respect, this index is an index of species dominance.
- total biomass (*g*): the summed mass of all enumerable taxa; blotted wet weight. -Infauna only-

Non-indigenous species (NIS)

The infaunal and epifaunal taxon lists generated from the grab samples and seabed imagery data were cross-referenced against lists of non-indigenous target species which have been selected for assessment of Good Environmental Status in GB waters under MSFD Descriptor 2 and identified as significant by the GB Non-Native Species Secretariat. These taxa are listed in 'Annex 4. Non-indigenous species lists'.

Annex 3. Ancillary infaunal and epifaunal outputs (SIMPER)

Table 11. Results from the infauna SIMPER analysis on square root transformed abundance data showing the first 10 taxa contributing to dissimilarity between the Broadscale Habitats (BSH), with the relative abundance and cumulative percentage of each taxon for each comparison. © Natural England and Cefas, 2023.

Taxa	A5.1 Subtidal coarse sediment	A5.4 Subtidal mixed sediments	Cumulative percentage
<i>Polycirrus</i>	1.47	0.40	2.49
Polynoidae	0.91	0.17	4.54
Nemertea	1.63	1.11	6.49
<i>Pista mediterranea</i>	1.14	0.40	8.41
<i>Nephtys cirrosa</i>	0.00	0.79	10.31
<i>Syllis garciai</i>	0.58	0.97	12.13
<i>Mediomastus fragilis</i>	0.80	0.24	13.94
<i>Aonides oxycephala</i>	0.71	0.00	15.57
<i>Glycera lapidum</i> (agg)	1.28	1.04	17.11
<i>Cliona celata</i>	0.67	0.00	18.64

Table 12. Results from the infauna SIMPER analysis on square root transformed abundance data showing the first 10 taxa contributing to similarity for 'A5.1 Subtidal coarse sediment', with the relative abundance and cumulative percentage of each taxon for each comparison. © Natural England and Cefas, 2023.

Taxa	Average abundance	Average similarity	Contribution percentage	Cumulative percentage
<i>Syllis garciai</i>	0.97	1.79	1.18	8.53
<i>Nephtys cirrosa</i>	0.79	1.42	0.60	6.79
Nemertea	1.11	1.27	0.74	6.06
<i>Glycera lapidum</i> (agg)	1.04	1.23	0.74	5.88
<i>Sertularia</i>	0.67	0.93	0.72	4.42
<i>Electra pilosa</i>	0.67	0.93	0.72	4.42
<i>Lumbrineris cingulata</i> (agg)	0.86	0.91	0.73	4.34
<i>Spiophanes bombyx</i>	0.76	0.86	0.74	4.10
<i>Paucibranchia bellii</i>	0.69	0.58	0.44	2.78
<i>Notomastus</i>	0.63	0.56	0.76	2.66

Table 13. Results from the infauna SIMPER analysis on square root transformed abundance data showing the first 10 taxa contributing to similarity for 'A5.4 Subtidal mixed sediments', with the relative abundance and cumulative percentage of each taxon for each comparison. © Natural England and Cefas, 2023.

Taxa	Average abundance	Average similarity	Contribution percentage	Cumulative percentage
Nemertea	1.63	4.49	14.46	12.27
<i>Glycera lapidum</i> (agg)	1.28	3.38	4.60	9.23
<i>Polycirrus</i>	1.47	3.34	7.89	9.14
<i>Pista mediterranea</i>	1.14	2.97	8.85	8.13
<i>Electra pilosa</i>	1.00	2.97	8.85	8.13
<i>Schizomavella</i>	1.00	2.97	8.85	8.13
<i>Spirobranchus lamarcki</i>	0.52	1.29	5.84	3.54
<i>Aonides oxycephala</i>	0.71	1.19	0.58	3.25
<i>Cliona celata</i>	0.67	1.11	0.58	3.04
Polynoidae	0.91	1.11	0.58	3.04

Table 14. Results from the infauna SIMPER analysis on square root transformed abundance data showing the taxa contributing to similarity for the non-hierarchical k-means cluster groups, with the relative abundance and cumulative percentage of each taxon for each comparison. Cluster group C & D contained single samples © Natural England and Cefas, 2023.

Cluster group	Taxa	Average abundance	Average similarity	Contribution percentage	Cumulative percentage
A	Nemertea	1.82	3.44	8.97	8.97
	<i>Glycera lapidum</i> (agg)	1.45	2.62	6.81	15.78
	<i>Phascolion (Phascolion) strombus strombus</i>	1.08	2.13	5.55	21.33
	<i>Electra pilosa</i>	1.00	2.13	5.55	26.89
	<i>Lumbrineris cingulata</i> (agg)	1.23	2.12	5.52	32.4
	<i>Echinocyamus pusillus</i>	1.06	1.82	4.73	37.13
	Serpulidae	1.07	1.78	4.65	41.78
	<i>Pista mediterranea</i>	0.88	1.52	3.96	45.74
	<i>Notomastus</i>	0.94	1.43	3.72	49.46
	<i>Syllis garciai</i>	1.03	1.23	3.21	52.67
D	Actiniaria	1.41	6.39	17.79	17.79
	<i>Syllis garciai</i>	1.21	4.52	12.58	30.36
	<i>Paucibranchia bellii</i>	1.37	4.52	12.58	42.94
	<i>Conopeum reticulum</i>	1.00	4.52	12.58	55.51
	<i>Scrupocellaria scruposa</i>	1.00	4.52	12.58	68.09
	<i>Escharella immersa</i>	1.00	4.52	12.58	80.67

Table 15. Results from the epifauna SIMPER analysis on square root transformed abundance data showing the taxa contributing to dissimilarity between the Broadscale Habitats (BSH), with the relative abundance and cumulative percentage of each taxon for each comparison. © Natural England and Cefas, 2023.

Taxa	A5.4 Subtidal mixed sediments	A3.2 Moderate energy infralittoral rock	Cumulative percentage
Biota > Bryozoa > Soft > Dendroid	0.05	0.77	10.61
Biota > Echinoderms > Sea stars > cf. <i>Asterias rubens</i> > <i>Asterias rubens</i>	0.77	0.68	20.75
Biota > Macroalgae > Red	0.04	0.67	29.73
Biota > Faunal turf	0.74	1.30	37.48
Biota > Macroalgae > Brown	0.19	0.52	44.10
Biota > Sponges > Massive forms > Simple	0.05	0.51	50.65
Biota > Bryozoa > Hard > Massive > cf. <i>Pentapora foliacea</i> > <i>Pentapora foliacea</i>	0.08	0.43	57.13
Biota > Molluscs > Gastropods > cf. <i>Calliostoma zizyphinum</i>	0.35	0.29	62.98
Biota > Macroalgae > Encrusting > Red > Calcareous	0.35	0.40	68.13
Biota > Sponges > Crusts > Encrusting	0.04	0.27	71.8

Table 16. Results from the epifauna SIMPER analysis on square root transformed abundance data showing the taxa contributing to similarity for 'A3.2 Moderate energy infralittoral rock', with the relative abundance and cumulative percentage of each taxon for each comparison. © Natural England and Cefas, 2023.

Taxa	Average abundance	Average similarity	Contribution percentage	Cumulative percentage
Biota > Faunal turf	1.30	15.13	28.6	28.60
Biota > Bryozoa > Soft > Dendroid	0.77	7.51	14.19	42.79
Biota > Macroalgae > Red	0.67	5.90	11.15	53.94
Biota > Echinoderms > Sea stars > cf. <i>Asterias rubens</i> > <i>Asterias rubens</i>	0.68	4.22	7.98	61.92
Biota > Sponges > Massive forms > Simple	0.51	3.51	6.64	68.56
Biota > Macroalgae > Encrusting > Red > Calcareous	0.40	3.05	5.76	74.32

Table 17. Results from the epifauna SIMPER analysis on square root transformed abundance data showing the taxa contributing to similarity for 'A5.4 Subtidal mixed sediment', with the relative abundance and cumulative percentage of each taxon for each comparison. © Natural England and Cefas, 2023.

Taxa	Average abundance	Average similarity	Contribution percentage	Cumulative percentage
Biota > Faunal turf	0.74	17.34	39.90	39.90
Biota > Worms > Polychaetes > Tube worms > Serpulidae > cf. <i>Spirobranchus</i> sp.	0.49	9.15	21.06	60.96
Biota > Echinoderms > Sea stars > cf. <i>Asterias rubens</i> > <i>Asterias rubens</i>	0.77	7.50	17.25	78.21

Table 18. Results from the epifauna SIMPER analysis on square root transformed abundance data showing the taxa contributing to similarity for the non-hierarchical k-means cluster groups, with the relative abundance and cumulative percentage of each taxon for each comparison. © Natural England and Cefas, 2023.

Cluster group	Taxa	Average abundance	Average similarity	Contribution percentage	Cumulative percentage
A	Biota > Faunal turf	1.29	15.66	27.40	27.40
	Biota > Bryozoa > Soft > Dendroid	0.91	10.34	18.10	45.50
	Biota > Macroalgae > Red	0.67	6.21	10.86	56.36
	Biota > Sponges > Massive forms > Simple	0.51	3.76	6.58	62.94
	Biota > Macroalgae > Encrusting > Red > Calcareous	0.43	3.60	6.30	69.24
	Biota > Worms > Polychaetes > Tube worms > Serpulidae > cf. <i>Spirobranchus</i> sp.	0.29	3.59	6.29	75.53
B	Biota > Macroalgae > Encrusting > Red > Calcareous	0.86	16.94	33.93	33.93
	Biota > Faunal turf	0.74	13.50	27.04	60.97
	Biota > Worms > Polychaetes > Tube worms > Serpulidae > cf. <i>Spirobranchus</i> sp.	0.73	11.89	23.82	84.79
C	Biota > Echinoderms > Sea stars > cf. <i>Asterias rubens</i> > <i>Asterias rubens</i>	1.56	14.77	37.75	37.75
	Biota > Faunal turf	0.95	5.83	14.90	52.65
	Biota > Worms > Polychaetes > Tube worms > Serpulidae > cf. <i>Spirobranchus</i> sp.	0.77	4.15	10.60	63.25
	Biota > Macroalgae > Encrusting > Red > Calcareous	0.74	3.59	9.17	72.43

Cluster group	Taxa	Average abundance	Average similarity	Contribution percentage	Cumulative percentage
D	Biota > Echinoderms > Sea stars > cf. <i>Asterias rubens</i> > <i>Asterias rubens</i>	1.30	24.82	42.24	42.24
	Biota > Faunal turf	0.82	15.42	26.25	68.49
	Biota > Worms > Polychaetes > Tube worms > Serpulidae > cf. <i>Spirobranchus</i> sp.	0.46	7.62	12.97	81.45
E	Biota > Faunal turf	0.66	34.98	52.81	52.81
	Biota > Worms > Polychaetes > Tube worms > Serpulidae > cf. <i>Spirobranchus</i> sp.	0.34	16.42	24.80	77.61
F	Biota > Faunal turf	0.70	14.66	53.96	53.96
	Biota > Bryozoa > Hard > Massive > cf. <i>Pentapora foliacea</i> > <i>Pentapora foliacea</i>	0.53	6.87	25.29	79.25

Annex 4. Non-indigenous species lists

Table 19. Taxa listed as non-indigenous species (present and horizon) which have been selected for assessment of Good Environmental Status in GB waters under MSFD Descriptor 2 (Stebbing and others, 2014). © Natural England and Cefas, 2023.

Species name	List	Species name	List
<i>Acartia (Acanthacartia) tonsa</i>	Present	<i>Alexandrium catenella</i>	Horizon
<i>Amphibalanus amphitrite</i>	Present	<i>Amphibalanus reticulatus</i>	Horizon
<i>Asterocarpa humilis</i>	Present	<i>Asterias amurensis</i>	Horizon
<i>Bonnemaisonia hamifera</i>	Present	<i>Caulerpa racemosa</i>	Horizon
<i>Caprella mutica</i>	Present	<i>Caulerpa taxifolia</i>	Horizon
<i>Magallana angulata</i>	Present	<i>Celtodoryx ciocalyptoides</i>	Horizon
<i>Magallana gigas</i>	Present	<i>Chama</i> sp.	Horizon
<i>Crepidula fornicata</i>	Present	<i>Dendostrea frons</i>	Horizon
<i>Diadumene lineata</i>	Present	<i>Agarophyton vermiculophyllum</i>	Horizon
<i>Didemnum vexillum</i>	Present	<i>Hemigrapsus penicillatus</i>	Horizon
<i>Dyspanopeus sayi</i>	Present	<i>Hemigrapsus sanguineus</i>	Horizon
<i>Ensis leei</i>	Present	<i>Hemigrapsus takanoi</i>	Horizon
<i>Eriocheir sinensis</i>	Present	<i>Megabalanus coccopoma</i>	Horizon
<i>Ficopomatus enigmaticus</i>	Present	<i>Megabalanus zebra</i>	Horizon
<i>Grateloupia doryphora</i>	Present	<i>Mizuhopecten yessoensis</i>	Horizon
<i>Grateloupia turuturu</i>	Present	<i>Mnemiopsis leidyi</i>	Horizon
<i>Hesperibalanus fallax</i>	Present	<i>Ocinebrellus inornatus</i>	Horizon
<i>Heterosigma akashiwo</i>	Present	<i>Paralithodes camtschaticus</i>	Horizon
<i>Homarus americanus</i>	Present	<i>Polysiphonia subtilissima</i>	Horizon
<i>Rapana venosa</i>	Present	<i>Pseudochattonella verruculosa</i>	Horizon
<i>Sargassum muticum</i>	Present	<i>Rhopilema nomadica</i>	Horizon
<i>Schizoporella japonica</i>	Present	<i>Telmatogeton japonicus</i>	Horizon
<i>Spartina anglica</i>	Present		
<i>Styela clava</i>	Present		
<i>Undaria pinnatifida</i>	Present		
<i>Urosalpinx cinerea</i>	Present		
<i>Watersipora subatra</i>	Present		

Table 20. Additional taxa listed as non-indigenous species in the JNCC ‘Non-native marine species in British waters: a review and directory’ report by Eno and others (1997) which have not been selected for assessment of Good Environmental Status in GB waters under MSFD. © Natural England and Cefas, 2023.

Species name (1997)	Updated name (2020)
<i>Thalassiosira punctigera</i>	<i>Ethmodiscus punctiger</i>
<i>Thalassiosira tealata</i>	
<i>Coscinodiscus wailesii</i>	
<i>Odontella sinensis</i>	<i>Biddulphia sinensis</i>
<i>Pleurosigma simonsenii</i>	
<i>Grateloupia doryphora</i>	
<i>Grateloupia filicina</i> var. <i>luxurians</i>	<i>Grateloupia subpectinata</i>
<i>Pikea californica</i>	
<i>Agardhiella subulata</i>	
<i>Solieria chordalis</i>	
<i>Antithamnionella spirographidis</i>	
<i>Antithamnionella ternifolia</i>	
<i>Polysiphonia harveyi</i>	<i>Melanothamnus harveyi</i>
<i>Colpomenia peregrina</i>	
<i>Codium fragile</i> subsp. <i>atlanticum</i>	
<i>Codium fragile</i> subsp. <i>tomentosoides</i>	<i>Codium fragile</i> subsp. <i>fragile</i>
<i>Gonionemus vertens</i>	
<i>Clavopsella navis</i>	<i>Pachycordyle michaeli</i>
<i>Anguillicoloides crassus</i>	
<i>Goniadella gracilis</i>	
<i>Marenzelleria viridis</i>	
<i>Clymenella torquata</i>	
<i>Hydroides dianthus</i>	
<i>Hydroides ezoensis</i>	
<i>Janua brasiliensis</i>	<i>Neodexiospira brasiliensis</i>
<i>Pileolaria berkeleyana</i>	
<i>Ammothea hilgendorfi</i>	
<i>Elminius modestus</i>	<i>Austrominius modestus</i>
<i>Eusarsiella zostericola</i>	
<i>Corophium sextonae</i>	<i>Monocorophium sextonae</i>

Species name (1997)	Updated name (2020)
<i>Rhithropanopeus harrisi</i>	
<i>Potamopyrgus antipodarum</i>	
<i>Tiostrea lutaria</i>	<i>Ostrea chilensis</i>
<i>Mercenaria mercenaria</i>	
<i>Petricola pholadiformis</i>	<i>Petricolaria pholadiformis</i>
<i>Mya arenaria</i>	

Annex 5. Marine litter categories

Table 21. Categories and sub-categories of litter items for Sea-Floor (European Commission, 2013). © Natural England and Cefas, 2023.

A: Plastic	B: Metals	C: Rubber	D: Glass/ Ceramics	E: Natural products/ Clothes	F: Miscellaneous
A1. Bottle	B1. Cans (food)	C1. Boots	D1. Jar	E1. Clothing/ rags	F1. Wood (processed)
A2. Sheet	B2. Cans (beverage)	C2. Balloons	D2. Bottle	E2. Shoes	F2. Rope
A3. Bag	B3. Fishing related	C3. Bobbins (fishing)	D3. Piece	E3. Other	F3. Paper/ cardboard
A4. Caps/ lids	B4. Drums	C4. Tyre	D4. Other		F4. Pallets
A5. Fishing line (monofilament)	B5. Appliances	C5. Other			F5. Other
A6. Fishing line (entangled)	B6. Car parts				
A7. Synthetic rope	B7. Cables			Related size categories A: $\leq 5*5 \text{ cm} = 25 \text{ cm}^2$ B: $\leq 10*10 \text{ cm} = 100 \text{ cm}^2$ C: $\leq 20*20 \text{ cm} = 400 \text{ cm}^2$ D: $\leq 50*50 \text{ cm} = 2500 \text{ cm}^2$ E: $\leq 100*100 \text{ cm} = 10000 \text{ cm}^2$ F: $\geq 100*100 \text{ cm} = 10000 \text{ cm}^2$	
A8. Fishing net	B8. Other				
A9. Cable ties					
A10. Strapping band					
A11. Crates and containers					
A12. Plastic diapers					
A13. Sanitary towels/ tampons					
A14. Other					

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