Benthic habitat mapping of Langness Marine Nature Reserve in the Isle of Man

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Benthic habitat mapping of Langness Marine Nature Reserve in the Isle of Man

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Abstract

A survey on the benthic habitats and communities of the Langness Marine Nature Reserve in the Isle of Man was carried out in 2024 Summer. The area was first designated as an inshore conservation zone in 2016, as maerl beds and an eelgrass meadow were found, which are habitats of conservation interest, followed by re-designation as Marine Nature Reserve (MNR) in 2018. As the MNR is comparatively new to the others, baseline habitat mapping of it has yet to be done. This study therefore aimed to map the benthic habitats and communities within the MNR, to provide baseline information for future management and monitoring efforts. A benthic imagery survey was conducted using a towed sledge, in which still images and footage of benthos were taken. The encountered habitats were classified into biotopes using both a statistical approach and a classification system. The survey results have identified 6 distinct benthic biotopes within the area of the MNR, with depth, the type of substratum and hydrodynamic regime as primary abiotic factors shaping the communities. No habitats of conservation interest have been identified. Although patches of maerl colonies have been found in the northern regions of the MNR, they are mostly composed of dead nodules. No large colonies of species of conservation interest or commercial species have been found.

Keywords:

Benthic Habitat; Mapping; Habitat classification; Marine Protected Area; Isle of Man

1. Introduction

Coastal benthic habitats are a key component of the marine ecosystem and are crucial to human survival. Apart from being a hub that nurtures a diversity of species, the ecosystem services offered, such as provision of food and abiotic resources, recycling of nutrients, and carbon sequestration, have justified their importance (Barbier et al., 2011; Hall, 2002; Snelgrove, 1999). However, benthic habitats are frequently experiencing disturbance, either by natural events, such as hydrodynamic activities and biological interactions (e.g. predation), or by human activities (Gray and Elliott, 2009; Hall and Harding, 1997; Jennings and Kaiser, 1998; Reise, 1978).

Regarding human disturbance to benthic habitats, fisheries activities are one the major players in bringing about adverse impacts to the benthic ecosystems. Unregulated fisheries activities could lead to drawbacks such as homogenisation of habitats, a decline in species biomass, abundance and diversity, as well as a shrink in the size structure and production of a community (Beukers-Stewart and Beukers-Stewart, 2009; Dayton et al., 1995; Jennings and Kaiser, 1998; Kaiser et al., 2006, 2002). Fortunately, since the late 20th century, the environmental management bodies around the globe have started to bring in an ecosystem-based approach (EBA) for fisheries management (FAO, 2003). Apart from the focus on protecting the targeted species, the EBA also considered the entire ecosystem in which the species live, aiming to preserve its structure, function, and diversity (Davies et al., 2021). Marine protected areas (MPAs) are established as part of the implementation of the EBA management (Gell and Roberts, 2003; Halpern and Warner, 2002; Roberts et al., 2001). With MPAs, the marine habitats in the protected sea areas are avoided from detrimental activities (Renn et al., 2024; Sala and Giakoumi, 2018), protecting the targeted species as well as its associated habitats and species (Mesnildrey et al., 2013).

Situated in the middle of the Irish Sea, the Isle of Man (IoM) is a self-governing UK Crown Dependency with a territorial sea covering a total area of approximately 4000 km^2 (Fig. 1) (DEFA, 2023). With such geographical privilege, it is not surprising that the fisheries sector has been a key player in the Manx economy for centuries (DEFA, 2023; Duncan and Emmerson, 2018). The king scallop, *Pecten maximus*, is the main fishery in Manx water, with the queen scallop, *Aequipecten opercularis*, coming second (DEFA, 2015; Duncan and Emmerson, 2018). The Department of Environment, Food and Agriculture (DEFA) Fisheries Directorate is a governmental body in the IoM responsible for the management and protection of its territorial sea, fisheries and their supporting ecosystems (Duncan and Emmerson, 2018). To date, 10 Marine Nature Reserves (MNRs) (a kind of MPA) have been established within the Manx inshore territorial waters (0-3 nm), protecting a total area of 430.75 km^2, which occupy 10.8% of the entire Manx territorial sea (Fig. 1). The MNRs are established for different reasons, including conservation purposes, fisheries management and experimental research, but it varies among MNRs (DEFA, 2024a, 2017).

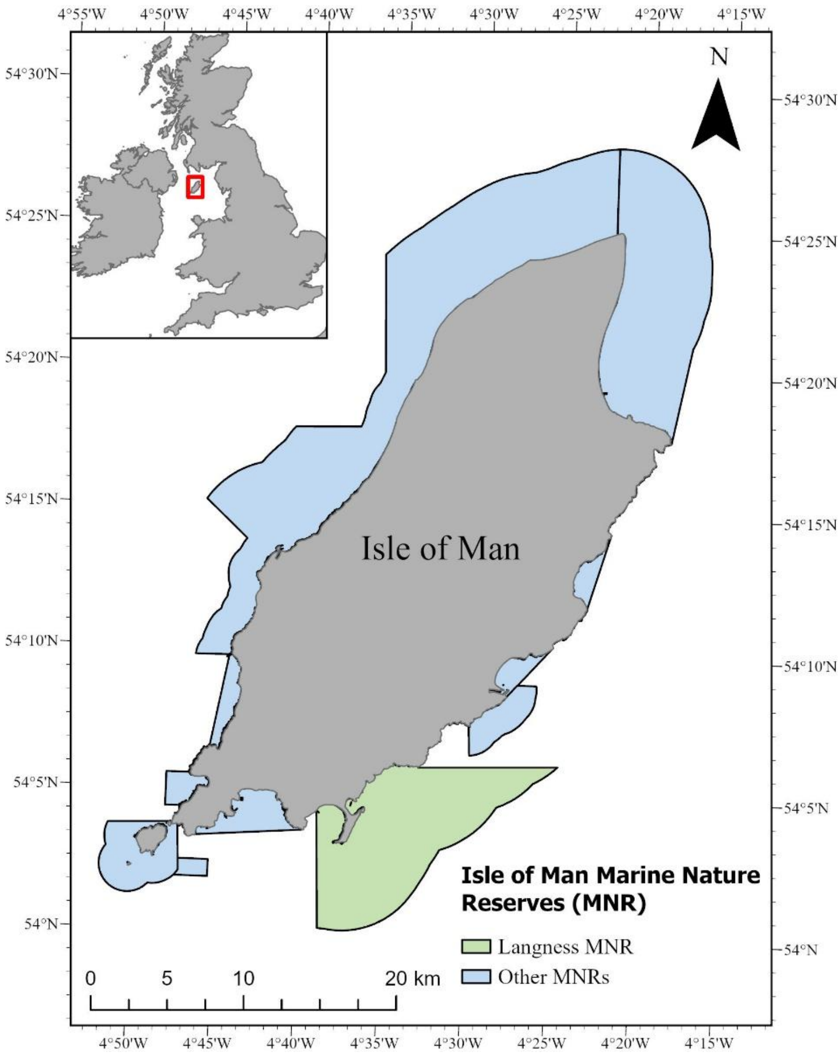


Fig. 1. A map of the Isle of Man, showing the area and location of the 10 Marine Nature Reserves (MNRs) designed in 2018. The location/area of the Langness MNR is shaded in green. The situation of the Isle of Man within the British Isles is shown on the smaller map at the top-left corner, indicated with a red box.

The coastal area of the Langness Peninsula was first in the spotlight in 2008. Thanks to its diverse rocky reef habitat, eelgrass meadow, and diverse sand/mud habitats, it has been identified as one of the candidate Marine Nature Reserve (MNR) sites in the *'Manx Marine Nature Reserve Project'* (DEFA, 2010; Howe, 2018; Thomas et al., 2018). Followed by the implementation of the *'Inshore Marine Zoning Plan for the 0-3 Nautical Mile Area of the Isle of Man Territorial Sea'* in 2016, the area has been designated as a 'conservation zone', with mobile fishing gear prohibited and habitats of conservation importance (for Langness, it is the maerl beds and an eelgrass meadow) protected (DEFA, 2017, 2016). On 1st September 2018, the area was re-designated as Langness Marine Nature Reserve (MNR) (Fig. 2) under the *Wildlife Act 1990*, becoming part of the 10 inshore MNRs network. General restrictions in MNR, such as bottom-towed fishing gear, are implemented in Langness MNR, but a specific management plan for the MNR is still under preparation as the MNR is relatively new (DEFA, 2018a, 2018b, 2017).

To protect the sensitive/vulnerable habitats and their associated species, it is necessary to know their distribution in the first place. Benthic habitat mapping with the inclusion of biotope classification is therefore being regarded as a useful tool for the management of marine-based resources (Fraschetti et al., 2024; Harris and Baker, 2012). As mentioned, the Langness MNR is relatively new, the baseline habitat mapping has therefore yet to be done. Though the general distribution of the benthic habitats within the Manx territorial sea was known, thanks to the previous coarse-scale survey (Hinz et al., 2008), habitats and species with restricted distribution are yet to be identified. Thus, surveys on a finer scale are required to be done in areas of conservation interest, such as the Langness MNR.

Given the aforementioned need, this study therefore aims to map the benthic habitats and communities within the MNR on a finer scale, determining the type, distribution and extent. The completion of the mapping work would provide baseline information for future management and monitoring efforts of the MNR, such as the assignment of conservation or fisheries management zone, just as in other MNRs.

2. Material and methods

2.1 Study Site

The study area, the Langness MNR, comprised a sector of the southeastern inshore waters of the IoM. It extends eastward from Santon Head (54° 06.0000' N, 04° 33.0000' W) and southward from Castletown Harbour (54° 04.3998' N, 04° 39.0000' W), out to 3 nautical miles from shore at an astronomical high tide, which covered a total area of 88.67 km^2 (DEFA, 2024a, 2024b) (Fig. 2) .

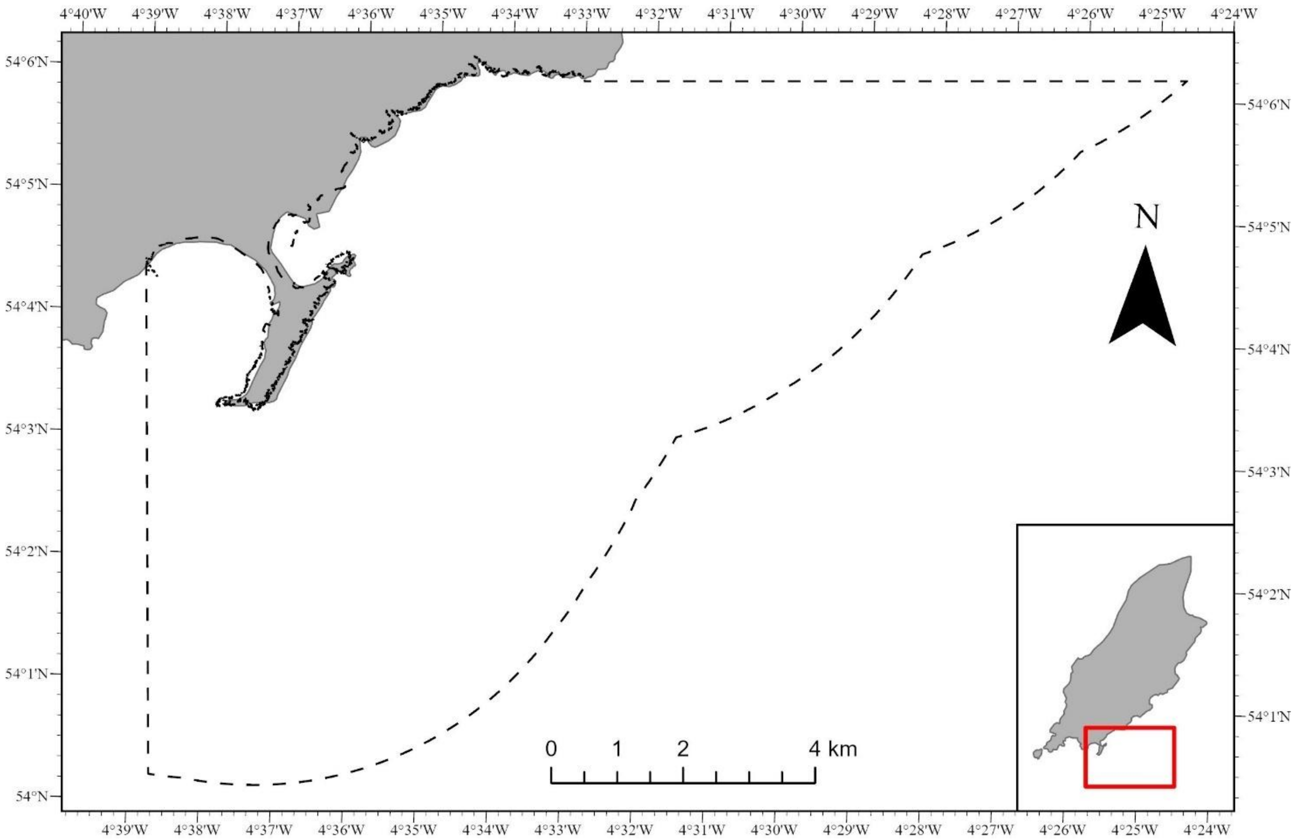


Fig. 2. A map showing the area of the Langness Marine Nature Reserve (MNR). Its situation within the Isle of Man's inshore waters is indicated on the small map at the bottom-right corner with a red box.

2.2 Habitat mapping

A grid system with a grid square size of 1km^2 each was used in this project to allocate sampling stations across the area of the MNR. The sampling stations were roughly 1km apart. At each station, a sledge with still image and video capability was deployed and towed along the seabed to record the benthos present. The sledge is composed of a metal frame on skids, with cameras and light fixed at the centre and oriented to face the seabed (Fig. 3). Two cameras in waterproof housing were used in this survey, namely a Canon EOS 400D, set to take a flashed photo every 10 seconds [Field of View (FOV) = 44 x 29 cm], and a GoPro HERO3 for recording continuous video footage (FOV = ~62 x 35 cm).

The sampling work took place over 4 days in June 2024 by onboarding the IoM Government's Fisheries Patrol Vessel, the Barrule, and completed 49 transects within the MNR. At each sampling station, the sledge was towed along the seabed at approximately 1 knot for around 10 minutes, to obtain a 10-minute video clip and 60 still photos for each transect. Position data, including GPS coordinates, time and vessel speed, were automatically logged every 30 seconds throughout the survey journey and manually recorded at the beginning and end of each tow to allow geo-referencing of the captured photographs. Water depth was also noted down at the start, middle and end of each tow.

Fig. 3. Photograph of the equipment, the sledge, used for collection of the benthic imagery data. Both the cameras and light were fixed on the raised unit at the centre.

2.3 BRUVS sampling

Baited remote underwater video systems (BRUVS) were used for the identification of mobile species present within the MNR. Each of the BRUVS is composed of a rectangular metal frame with three GoPro cameras (either HERO3 or HERO3+, settings: 1080p, 60/50/30 fps, Wide FOV) attached on top, viewing at three different angles (top-down, top-45°left, and top-45°right) (Fig. 4). Bait (herring, *Clupea harengus*) packed in a mesh bag was fixed at the bottom of the frame (in the centre), to produce a scent for attracting mobile species. A total of 20 BRUVS were deployed, and each was left on the seabed for at least an hour. At each deployment site, GPS coordinates, water depth, as well as start and end time of deployment were recorded.

Fig. 4. Photograph of the BRUVS, equipment used for collecting mobile species data. Three GoPro cameras at different viewing angles were fixed on top of the rectangular metal frame.

2.4 Analysis of images and videos

2.4.1 Visibility and Quality Assessment

To ensure data reliability, the still images and video footage captured were assessed for visibility and quality before any further analysis. The assessment was done by applying a standardised scoring system adapted from Hannah and Blume (2012) (Table 1). Based on the defined criteria, the images and videos were scored from 0 to 3; those that scored 0 on either visibility or quality were omitted from further analysis.

Table 1

The scoring system applied for the visibility and quality assessment of the images and videos captured. (Hannah and Blume, 2012).

Score	Visibility	Quality
0	The field of view is completely obscured by close-up species or suspended sediment.	The image/video is completely blurred or has major problems with lightning/viewing angle.
1	The field of view is greatly obscured (>50%) by close-up species or suspended sediment.	The image/video is greatly blurred (>50%) or has some problems with lightning/viewing angle.
2	The field of view is partially obscured (<50%) by close-up species or suspended sediment.	The image/video is greatly blurred (<50%) or has minor problems with lightning/viewing angle.
3	The field of view is clear/of insignificant obstruction.	The image/video is clear/of insignificant quality issues.

2.4.2 Analysis of images from the towed sledge

The still images were analysed using the image annotation function of a web-based application, BIIGLE. (Langenkämper et al., 2017). Three types of data were extracted from the analysed images, including 1) the percentage cover of the fauna, flora and physical benthic substrate by applying the point sampling technique (Fig. 5) (Ninio et al., 2003; Ryan, 2004; Wakeford et al., 2008); 2) the presence/absence of faunal and floral taxa; and 3) the abundance of countable epifauna. 5 images were analysed per towed transect, and each was captured at an interval of 120 seconds apart, achieving an even distribution of analysed images throughout the 10-minute tow. In case of poor visibility or quality (scored 0), the image captured 10 seconds before or after was used as a replacement for the image analysis.

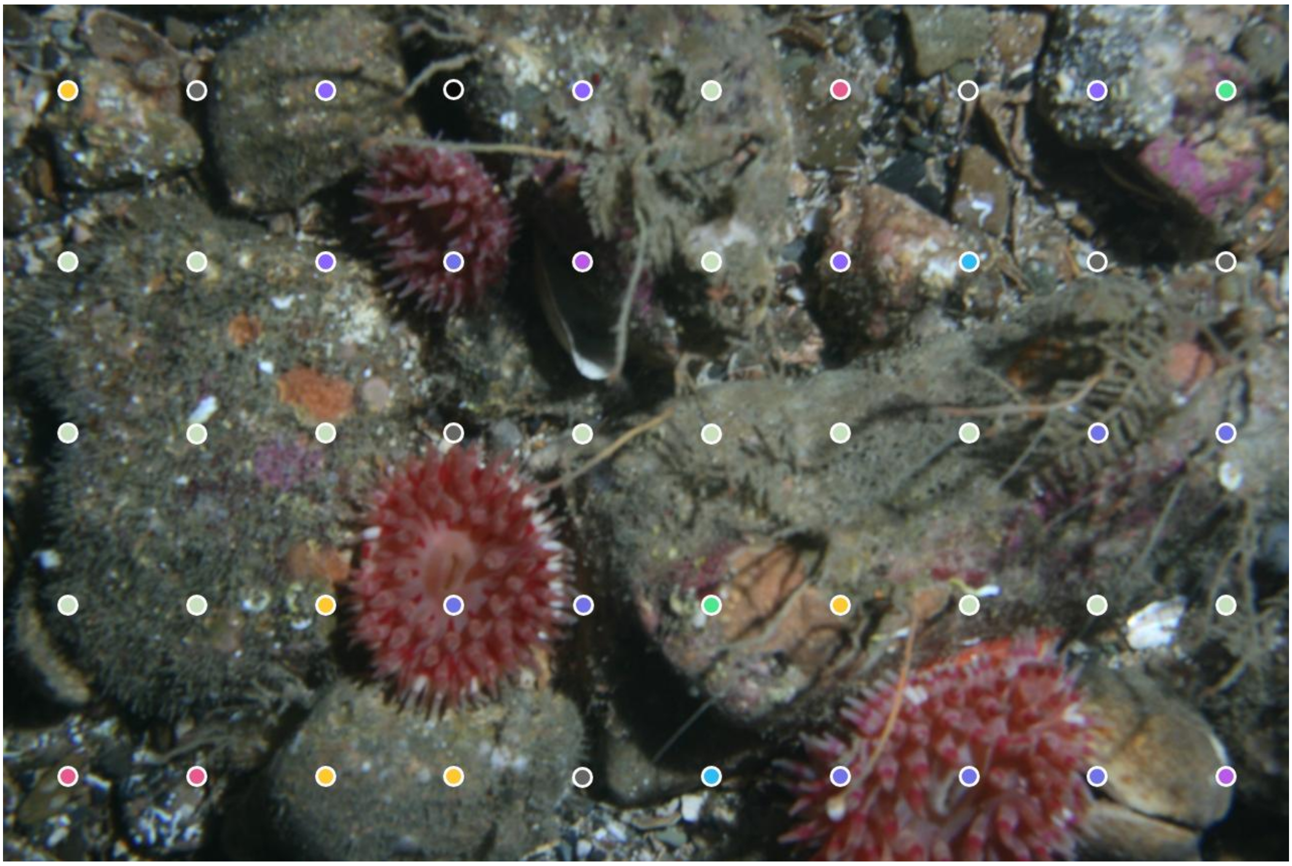


Fig. 5. An example image showing the (regular) point sampling technique applied for obtaining the relative percentage cover data. The fauna, flora, or physical benthic substrate found at each of the 50 points were identified, with each point taken as a 2% cover. For this example, the Dahlia anemone, *Urticina felina*, has been identified at 6 points, thus covering 12% of this image.

All taxa encountered were identified to the lowest possible taxonomical level, using several photo identification guides, namely Moen and Svensen (2004), Kay and Dipper (2009), Bunker et al. (2012), Porter (2012), Sterry and Cleave (2012), Wood (2013), and Wood (2018). Broad descriptive categories were used in the case of problematic taxa identification. Physical benthic substrates were determined visually and described into board categories based on a simplified version of the Wentworth scale (Wentworth, 1922) (Table 2). The described substrates include boulders, cobbles, dead maerl, dead shells, shell fragments, pebbles, and granules.

Table 2

A simplified version of the Wentworth scale, used for physical benthic substrate determination (Wentworth, 1922).

Classification	Particle size (diameter)
Boulders	>256 mm
Cobbles	64 – 256 mm
Pebbles	4 – 64 mm
Granules	2 – 4 mm

2.4.3 Analysis of videos from the BRUVS

The videos were also analysed with BIIGLE (Langenkämper et al., 2017), using its video annotation function. The duration of the analysis for each video was standardised as 60 minutes. MaxN, a conservative, commonly used approach for the estimation of the total number of individuals from a species (Cappo, 2010; Whitmarsh et al., 2017), was applied to estimate the abundance of mobile species at each BRUVS station. For any species identified in a video, its MaxN is defined as the maximum number of individuals observed in a single frame (Ebner et al., 2009; Loiseau et al., 2016). Since each BRUVS unit has three analysed videos, for an identified mobile species, its abundance estimate at a BRUVS station was determined by referring to its maximum MaxN value obtained from the video analyses.

2.5 Data Analysis

All multivariate analyses were performed using functions in PRIMER 7 (details in the following sections), whereas the univariate analyses were done using the packages installed in RStudio. All presented maps were prepared in ArcGIS Pro.

2.5.1 Biotope classification

A biotope was assigned to each of the benthic habitats/communities identified from the previous analyses of the geo-referenced still images. A biotope was assigned through two methods: 1) using statistical method (multivariate) in PRIMER 7; and 2) application of the habitat classification system, '*The Marine Habitat Classification for Britain and Ireland*' (MHCBI) (Version 22.04) (JNCC, 2022).

2.5.1.1 Biotope classification in PRIMER 7

A CLUSTER analysis (hierarchical agglomerative method) with the inclusion of similarity profile (SIMPROF) tests (for defining significant clusters, $p < 0.05$) was performed on the similarity matrix of the square-root transformed percentage cover data (Clarke et al., 2014, 2008; Gordon, 1987). The sampling stations were grouped according to their similarity in benthic community assemblages, forming individual 'clusters', and each 'cluster' was defined as a distinctive biotope.

With the defined biotopes as a factor, ANOSIMs (Analysis of similarity) were run on the similarity matrixes of the square-root transformed percentage cover data, taxa presence/absence data, and countable epifauna abundance data to determine if the community assemblages of the defined biotopes are significantly different from each other (Clarke and Green, 1988). As a follow-up analysis, SIMPERs (Similarity percentage) were carried out on the aforementioned square-root transformed data, to identify the discriminating taxon that contributed to the distinctiveness of the biotopes (Clarke, 1993). A non-metric multidimensional scaling (nMDS) plot was eventually used to visualise the differences between biotopes (Kruskal and Wish, 1978).

2.5.1.2 MHCBI biotope classification

The defined biotopes in the MHCBI system are categorized in a 6-level hierarchical structure (Table 3) (JNCC, 2022). Biotopes in the first 3 levels are defined based on physical parameters, including water depth, substrate type, wave energy and current energy. Further down the hierarchy, the biological community information is also included in defining the biotopes.

Table 3

An example of the application MHCBI system for biotope assignment.

Level	Category	Example	Code
Level 1	Environment	Marine	-
Level 2	Broad habitat type	Sublittoral sediment	SS
Level 3	Habitat complex	Sublittoral macrophyte-dominated communities on sediments	SS.SMp
Level 4	Biotope complex	Kelp and seaweed communities on sublittoral sediment	SS.SMp.KSwSS
Level 5	Biotope	Saccharina latissima and red seaweeds on infralittoral sediments	SS.SMp.KSwSS.SlatR
Level 6	Sub-biotope	Saccharina latissima and robust red algae on infralittoral gravel and pebbles	SS.SMp.KSwSS.SlatR.Gv

A biotope in the MHCBI system was assigned to each sampling station (analysed still image), based on both the measured or obtained abiotic and biotic data. For abiotic parameters, water depth was measured during sampling, substrate type was determined during the analysis of still images, and wave and current energy were obtained from the EMODnet Seabed Habitats portal (EMODnet, 2022). As for the biotic component, both the still images and footage captured by the towed sledge within a similar time frame (±30 seconds) were used for determining the benthic taxon present. All biotopes were assigned to the lowest possible level.

ANOSIMs followed by SIMPERs were done in a similar approach as mentioned in the previous section but the factor was changed to the identified MHCBI biotopes. A nMDS plot was also used to visualise the differences. In addition, the species richness (number of species, *S*), summed abundance of countable epifauna and summed algal percentage cover of each sampling station were calculated. The means were then tested for differences among biotopes using ANOVAs (Analysis of variance), or Kruskal–Wallis tests, in case of failure to fulfil parametric assumptions of ANOVA (Rohlf, 2011).

2.5.2 Creation of habitat maps

Maps of the estimated extent of the identified biotopes (both classification methods) within the Langness MNR boundary were created through Euclidean allocation analysis of point samples in ArcGIS Pro. The biotope assigned to each sampling station was extrapolated to the cells nearby, eventually forming a map of biotopes covering the area of the MNR.

2.5.3 Environmental variables

The relationship between environmental variables and benthic community assemblage was assessed using the BEST function (BIO-ENV routine) in PRIMER 7 (Clarke and Gorley, 2015). The considered variables include water depth, the coverage of different substrate types, algal coverage, wave energy, and current energy. Through the 'BEST' analysis, the variable(s) that 'best' correlate with the community assemblage were identified.

2.5.4 Data from the BRUVS

An ANOSIM with MHCBI biotopes as a factor was run on the similarity matrix of the square-root transformed mobile species abundance data to test for significant differences in community assemblage between biotopes. The MHCBI biotope associated with each BRUVS station was determined based on the created biotope map. A SIMPER was also carried out on the aforementioned square-root transformed data as a follow-up analysis to identify the discriminating mobile species that contributed to the distinctiveness of the biotopes. An nMDS plot was eventually applied for visualization of the differences in community assemblage between biotopes. In addition, the species richness (number of species, *S*) of each sampling station was calculated and the mean was then tested for differences among biotopes using the Kruskal–Wallis test.

A 'BEST' analysis was also done to identify which of the three environmental variable(s), namely water depth, wave energy, and current energy, 'best' correlate with the structure of community composition.

3. Results

3.1 Towed sledge sampling

Due to time constrain, 75 images captured from 15 towed transects (Fig. 6) were selected for analysis to obtain percentage cover and species data. The images were of acceptable quality only, most had minor focus issues due to gear malfunctioning. Only 4% of the images scored 3 in both visibility and quality while the majority (~90%) scored 2 in quality and 3 in visibility.

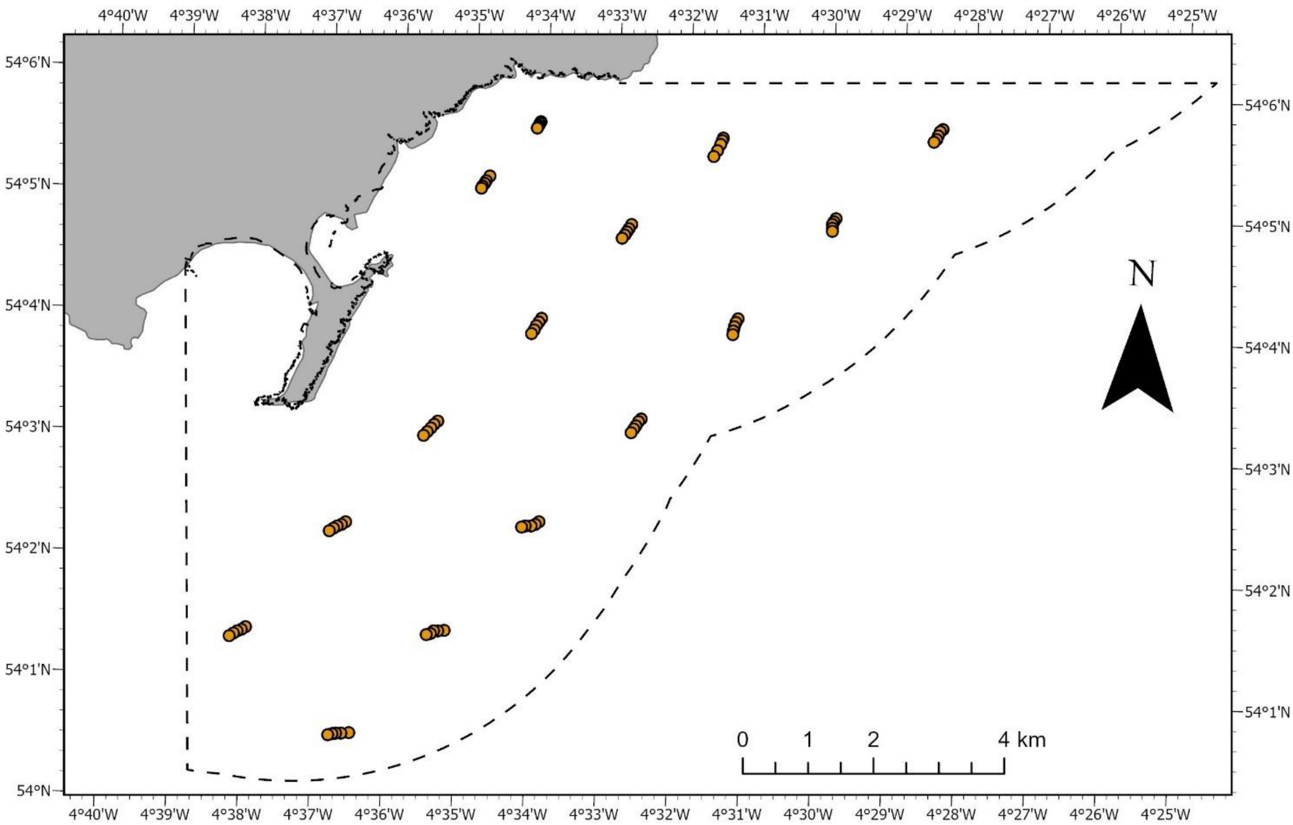


Fig. 6. A map showing the location of the 75 analysed still images taken along the 15 towed transects in Langness MNR.

3.1.1 Identified taxa

A total of 82 taxa were identified from the analysed still images (supplementary data, Table A1), including 18 algae (22%), 16 cnidarians (20%), 15 molluscs (18%), 8 arthropods (10%), 6 bryozoans (7%), 6 sponges (7%), 4 echinoderms (5%), 3 algae/hydroids/bryozoans mix (4%), 2 annelids (2%), 2 ascidians (2%), and 2 teleosts (2%). More than 80% of the taxa were identified to at least family level, 73% were identified to species or genus level, and the remaining taxa were categorised into broad descriptive categories.

Species richness in individual images ranged from 3 to 18 taxa, with an average of 10 taxa per image. 7 taxa were commonly encountered, each found in more than 40% of the analysed still images. These taxa include brownish-green encrusting bryozoan, Serpulidae spp., Corallinaceae spp., muddy surface turf, *Parasmittina trispinosa*, *Glycymeris glycymeris*, and *Steromphala cineraria*. If only the countable epifauna is considered, the top five most common taxa include *Glycymeris glycymeris* (65%), *Steromphala cineraria* (48%), *Galathea intermedia* (32%), *Gibbula magus* (29%), and *Calliostoma zizyphinum* (19%).

Taxa with conservation and commercial importance were identified in Langness MNR, namely maerl and queen scallop, *Aequipecten opercularis*. The maerl has a restricted distribution, it was only present in the northern region of the MNR, both inshore and offshore. Live maerl was present in 9% of the analysed still images, with an average cover of 0.56 ± 0.18%, while dead maerl was sighted in 40% of the images and averaged at 4.70 ± 0.54% cover. As for the queen scallop, only a single individual was recorded from the analysed still images, in which the sampling station was situated in the centre of the MNR.

3.1.2 Environmental variables

The water depth (below CD) of the sampling stations ranged from 19.1m to 38.7m, with an average of 32.0±0.57m (Fig. 7a). The substratum across the sampling area was heterogenous, with granules, pebbles, cobbles, boulders, shells, and coarse sediments. Most of the sampling areas have substrates mainly composed of pebbles and cobbles, with some degree of shells and coarse sediments. The strength of the current and wave in these areas was generally weak to moderate. In areas with substratum consisting of boulders, e.g. the coastal waters in front of Langness Peninsula and Port Grenaugh, the current or wave strength was comparatively stronger (Fig. 7b).

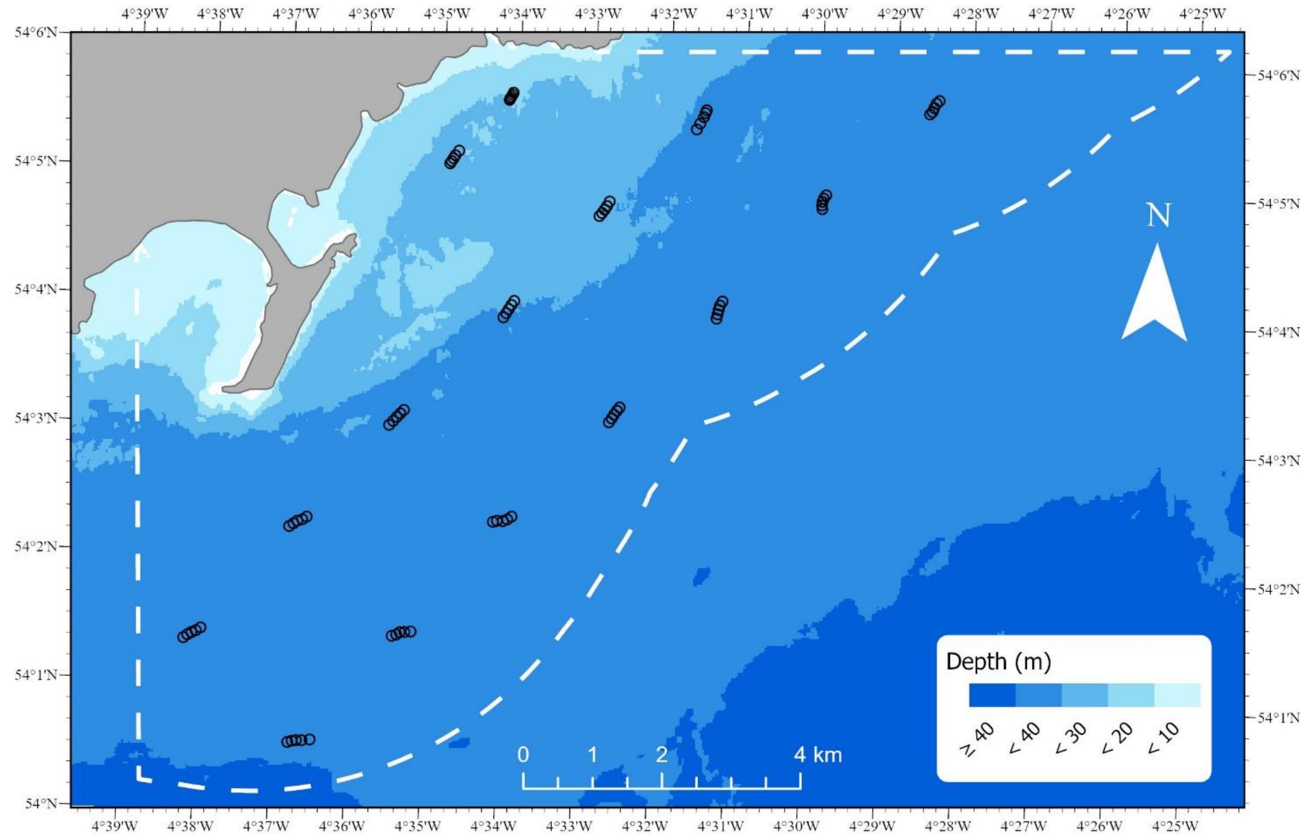


Fig. 7a. A map showing the bathymetry (below CD) across the areas of the Langness MNR (EDINA, 2020), with locations of towed sledge sampling stations (only those with image analysis done) overlaid on top.

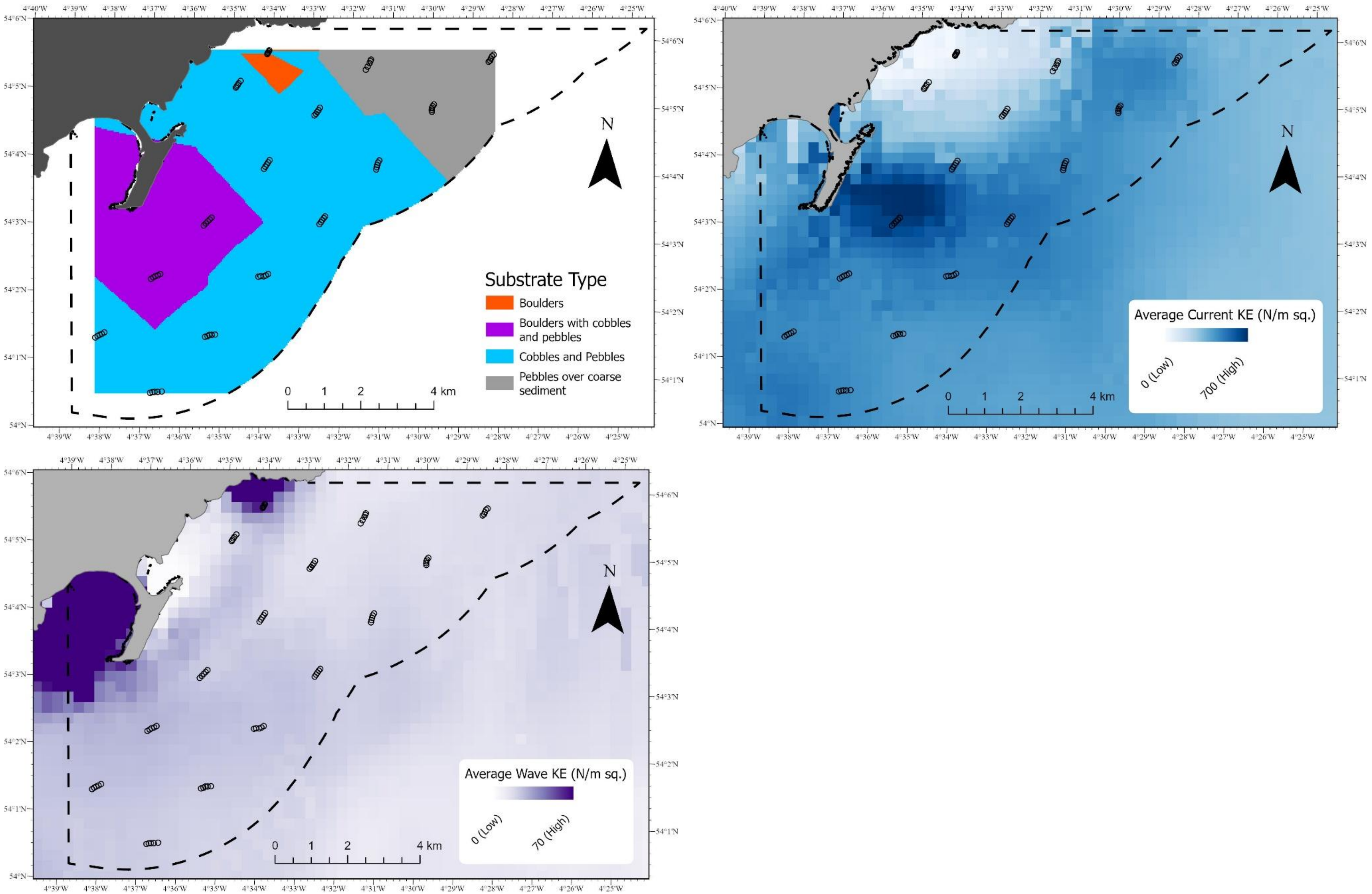


Fig. 7b. A map showing the substrate type, current energy (N/m^2) (EMODnet, 2022), and wave energy (N/m^2) (EMODnet, 2022) across the areas of the Langness MNR, with locations of towed sledge sampling stations (only those with image analysis done) overlaid on top.

3.1.3 PRIMER biotopes

Based on the percentage cover data, the PRIMER statistical approach has identified 9 clusters of benthic communities (supplementary data, Fig. A1) in Langness MNR. Each 'cluster' is defined as a distinct biotope, named with an alphabet (a-i). The associated PRIMER biotope of each sampling point (analysed still image) and their distribution within the Langness MNR boundary is shown on the map in Figure 8.

ANOSIMs have confirmed the significant difference in community structure among biotopes, in terms of both the percentage cover data ($R = 0.724$, $p = 0.001$) (Fig. 9) and taxa presence/absence data ($R = 0.431$, $p = 0.001$). The summary of each of the identified biotopes is provided in Table 4 with the inclusion of the SIMPER analysis results.

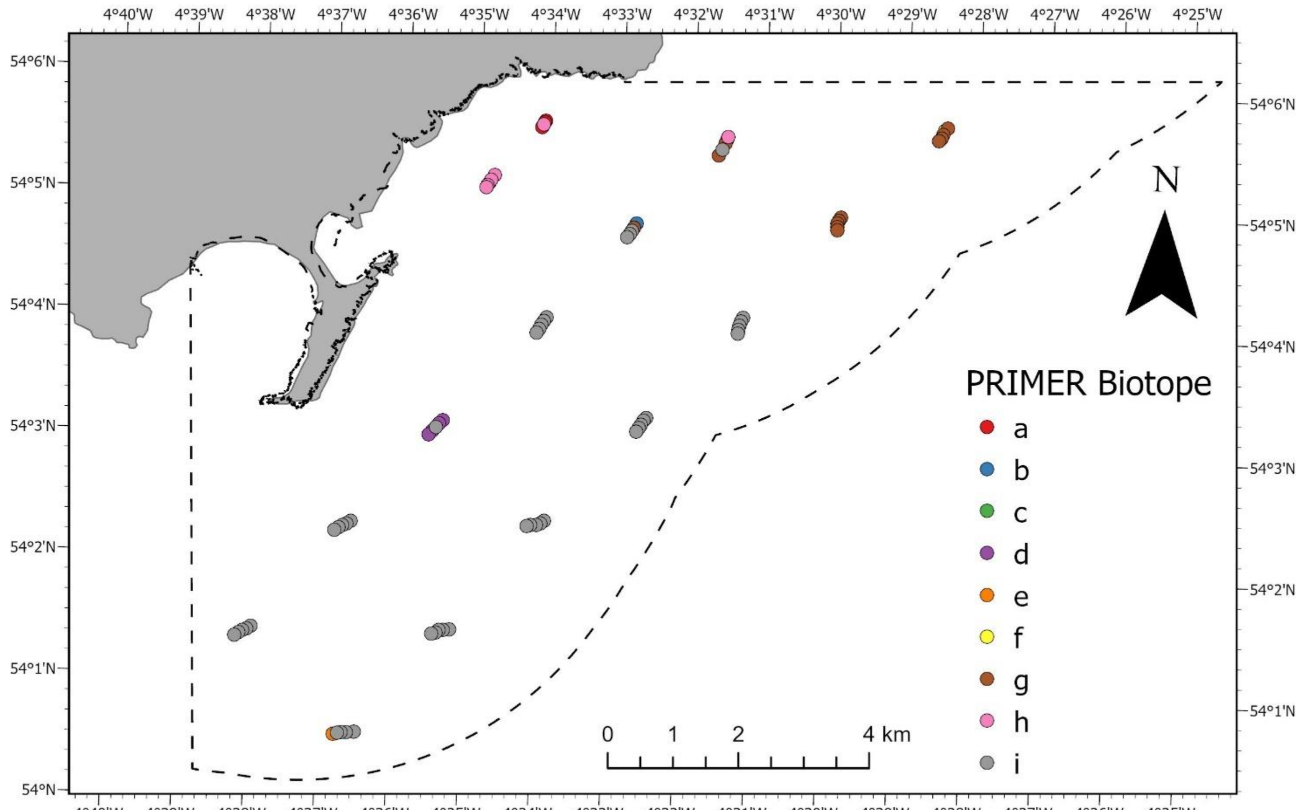
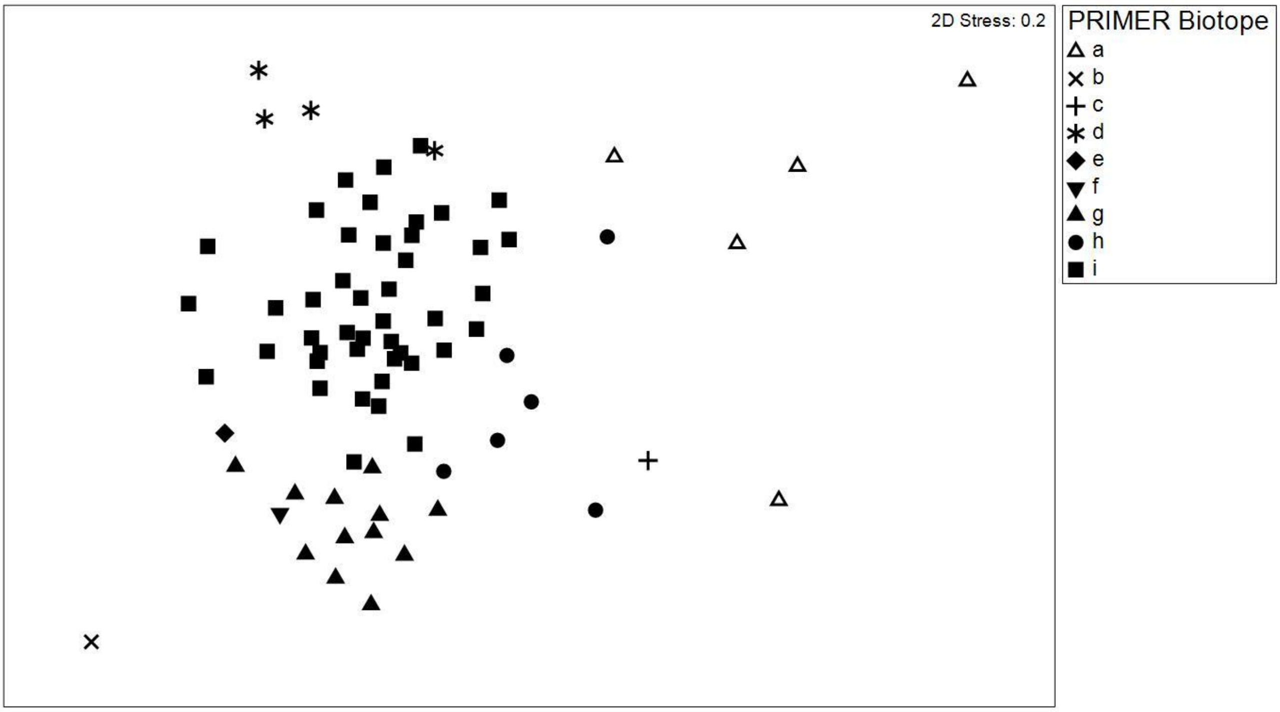


Fig. 8. A map showing the associated PRIMER biotope of each sampling point (analysed still image) and their distribution within the Langness MNR boundary.



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307 **Fig. 9.** An nMDS plot showing the relationship between communities of each sample. The plot was created using
308 percentage cover data, with each sample assigned a symbol according to their associated biotope. Points in close proximity
309 indicate high similarity with each other while points further apart indicate low similarity.

Table 4

A summary of the benthic biotopes identified in Langness MNR using the PRIMER statistical approach. The table below includes the total number of sampling sites (still images used) for each biotope, the average similarity in percentage cover data among sampling sites within each biotope (full SIMPER analysis result of the percentage cover data is available in the supplementary data, Table A2), and the discriminating taxa for each biotope (the taxa that contributed to both within biotope similarity and between biotopes dissimilarity in terms of community composition), based on the taxa presence/absence data.

PRIMER Biotope	No. of sampling sites (still images used)	Average similarity	Discriminating taxa
a	5	43%	Branching red seaweed, *Clavelina lepadiformis*, *Delesseria sanguinea*, Flat brown seaweed, Mixed turf of algae with bryozoan and/or hydroid, *Parasmittina trispinosa*, *Phyllophora spp.*, *Plocamium spp.*, *Schizomavella spp.*, *Steromphala cineraria*, Thin flat red seaweed
b	1	100%	*Calliostoma zizyphinum*, *Galathea intermedia*, *Halecium spp.*, *Hydrallmania falcata*, *Nemertesia antennina*, *Pagurus bernhardus*, *Pomatoschistus spp.*
c	1	100%	Serpulidae spp.
d	4	61%	Anomiidae spp., *Corynactis viridis*, *Crisia spp.*, *Schizomavella spp.*, *Steromphala cineraria*, *Tubularia indivisa*
e	1	100%	Small pinkish crab, *Synarachnactis lloydii*
f	1	100%	*Steromphala cineraria*
g	12	69%	*Gibbula magus*, *Glycymeris glycymeris*, *Steromphala cineraria*
h	6	61%	Brownish green encrusting bryozoan, *Glycymeris glycymeris*, *Hapalidiaceae spp.*, *Nemertesia antennina*, Serpulidae spp.
i	44	60%	*Galathea intermedia*, *Glycymeris glycymeris*, Mixed turf of bryozoan and hydroid, Muddy surface turf, *Steromphala cineraria*

3.1.4 MHCBI biotopes

Based on the percentage cover data, the MHCBI classification system approach has identified 6 distinct biotopes in Langness MNR. The associated MHCBI biotope of each sampling point (analysed still image) and its distribution within the Langness MNR boundary are shown on the map in Figure 10.

ANOSIMs have confirmed the significant difference in community structure among biotopes, in terms of the percentage cover data (R = 0.585, p = 0.001) (Fig. 11), taxa presence/absence data (R = 0.447, p = 0.001), and countable epifauna abundance data (R = 0.505, p = 0.001). The summary of each of the identified biotopes is provided in Table 5 with the inclusion of the SIMPER analysis results.

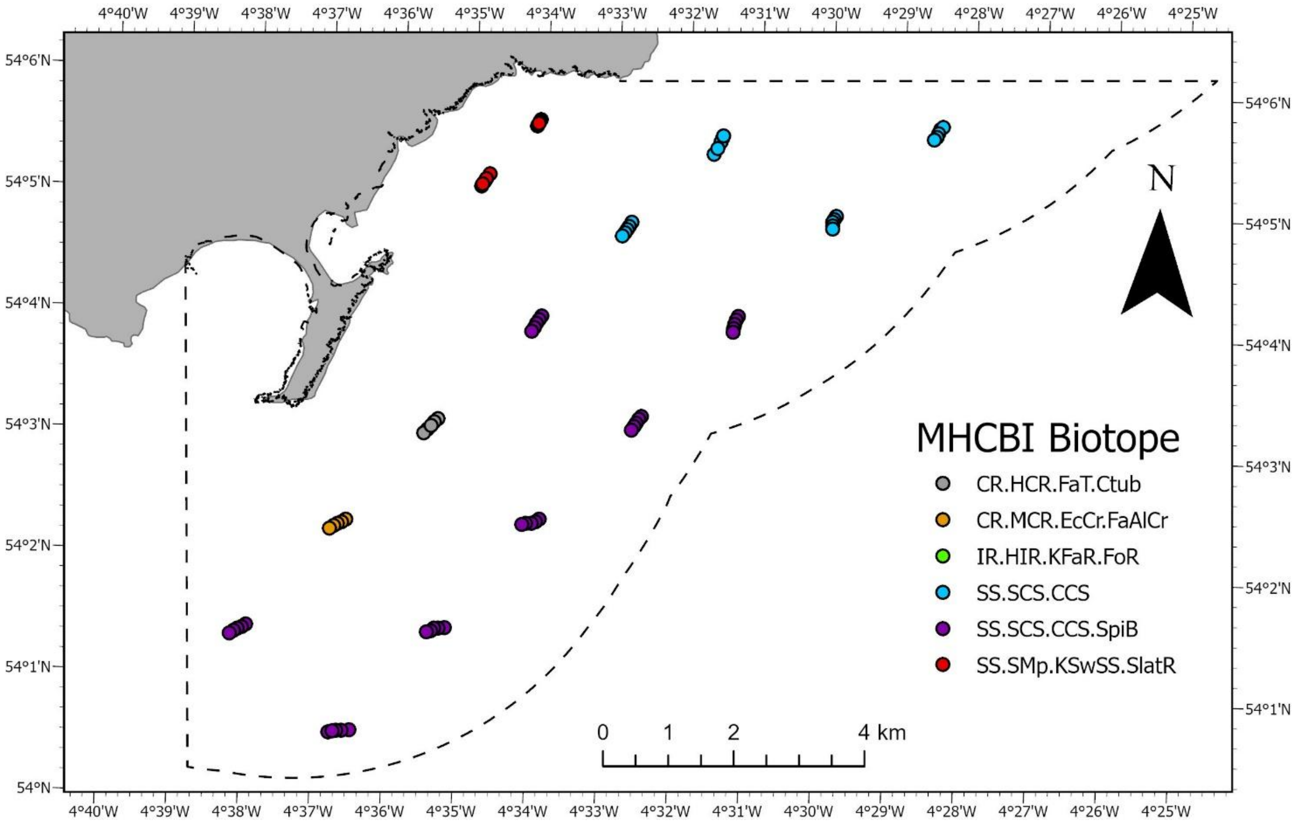
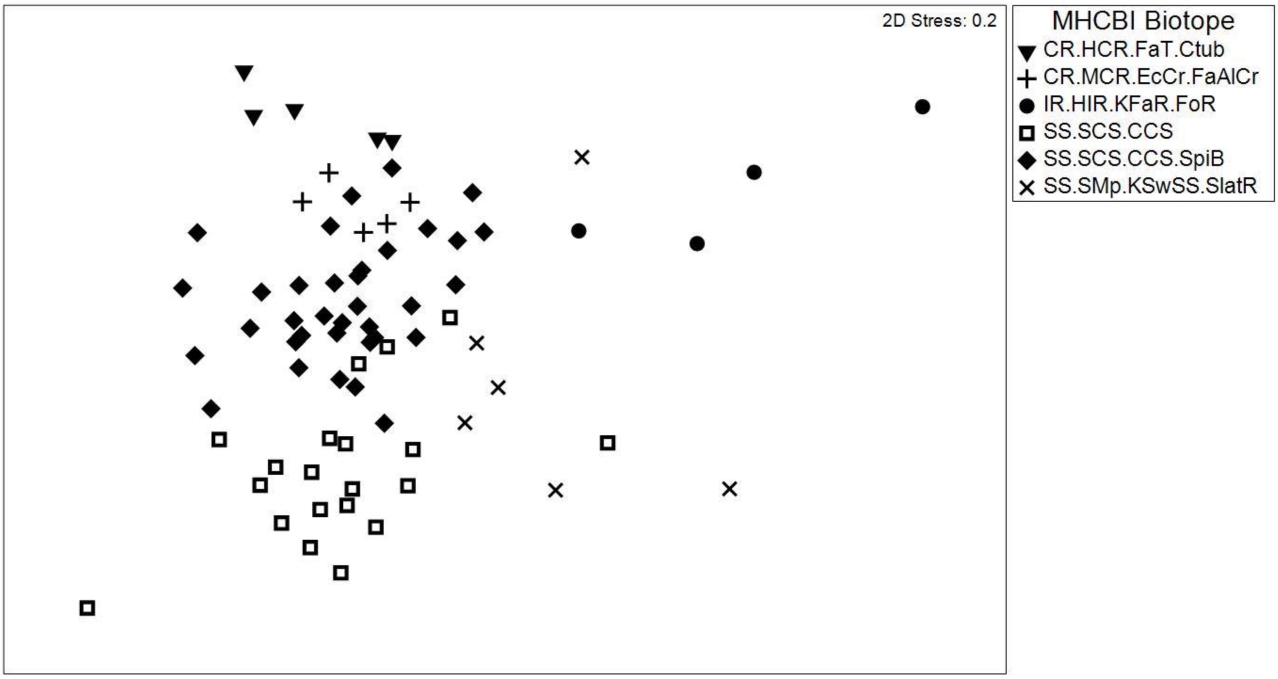


Fig. 10. A map showing the associated MHCBI biotope of each sampling point (analysed still image) and their distribution within the Langness MNR boundary.



331

332 **Fig. 11.** An nMDS plot showing the relationship between communities of each sample. The plot was created using
333 percentage cover data, with each sample assigned a symbol according to their associated biotope. Points in close proximity
334 indicate high similarity with each other while points further apart indicate low similarity.

Table 4

A summary of the benthic biotopes identified in Langness MNR using the MHCBI classification system approach. The table below includes the total number of sampling sites (still images used) for each biotope, the average similarity in percentage cover data among sampling sites within each biotope (full SIMPER analysis result of the percentage cover data is available in the supplementary data, Table A3), and the discriminating taxa for each biotope (the taxa that contributed to both within biotope similarity and between biotopes dissimilarity in terms of community composition), based on the taxa presence/absence data.

MHCBI Biotope	Biotope no.	No. of sampling sites (still images used)	Average similarity	Discriminating taxa
CR.HCR.FaT.Ctub Tubularia indivisa on tide-swept circalittoral rock	1	5	59%	Anomiidae spp., *Balanus spp.*, *Corynactis viridis*, *Crisia spp.*, Mixed turf of bryozoan and hydroid, *Schizomavella spp.*, *Steromphala cineraria*, *Tubularia indivisa*
CR.MCR.EcCr.FaAlCr Faunal and algal crusts on exposed to moderately wave-exposed circalittoral rock	2	5	69%	*Balanus spp.*, *Calliostoma zizyphinum*, *Corynactis viridis*, *Tubularia indivisa*
IR.HIR.KFaR.FoR Foliose red seaweeds on exposed lower infralittoral rock	3	4	48%	*Delesseria sanguinea*, *Dictyota dichotoma*, Mixed turf of algae with bryozoan and/or hydroid, *Nemertesia antennina*, *Parasmittina trispinosa*, *Phyllophora spp.*, *Schizomavella spp.*
SS.SCS.CCS Circalittoral coarse sediment	4	20	59%	*Glycymeris glycymeris*, *Parasmittina trispinosa*, *Steromphala cineraria*
SS.SCS.CCS.SpiB Spirobranchus triqueter with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles	5	35	60%	Corallinaceae spp., *Galathea intermedia*, *Glycymeris glycymeris*, Mixed turf of bryozoan and hydroid, Muddy surface turf, *Parasmittina trispinosa*, *Steromphala cineraria*
SS.SMp.KSwSS.SlatR Saccharina latissima and red seaweeds on infralittoral sediments	6	6	52%	Brownish green encrusting bryozoan, *Calliostoma zizyphinum*, *Gibbula magus*, Hapalidiaceae spp., Mixed turf of algae with bryozoan and/or hydroid, Muddy surface turf, *Nemertesia antennina*, *Plocamium spp.*, Serpulidae spp., *Steromphala cineraria*

3.1.5 Summary of biotope classifications

In summary, the two biotope classification approaches have identified 9 (PRIMER) and 6 (MHCBI) biotopes respectively. The associated biotope of each sampling point was extrapolated to its nearby areas, creating maps showing the estimated distribution of biotopes within the Langness MNR boundary (Fig. 12). Considering the suitability of the approach to the data collected, the MHCBI classification system has been adopted for the remaining analysis of the data (to be further explained in discussion).

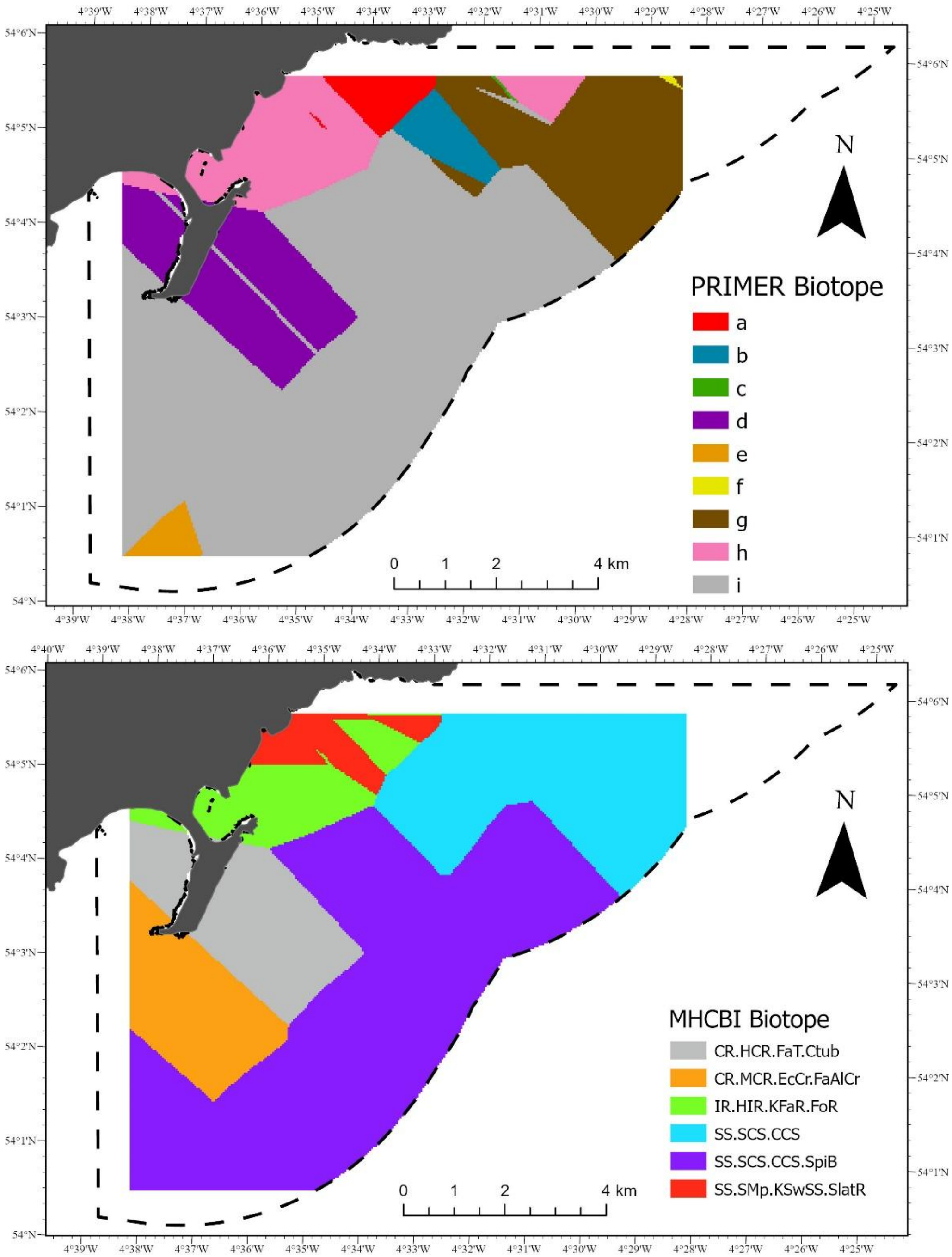


Fig. 12. Maps showing the estimated distribution of PRIMER biotopes (above) and MHCBI biotopes (below) within the Langness MNR boundary.

3.1.6 Patterns among the MHCBI biotopes identified

There was a significant variation in mean species richness among the MHCBI biotopes identified ($F_{5,70} = 6.56$, $p < 0.001$), ranging from 8 taxa per image in biotope 4 to 15 taxa per image in biotope 1 (Fig. 13). In addition, a significant difference in countable epifauna abundance ($X^2 = 32.8$, df = 5, $p < 0.001$) and algal percentage cover ($X^2 = 24.4$, df = 5, $p < 0.001$) was also found across the MHCBI biotopes. Biotope 5 has the highest mean in the summed abundance of the countable epifauna (11 individuals per image), while the mean of the summed algal percentage cover peaked in biotope 3 (41%) (Fig. 13).

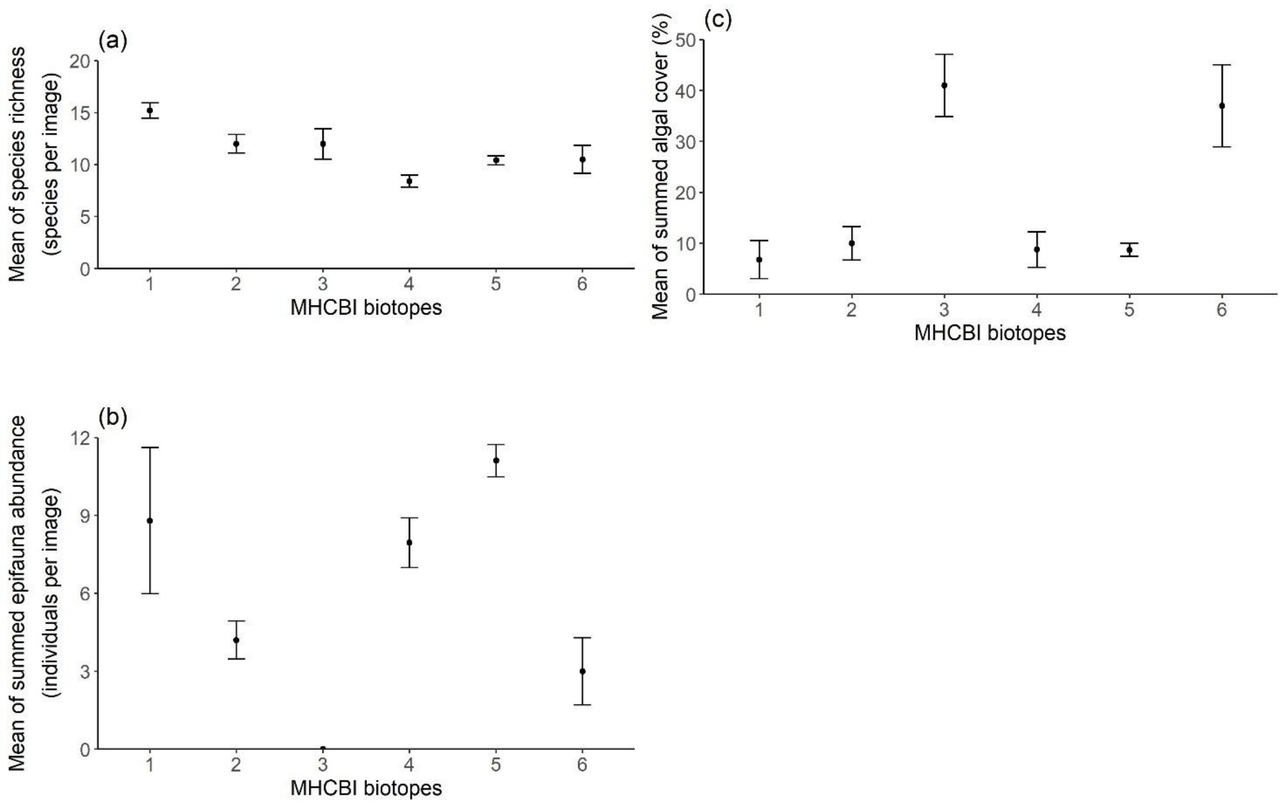


Fig. 13. Graphs showing the means (± S.E.) of (a) species richness, (b) summed countable epifauna abundance, and (c) summed algal percentage cover (%) across the 6 MHCBI biotopes identified. Biotope numbers align with those used in Table 4.

Environmental variables also varied across the MHCBI biotopes identified, including water depths (below CD), coverage of different substrate types, average current energy, and average wave energy (Fig. 14). Species richness appeared to be relatively more correlated to the percentage cover of the substrate types. Biotopes with a substratum of higher portions of cobbles and boulders, e.g. biotopes 1 and 2, have displayed higher species richness (Fig. 13 and 14). Taking all 11 environmental parameters into consideration, the 'BEST' analysis using the taxa presence/absence data has found that the community assemblage of the biotopes was best described by 5 factors, including water depth, percentage cover of boulders and pebbles, and average energy of current and wave (correlation of 0.623).

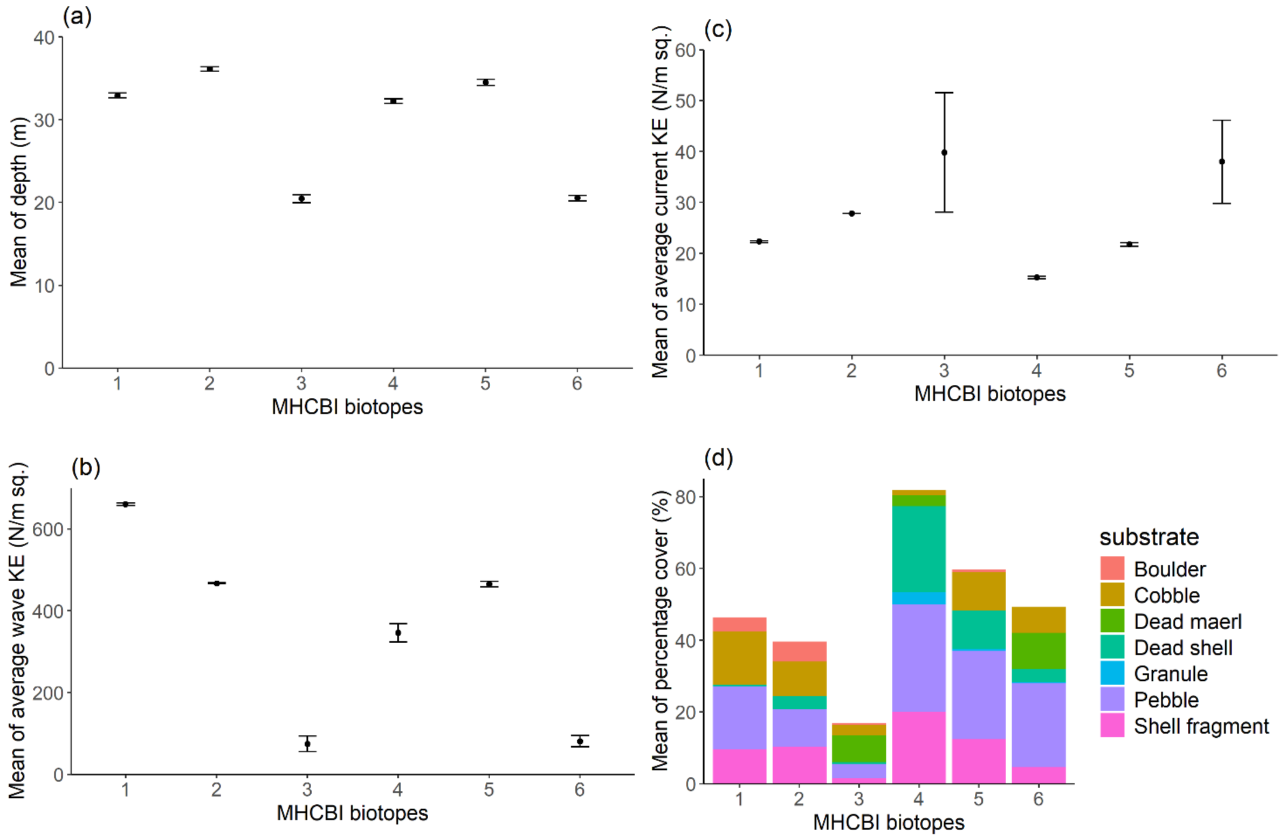


Fig. 14. Graphs showing the means (± S.E.) of (a) water depth (m), (b) average wave energy ((N/m^2), (c) average current energy ((N/m^2), and (d) percentage cover of substrates (%) across the 6 MHCBI biotopes identified. Biotope numbers align with those used in Table 4.

3.2 BRUVS Sampling

Due to time constraints and gear malfunctioning, of the 20 BRUVS deployed, only data from 10 BRUVS were analysed. The deployment sites of these BRUVS have a water depth (below CD) ranging from 21.8m to 37.3m, consist of 4 types of substrata, and were spread across 5 types of MHCBI biotopes identified previously (Fig. 15).

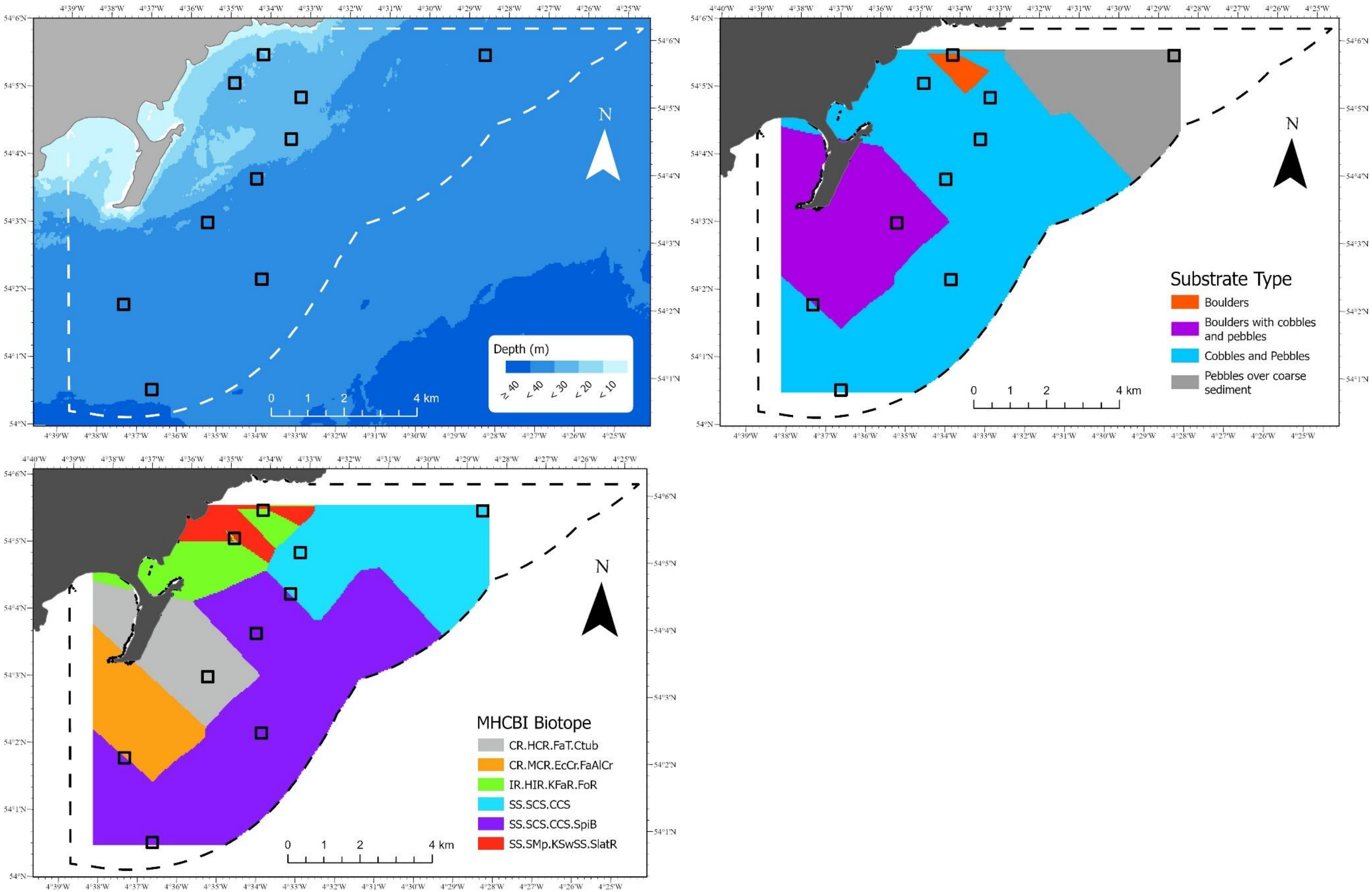


Fig. 15. Maps showing the bathymetry (below CD) (EDINA, 2020), substrate type, and identified MHCBI biotopes across the areas of the Langness MNR, with locations of BRUVS deployment (only those with video analysis done) overlaid on top.

Mobile species communities associated with each MHCBI biotope identified were significantly different (R = 0.846, p = 0.001) (Fig. 16), but the communities did not differ significantly when substrate types were used for the categorization of habitats ($R = 0.262$, $p = 0.167$). The species richness did not differ significantly across the MHCBI biotopes ($X^2 = 4.25$, df = 4, $p = 0.374$), but a relatively higher means was found in biotope 4 (12 taxa per footage) and biotope 6 (10 taxa per footage), in which their substratum was mainly composed of pebbles and cobbles, with some degree of coarse sediment (Fig. 15).

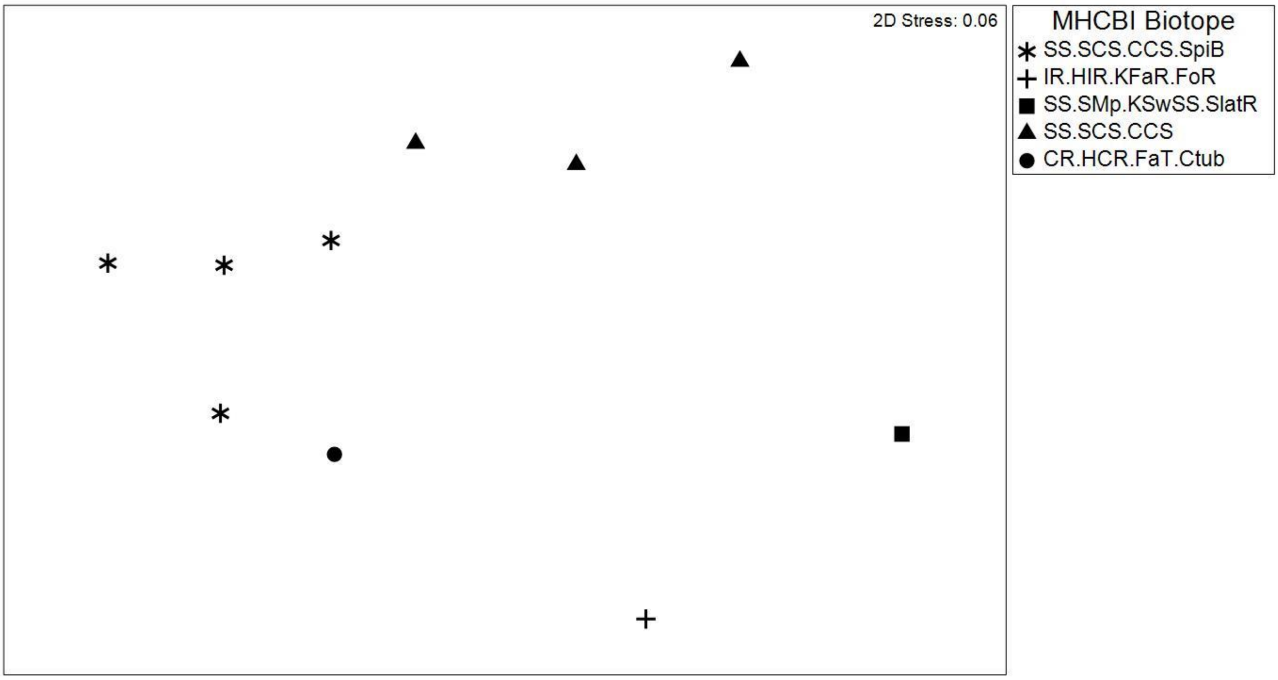


Fig. 16. An nMDS plot showing the relationship between mobile species communities of each BRUVS sample. The plot was created using the abundance data (MaxN), with each sample assigned a symbol according to its associated biotope. Points in close proximity indicate high similarity with each other while points further apart indicate low similarity.

A total of 41 taxa were identified from the analysed BRUVS footage (appendix, Table A5), including 15 teleosts (37%), 13 arthropods (32%), 6 molluscs (15%), 4 echinoderms (10%), 2 elasmobranchs (5%), and 1 ctenophore (3%). The most frequently encountered taxon was found to be the small-spotted catshark, *Scyliorhinus canicular*, which was present in every analysed BRUVS footage, with an average of 1.70±0.40 individuals per footage and a maximum abundance of 4 individuals recorded in two BRUVS (in biotopes 4 and 6). The other elasmobranch recorded, the nursehound, *Scyliorhinus stellaris*, was only sighted in two BRUVS footages (in biotopes 1 and 6), with an abundance of 2 and 3 individuals respectively. The brown shrimp, *Crangon crangon*, was the second-most frequently encountered taxon, recorded in 8 of the BRUVS footage (in biotopes 1, 3, 4 and 5). It averaged at 9.75±2.91 individuals per footage and a maximum abundance of 25 individuals was sighted in one BRUVS (in biotope 5). Other commonly sighted taxa, each recorded in 4 or more BRUVS footage, include the edible sea urchin, *Echinus esculentus*, common whelk, *Buccinum undatum*, butterfish, *Pholis gunnellus*, Sea gooseberry, *Pleurobrachia pileus*, and Bernhard's hermit crab, *Pagurus bernhardus*. In addition, though only recorded in 2 (in biotopes 3 and 6) and 3 (in biotopes 4 and 5) BRUVS respectively, the poor cod, *Trisopterus minutus*, and netted dog whelk, *Tritia reticulata*, both have a relatively high mean abundance, averaging at 64.0±57.0 and 20.7±14.5 individuals per footage respectively. The poor cod has a maximum abundance record of 121 individuals in one BRUVS (in biotope 6) while that of the netted dog whelk was 49 individuals (in biotope 5).

Taking the environmental variables into account, in terms of a single factor, it was found that the mobile species communities were best described by the average energy of current in the area (correlation of 0.452). With an additional factor of average wave energy included, the correlation increased further (correlation of 0.495).

4. Discussion

Langness MNR contains a range of benthic habitats, from pebbly sand to algal-dominated stony rocky substrate. Most of the MNR areas are characterised by coarse sediments and the commonest taxa were encrusting species, such as Serpulidae spp. and *Parasmittina trispinosa*. Dead maerl and encrusting coralline algae were frequently encountered, both appeared in more than 40% of the analysed images; conversely, live maerl were rarely sighted and only recorded in 7 images. In comparison to other MNRs, the epifauna species richness in Langness was higher than Laxey and Niarbyl Bay and comparable to Port Erin Bay, Ramsey Bay, Douglas Bay (Garratt et al., 2022a, 2022b, 2022c, 2022d, 2022e).

Environmental processes are major determinants of marine communities and habitats. The hydrodynamic regime affects the distribution of different types of sediment, forming different substratum within an area. The varied substratum created different habitats and thus shaped different communities of species (Connor et al., 2004). This study has identified the substrate composition, water depth, and strength of wave and current energy as the most important factors in shaping the composition of benthic communities. It is believed that a further increase in variation of these factors would result in more significant differences among the communities identified. Meanwhile, it is important to note that environmental factors are interactive, as mentioned, and they do not act independently. The scope of this study is only to identify the factors that best correlate with the community data, not to study the effect of individual factors.

Environmental drivers of BRUVS communities were similar and also had a combination of water depth, strength of wave and current energy as the best descriptor of community composition. Though the community composition was significantly different across the MHCBI biotopes, they did not differ significantly across different types of substrata, and no association between species richness and algal cover has been recognised. The condition might be explained by the mobile nature of the species. As mentioned in Kaiser et al. (2020), mobile taxa are less associated with environmental conditions when compared with the sessile component of a community. The mobile taxa identified in the BRUVS communities, such as fishes and crustaceans, might not have specific habitat requirements, but they rely on hydrodynamic activities to assist their movements, migration, and foraging activities.

This study aimed to create a map of the distribution of biotopes, in which a biotope is assigned based on biotic and abiotic factors (Connor et al., 2004). The PRIMER approach for biotope classification only takes account of the percentage cover data of the analysed still images. Though the substrate information is included, other environmental variables were excluded, as well as other taxa that were absent in the percentage cover data. Conversely, the MHCBI classification system approach has considered several environmental data, including depth and energy of wave and current, and has included both the percentage cover and tax presence/absence data from the analysed images, for the assignment of biotopes. In addition, with such an approach, the information obtained from the video footage can also be considered for a more accurate assignment of the biotope, since still images only provide sections of the seabed, whereas the continuity of video footage can offer a broader view of the seabed. Given the MHCBI classification system approach can cope with variations in habitats and communities, it is regarded as a more suitable approach for biotope assignment in this study.

Due to gear malfunctioning, the majority of still images (~90%) captured had minor focus issues and thus, were not of the best quality for analysis. This issue had an impact on species identification, as some taxa encountered could only be identified to family level or even assigned to broad descriptive categories due to the blurriness of the image. It is believed that this might have affected the number of taxa identified, the recognition of the overall community, and potentially the accuracy of biotope assignments. However, since the issue was caused by equipment failure, not much could be done to mitigate the impact for the current study. In future studies, it is suggested to carry out several in-water trials for the survey equipment before the actual survey, to ensure that the settings are correct and the gear itself is functioning properly. As for this study, if possible, it would be ideal to redo some of the tows, to get a more accurate picture of the habitats and communities present in the area.

Though the identification level for the same taxa was consistent throughout the data analysis process, there was a variation in the taxonomical levels for the identification of different taxa. Some were identified to species level, while to the other extreme, some were only able to be grouped into broad descriptive categories, especially for bryozoans, hydroids, and algae. Several species are likely to be present in the same group for these categories. Thus, if all encountered taxa have been identified to species level, the assignments of biotopes might differ.

One of the drawbacks of benthic imagery surveys is that they failed to account for the presence of small epifauna as well as infaunal community (Beisiegel et al., 2017). Since infauna are a key component of benthic communities (Elliott, 1994), and a large proportion of the sampling stations in this study have sediment-based substratum, the inclusion of benthic grab sampling would help complete the identification of all taxa present in a particular benthic community, improving the accuracy of the eventual biotope assignments.

Constrained by time, it was only possible to conduct 1 tow in each sampling grid, and though still images of benthic habitats were taken at frequent intervals of 10 seconds in each tow, only 1 image was selected for analysis every 120 seconds. Many previous studies elsewhere on coastal benthic communities (e.g. Hernández-Fernández et al., 2019; Wahl, 2001) have found that the assemblage, coverage, and diversity of benthic fauna could vary on a small spatial scale. As such, in this study, the single tow done in each sampling grid and the limited amount of analysed still images might not have captured all habitats and communities present within the area of the grid. It is therefore suggested that future studies could focus on areas of particular interest, complete multiple tows in a single grid, and analyse more still images per tow, aiming to obtain a more representative assessment of the habitats and communities present.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article is attached at the end.

References

Barbier, E.B., Hacker, S.D., Kennedy, C., Koch, E.W., Stier, A.C., Silliman, B.R., 2011. The value of estuarine and coastal ecosystem services. Ecol. Monogr. 81, 169–193. https://doi.org/10.1890/10-1510.1

Beisiegel, K., Darr, A., Gogina, M., Zettler, M.L., 2017. Benefits and shortcomings of non-destructive benthic imagery for monitoring hard-bottom habitats. Mar. Pollut. Bull. 121, 5–15. https://doi.org/10.1016/j.marpolbul.2017.04.009

Beukers-Stewart, B.D., Beukers-Stewart, J., 2009. Principles for management of inshore scallop fisheries around the United Kingdom (Marine Ecosystem Management Report No. 1), Report to Natural England, Scottish Natural Heritage and Countryside Council for Wales. University of York.

Bunker, F., Brodie, J.A., Maggs, C.A., Bunker, A., 2012. Seaweeds of Britain and Ireland. Wild Nature Press, Plymouth.

Cappo, M., 2010. Development of a baited video technique and spatial models to explain patterns of fish biodiversity in inter-reef waters (phd). James Cook University. https://doi.org/10.25903/amq5-bb14

Clarke, K., Gorley, R., 2015. PRIMER version 7: User manual/tutorial.

Clarke, K.R., 1993. Non-parametric multivariate analyses of changes in community structure. Aust. J. Ecol. 18, 117–143. https://doi.org/10.1111/j.1442-9993.1993.tb00438.x

Clarke, K.R., Gorley, R.N., Somerfield, P.J., Warwick, R.M., 2014. Change in marine communities: an approach to statistical analysis and interpretation, 3rd edn. Primer-E Ltd, Plymouth.

Clarke, K.R., Green, R.H., 1988. Statistical design and analysis for a'biological effects' study. Mar. Ecol. Prog. Ser. 213–226.

Clarke, K.R., Somerfield, P.J., Gorley, R.N., 2008. Testing of null hypotheses in exploratory community analyses: similarity profiles and biota-environment linkage. J. Exp. Mar. Biol. Ecol., Marine ecology: A tribute to the life and work of John S. Gray 366, 56–69. https://doi.org/10.1016/j.jembe.2008.07.009

Connor, D.W., Allen, J.H., Golding, N., Lieberknecht, L.M., Northen, K.O., Reker, J.B., 2004. The Marine Habitat Classification for Britain and Ireland. Version 04.05. JNCC, Peterborough.

Davies, B.F.R., Holmes, L., Rees, A., Attrill, M.J., Cartwright, A.Y., Sheehan, E.V., 2021. Ecosystem Approach to Fisheries Management works—How switching from mobile to static fishing gear improves populations of fished and non-fished species inside a marine-protected area. J. Appl. Ecol. 58, 2463–2478. https://doi.org/10.1111/1365-2664.13986

Dayton, P.K., Thrush, S.F., Agardy, M.T., Hofman, R.J., 1995. Environmental effects of marine fishing. Aquat. Conserv. Mar. Freshw. Ecosyst. 5, 205–232. https://doi.org/10.1002/aqc.3270050305

DEFA, 2024a. Marine Nature Reserves [WWW Document]. Off. Isle Man Gov. Website. URL https://www.gov.im/MNR (accessed 4.7.24).

DEFA, 2024b. Closed or restricted area maps [WWW Document]. Off. Isle Man Gov. Website. URL https://www.gov.im/categories/business-and-industries/commercial-fishing/closed-or-restricted-area-maps/ (accessed 4.7.24).

DEFA, 2023. THE ISLE OF MAN FISHERIES STATEMENT. A strategic framework for the sustainable management of sea fisheries in the Isle of Man territorial sea.

DEFA, 2018a. Wildlife Act 1990. Manx Marine Nature Reserves Byelaws 2018.

DEFA, 2018b. Wildlife Act 1990. Manx Marine Nature Reserves (Designation) Order 2018.

DEFA, 2017. Consultation on the designation of inshore Marine Nature Reserves. Consultation Paper.

DEFA, 2016. Consultation on Inshore Marine Zoning Plan for the 0-3 Nautical Mile Area of the Isle of Man Territorial Sea.

DEFA, 2015. Future Fisheries: A 5-year strategy for the sustainable development of the Isle of Man's sea fisheries and marine environment 2016-2021 (Strategy Document No. GD No. 2015/0063). Department of Environment, Food and Agriculture, Isle of Man Government, Isle of Man.

DEFA, 2010. Developing a Marine Nature Reserve for Ramsey. Full Consultation Document.

Duncan, P., Emmerson, J., 2018. Commercial Fisheries & Sea Angling, in: Manx Marine Environmental Assessment (2nd Ed.). Isle of Man Government, p. 71.

Ebner, B., Clear, R., Godschalx, S., Beitzel, M., 2009. In-stream behaviour of threatened fishes and their food organisms based on remote video monitoring. Aquat. Ecol. 43, 569–576. https://doi.org/10.1007/s10452-008-9192-9

EDINA, 2020. Marine Digimap [WWW Document]. EDINA Digimap Ordnance Surv. Serv. URL https://digimap.edina.ac.uk/roam/map/marine (accessed 10.24.24).

EMODnet, 2022. Seabed Habitats. EUSeaMap - Broad-scale Seabed Habitat Map for Europe [WWW Document]. Eur. Mar. Obs. Data Netw. EMODnet. URL https://emodnet.ec.europa.eu/en/seabed-habitats (accessed 5.3.24).

FAO, 2003. Fisheries management. 2. The ecosystem approach to fisheries, FAO Technical Guidelines for Responsible Fisheries. FAO, Rome, Italy.

Fraschetti, S., Strong, J., Buhl-Mortensen, L., Foglini, F., Gonçalves, J.M.S., González-Irusta, J.M., Lillis, H., Lindegarth, M., Martin, G., Menot, L., O'Keeffe, E., Pascoal, A., Salomidi, M., Schoening, T., Bayo Ruiz, F., 2024. Marine habitat mapping. https://doi.org/10.5281/zenodo.11203128

Garratt, M.J., Allison, C., Patel, J., Bloor, I.S.M., Emmerson, J.A., Jenkins, S.R., 2022a. Benthic Habitat Mapping: Niarbyl Bay Marine Nature Reserve (Sustainable Fisheries and Aquaculture Report (IoM)). Bangor University.

Garratt, M.J., Allison, C., Patel, J., Bloor, I.S.M., Emmerson, J.A., Jenkins, S.R., 2022b. Benthic Habitat Mapping: Laxey Bay Marine Nature Reserve (Sustainable Fisheries and Aquaculture Report (IoM)). Bangor University.

Garratt, M.J., Bloor, I.S.M., Emmerson, J.A., Jenkins, S.R., 2022c. Benthic Habitat Mapping: Port Erin Bay Marine Nature Reserve (Sustainable Fisheries and Aquaculture Report (IoM)). Bangor University.

Garratt, M.J., Bloor, I.S.M., Emmerson, J.A., Jenkins, S.R., 2022d. Benthic Habitat Mapping: Douglas Bay Marine Nature Reserve (Sustainable Fisheries and Aquaculture Report (IoM)). Bangor University.

Garratt, M.J., Dempster, N.C., Bloor, I.S.M., Emmerson, J.A., Jenkins, S.R., 2022e. Benthic Habitat Mapping: Ramsey Bay Marine Nature Reserve (Sustainable Fisheries and Aquaculture Report (IoM)). Bangor University.

Gell, F.R., Roberts, C.M., 2003. Benefits beyond boundaries: the fishery effects of marine reserves. Trends Ecol. Evol. 18, 448–455. https://doi.org/10.1016/S0169-5347(03)00189-7

Gordon, A.D., 1987. A Review of Hierarchical Classification. J. R. Stat. Soc. Ser. Gen. 150, 119–137. https://doi.org/10.2307/2981629

Gray, J.S., Elliott, M., 2009. Ecology of marine sediments: from science to management. Oxford University Press.

Hall, S.J., 2002. The continental shelf benthic ecosystem: current status, agents for change and future prospects. Environ. Conserv. 29, 350–374.

Hall, S.J., Harding, M.J.C., 1997. Physical Disturbance and Marine Benthic Communities: The Effects of Mechanical Harvesting of Cockles on Non-Target Benthic Infauna. J. Appl. Ecol. 34, 497–517. https://doi.org/10.2307/2404893

Halpern, B.S., Warner, R.R., 2002. Marine reserves have rapid and lasting effects. Ecol. Lett. 5, 361–366. https://doi.org/10.1046/j.1461-0248.2002.00326.x

Hannah, R.W., Blume, M.T.O., 2012. Tests of an experimental unbaited video lander as a marine fish survey tool for high-relief deepwater rocky reefs. J. Exp. Mar. Biol. Ecol. 430–431, 1–9. https://doi.org/10.1016/j.jembe.2012.06.021

Harris, P.T., Baker, E.K., 2012. 1 - Why Map Benthic Habitats?, in: Harris, P.T., Baker, E.K. (Eds.), Seafloor Geomorphology as Benthic Habitat. Elsevier, London, pp. 3–22. https://doi.org/10.1016/B978-0-12-385140-6.00001-3

Hernández-Fernández, L., González de Zayas, R., Weber, L., Apprill, A., Armenteros, M., 2019. Small-Scale Variability Dominates Benthic Coverage and Diversity Across the Jardines de La Reina, Cuba Coral Reef System. Front. Mar. Sci. 6. https://doi.org/10.3389/fmars.2019.00747

Hinz, H., Murray, L.G., Gell, F., Hanley, L., Horton, N., Whiteley, H., Kaiser, M.J., 2008. Seabed habitats around the Isle of Man (Fisheries & Conservation report No. 12).

Howe, V.L., 2018. Subtidal Ecology, in: Manx Marine Environmental Assessment (2nd Ed.). Isle of Man Government, p. 48.

Jennings, S., Kaiser, M.J., 1998. The Effects of Fishing on Marine Ecosystems, in: Blaxter, J.H.S., Southward, A.J., Tyler, P.A. (Eds.), Advances in Marine Biology. Academic Press, pp. 201–352. https://doi.org/10.1016/S0065-2881(08)60212-6

JNCC, 2022. The Marine Habitat Classification for Britain and Ireland Version 22.04 [WWW Document]. URL https://mhc.jncc.gov.uk/ (accessed 4.5.24).

Kaiser, M.J., Attrill, M.J., Jennings, S., Thomas, D., 2020. Marine Ecology: Processes, Systems, and Impacts, 3rd ed. Oxford University Press.

Kaiser, M.J., Clarke, K.R., Hinz, H., Austen, M.C.V., Somerfield, P.J., Karakassis, I., 2006. Global analysis of response and recovery of benthic biota to fishing. Mar. Ecol. Prog. Ser. 311, 1–14. https://doi.org/10.3354/meps311001

Kaiser, M.J., Collie, J.S., Hall, S.J., Jennings, S., Poiner, I.R., 2002. Modification of marine habitats by trawling activities: prognosis and solutions. Fish Fish. 3, 114–136. https://doi.org/10.1046/j.1467-2979.2002.00079.x

Kay, P., Dipper, D.F., 2009. A Field Guide to the Marine Fishes of Wales and Adjacent Waters. Marine Wildlife.

Kruskal, J.B., Wish, M., 1978. Multidimensional Scaling. SAGE.

Langenkämper, D., Zurowietz, M., Schoening, T., Nattkemper, T.W., 2017. BIIGLE 2.0 - Browsing and Annotating Large Marine Image Collections. Front. Mar. Sci. 4. https://doi.org/10.3389/fmars.2017.00083

Loiseau, N., Kiszka, J., Bouveroux, T., Heithaus, M., Soria, M., Chabanet, P., 2016. Using an unbaited stationary video system to investigate the behaviour and interactions of bull sharks Carcharhinus leucas under an aquaculture farm. Afr. J. Mar. Sci. 38, 73–79. https://doi.org/10.2989/1814232X.2016.1156578

Mesnildrey, L., Gascuel, D., Pape, O.L., 2013. Integrating Marine Protected Areas in fisheries management systems: some criteria for ecological efficiency. Aquat. Living Resour. 26, 159–170. https://doi.org/10.1051/alr/2013056

Moen, F.E., Svensen, E., 2004. Marine Fish & Invertebrates of Northern Europe. Kom.

Ninio, R., Delean, S., Osborne, K., Sweatman, H., 2003. Estimating cover of benthic organisms from underwater video images: variability associated with multiple observers. Mar. Ecol. Prog. Ser. 265, 107–116. https://doi.org/10.3354/meps265107

Porter, D.J., 2012. Bryozoans and Hydroids of Britain and Ireland. Marine Conservation Society, Ross-on-Wye.

Reise, K., 1978. Experiments on epibenthic predation in the Wadden Sea. Helgoländer Wiss. Meeresunters. 31, 55–101. https://doi.org/10.1007/BF02296991

Renn, C., Rees, S., Rees, A., Davies, B.F.R., Cartwright, A.Y., Fanshawe, S., Attrill, M.J., Holmes, L.A., Sheehan, E.V., 2024. Lessons from Lyme Bay (UK) to inform policy, management, and monitoring of Marine Protected Areas. ICES J. Mar. Sci. 81, 276–292. https://doi.org/10.1093/icesjms/fsad204

Roberts, C.M., Bohnsack, J.A., Gell, F., Hawkins, J.P., Goodridge, R., 2001. Effects of Marine Reserves on Adjacent Fisheries. Science 294, 1920–1923. https://doi.org/10.1126/science.294.5548.1920

Rohlf, F.J., 2011. Biometry. W. H. Freeman.

Ryan, D.A.J., 2004. Point sampling strategies for estimating coverage from benthic video transects. Environmetrics 15, 193–207. https://doi.org/10.1002/env.634

Sala, E., Giakoumi, S., 2018. No-take marine reserves are the most effective protected areas in the ocean. ICES J. Mar. Sci. 75, 1166–1168. https://doi.org/10.1093/icesjms/fsx059

Snelgrove, P.V.R., 1999. Getting to the Bottom of Marine Biodiversity: Sedimentary Habitats: Ocean bottoms are the most widespread habitat on Earth and support high biodiversity and key ecosystem services. BioScience 49, 129–138. https://doi.org/10.2307/1313538

Sterry, P., Cleave, A., 2012. British Coastal Wildlife (Collins Complete Guides). HarperCollins UK.

Thomas, A., Howe, V.L., Duncan, P.F., 2018. Marine and coastal conservation, in: Manx Marine Environmental Assessment (2nd Ed.). Isle of Man Government, p. 48.

Wahl, M., 2001. Small scale variability of benthic assemblages: biogenic neighborhood effects. J. Exp. Mar. Biol. Ecol. 258, 101–114. https://doi.org/10.1016/S0022-0981(00)00348-8

Wakeford, M., Done, T.J., Johnson, C.R., 2008. Decadal trends in a coral community and evidence of changed disturbance regime. Coral Reefs 27, 1–13. https://doi.org/10.1007/s00338-007-0284-0

Wentworth, C.K., 1922. A Scale of Grade and Class Terms for Clastic Sediments. J. Geol. 30, 377–392.

Whitmarsh, S.K., Fairweather, P.G., Huveneers, C., 2017. What is Big BRUVver up to? Methods and uses of baited underwater video. Rev. Fish Biol. Fish. 27, 53–73. https://doi.org/10.1007/s11160-016-9450-1

Wood, C., 2018. The Diver's Guide to Marine Life of Britain and Ireland: Second Edition. Princeton University Press.

Wood, C., 2013. Sea Anemones and Corals of Britain and Ireland, 2nd Revised edition. ed. Princeton University Press, Plymouth.

Supplementary data

Table A1

List of taxa identified from the benthic still images taken in the Langness MNR, Isle of Man.

Phylum	**Taxon**	**Phylum**	**Taxon**
Annelids	*Lanice conchilega*	Molluscs	*Aequipecten opercularis*
	Serpulidae spp.		*Anomiidae spp.*
Arthropods	*Galathea intermedia*		*Glycymeris glycymeris*
	Pagurus bernhardus		Buccinidae spp.
	Pagurus prideaux		*Calliostoma zizyphinum*
	Pandalus spp.		*Colus spp.*
	Pisidia longicornis		*Coryphella spp.*
	Polybius depurator		*Gibbula magus*
	Small pinkish crab		*Nucella lapillus*
	Balanus spp.		*Ocenebra erinaceus*
Bryozoans	*Crisularia plumosa*		Rissoidae spp.
	Parasmittina trispinosa		*Steromphala cineraria*
	Reptadeonella violacea		*Trivia monacha*
	Schizomavella spp.		*Acanthochitona spp.*
	Crisia spp.		Greyish shell gastropod
	Brownish green encrusting bryozoan	Sponges	*Dysidea fragilis*
Ascidians	*Ascidia spp.*		*Hemimycale columella*
	Clavelina lepadiformis		*Tethya aurantium*
Teleosts	*Pomatoschistus spp.*		Dark brownish encrusting sponge
	Taurulus bubalis		Orange colonial sponge
Cnidarians	*Corynactis viridis*		Yellow colonial sponge
	Cylista elegans	Turf complex	Mixed turf of algae with bryozoan and/or hydroid
	Epizoanthus spp.		Mixed turf of bryozoan and hydroid
	Synarachnactis lloydii		Muddy surface turf
	Urticina felina	Algae	*Bonnemaisonia asparagoides*
	Abietinaria abietina		Corallinaceae spp.
	Halecium spp.		*Cryptopleura ramosa*
	Halopteris spp.		*Delesseria sanguinea*
	Hydrallmania falcata		*Dictyota dichotoma*
	Kirchenpaueria pinnata		Hapalidiaceae spp.
	Nemertesia antennina		*Heterosiphonia plumosa*
	Nemertesia ramosa		*Laminaria hyperborea*
	Tubularia indivisa		*Nitophyllum punctatum*
	Alcyonium digitatum		*Phycodrys rubens*
	Muddy branching hydroid		*Phyllophora spp.*
	Short stalky hydroid		*Plocamium spp.*
Echinoderms	*Crossaster papposus*		*Rhodophyllis spp.*
	Henricia spp.		Branching red seaweed
	Echinus esculentus		Flat brown seaweed
	Psammechinus miliaris		Fluffy colonial red seaweed
			Fluffy green seaweed
			Thin flat red seaweed

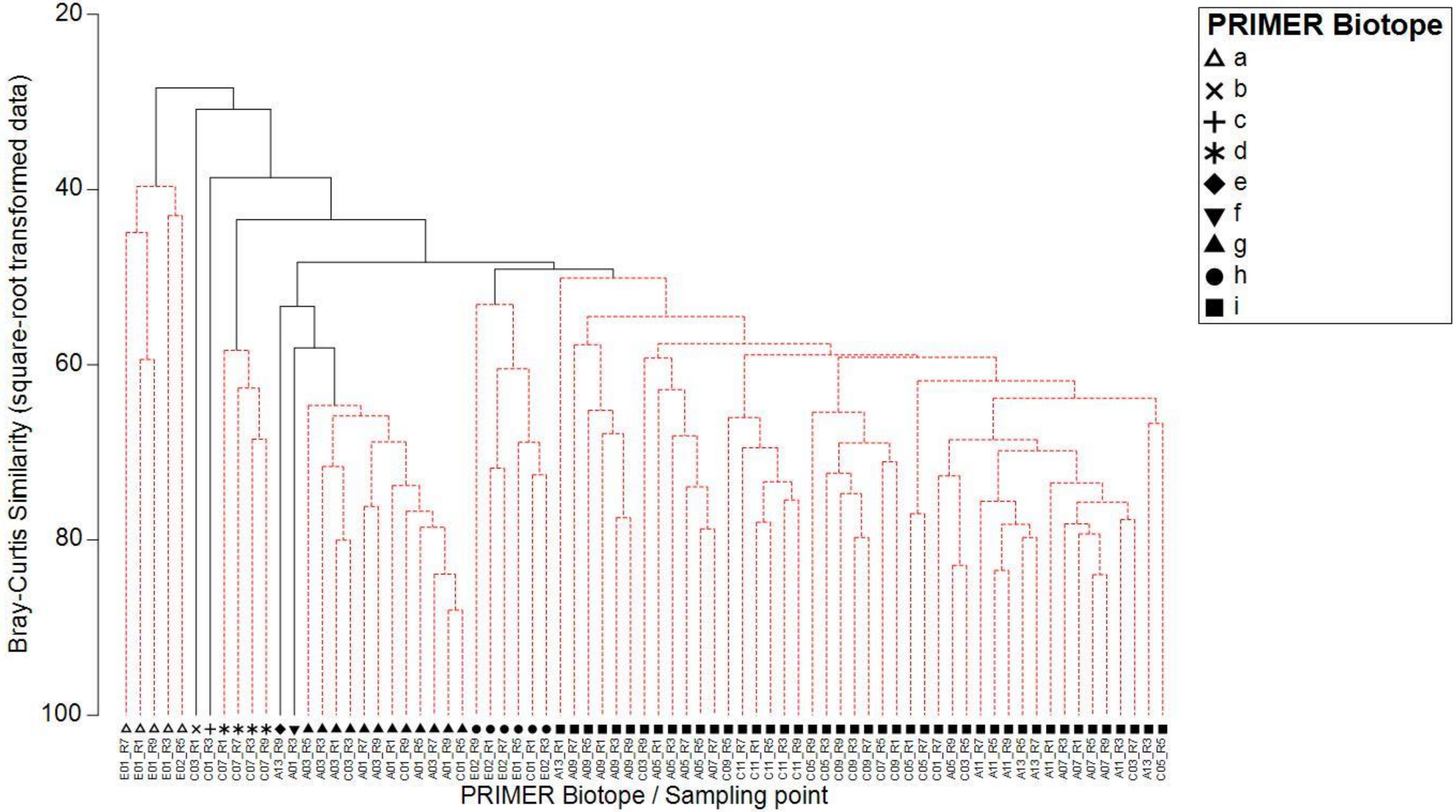

Fig. A1. A dendrogram showing the result of the CLUSTER analysis with the inclusion of similarity profile (SIMPROF) tests ($p < 0.05$) on the similarity matrix of the square-root transformed percentage cover data. Each resultant 'cluster' is defined as a distinctive biotope.

Table A2

Results of the SIMPER analysis on the community composition (percentage cover data) of the biotopes identified through the PRIMER statistical approach. The taxa that contributed the most to the similarities within the biotope are listed, with the percentage cut-off set at 90%.

Taxa / Substratum	Av.%cover	Av.Sim	Sim/SD	Contrib%	Cum.%
Biotope a - average similarity: 42.99%					
Muddy surface turf	2.99	8.59	3.46	19.99	19.99
Mixed turf of algae with bryozoan and/or hydroid	3.51	7.69	1.71	17.88	37.86
Corallinaceae spp.	3.16	6.86	2.51	15.95	53.81
Pebble	2.36	3.79	1.02	8.82	62.64
Branching red seaweed	1.78	3.79	1.14	8.81	71.45
Phyllophora spp.	1.95	3.24	0.94	7.53	78.98
Plocamium spp.	1.88	2.61	0.62	6.07	85.05
Thin flat red seaweed	1.41	1.7	0.58	3.96	89.01
Heterosiphonia plumosa	1.59	1.03	0.32	2.39	91.4
Biotope d - average similarity: 61.48%					
Pebble	4.39	11.48	4.87	18.67	18.67
Cobble	3.95	9.35	2.68	15.21	33.88
Corynactis viridis	3.47	6.7	2.05	10.89	44.78
Mixed turf of bryozoan and hydroid	2.51	5.75	2.81	9.35	54.12
Shell fragment	2.51	5.71	3.09	9.3	63.42
Muddy surface turf	1.71	4.58	6	7.46	70.88
Anomiidae spp.	1.56	4.29	25.73	6.97	77.85
Tubularia indivisa	1.79	3.12	0.91	5.07	82.92
Boulder	1.47	2.4	0.89	3.91	86.83
Serpulidae spp.	1.32	2.2	0.91	3.59	90.41
Biotope g - average similarity: 69.46%					
Pebble	5.71	21.35	5.05	30.73	30.73
Shell fragment	5.05	19.17	6.97	27.59	58.33
Dead shell	4.6	15.26	2.45	21.98	80.3
Granule	1.35	3.31	1.06	4.77	85.07
Corallinaceae spp.	1.26	2.96	0.82	4.27	89.33
Dead maerl	1.44	2.88	0.67	4.14	93.48
Biotope h - average similarity: 60.69%					
Pebble	4.97	14.62	3.28	24.09	24.09
Dead maerl	3.8	11.33	4.81	18.68	42.77
Corallinaceae spp.	3.11	8.9	3.66	14.67	57.44
Shell fragment	2.78	6.73	2.59	11.1	68.54
Cobble	2.56	6.24	1.35	10.28	78.82
Dead shell	1.62	3.45	1.35	5.69	84.51
Muddy surface turf	1.62	3.39	1.35	5.58	90.09
Biotope i - average similarity: 59.66%					
Pebble	4.61	12.75	2.37	21.38	21.38
Shell fragment	3.16	8	2.02	13.41	34.79
Cobble	2.88	7.24	1.96	12.14	46.93
Muddy surface turf	2.69	6.95	1.99	11.64	58.57
Serpulidae spp.	2.3	6.08	2.43	10.18	68.76
Corallinaceae spp.	2.6	6.04	1.4	10.13	78.89
Dead shell	2.49	4.74	0.95	7.94	86.83
Brownish green encrusting bryozoan	1.81	3.83	1.06	6.42	93.25

Table A3

Results of the SIMPER analysis on the community composition (percentage cover data) of the biotopes identified through the application of the MHCBI classification system. The taxa that contributed the most to the similarities within the biotope are listed, with the percentage cut-off set at 90%.

Taxa / Substratum	Av.%cover	Av.Sim	Sim/SD	Contrib%	Cum.%
CR.HCR.FaT.Ctub - average similarity: 59.30%					
Pebble	4.08	10.33	4.48	17.42	17.42
Cobble	3.65	8.45	2.94	14.26	31.68
Corynactis viridis	3.34	6.93	2.52	11.69	43.37
Shell fragment	2.9	6.46	2.81	10.89	54.27
Muddy surface turf	2	4.83	5.38	8.15	62.41
Anomiidae spp.	1.53	4.29	28.17	7.24	69.66
Mixed turf of bryozoan and hydroid	2.01	3.45	1.03	5.81	75.47
Boulder	1.74	3.22	1.08	5.43	80.9
Corallinaceae spp.	2.09	3.1	0.97	5.23	86.13
Serpulidae spp.	1.34	2.63	1.16	4.44	90.57
CR.MCR.EcCr.FaAlCr - average similarity: 69.23%					
Serpulidae spp.	3.44	10.15	8.24	14.66	14.66
Muddy surface turf	3.2	9.54	6.78	13.79	28.45
Pebble	3.2	9.38	6.59	13.54	41.99
Shell fragment	3.15	8.68	3.96	12.53	54.52
Cobble	3.02	8.31	3.78	12.01	66.53
Brownish green encrusting bryozoan	2.81	7.56	2.97	10.92	77.46
Corallinaceae spp.	2.99	7.48	3.09	10.8	88.25
Boulder	2.04	4	1.03	5.78	94.04
IR.HIR.KFaR.FoR - average similarity: 47.81%					
Mixed turf of algae with bryozoan and/or hydroid	4.32	11.89	4.13	24.87	24.87
Muddy surface turf	3.31	10.33	19.98	21.61	46.48
Corallinaceae spp.	3.03	8.44	5.6	17.65	64.13
Phyllophora spp.	2.7	6.69	2.7	13.98	78.12
Pebble	1.67	2.72	0.86	5.69	83.81
Plocamium spp.	1.41	1.61	0.41	3.36	87.17
Dead maerl	1.88	1.43	0.41	2.99	90.16
SS.SCS.CCS - average similarity: 58.75%					
Pebble	5.13	16.56	2	28.19	28.19
Shell fragment	4.25	14.02	2.54	23.86	52.06
Dead shell	4.45	13.54	2.01	23.05	75.11
Corallinaceae spp.	1.91	3.63	0.9	6.18	81.28
Glycymeris glycymeris	1.1	2.45	0.81	4.16	85.45
Granule	1.3	2.17	0.69	3.7	89.14
Dead maerl	1.21	1.97	0.54	3.36	92.5
SS.SCS.CCS.SpiB - average similarity: 59.65%					
Pebble	4.68	13.17	2.35	22.08	22.08
Shell fragment	3.13	7.87	1.8	13.2	35.28
Cobble	2.97	7.64	2.01	12.81	48.1
Muddy surface turf	2.57	6.39	1.74	10.72	58.82
Serpulidae spp.	2.27	6.31	3.01	10.58	69.4
Dead shell	2.62	5.16	0.97	8.65	78.05
Corallinaceae spp.	2.33	5.01	1.14	8.4	86.45
Brownish green encrusting bryozoan	1.72	3.65	1.03	6.11	92.56

Taxa / Substratum	Av.%cover	Av.Sim	Sim/SD	Contrib%	Cum.%
SS.SMp.KSwSS.SlatR - average similarity: 51.84%					
Pebble	4.76	13.93	4.62	26.87	26.87
Corallinaceae spp.	3.39	8.09	2.18	15.61	42.48
Cobble	2.46	6.19	1.36	11.94	54.42
Dead maerl	2.77	5.78	1.17	11.15	65.57
Shell fragment	1.8	3.44	1.27	6.63	72.2
Muddy surface turf	1.67	3.41	1.32	6.58	78.79
Dead shell	1.62	3.16	1.32	6.1	84.89
Hapalidiaceae spp.	1.45	2.24	0.74	4.33	89.21
Mixed turf of algae with bryozoan and/or hydroid	1.14	1.88	0.78	3.63	92.84

Table A4

List of taxa identified from the BRUVS footages taken in the Langness MNR, Isle of Man.

Phylum	Taxon	Phylum	Taxon
Arthropods	*Atelecyclus rotundatus*	Teleosts	*Gobius paganellus*
	Cancer pagurus		*Labrus bergylta*
	Cragon cragon		*Labrus mixtus*
	Crangon allmanni		*Pholis gunnellus*
	Inachus spp.		*Pollachius pollachius*
	Liocarcinus spp.		*Pomatoschistus flavescens*
	Necora puber		*Pomatoschistus spp.*
	Pagurus bernhardus		*Syngnathus schlegeli*
	Pagurus prideaux		*Trisopterus minutus*
	Eurynome aspera	Ctenophore	*Pleurobrachia pileus*
	Munida rugosa	Echinoderms	*Henricia spp.*
	Pisidia longicornis		*Marthasterias glacialis*
	Xantho spp.		*Echinus esculentus*
Elasmobranchs	*Scyliorhinus canicula*		*Ophiothrix fragilis*
	Scyliorhinus stellaris	Molluscs	*Bittium reticulatum*
Teleosts	Blenniiformes spp.		*Buccinum undatum*
	Blennius ocellaris		*Calliostoma zizyphinum*
	Chelidonichthys cuculus		*Neptunea antiqua*
	Ctenolabrus rupestris		*Nucella lapillus*
	Diplecogaster bimaculata		*Tritia reticulata*
	Gobiidae spp.		