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Report 4

Wyville-Thomson Ridge Special Area of Conservation Monitoring Report

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Executive Summary

The Wyville-Thomson Ridge Special Area of Conservation (SAC), hereafter WTR, lies to the north- west of mainland Scotland at the northern end of the Rockall Trough, with the closest land approximately 77 km away at Rona, Scotland. This offshore marine protected area (MPA) protects an area of 1,740 km² and is designated to protect Annex I reef. The ridge is composed of extensive areas of stony reef interspersed with gravel and bedrock reef along the flanks. Variation in oceanographic conditions driven by merging water bodies and the unique ocean floor topography allows for many different communities to exist within WTR. WTR thereby functions as a transitional area between differing water masses and the communities associated with those. Clearly, WTR is a highly varied, unique and biodiverse site.

The Joint Nature Conservation Committee (JNCC) and the Scottish Government's Marine Directorate (previously known as Marine Scotland Science and hereafter referred to as the Marine Directorate) completed surveys 1517S and 1218S in 2017 and 2018 to collect imagery and video data to characterise the benthic communities at the MPA. This data will form the first point in a benthic monitoring time series at WTR.

A summary of report objectives and their outcomes are provided in the table below.

Table ES 1. Objectives and outcomes of the 2017 and 2018 Wyville-Thomson Ridge Special Area of Conservation surveys.

Objective	Key outcomes
1. Describe the characteristic biological communities of the Annex I Reef	Ten epifauna community cluster groups were identified at the site. One of those communities may be an artefact of changing survey and/or analytical methods. Sponges are a key component of the communities found at the MPA. This is not restricted to the typical Ostur-type communities observed in one specific cluster group but appears true for the MPA.
2. Present information relating to supporting processes which are known to influence the designated and additional habitat and species features.	Large-scale patterns in community composition are linked to oceanographic conditions and its linked parameter seawater temperature. Further small-scale separation was driven by changes in substrate composition, ranging from soft sediment (high contribution of mud to the sediment composition) to that dominated by hard substrate (high contribution of boulder and cobble). Near-bottom water current velocity magnitude was also observed to be a significant, albeit less important, driver of community change. Findings in this report also add to our understanding of the patchy nature of deep-sea sponge aggregations, particularly when associated to Annex I Reef iceberg ploughmarks.
3. Describe the extent and distribution of the Annex I Reef	Results suggest an extent and distribution of Annex I reef largely in agreement with previous Annex I reef v3.8 2022 information. However, some sampling stations outside of the previously identified Annex I reef (v3.8 2022) did also meet the threshold values, indicating that Annex I reef may extend further south than previously thought.
4. Present any evidence of impact of anthropogenic activity observed within the site.	There were several observations of non-natural materials and potential anthropogenic activity. No non-indigenous species were observed.

Objective	Key outcomes
5. Recommend future monitoring approaches for the site, and other sites containing comparable features.	• This work identified the key role of still image characteristics (image quality and field of view) on our ability to accurately and precisely detect the presence and abundance of key taxa. This highlights the importance of improving still image sampling methods and/or incorporating a strict image selection step prior to data extraction. • Results demonstrated the potential influence of imagery sample processing methods to identify communities present. Species identification consistency is increasingly important when building time series datasets. Recent methodological improvements in the use of online imagery platform BIIGLE will help standardise species identification methods. Future advancements in machine learning techniques may further allow for more objective, time and resource efficient (re-)analysis of imagery samples, with the added benefit of this method being reproducible across MPAs. • Sample size at a station (i.e. the Total Viewable Area (TVA) for epifauna community identification) should be considered carefully to ensure community changes over time can be detected and attributed to underlying drivers. • Spatial variability in biological change should be considered for MPAs with high environmental complexity such as WTR. For time series analysis, one should consider: 1. Spatial differences in the direction and magnitude of environmental change. 2. Spatial differences in community vulnerability to environmental change. • Because of the diverse physical characteristics of the MPA and likely variable rates of environmental change in relation to those, we recommend installing environmental data logger fixed to the seabed. This will allow long-term monitoring of environmental conditions across the site as changes in oceanographic conditions will likely affect communities present.

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Abbreviations

Acronym	Description
CP2	Charting Progress 2
DSSA	Deep-sea sponge aggregations
FoV	Field of view
GLM	Generalised linear model
JNCC	Joint Nature Conservation Committee
NMBAQC	North East Atlantic Marine Biological Analytical Quality Control Scheme
MESH	Mapping European Seabed Habitats
MHC	Marine Habitats Classification for Britain and Ireland
MPA	Marine Protected Area
MSFD	Marine Strategy Framework Directive
MSS	Marine Scotland Science (now SGMD)
NIS	Non-Indigenous Species
nMDS	Non-metric Multidimensional Scaling
OSPAR	The Convention for the Protection of the Marine Environment of the North-East Atlantic
PMF	Priority Marine Feature
RDA	Redundancy analysis
RV	Research Vessel
SAC	Special Area of Conservation
SACO	Supplementary Advice on Conservation Objectives
SAD	Site Assessment Document
SE	Standard error
SGMD	SGMD Scottish Government's Marine Directorate (formerly known as Marine Scotland Science (MSS))
SIMPER	Similarity Percentages analysis
SNCB	Statutory Nature Conservation Body
SSI	Simple structure index
TOBI	Towed Ocean Bottom Instrument
TVA	Total viewable area
WoRMS	World Register of Marine Species
WTR	Wyville Thomson Ridge

1 Introduction

The Wyville-Thomson Ridge Special Area of Conservation (SAC), hereafter referred to as 'WTR', is part of a network of Scottish Marine Protected Areas (MPAs) designated under the EU Habitats Directive (1992), transposed into UK law by the Conservation of Offshore Marine Habitats and Species Regulations (2017). These Scottish MPAs contribute to an ecologically coherent network of MPAs across the North-east Atlantic, as agreed under the Oslo Paris (OSPAR) Convention and other international commitments to which the UK is a signatory.

WTR was formally designated as an SAC by the UK Government in September 2017. This monitoring report primarily explores data acquired from the first two dedicated supplementary monitoring surveys of WTR. The specific aims of the report are discussed in more detail in Section 1.5.

1.1 Site overview

WTR lies to the north-west of mainland Scotland at the northern end of the Rockall Trough, with the closest land approximately 77 km away at Rona, Scotland. The site is approximately 149 km away from Cape Wrath on mainland Scotland (Figure 1). WTR lies within the wider 'Charting Progress 2' (CP2) habitat assessment regions 'Scottish continental shelf' and 'Atlantic North-West Approaches, Rockall Trough and Faroe Shetland Channel' (JNCC 2022a). This offshore MPA protects an area of 1,740 km² and is designated to protect Annex I reef found in ridges approximately 20 km wide and 70 km long, rising from depths of over 1,000 m to less than 400 m at the summit. The ridge is composed of extensive areas of stony reef interspersed with gravel and bedrock reef along the flanks. The stony reef is thought to have been formed by the ploughing movement of icebergs through the seabed at the end of the last glacial maximum. The rock and stony reef areas support diverse biological communities, representative of hard substratum in deep water. Communities on the bedrock reef vary in species composition between the two sides of the ridge due to the influences of different water masses (JNCC 2010; Howell *et al.* 2007). This combination of water masses in one area is unique in UK waters.

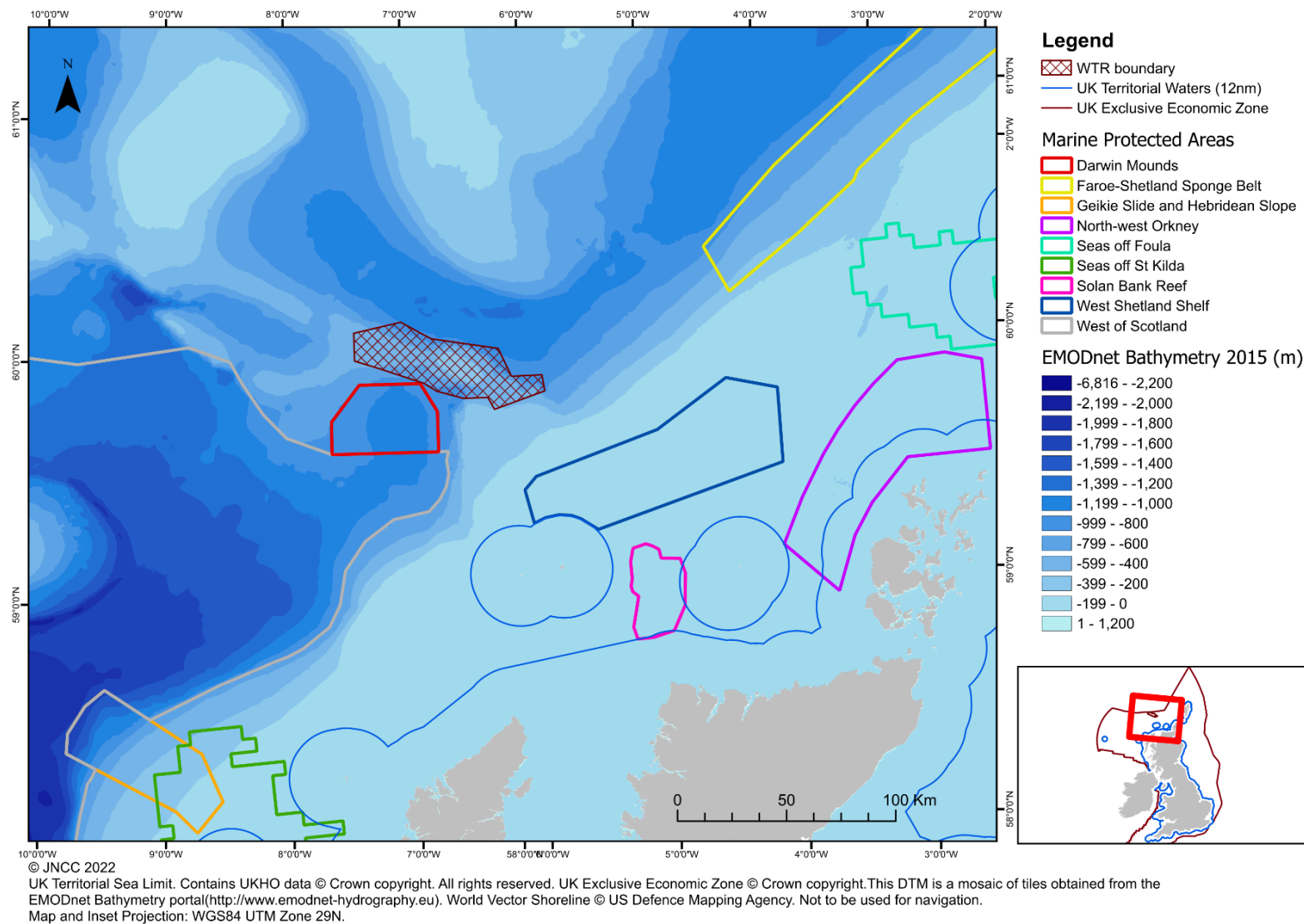


Figure 1. Map showing the location of the Wyville-Thomson Ridge Special Area of Conservation (SAC) in the context of Marine Protected Areas in the territorial waters of the United Kingdom.

1.2 Existing data and habitat maps

Existing data products were sourced from three previous surveys to WTR:

- 1999 Strategic Environmental Assessment (SEA 1) survey.
- 2006 Strategic Environmental Assessment (SEA 7) survey.
- 2012 JNCC/Marine Scotland Science (MSS; now referred to as the Marine Directorate) survey to WTR.

1.2.1 SEA1 survey

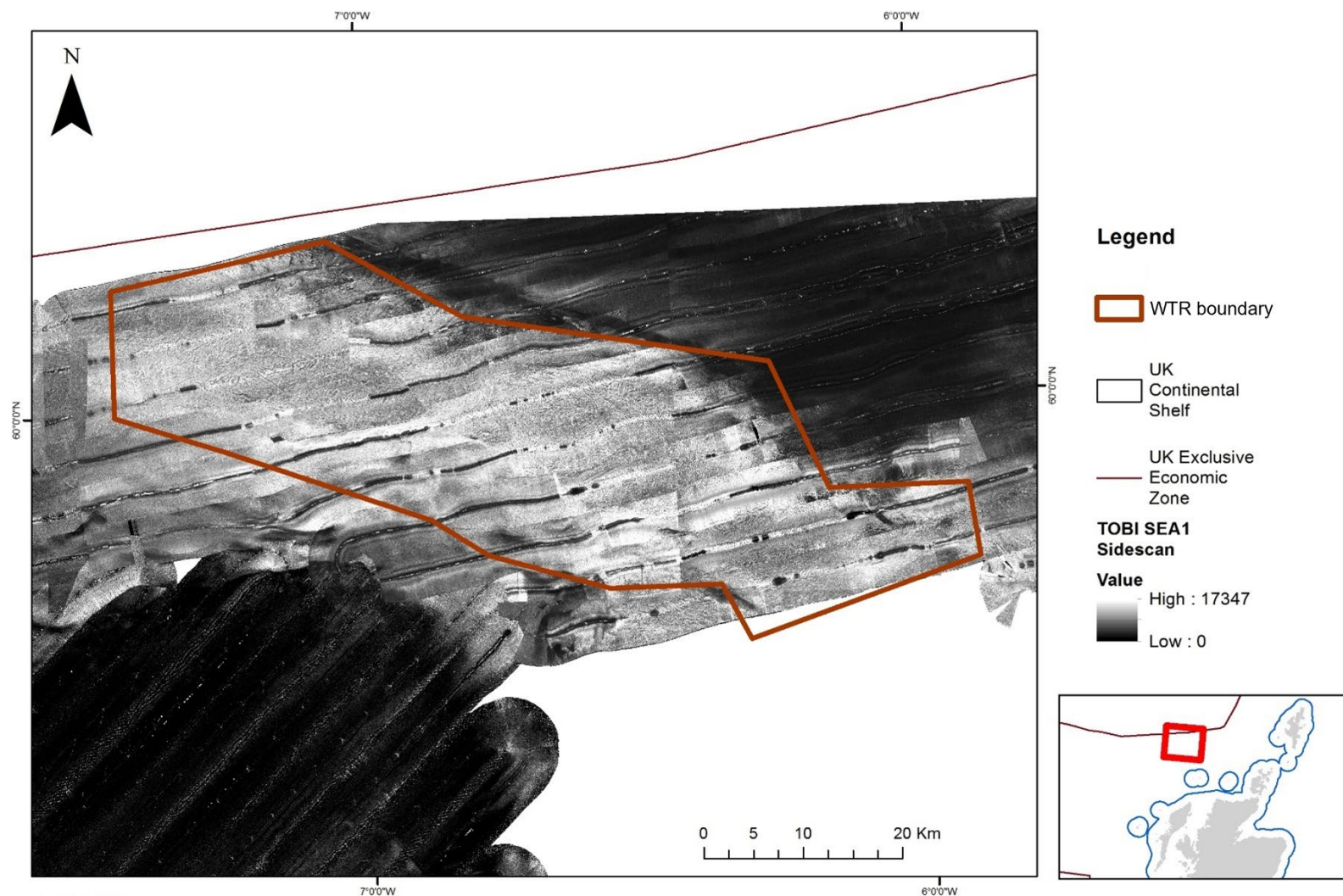
The UK Department of Trade and Industry conducted a Strategic Environmental Assessment (SEA) of the implications of licensing for oil and gas exploration and production, in parts of a previously disputed area north-west of Scotland, between Shetland and the Faroe Islands. This survey included the collection of core samples, seabed imagery and side scan sonar data at WTR to improve understanding of the seabed substrates (Figure 2; Masson *et al.* 2000; Henry & Roberts 2004).

1.2.2 SEA7 survey

A collaborative survey programme was set up between the Department of Trade and Industry and the Department of Food and Rural Affairs in 2006, with the aims of obtaining biological and oceanographic data from the deep-water areas to the north-west of the UK to allow broad-scale assessment of the impacts of current and possible future human activities (Howell *et al.* 2013; Narayanaswamy *et al.* 2006; Stewart & Davies 2007). The survey took place aboard the commercial research vessel *Franklin*, and both acoustic and imagery sampling was conducted across eight sites including at WTR. Acoustic sampling provided both bathymetry and backscatter data, providing a base-map of topography of WTR (Figure 3), as well as a seafloor acoustic reflectivity map. The structure of benthic communities was analysed, and distinct benthic communities were present at WTR, with community structure strongly influenced by temperature, depth, and sediment type (Howell *et al.* 2013). The imagery analysis also supported the presence of Annex I reefs, including cold-water corals (Figure 4).

1.2.3 2012 JNCC/Marine Scotland Science survey

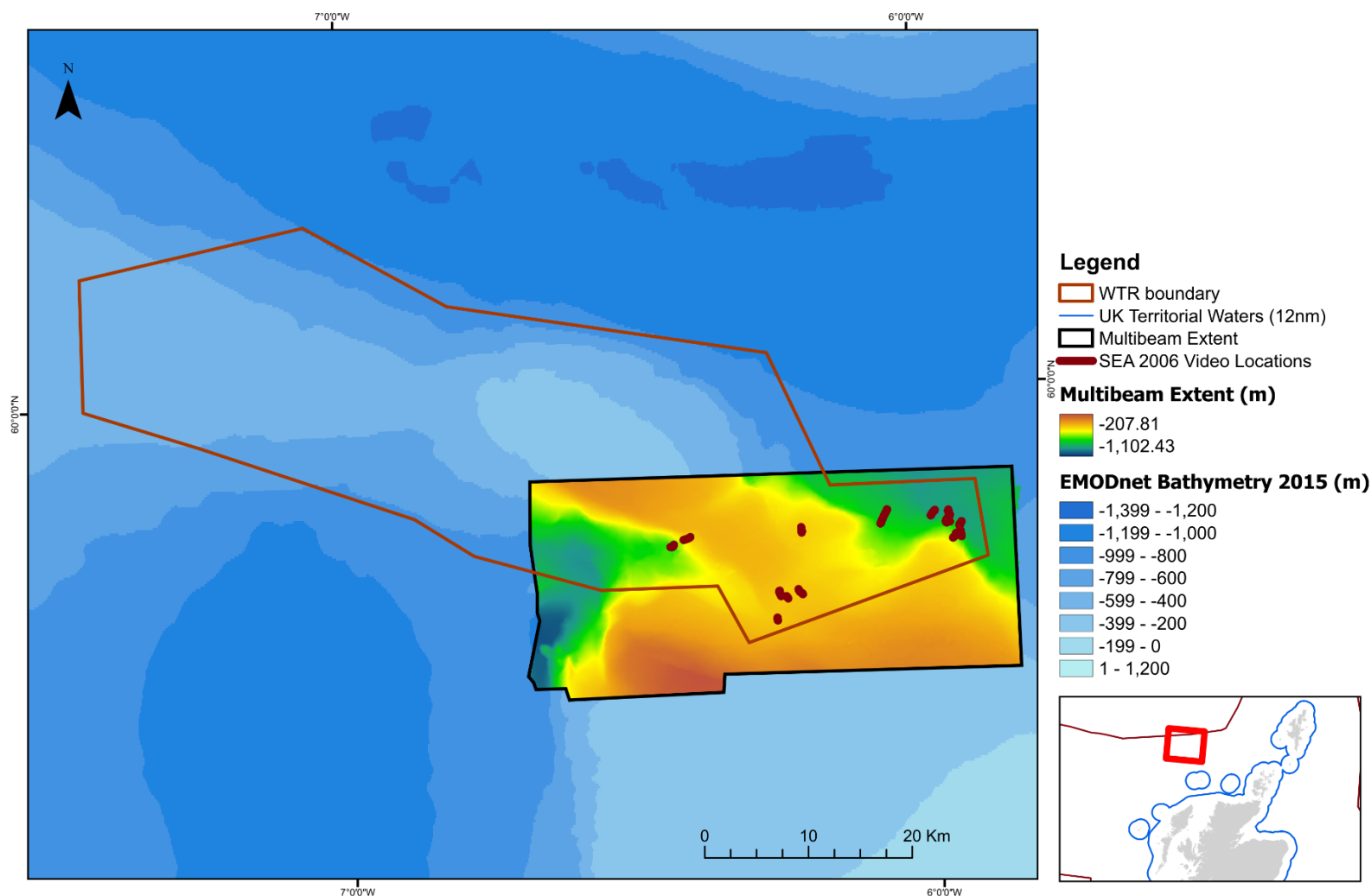
In 2012, JNCC and Marine Scotland Science completed an offshore survey of WTR aboard the RV *Scotia*. The main aim of the survey (code 1512S) was to gather evidence to facilitate fisheries management discussions, and to assist in the development of methods for future Marine Protected Sites monitoring (Eggett *et al.* 2018). Video and camera imagery were collected to gather evidence on the presence and extent of the Annex I reef feature of the WTR (Eggett *et al.* 2018). Annex I reefs were identified, and reef quality was categorised into low, medium and high-quality reef (Figure 4).



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Figure 2. Map of Wyville-Thomson Ridge Special Area of Conservation (WTR) showing existing sidescan data (collected during the SEA1 survey).



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Figure 3. Map of Wyville-Thomson Ridge Special Area of Conservation (WTR) showing multibeam data (collected during the SEA7 survey).

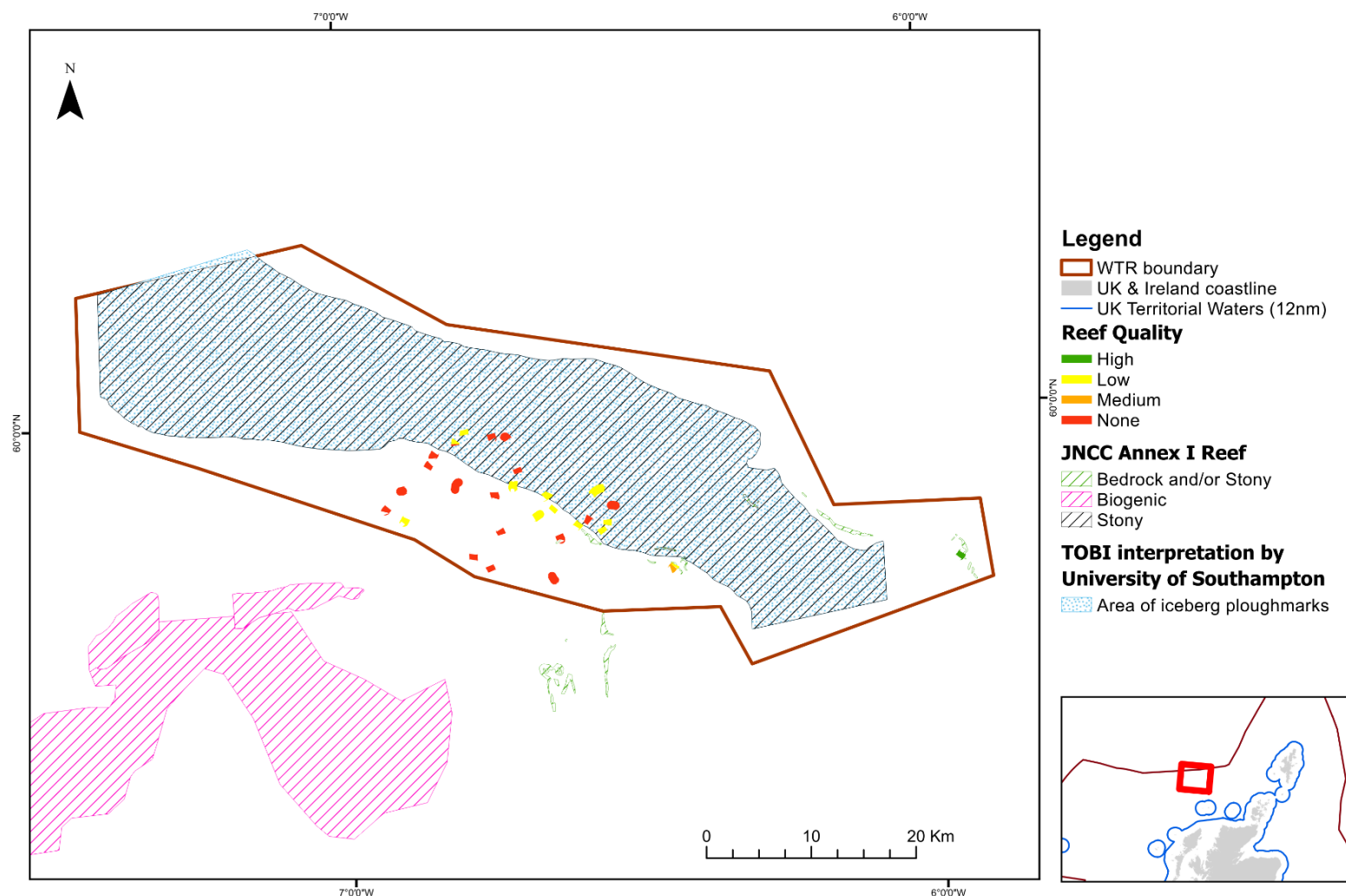


Figure 4. Map of Wyville-Thomson Ridge Special Area of Conservation (WTR) showing Annex I Stony Reef - iceberg ploughmarks distribution (collected during the SEA7 survey and 2012 JNCC/MSS survey). Reef quality index followed stony reef guidance (Irving 2009).

1.3 Annex I Reef

Reefs are formed by biogenic concretions or non-biogenic substrata, which arise from the seafloor and so are topographically distinct from their surroundings (European Commission 2013a). They are generally found in the subtidal zone but may extend in a broken transition into the intertidal zone. Annex I reefs include biogenic reefs, bedrock reefs and stony reefs.

The UK has a greater range and extent of rocky reefs than biogenic reefs, and rocky reefs are extremely variable in their structure, and in the communities they support (Brown *et al.* 1997). They range from vertical rock walls to horizontal ledges, sloping or flat bed rock, broken rock, boulder fields, and aggregations of cobbles. A variety of invertebrates can inhabit rocky reefs, including sponges, corals, and sea squirts, which attach to the rock surface. Mobile species, such as fish, lobsters and crustaceans, may also use rocky reefs for shelter. Both types of rocky reefs – bedrock reefs and stony reefs – are protected features within WTR.

1.3.1 Bedrock reef

Bedrock reef occurs where the bedrock that underlies surface sediments on the seafloor arises from the surrounding seabed, creating a habitat that is colonised by many different marine animals and plants. Bedrock is consolidated rock and can be composed of most rock types (granite, limestone, sandstone, etc.).

1.3.2 Stony reef

Stony reef occurs where 10% or more of the seabed substratum are composed of particles greater than 64 mm across, (i.e. cobbles and boulders; European Commission 2013a). The remaining supporting 'matrix' could be of smaller sized material. The reef may be consistent in its coverage, or it may form patches with intervening areas of finer sediment. Epifaunal species dominate biological cover. Stony reef should be topographically distinct from the surrounding sea floor with a minimum area of 25 m² (this also applies to the total area of a patchy reef) (Irving 2009).

Iceberg ploughmarks can be considered as a special type of stony reef. They occur along the UK continental shelf edge off northern and western Scotland, including in WTR (Irving 2009). Iceberg 'ploughmarks' consist of ridges of boulders, cobbles and gravel where finer sediments have been winnowed away by high energy currents at the site, interspersed with finer sediment troughs up to 5–10 m deep (Masson *et al.* 2000). They are thought to have been formed by the ploughing movement of icebergs through the seabed at the end of the last ice age. The iceberg ploughmarks in WTR are stable and consolidated and have been classified as stony reef (Irving 2009).

1.3.3 Biogenic reef

Biogenic reefs are made up of hard matter, formed by animals themselves. The reef structure can be composed of the reef-building organism (including its tubes or shells), or it may also be composed of sediments, stones and shells that the organism has bond together. In the deep sea, the main species that form biogenic reefs include cold-water corals (e.g. *Lophelia pertusa*, *Madrepora oculata* and *Solenosmilia variabilis*). Biogenic reefs can provide complex habitats for species assemblages, such as for sponges, bryozoans, and sea squirts.

1.4 OSPAR threatened and/or declining species

1.4.1 Deep-sea sponge aggregations

Deep-sea sponge aggregations (DSSA) are listed in the OSPAR list of threatened and/or declining species and habitats (OSPAR 2008) and are defined by OSPAR as occurring in the deep-sea (typically at depths between 250 m and 1,300 m). They are primarily characterised by the presence of structure-forming glass sponges (Hexactinellida) or giant demosponges (Demospongiae) (OSPAR 2010). Sponge aggregation densities are defined by OSPAR as ranging from 0.5 – 24 sponges per m² (Henry & Roberts 2014; OSPAR 2010). They are biodiversity hotspots, supporting a range of species that are unique to the surrounding seafloor communities. DSSA are found in a wide range of habitats from muddy sediments to rock. In the Faroe-Shetland region aggregations are often related to iceberg plough marks, attaching to the hard and coarse substrates associated with the scoured seabed (Marine Scotland (now Marine Directorate) 2016). Sponge tissue is composed of small, spine-like, silicone spicules. Spicules from dead sponges form dense mats and can alter seabed characteristics, which in turn provide shelter for a wide range of small animals and elevated habitats for filter feeders (Tyler-Walters *et al.* 2016). Deep-sea sponges are thought to be slow-growing, and sponge communities are likely to take many years or even decades to recover, if damaged. Physical disturbance is the greatest anthropogenic threat to sponge communities in the deep sea, and it is probable that bottom trawling and increased amounts of sediment in the water significantly damage DSSA. Resource exploitation (oil and gas operations) and future bioprospecting also pose potential threats to the survival of sponges (Tyler-Walters *et al.* 2016). Sponges are historically difficult to identify to species level and enumerate from imagery. Berman *et al.* (2013) highlighted morphological monitoring for sponge assemblages as an effective tool for imagery analysis and monitoring purposes. Within this report sponge identification is assigned to morphotypes based on descriptions by Berman *et al.* (2013).

1.5 Aims and objectives

1.5.1 Conservation objectives

High-level, site-specific conservation objectives serve as a benchmark against which to monitor and assess the efficacy of management measures, once in place, in protecting designated features within MPAs.

The Conservation Objectives for WTR are for the feature to be in favourable condition thus ensuring site integrity in the long term and contribution to Favourable Conservation Status of Annex I Reefs (JNCC 2018a).

This contribution would be achieved by maintaining or restoring, subject to natural change:

- The extent and distribution of the qualifying habitat in the site.
- The structure and function of the qualifying habitat in the site.
- The supporting processes on which the qualifying habitat relies.

Within WTR, Annex I reefs are currently considered to be in Unfavourable Condition, and so the objective for the site is to recover Annex I reefs to Favourable Condition (JNCC 2020).

1.5.2 Definition of ‘Favourable Condition’

The Supplementary Advice on Conservation Objectives (SACO) for WTR (JNCC 2018b) provides advice on the Conservation Objectives for Annex I reef bedrock and stony reef features. The advice includes detail on attributes that fall into broad themes: extent and distribution, structure and function, and supporting processes, as detailed below. Once these Conservation Objectives are met, the feature is deemed to be in Favourable Condition.

1.5.2.1 Extent and distribution

The extent of a habitat feature refers to the total area in the site occupied by the qualifying feature and must also include consideration of its distribution. A reduction in feature extent has the potential to alter the physical and biological functioning of sediment habitat types (Elliot *et al.* 1998). The distribution of a habitat feature influences the component communities present and can contribute to the condition and resilience of the feature (JNCC 2004a). Rocky habitats are defined by composition (particle size), energy level, and biological assemblages.

1.5.2.2 Structure and function

Structure encompasses the physical and biological components of a habitat type and the key and influential species present. Physical structure refers to topography, sediment composition and distribution. Physical structure can have a significant influence on supporting processes such as the hydrodynamic regime operating at varying spatial scales in the marine environment, as well as influencing the presence and distribution of associated biological communities (Elliot *et al.* 1998). This is particularly true of rock features which can be large-scale topographic features. The biological structure refers to the key and influential species and characteristic communities present. Biological communities are important in not only characterising the rock feature but supporting the health of the feature (i.e. its conservation status and the provision of ecosystem services by performing functional roles).

Functions are ecological processes that include sediment processing, secondary production, habitat modification, supply of recruits, bioengineering and biodeposition. These functions rely on the supporting natural processes and the growth and reproduction of those biological communities which characterise the habitat and provide a variety of functional roles within it (Norling *et al.* 2007) (i.e. key and influential species and characteristic communities). These functions can occur at several temporal and spatial scales and help to maintain the provision of ecosystem services locally and to the wider marine environment (ETC 2011). Ecosystem services typically provided by rock features include nutrition. This is due to the level of primary and secondary productivity on or around rock habitat, a range of fish species use these areas as feeding and nursery grounds (Ellis 2012), depending upon the biogeographic region.

1.5.2.3 Supporting processes

Rocky habitats rely on a range of supporting natural processes to support the functions (ecological processes) and help any recovery from adverse impacts. For the site to fully deliver the conservation benefits set out in the statement on conservation benefits, the following natural supporting processes must remain largely unimpeded: hydrodynamic regime and water quality.

Hydrodynamic regime refers to the speed and direction of currents, seabed shear stress and wave exposure. These mechanisms circulate food resource and propagules, influence water properties by distributing dissolved oxygen, and facilitating gas exchange from the surface to the seabed (Chamberlain *et al.* 2001; Biles *et al.* 2003; Hiscock *et al.* 2004; Dutertre *et al.* 2012). Shape and surface complexity of rock features can be influenced by coarse as well as finer-scale oceanographic processes, supporting the formation of topographic bedforms.

The hydrodynamic regime plays a critical role in the natural formation, size structure and erosion of rock feature.

Contaminants may also impact the ecology of a rock feature through a range of effects on different species within the habitat, depending on the nature of the contaminant (JNCC 2004b; UKTAG 2008).

1.5.3 Report aims and objectives

The primary aim of this monitoring report is to explore and describe the attributes of the features within WTR to enable future assessments of feature condition as part of a separate process (i.e. to determine whether Conservation Objectives have been achieved). The results presented will be used to develop recommendations for future monitoring, including the operational testing of specific metrics which may indicate whether the condition of the features has been conserved, improved or declined. The report objectives are outlined in Table 1.

This report does not aim to assess the condition of the designated features. – Statutory Nature Conservation Bodies (SNCBs) use evidence from 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.

Table 1. Objectives for Wyville-Thomson Ridge Special Area of Conservation 2017 & 2018 monitoring report.

Objective	Feature attributes	Sub- attributes	Outputs
1. Describe the characteristic biological communities of the Annex I Reef.	Biological structure	Description and spatial distribution of biological communities. Presence and abundance of key structural and influential species.	• Multivariate analysis of epifaunal data on selected still imagery to: - Identify presence and patterns in epifaunal communities. - Identify key structural and influential taxa representing the identified communities. - Describe abundance and distribution of specific protected species and habitats (Priority Marine Feature habitats and species). • Map of biological communities. • Map of deep-sea sponge aggregation. • Map of biotopes.
2. Present information relating to supporting processes which are known to influence the designated and additional habitat and species features.	Supporting processes	-	• Map of conductivity from CTD at selected sampling stations. • Map of temperatures from CTD at selected sampling stations. • Analysis of modelled near-bottom water current velocity and direction. • Map of substrate composition (from still imagery) at selected sampling stations. • Graphs of biological cluster group associated environmental conditions at selected sampling stations. • BIOENV/BEST and RDA analyses to examine environmental drivers of community composition.

Objective	Feature attributes	Sub- attributes	Outputs
3. Describe the extent and distribution of the Annex I Reef-	Extent and distribution	-	• Substrate composition analysis (from video imagery) at all sampling stations. • Map of the extent and distribution of Annex I Reef at all sampling stations.
4. Present any evidence of impact of anthropogenic activity observed within the site.	n/a	-	• Description of observed anthropogenic evidence including marine litter and anthropogenic activities. • Map of observations of anthropogenic evidence.
5. Recommend future monitoring approaches for the site, and other sites containing comparable features.	n/a	-	Set of recommendations regarding: • Imagery data quality. • Future monitoring at WTR. • General recommendations on analysis and interpretation. • Site management.

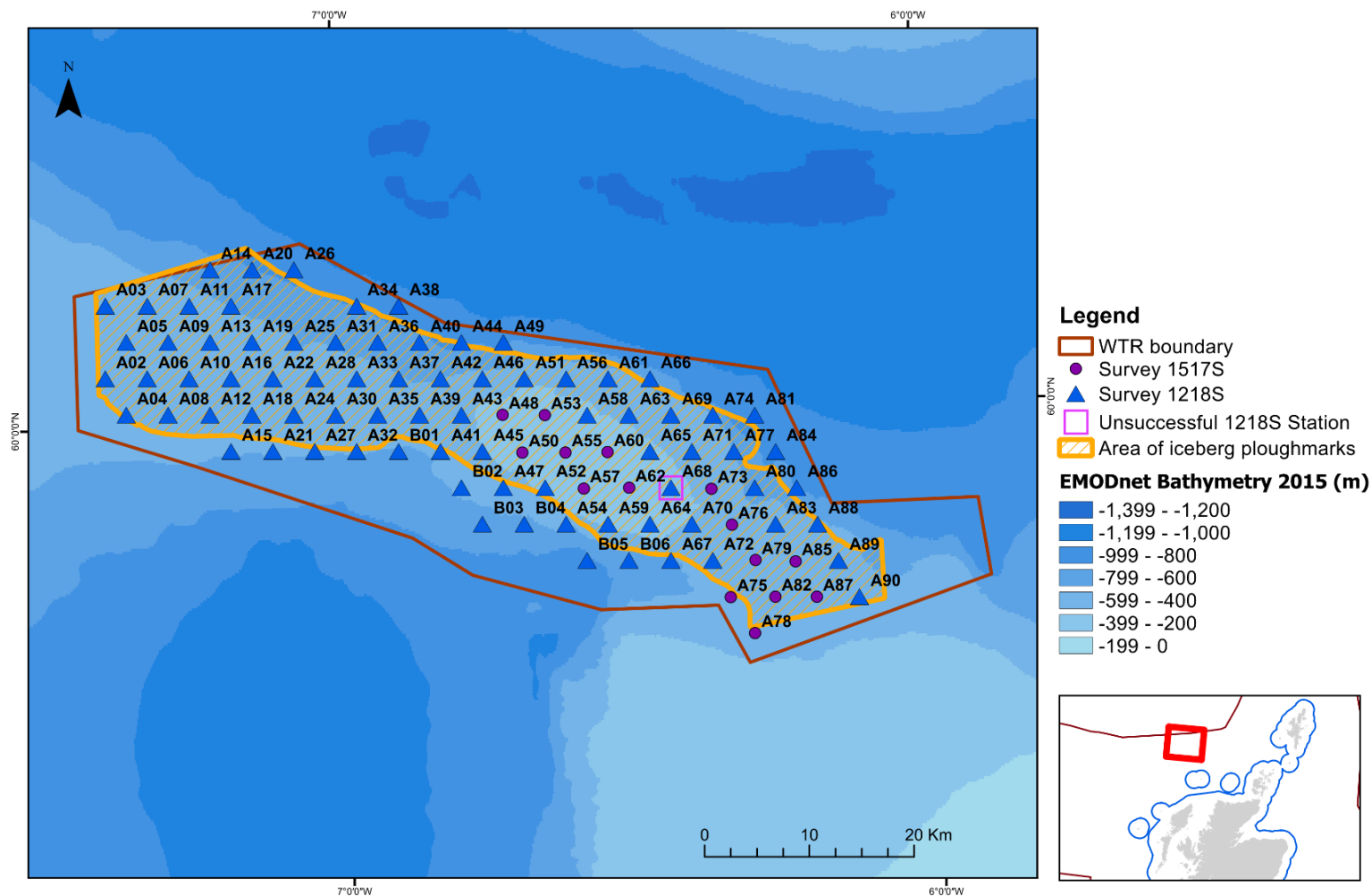
2 Methods

2.1 Survey design

This report examines data collected on two JNCC/MSS surveys to WTR. The first survey was undertaken by JNCC and MSS on the RV *Scotia* between 20 October and 9 November 2017 (cruise code 1517S). The primary objective of the survey was to collect data for Sentinel Monitoring of long-term trends of the Annex I reef feature to better understand long-term temporal and spatial patterns in epibenthic faunal communities across the site (Taylor *et al.* 2019a).

The camera-based survey was designed to compare biological communities encountered on the Arctic and North Atlantic sides of the ridge, as well as biological communities on top and on either side of the ridge. The camera tows were targeted on the Annex I reef “iceberg plough-mark” feature, as delineated by the National Oceanography Centre (NOC) using Towed Ocean Bottom Instrument (TOBI) sidescan data collected by NOC in 1996 and 1998 (Masson 1997). Stations were assigned using a triangular systematic grid. Stations were a minimum of 3 km apart to ensure sampling points were independent of each other. Due to adverse weather conditions, it was only possible to complete a total of 15 drop-camera stations WTR in 2017 (Taylor *et al.* 2019a; Figure 5).

A second survey was undertaken by JNCC and MSS on the RV *Scotia* between 21 August and 15 September 2018 (cruise code 1218S). The primary objective of this survey was to complete the grid of Sentinel Monitoring stations planned for the 2017 survey (Taylor *et al.* 2019b). 76 Stations were successfully completed on the 2018 survey (Figure 5). Sampling at one additional station (station code A68) was attempted during survey 1218S, however due to adverse weather conditions (moderate swell and high winds) the sampling at this station was aborted (Figure 5).



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Figure 5. Map of ground truth samples at Wyville-Thomson Ridge Special Area of Conservation (WTR). Purple filled circles denote stations sampled during 1517S, blue filled triangles denote stations sampled during 1218S. The unsuccessful drop-frame camera station (station A68) is indicated by the square box. Text labels denote station codes.

2.2 Data acquisition

2.2.1 Seabed imagery

A total of 91 drop-down camera tows (approximately 200 m in length each) were successfully collected during the 2017 and 2018 surveys (Figure 5).

Imagery data were collected in accordance with MESH (Mapping European Seabed Habitats) guidelines (Coggan *et al.* 2007). The parameters that video and still imagery data were analysed for are outlined in Table 2.

Table 2. Obtained information from video and still imagery data.

Video	Stills
Identification of habitats	Identification and enumeration of epifauna
Provide semi-quantitative data on seabed characteristics	Enumeration of substrate composition
Note transitions between habitats	
Record any visually detectable litter and anthropogenic impacts	

2.2.2 Environmental data

A Multiparameter CTD profiler was attached to the drop-frame which collected *in situ* oceanographic data (temperature, conductivity and depth). CTD data was extracted and matched to the selected images using their timestamp and subsequently averaged to obtain one value per sampling station. Stills image associated substrate composition data was aggregated for each station. During this process, the respective seabed sampling area, referred to as Field of View (FoV), of the selected images was taken into account.

Information on near bed water current velocity and direction (at 90% depth from sea surface) was obtained from Task 2G of the Marine Biodiversity R&D Programme (Project Code: MB0102; Lambkin *et al.* 2010). Station values were estimated as the nearest available Task 2G datapoint.

2.3 Data preparation, numerical and statistical analyses

2.3.1 Epifauna community analysis

2.3.1.1 Data extraction

Biological and environmental data were extracted from the drop camera video and stills imagery following NMBAQC guidelines (Turner *et al.* 2016). Benthic habitats were classified from all imagery using the JNCC Marine Habitat Classification for Britain & Ireland scheme (MHC; JNCC 2022b). Data from the 2017 and 2018 surveys were analysed by Envision Mapping Ltd. (Benson & Sotheran 2018; Benson *et al.* 2020) and subjected to external quality assurance. For the 2018 dataset, epibiota were identified and tagged using a nested CATAMI classification using the annotation web service BIIGLE.

2.3.1.2 Biological data truncation

The biological datasets were examined and truncated to ensure subsequent analyses were robust and any erroneous entries were removed. For example, records of juveniles and mobile species were removed. Three taxa had their abundance enumerated using different methods (e.g. counts or cover) across the 1517S and 1218S surveys. This inhibited our ability to compare their abundances between stations across the two datasets. The taxa of concern were Cirripedia, Reteporella and Serpulidae. These taxa were removed from the dataset prior to epifauna community analysis. Full details of the truncation protocol for epifauna are available in Appendix 2.

2.3.1.3 Still image selection

Sampling size is key in our ability to correctly and precisely describe biotic communities (Chao & Jost 2012). However, benthic still images varied greatly in their quality, ranging from “poor” to “excellent”. For detail on image quality classification and examples of variables affecting those, please see the North East Atlantic Marine Biological Analytical Quality Control (NMBAQC) image quality guidelines outlined by Turner *et al.* 2016. Images further differed in their characteristics by differing FoV.

Both image quality and FoV may impact the epifauna taxa that can be identified. For example, one may be less likely to observe conspicuous or small taxa with a poorer quality image. Similarly, an increased FoV and associated ground pixel size may impact the type of taxa that can be observed and the taxonomic level that individuals can be identified to.

Altered image quality and FoV can therefore affect our ability to accurately and adequately identify and quantify epifauna taxa present. This impacts our ability to meet the first objective of this report to describe the composition and distribution benthic communities present.

Several analytical and filtering steps were required to ensure appropriate still images were used for further epifaunal community analysis. Those steps were undertaken to:

- I) understand how the quality of the biotic dataset was affected by still image characteristics (quality and FoV), and
- II) to identify the optimal subset of images for further epifauna community analysis, whilst considering effects on sampling size.

Benthic image analytical and filtering steps undertaken are outlined below. Further details on the image selection process are available in Appendix 2.

Still Image selection steps

1. Species accumulation curves were created to identify the optimal sampling size (i.e. the seabed area sampled) across stations and habitats at the site. The variable image FoV was considered to calculate the cumulative area of the seabed sampled (termed total viewable area – TVA) across images.
2. Variability in image quality (as per NMBAQC guidelines; Turner *et al.* 2016) and FoV was explored.
3. The role of image quality and FoV on our ability to detect and quantify key (morpho-) taxa was investigated. Relationships were identified and described using different mathematical models. Note that only images from survey 1218S were included in this step to avoid the influence of a potential survey – effect.

Steps 2 and 3 identified a large variability in image quality and FoV and an impact on our ability to accurately detect the occurrence and/ or abundance of all taxa investigated. Based

on those results an image selection step was deemed necessary. To obtain the best available dataset for further benthic community analyses different image filtering approaches were considered.

4. After selection of only Good+ quality images, the trade-off between I) the minimum sampling size at a station; II) still image consistency (i.e. FoV filtering criteria); and III) the number of stations included in the final dataset (i.e. the stations that met the minimum sampling size after image filtering has taken place) was explored.
5. To obtain the final biological dataset, still images were filtered having a quality classed as “Good” and above (Turner *et al.* 2016) and with an FoV ranging from 0.5 – 5.0 m². Stations were included when containing a sampling size of at least 15 m². These selection criteria thresholds were deemed most appropriate to provide an optimal subset of images for subsequent benthic community analysis. 45 Stations could be included for further epifauna community analysis.

2.3.1.4 Data preparation

The resulting biological datasets were combined and normalised to produce a single ‘relative abundance matrix’ for each sampling station. This was then transformed into a ‘relative density’ matrix by taking into account the sampling size or TVA at a station. A detailed overview of the data preparation and analysis process tree is provided in Appendix 2.

2.3.1.5 Statistical analyses

The suite of statistical tests that were performed on the data are outlined in Table 3. To identify the different biological communities present at the site, a k-means cluster analysis was performed, and their separation was visualised using an nMDS procedure. Cluster groups were further investigated for key and influential species using a Multi-level Pattern analysis and univariate biodiversity matrices were calculated for each identified cluster group. Finally, environmental variables (see Section 2.2.2) were investigated to improve our understanding of drivers in spatial distribution of epifaunal cluster groups. To identify the key environmental variables in shaping biological assemblages, RDA and BIOENV analysis were performed. Details of the statistical analyses are available in Appendix 2.

Table 3. Epifaunal statistical analyses conducted.

Statistical Method	Application
K-means cluster analysis	To identify groupings of epifauna assemblages across WTR.
Non-metric multidimensional scaling (nMDS)	To visually explore the relationships between samples, epifauna community cluster groups and habitats.
Multi-level pattern analysis	To identify characterising taxa in each epifauna cluster group.
Redundancy Analysis (RDA)	To investigate the association between environmental variables (including depth, near bed water current velocity, sediment type, temperature and conductivity, survey, and geographic position) and the biological communities.
BIOENV	To identify the best subset of environmental variables to explain variation across biological assemblages in the most parsimonious way.

2.3.2 Extent and distribution of Annex I stony reef

The classification of Annex I stony reef is based on three criteria (Irving 2009):

- Substrate composition
- Elevation
- Extent

The extent and distribution of Annex I stony reef inside and outside of the iceberg ploughmarks area was classified using only the substrate composition criterion as other information was absent. The analysis was carried out on video data from the 1517S and 1218S surveys for all stations sampled.

The relative density of stony substrata (i.e. combined cover of cobble and boulder) was calculated for each station. In cases where substrate cover values were recorded as '< 5%', these values were converted to 3% for analysis. The relative density values were then compared against the substrate composition threshold outlined in the Annex I stony reef guidance (Irving 2009). Stations with stony substrata coverage of at least 10% were classed as potential stony reef. Note that the identification of stony reef solely based on the substrate composition only allows the identification of potential stony reef to a low certainty (Irving 2009), and these results should therefore be interpreted with a degree of caution.

A map was created showing the extent and distribution of Annex I reef within WTR.

This map includes detailed information on:

- The extent of the iceberg ploughmarks area (Masson 1997).
- The relative density of stony substrata at each station surveyed in 1517S and 1218S.

2.3.3 Extent and distribution of Deep-Sea Sponge Aggregations

Although WTR was not designated for the protection of DSSA (JNCC 2018a), the epifaunal community analysis showed a high abundance of sponge morphotypes, indicating their important contribution to benthic communities at WTR. As DSSA are covered under the OSPAR database of threatened and/or declining habitats (OSPAR 2010), an assessment on the presence of DSSA across WTR was carried out following the guidance outlined by Henry and Roberts (2014).

The selected imagery data was used to verify the presence of the habitat using three criteria: density, habitat and ecological function, as detailed in Henry and Roberts (2014). The use of these criteria also allowed a confidence score to be assigned to each record, relating to how likely the record was a deep-sea sponge aggregation according to the OSPAR definition (OSPAR 2010).

The methods used to assess each of the criteria included:

- **Density:** The density of sponges was calculated for both solitary and colonial morpho-taxa by dividing the sum of sponge counts/% cover by the total viewable area covered at a station. Any stations with counts greater than 0.5 per m² or 1% cover for solitary vs encrusting morphotypes were considered to meet the OSPAR criteria for DSSA (OSPAR 2010).
- **Habitat:** This criterion was met if it could be confirmed that the record of potential DSSA was characterised by sponges or that it could **not** be described as any other

habitat forming assemblage such as corals, seapens, cerianthid anemones or *Lanice* polychaetes (Henry & Roberts 2014). This was done using Multi-level Pattern analysis to identify the characterising taxa within the assemblage. If the taxa identified by the Multi-level Pattern analysis included both sponge species and another habitat-forming species, evidence that sponges characterised the habitat more strongly than the other species had to be provided for the habitat criterion to be met.

- **Ecological function:** DSSA are known to play an important functional role in the ecosystems they are present. For example, they provide habitats for fauna such as echinoderms (particularly ophiuroids), crustaceans, hydroids, attached polychaetes and fish (OSPAR 2010). For the ecological function criterion to be met, SIMPER analysis had to identify the characterising taxa of the assemblage to be fauna that are typically associated with DSSA as outlined by OSPAR (2010).

2.3.4 Non-indigenous species

The epifaunal taxon list generated from the seabed imagery data were cross-referenced against lists of non-indigenous target species (NIS). These lists have been selected for assessment of Good Environmental Status in UK waters under Marine Strategy Framework Directive (MSFD) Descriptor 2 and identified as significant by the Great Britain Non-Native Species Secretariat. These taxa are listed in Appendix 12.

3 Results

3.1 Benthic Image Data Quality and Selection

3.1.1 Optimal sampling size

For surveys 1517S and 1218S, the sampled seabed ranged between 19 – 61 m² and 1.1 – 255 m² TVA at a station.

When species accumulation curves were examined, there was a failure to reach the asymptote at all stations. This indicated that the optimal sampling size exceeded the realized sampling size for all stations (Appendix 3; Figure A2), meaning that the number of images taken at each station was not sufficient to fully capture the biological communities present at that location.

3.1.2 Variation in Image quality & Field of View and associated data quality

3.1.2.1 Image quality and FoV variability

For images from surveys 1517S and 1218S combined, image FoV varied 1000-fold, with FoV ranging between 0.052 and 49 m² across images. There was an average FoV of $1.45 \text{ m}^2 \pm 0.057 \text{ SE}$ and $5.82 \text{ m}^2 \pm 0.27 \text{ SE}$ for surveys 1517S and 1218S respectively.

Image quality following NMBAQC guidelines (Turner *et al.* 2016) varied between “Very poor”, “Poor”, “Good” and “Excellent” across the 1517S and 1218S surveys, with a large proportion identified as “Poor” or “Very poor” (Figure 6). As “Excellent” quality images were rare; they were grouped together with “Good” quality images to form a new image quality group labelled “Good+” for further analyses.

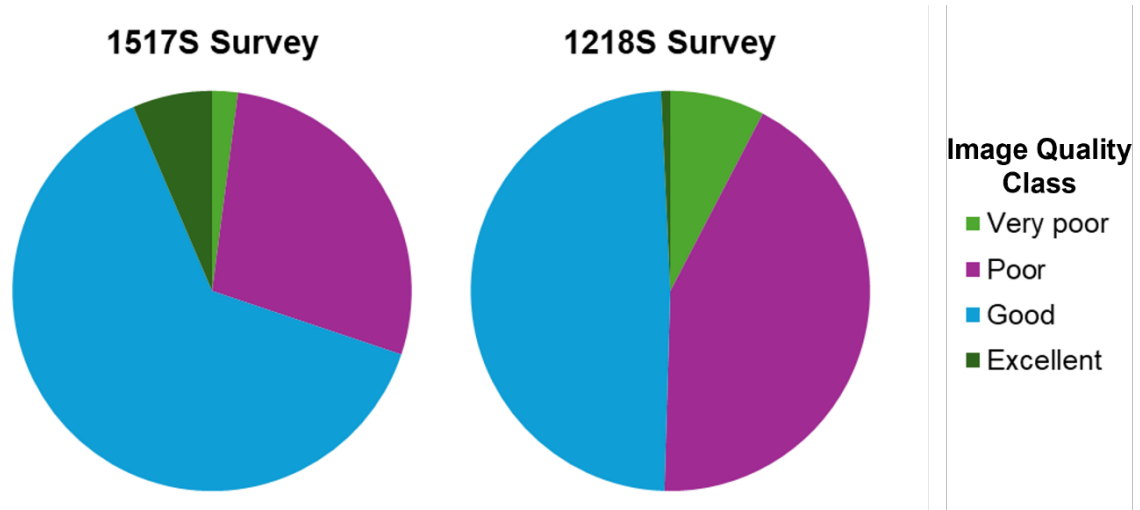


Figure 6. Pie charts showing the proportion of image qualities from surveys 1517S and 1218S following NMBAQC guidelines (Turner *et al.* 2016). N = 6463 and 31636 images for surveys 1517S and 1218S respectively.

Further detail on variables that impact image quality and its potential impact on the accurate and precise detection of benthic communities can be found in Appendix 5.

3.1.2.2 Association between image characteristics and Porifera observation

The potential relationship between the observation of different Porifera morphological forms (erect, massive and encrusting) and image characteristics Quality and FoV was examined. Statistical models investigated the role of image quality on:

- 1) the detection of Porifera presence and
- 2) the relationship with observed Porifera density. These are the key results:

Still image FoV effect:

- Massive and erect Porifera density observations reduced when image FoV increased. This relationship was not observed for the encrusting morpho-type.
- Images with an increased FoV were associated with a lower detection rate (i.e. identified presence) of encrusting Porifera.

Still image quality effect:

- “Poor” and “Very poor” quality images resulted in an undervaluation of Porifera abundances compared to “Good+” quality images. This effect was more pronounced for “very poor” compared to “poor” quality images. This relationship was observed for almost all morpho-type – image quality comparisons.
- In contrast, a lower image quality surprisingly increased the detection rate of encrusting Porifera presence. Again, this relationship was stronger for ‘Very poor’ quality compared to ‘Poor’ quality images.

Full details model selection results and Porifera abundance – image characteristic relationships are outlined in Appendix 4.

3.1.2.3 Association between image characteristics and (morpho-)taxon observation

As above, the potential relationship between image characteristics (Quality and FoV) and the abundance of the 12 most abundant morpho-taxa (excluding Porifera) was investigated.

Still image FoV effect:

- For images with a larger FoV, we observed a significant negative relationship with both the detection and the observed density of all taxa investigated. This means that with a larger FoV both the occurrence *and* the abundance of key taxa are likely to be underestimated.

Still image Quality effect:

- For images with reduced image quality, this had a predominantly negative association with taxon abundances. However, this relationship was not observed for all taxa – image quality relationships investigated (generally taxa with lower abundances), and an opposite pattern was observed for two of the 12 taxa investigated (Bryozoa and Echinodea). Again, ‘very poor’ quality images generally affected species densities more negatively than ‘poor’ quality images in comparison to ‘good+’ quality images, indicating an increased underestimation of taxon abundance when image quality becomes worse.

Full details model selection results and (morpho-)taxon abundance – image characteristic relationships are outlined in Appendix 4.

3.1.3 Data selection for epifauna community analysis

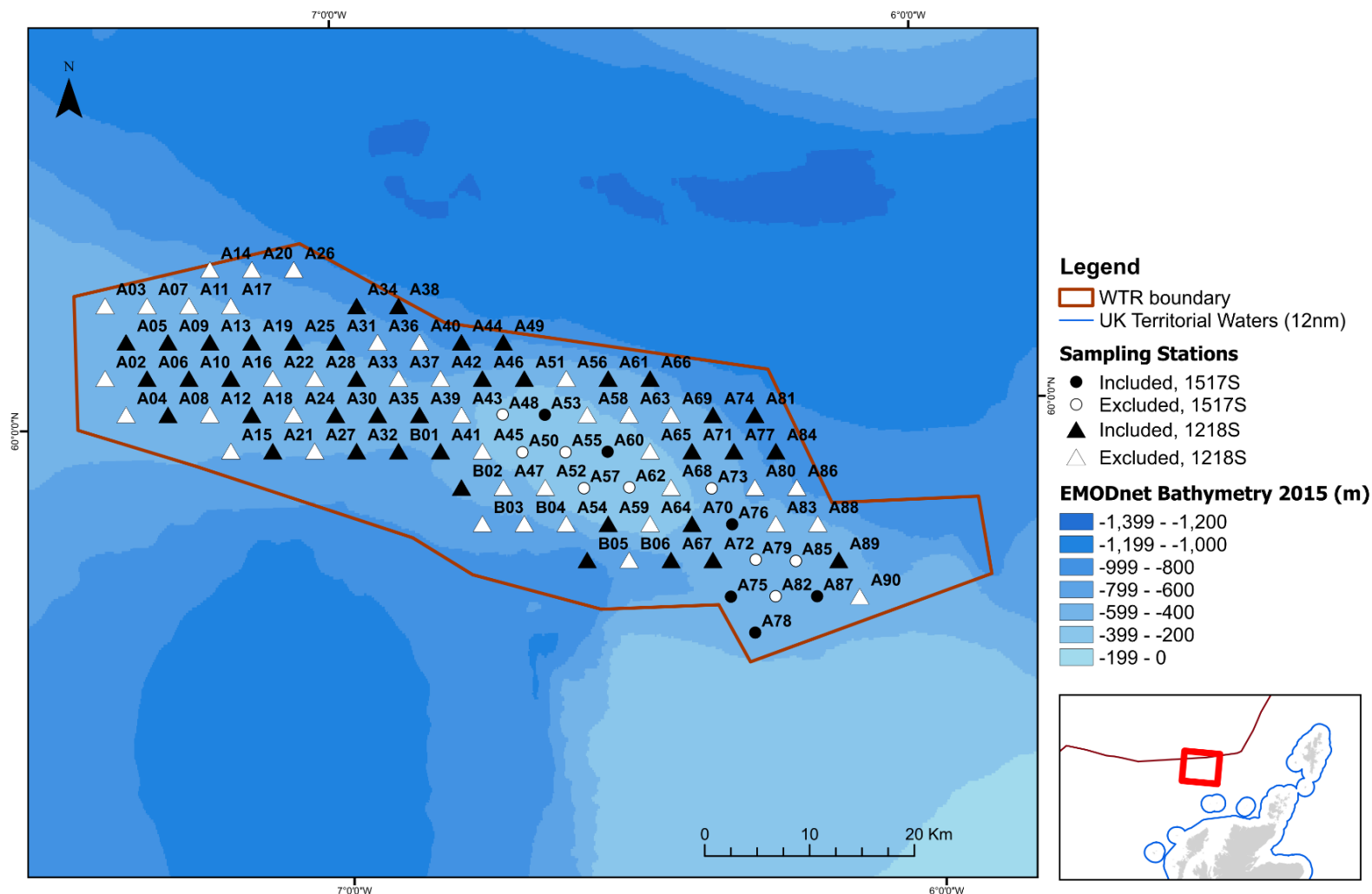
Results from Section 3.1.2 indicate that including “Poor” or “Very poor” quality images lead to bias in the estimation of the occurrence and/ or density for most morpho-taxa investigated. As a result, only images with “Good+” quality were included in further analyses, reducing the images available for analysis by 43% (Appendix 5; Table A5).

Results from Section 3.1.2 also indicate that epifauna community analysis bias will arise when including a larger FoV range. Although filtering images with an FoV within a narrower FoV range will increase data quality, this simultaneously has consequences for the number of images available for analysis (i.e. data quantity).

As indicated in Section 3.1.1, maintaining an as large as possible sample size or TVA at stations, and maintaining an even TVA across stations at the MPA, is important for data quality. However, narrowing FoV restrictions and increasing TVA thresholds may limit the number of stations that can be included for analysis.

The trade-off between dataset quality (i.e. a small FoV range for the images and large minimum TVA for each station) and dataset size was further explored (Appendix 5; Table A6). A FoV range per image of 0.5 – 5.0 m² and a minimum TVA per station of 15 m² was considered the best compromise between data quality and quantity. Image selection steps combined resulted in the selection of n = 361 images, only 17.5% of the original dataset size (Appendix 5; Table A5).

The image selection procedure resulted in the selection of 45 out of 91 stations available for analysis, comprising of six stations sampled in 2017 and 39 stations in 2018 as part of surveys 1517S and 1218S respectively (Figure 7).



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Figure 7. Map of the location of stations excluded (open symbols) and included (black filled symbols) for epifauna community analysis following image selection of 1517S (circles) and 1218S (triangles) at Wyville-Thomson Ridge Special Area of Conservation (WTR).

3.2 Epifaunal community analysis

3.2.1 Epifauna community composition

Following truncation, segmentation, removal of taxa with differing abundance enumeration methods and the selection of still image data of sufficient quality and within the preset FoV range, the epifauna data from the 1517S and 1218S surveys of WTR obtained a total of 89 distinct morpho-taxonomic entries across 45 stations. This includes indeterminate taxa described at the morphological level (morpho-taxa) and identified taxa at the species or genus level.

3.2.2 Epifauna community structure

To understand spatial patterns in the epifauna communities across stations, a k-means cluster analysis was performed.

The cluster analysis identified 10 groups (Groups A to J) as the optimal number of groups for the 45 stations at WTR (Appendix 6). The number of stations in cluster groups ranged from two (cluster groups E and G) to seven (cluster group I).

An nMDS plot provides limited support for the separation of benthic communities based on the habitat observed at a station (Figure 8). M.AtMB.Mx habitat (see Table 4 for description of habitat abbreviations) was separated from the main cluster of stations, observed in cluster groups D, G and H. Similarly, M.AtUB.Rock habitat is partly distinct, observed in cluster group D. Separation of the other clusters does not appear associated with differences in habitat (Figure 8).

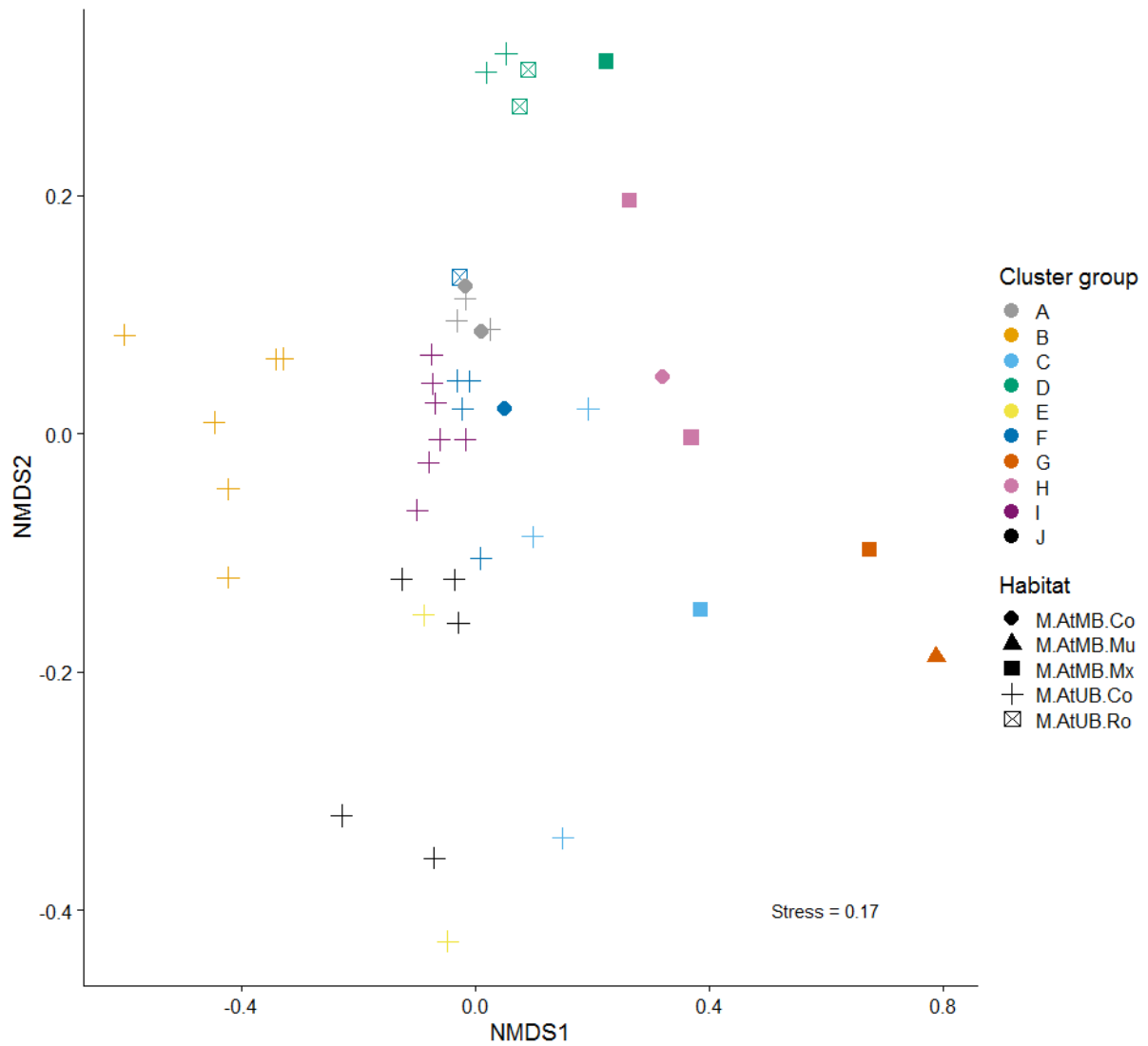


Figure 8. Non-metric multidimensional ordination of Hellinger transformed epibiotic data at Wyville-Thomson Ridge Special Area of Conservation. Individual datapoints represent sampling stations. Different colours represent the respective K-means community cluster groups and symbols represent the habitat identified at the station. For habitat abbreviation description see Table 4. Analysis is based on selected images from surveys 1517S and 1218S.

Table 4. Habitat abbreviation and description following Marine Habitat Classification of Britain and Ireland (MHC; JNCC 2022b) at stations at Wyville-Thomson Ridge Special Area of Conservation, based on selected images from surveys 1517S and 1218S.

Habitat Abbreviation	Description
M.AtMB.Co	Atlantic mid bathyal coarse sediment
M.AtMB.Mu	Atlantic mid bathyal mud
M.AtMB.Mx	Atlantic mid bathyal mixed sediment
M.AtUB.Co	Atlantic upper bathyal coarse sediment
M.AtUB.Ro	Atlantic upper bathyal rock and other hard substrata

3.2.3 Spatial distribution of epifaunal structure

In order to understand potential drivers of the epifauna community cluster groups as indicated in Section 3.2.2, the geographic location of stations belonging to the respective cluster groups was explored first (Figure 9). Most cluster groups showed grouping in space, except for cluster groups **C** and **E**.

Group **A** stations were found across a relatively large area on the SW flank of the ridge between ~ 400 – 860 m (Appendix 7; Figure 9).

Groups **C** and **E** showed no clear clustering in space, with stations located across the WTR (Figure 9).

Group **B** stations were all found on top of the ridge (Figure 9). Unlike other groups, stations in this group were all sampled as part of survey 1517S.

Group **D** stations were found along the NE flank of the ridge within a depth band between ~ 550 - 700 m (Appendix 7; Figure 9).

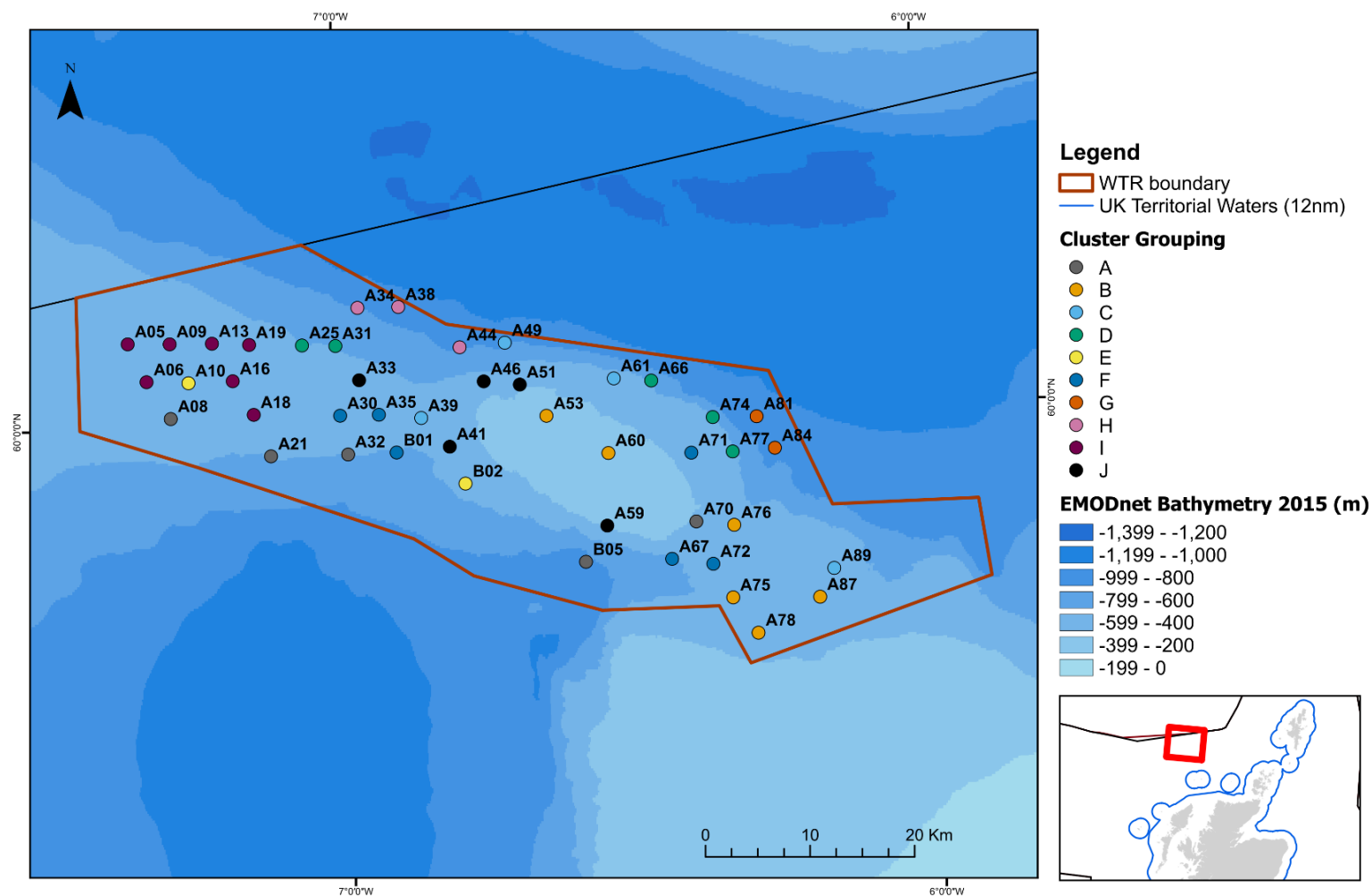
Group **F** stations were positioned on the southern flank and top of the ridge (Figure 9).

The two stations in group **G** were located close to each other, at 838 – 880 m depth on the East flank of the ridge (Appendix 7; Figure 9).

Group **H** stations were located in proximity to each other, positioned on the northern flank of the ridge (Figure 9).

Group **I** stations showed distinct spatial clustering. Stations were all found at the NE end of the WTR (Figure 9).

Lastly, group **J** stations were located in the central region of the WTR, concentrated around the central area on top of the ridge (Figure 9).



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Figure 9. Map of Wyville-Thomson Ridge Special Area of Conservation (WTR) showing station cluster groups as identified by the k-means partitioning analysis. Different colours represent the k-means cluster group to which a station was assigned. Station names have been added to the map. Based on selected images from surveys 1517S and 1218S.

3.2.4 Key and influential taxa

To understand the key and influential taxa of the identified epifauna community cluster groups, a Multi-level Pattern analysis was performed. This analysis is a measure of the association between a taxon (or morpho-taxon) and cluster groups. Taxa which score highly are those that frequently and/or predominantly found at the stations within the investigated cluster group.

Of the 89 morpho-taxa present in the dataset, 30 were identified as having a significant indicator value ($p < 0.05$) for one of the 10 defined cluster groups (Table 5).

The analysis revealed that the highest number of strongly associated taxa were found for cluster groups D, G, and H. For those cluster groups, five to 10 strongly associated taxa were identified (Table 5), indicating comparatively distinct and unique communities.

In contrast, cluster groups A, E and J had no associated characterising species (Table 5). This indicates that no taxa were uniquely associated to these groups and/or taxa had a low specificity across stations within these cluster groups.

Table 5. Results from the Multi-level Pattern analysis of epifaunal assemblages showing taxa with significant ($p < 0.05$) indicator values for each k-means cluster group. A and B are components of the IndVal statistic. Component A represents a taxon's specificity: the proportion of the different sites that the taxon is recorded from. Component B represents a taxon's fidelity: the proportion of the total number of individuals of the taxon that are recorded at the specific site. The IndVal statistic is the combination of A and B.

Cluster	Main morpho-taxa	A	B	IndVal Statistic	p. Value
A	<i>No characterising species</i>	-	-	-	-
B	Faunal crust	1.0	1.0	1.0	0.001
	Faunal turf	1.0	1.0	1.0	0.001
	Caridea	1.0	0.67	0.82	0.011
	Porifera arborescent	1.0	0.50	0.71	0.011
C	Porifera encrusting	0.77	1.0	0.88	0.003
D	Ophiuroidea	0.99	1.0	1.0	0.001
	Crinoidea	0.96	1.0	0.99	0.001
	Porifera massive simple	0.67	1.0	0.82	0.011
	Brachiopoda	0.69	0.8	0.74	0.028
	Ceramaster	0.78	0.6	0.69	0.023
	Porifera encrusting – yellow	0.45	1.0	0.67	0.007
	Porifera encrusting – white	0.38	1.0	0.62	0.041
E	<i>No characterising species</i>	-	-	-	-
F	Bryozoa branching – white	0.80	1.0	0.90	0.001
	Anthozoa	0.54	1.0	0.74	0.013

Cluster	Main morpho-taxa	A	B	IndVal Statistic	p. Value
G	Holothuroidea	1.0	1.0	1.0	0.003
	Pycnogonida	0.98	1.0	0.99	0.003
	Terebellidae	0.94	1.0	0.97	0.005
	Isopoda	0.66	1.0	0.82	0.006
	Cnidaria	0.60	1.0	0.77	0.018
H	Porifera massive simple - white	0.82	1.0	0.91	0.005
	Alcyonacea	0.71	1.0	0.84	0.019
	Octocorallia	0.67	1.0	0.82	0.006
	Scyphozoa	1.0	0.67	0.82	0.005
	Porifera tubes	0.85	0.67	0.75	0.008
	Hydrozoa	0.83	0.67	0.74	0.013
	Animalia	0.50	1.0	0.71	0.020
	Corymorpha	0.72	0.67	0.69	0.032
	Porifera massive balls	0.70	0.67	0.68	0.022
	<i>Cf. Halcampoides</i>	0.68	0.67	0.67	0.036
I	<i>Psolus squamatus</i>	0.77	0.57	0.67	0.025
J	<i>No characterising species</i>	-	-	-	-

3.3 Environmental drivers of epifauna community structure

3.3.1 Depth, Temperature and Conductivity

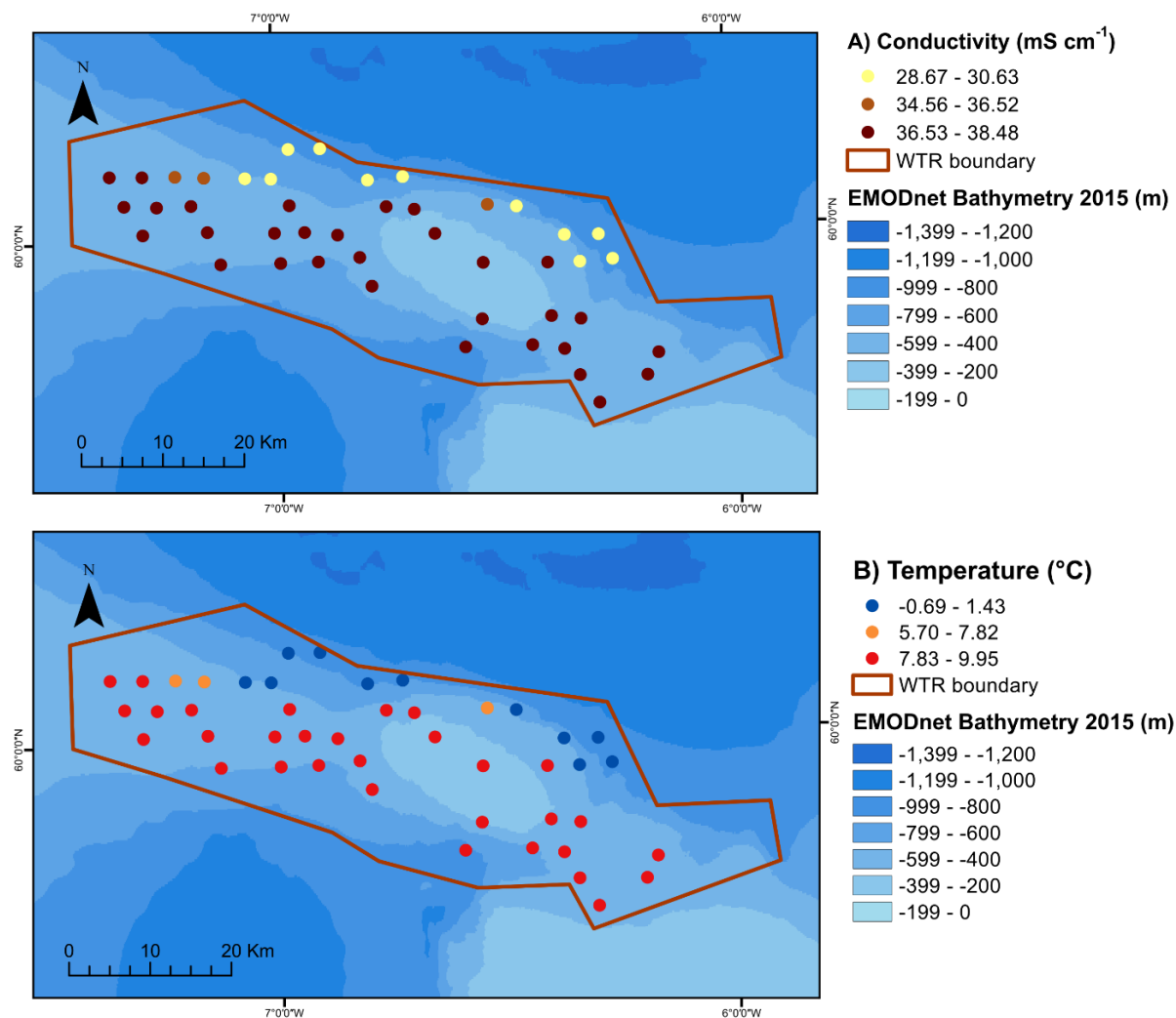
Depth across the 45 stations included for analysis ranged between 349 m (Station A53) and 899 m (station B05), with a mean depth of 554 m $\pm$ 22 SE as measured by the ships Davis system. The CTD recorded *in situ* depths with depths ranging between 342 m (station A53) and 880 m (station A81), and a mean depth of 553 m $\pm$ 21 SE. On average there was a 16.9 m $\pm$ 2.9 SE (absolute values) discrepancy between the *in situ* and top side (Davis system) depth measurements (n = 45).

Conductivity varied across the stations at WTR MPA. The lowest conductivity values (28.6 – 29.9 PSU) were recorded at 11 stations located at the bottom of the north east flank of WTR (Appendix 7; Figure 10a). All other stations had conductivity levels between 35.0 and 38.5 mS cm⁻¹ (Appendix 7; Figure 10a). The six stations that reported the highest conductivity (37.9 - 38.5 mS cm⁻¹) were located on top of the ridge and were sampled in 2017 (Appendix 7; Figure 10a).

Similar observations were made for patterns in temperature across WTR, with the same 11 stations that reported low conductivity values showing low temperatures.

These stations reported temperatures ranging from -0.70 to 0.82 °C (Appendix 7; Figure 10b). The remaining 34 stations reported temperatures ranging from 6.4 to 9.9 °C (Appendix 7; Figure 10a), with the highest temperatures (9.4 to 9.9 °C) observed at six stations located on top of the ridge, again, sampled in 2017 (Appendix 7; Figure 10b).

Across epifauna community cluster groups, there is a clear variation in *in situ* depth, temperature and conductivity measurements. The largest mean depth was observed for cluster groups G and H (Appendix 7; Figure 11a). Mean temperature and conductivity were lowest for cluster groups G and H and highest for cluster group B (Appendix 7; Figures 11b - c).



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Figure 10. Map of Wyville-Thomson Ridge Special Area of Conservation (WTR) showing average A) conductivity and B) temperature at different stations across the MPA based on associated CTD data from selected samples from surveys 1517S and 1218S.

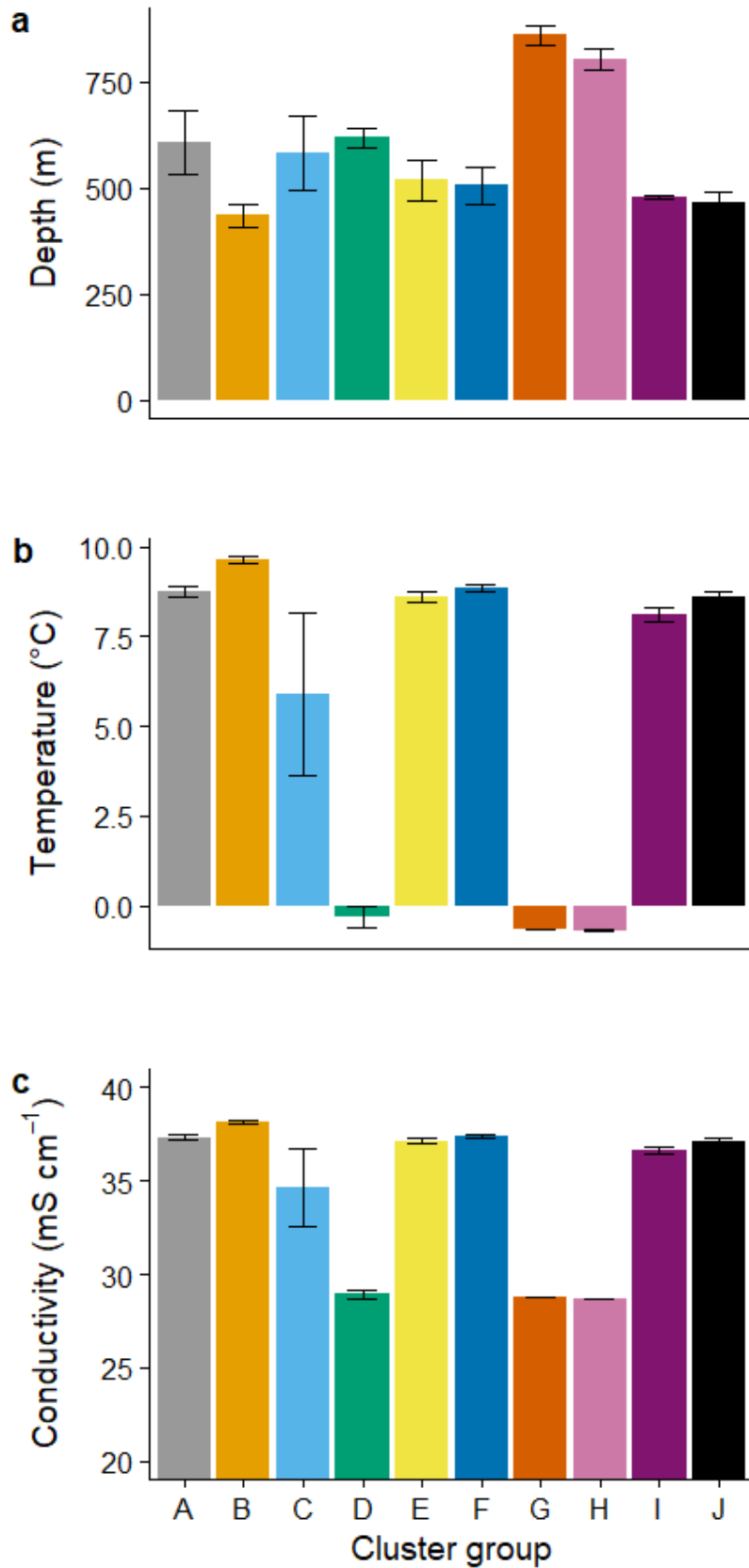


Figure 11. Bar charts showing *In situ* depth, temperature and conductivity information across cluster groups at Wyville-Thomson Ridge Special Area of Conservation. Error bars represent SE. N = 5, 6, 4, 5, 2, 6, 2, 3, 7 and 5 for cluster groups A – J, respectively. Based on selected images from surveys 1517S and 1218S.

3.3.2 Near-bottom water currents

The mean annual near bottom current direction at WTR is characterized by a north flowing relatively weak current at the southern end of the ridge and a stronger south-westerly flow originating north-west of the ridge. A strong current with a calculated annual magnitude of 0.43 ms^{-1} is observed on top of the ridge in westerly direction.

The calculated annual near bottom current magnitude at WTR ranged between 5.5×10^{-3} (station A78 – at the southern tip of WTR) to 0.43 ms^{-1} (stations A25; A30; A31; A44; A46 and B01 – situated around the central area on top of the ridge; Appendix 7; Table A7).

Although within cluster group variation in near-bottom current magnitude was large as indicated by the large SE range, variation between some epifauna community cluster groups can be observed (Appendix 7; Figure 12; Table A8). A comparatively weak near-bed current magnitude can be observed for cluster groups B and G.

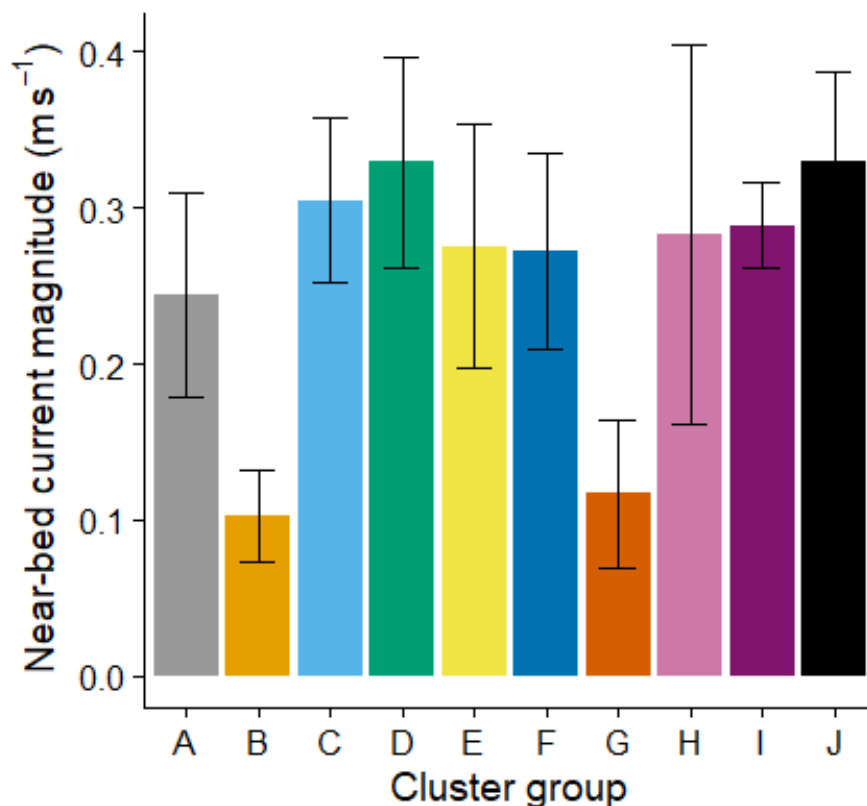


Figure 12. Bar chart showing near-bed current magnitude across cluster groups at Wyville-Thomson Ridge Special Area of Conservation. Error bars represent SE. N = 5, 6, 4, 5, 2, 6, 2, 3, 7 and 5 stations for cluster groups A – J, respectively. Based on selected images from surveys 1517S and 1218S.

3.3.3 Substrate composition

The substrate composition at WTR was dominated by the cover of **pebbles**, found at every station and with an average contribution of $68\% \pm 2.8 \text{ SE}$ of the seafloor at the site ($n = 45$) (Appendix 7; Figure 13; Table A9). Its contribution at the stations ranged between 4.0% (station A81) and 89% (station A33).

The second most abundant substrate type was **sand** (0.063 – 2 mm grain size), which was observed at 44 of the 45 stations (absent at station B01) (Appendix 7; Figure 13; Table A9). When present, its substrate contribution ranged between 7.7% (station A05) and 54% (station A81). Mean substrate contribution of sand at the site was $19\% \pm 1.8$ SE ($n = 45$).

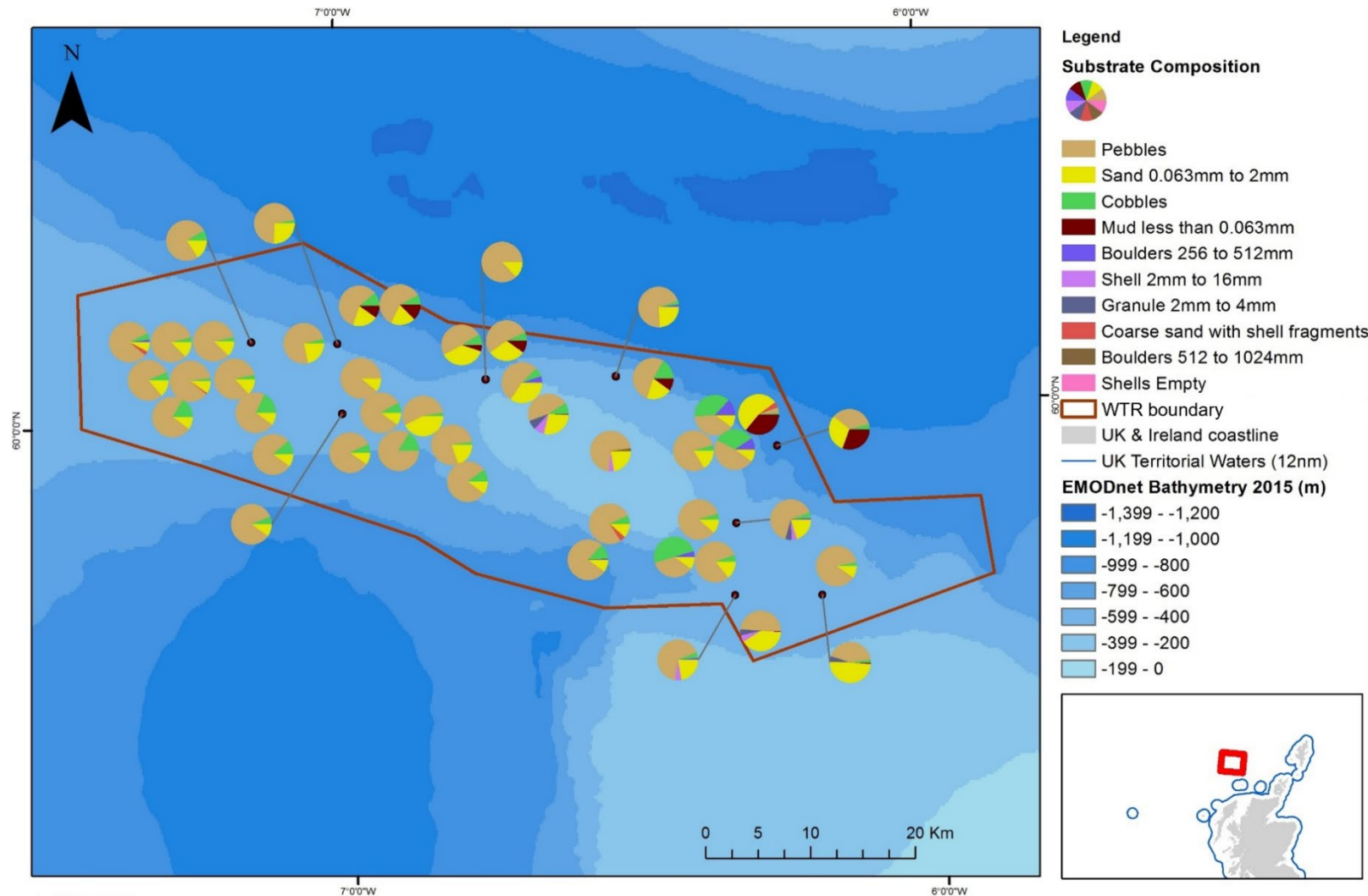
Thirdly, **cobble** substrate was present at 44 of the 45 stations at WTR, only being absent at station A33 (Appendix 7; Figure 13; Table A9). Its substrate contribution (when present) ranged between 2.6% (station A60) and 50% (station A67). Mean substrate contribution of cobbles at the site was $8.6\% \pm 1.5$ SE.

Soft sediment **mud** (< 0.063 mm grain size) was rare and only found at 10 stations on the NE flank of the ridge (Appendix 7; Figure 13; Table A9). Here, mud contributed between 1.0% (stations A53, A78) and 36% (station A81) of the substrate composition. Mean substrate contribution of mud at the site was $2.7\% \pm 1.2$ SE ($n = 45$).

Boulders (256 – 512 mm) were found at 13 of the stations at WTR (Appendix 7; Figure 13; Table A9). When present, it contributed between 0.52% (station A78) and 13% (station A74) to the substrate. Mean substrate contribution of Boulders (256 – 512 mm) at the site was $0.97\% \pm 1.0$ SE.

Other substrate types observed were Shell (2 – 16 mm); Granule (2 – 4 mm); Coarse sand with shell fragments; Large boulders (512- 1,024 mm) and Empty shells. Those substrate types contributed up to a maximum of 8.0% to the substrate at a station, with a mean substrate contribution of < 0.6% across stations at the site.

Across epifauna community cluster groups, variation in substrate contribution of all main substrate types was large (Figure 14). Cluster group G was dominated by soft sediment types of Sand and Mud (Figure 14b, d), while cluster group D specifically and group F, to a lesser extent, were characterised by the relatively high contribution of the large stone types of Cobble and Boulder (Figure 14c, e).



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Figure 13. Map of Wyville-Thomson Ridge Special Area of Conservation (WTR) showing the sediment composition at sampling stations. Substrate composition analysis is based on selected still imagery samples from surveys 1517S and 1218S.

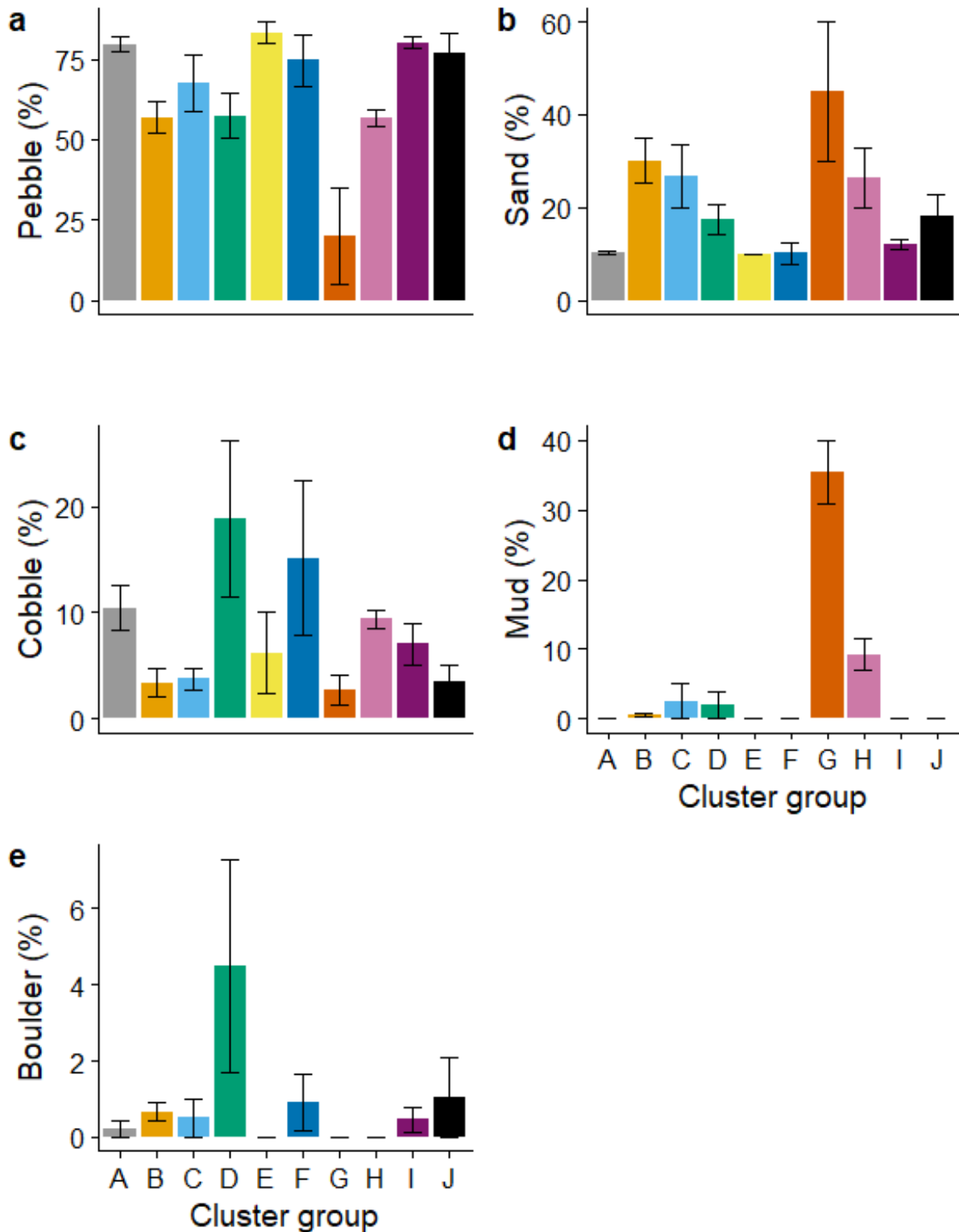


Figure 14. Bar charts showing the contribution (%) to substrate composition of the five most abundant substrate types across cluster groups at Wyville-Thomson Ridge Special Area of Conservation. Error bars represent SE. Substrate types are ordered by relative contribution at the site. N = 5, 6, 4, 5, 2, 6, 2, 3, 7 and 5 stations for cluster groups A – J, respectively. Based on selected images from surveys 1517S and 1218S.

3.3.4 Association between biotic communities and environmental data

The association between epifauna community structure and the investigated potential environmental drivers was further explored. Environmental parameters included in the analysis were the above described *in situ* conductivity, temperature and depth measurements; substrate composition (% contribution of different substrate classes); near-bottom current direction (separated in N-S and E-W components) and magnitude. Latitude, Longitude and year of survey (categorical factor) were also included in the analysis.

As temperature and conductivity were highly autocorrelated (Pearson's correlation value of 1.0), those variables can be seen as interchangeable and only temperature was kept in the analysis.

Among the environmental variables investigated, near-bottom water current velocity; temperature and the substrate contribution of Pebble, Cobble and Boulder (256 – 512 mm) were found to have a significant ($p < 0.05$) relationship with epifauna community composition. Other variables (depth, near-bottom water current direction, survey) were not significantly associated to epifauna communities.

The RDA analysis explained a total of 59.7% of the variation in the biological data with 51.9% explained by the primary axis (RDA1) and 7.8% by the secondary axis (RDA2) (Figure 15). The RDA plot illustrated limited separation of cluster groups, with Groups A, D and F largely associated with an increase in Boulder and Cobble substrate coverage along RDA1 (Figure 15).

A subsequent BioEnv analysis indicated that three environmental variables together were best able to describe the community data in the most parsimonious way. Those were Temperature and the contribution of Boulder (256 – 512 mm diameter) and Cobble to the substrate composition. Together those environmental variables explained 51.2% of the observed variation in epifauna community data.

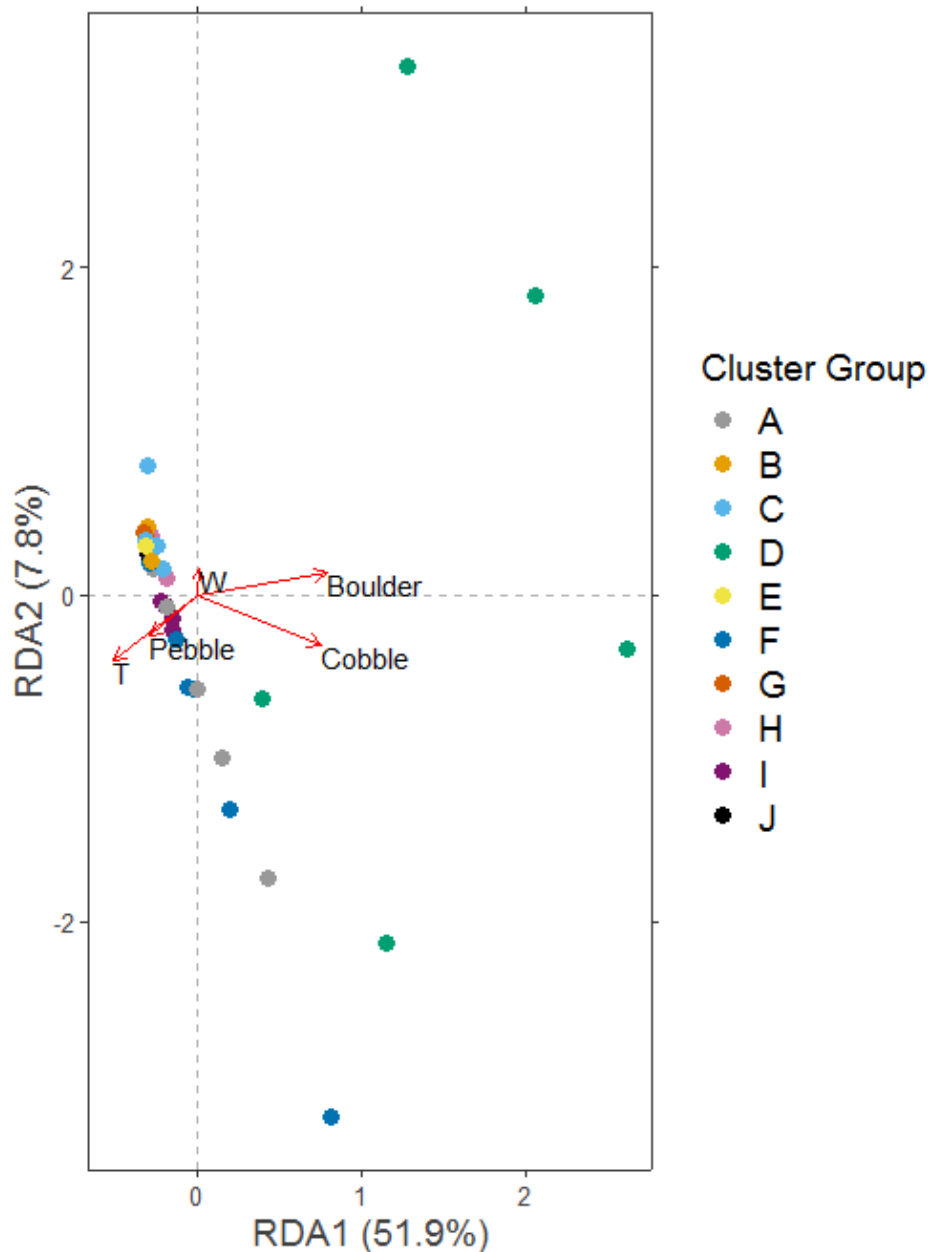


Figure 15. Redundancy analysis (RDA) ordination diagram of benthic communities at Wyville-Thomson Ridge Special Area of Conservation. Arrows represent the strength (arrow length) and direction of individual environmental variables (arrow labels) in explaining variation in benthic communities. Only environmental variables with a significant ($p < 0.05$) fit to the communities have been included. W = near-bottom water current velocity magnitude, T = temperature. Boulder = boulders of size 256 – 512 mm. Boulder and Cobble elements represent their respective contribution (%) to the substrate composition.

3.4 Epifauna biodiversity

Univariate biodiversity analysis was conducted on the solitary (count) and encrusting and colonial (% cover) epifauna abundance data separately. Note that H' diversity was only calculated for count data.

3.4.1 Species abundance

At WTR, the average total abundance of all solitary individuals (those with count abundance information) was 13 ± 2.9 SE individuals m^{-2} , ranging between 0.42 and 88 individuals m^{-2} across the 45 stations (Appendix 8; Table A10). The average total abundance of encrusting and colonial morpho-taxa (those with % cover abundance information) was $8.9\% \pm 1.6$ SE, ranging between zero and 37.3% cover across the 45 stations (Appendix 8; Table A10).

Across epifauna community cluster groups, the average total abundance of solitary morpho-taxa ranged between 1.91 (group J) and 60.7 (group D) individuals m^{-2} (Appendix 8; Figure 16a; Table A11). The average total abundance of encrusting and colonial morpho-taxa ranged from 0.072 (group G) to 25% cover (group D) (Appendix 8; Figure 16b; Table A12).

3.4.2 Morpho-taxon richness

The average richness of solitary taxa was 11.4 ± 0.61 SE ($n = 45$) at a station, ranging between three and 21 morpho-taxa across the stations (Appendix 8; Table A10). For encrusting and colonial morpho-taxa, the average richness was 2.9 ± 0.22 SE morpho-taxa at a station ($n = 45$), ranging between zero and five morpho-taxa across the stations (Appendix 8; Table A10). When count and cover taxa were combined, morpho-taxon richness was 14.3 ± 0.71 SE ($n = 45$), with a minimum of three and a maximum of 25 morpho-taxa across stations (Appendix 8; Table A10).

Across epifauna community cluster groups, the average richness of solitary morpho-taxa ranged from five (group E) to 18 (group H) (Appendix 8; Figure 16c; Table A11). The average richness of encrusting morpho-taxa ranged from 0.50 (group E) to 4.2 (group B) (Appendix 8; Figure 16d; Table A12).

3.4.3 H' diversity

Biodiversity - as measured by Shannon-Wiener diversity index (H') - was calculated for solitary morpho-taxa. At WTR, average H' for solitary morpho-taxa was 1.7 ± 0.062 SE ($n = 45$), ranging between 0.77 and 2.4 across WTR (Appendix 8; Table A10).

Across epifauna community cluster groups, the average H' diversity of solitary morpho-taxa ranged from 1.05 (group D) to 2.16 (group H) (Appendix 8; Figure 16e; Table A11).

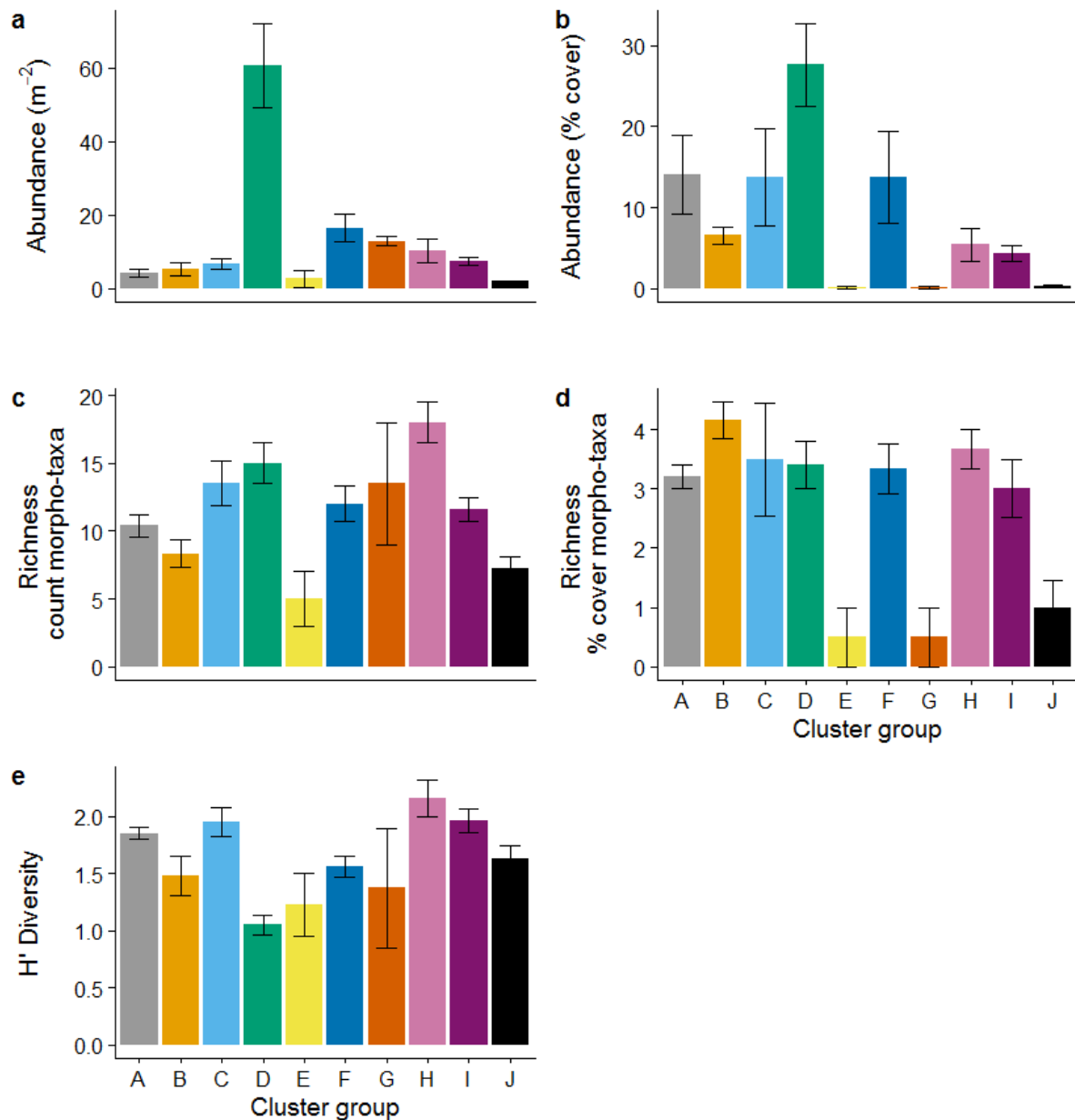


Figure 16. Bar charts showing epifauna biodiversity indices for solitary morpho-taxa (a, c, and e) and encrusting or colonial morpho-taxa (b, d) with count vs % cover abundance data across cluster groups at Wyville-Thomson Ridge Special Area of Conservation. Error bars represent SE. N = 5, 6, 4, 5, 2, 6, 2, 3, 7 and 5 stations for cluster groups A – J, respectively. Based on selected images from surveys 1517S and 1218S.

3.5 Biotopes

The closest matches of MHC biotopes to faunal groupings identified from the video imagery data are described below.

A total of 101 video segments were analysed, sampled across the 92 video stations at WTR. From the video segments there were 20 different BSH (habitat or biotope) classes observed, among which 86 segments were classified to biotope level (Table 6; Figure 17). Four identified biotopes are newly proposed additions to the habitat classification system (M.AtMB.Mx.[DeeSpo]; M.AtUB.[Ro.CriCom]; M.AtUB.Co.[DeeSpo]; M.AtUB.Ro.[UrcCom.CidUrc]; Table 6). Two biotopes, M.AtUB.Co.SpaEnc and

M.AtUB.Co.UrcCom.CidUrc, accounted for half of the video segment classifications (Table 6).

Table 6. Number of occurrences of habitats and biotopes observed from video analysis of the 1517S and 1218S surveys of Wyville-Thomson Ridge Special Area of Conservation. Secondary biotope frequencies are indicated in brackets. MHC = Marine Habitat Classification of Britain and Ireland (JNCC 2022b).

Habitats

MHC Code	MHC Classification	1517S	1218S	Total
M.AtMB.Co	Atlantic mid bathyal coarse sediment	-	1	1
M.AtMB.Mu	Atlantic mid bathyal mud	-	1	1
M.AtMB.Mx	Atlantic mid bathyal mixed sediment	-	6	6
M.AtUB.Co	Atlantic upper bathyal coarse sediment	5	-	5

Biotopes

MHC Code	MHC Classification	1517S	1218S	Total
M.AtMB.Co.CriCom	Crinoid dominated community on Atlantic mid bathyal coarse sediment	-	1	1
M.AtMB.Co.SpaEnc	Sparse encrusting community on Atlantic mid bathyal coarse sediment	-	4	4
M.AtMB.Co.UrcCom.CidUrc	Cidarid urchin assemblage on Atlantic mid bathyal coarse sediment	-	6	6
M.AtMB.Mx.[DeeSpo]	Deep sponge aggregation on Atlantic mid bathyal mixed sediment	-	1	1
M.AtMB.Ro.MixCor.DisLop	Discrete Lophelia pertusa colonies on Atlantic mid bathyal rock and other hard substrata	-	1	1
M.AtMB.Ro.SpaEnc	Sparse encrusting community on Atlantic mid bathyal rock and other hard substrata	-	1	1
M.AtUB.[Ro.CriCom]	Crinoid dominated community on Atlantic upper bathyal coarse sediment	-	3	3
M.AtUB.Co.[DeeSpo]	Deep sponge aggregation on Atlantic upper bathyal coarse sediment	1 (1)	1	2

MHC Code	MHC Classification	1517S	1218S	Total
M.AtUB.Co.CriCom	Crinoid dominated community on Atlantic upper bathyal coarse sediment	-	4	4
M.AtUB.Co.MixCor	Mixed cold water coral community on Atlantic upper bathyal coarse sediment	-	1	1
M.AtUB.Co.SpaEnc	Sparse encrusting community on Atlantic upper bathyal coarse sediment	10	10	20
M.AtUB.Co.SolScl	Solitary scleractinian field on Atlantic upper bathyal coarse sediment	-	1	1
M.AtUB.Co.UrcCom. CidUrc	Cidarid urchin assemblage on Atlantic upper bathyal coarse sediment	-	34	34
M.AtUB.Ro.[UrcCom. CidUrc]	Cidarid urchin assemblage on Atlantic upper bathyal rock and other hard substrata	-	1	1
M.AtUB.Ro.DeeSpo	Deep sponge aggregation on Atlantic upper bathyal rock and other hard substrata	-	5	5
M.AtUB.Ro.SpaEnc	Sparse encrusting community on Atlantic upper bathyal rock and other hard substrata	-	1	1
Unidentified	-	-	2	2

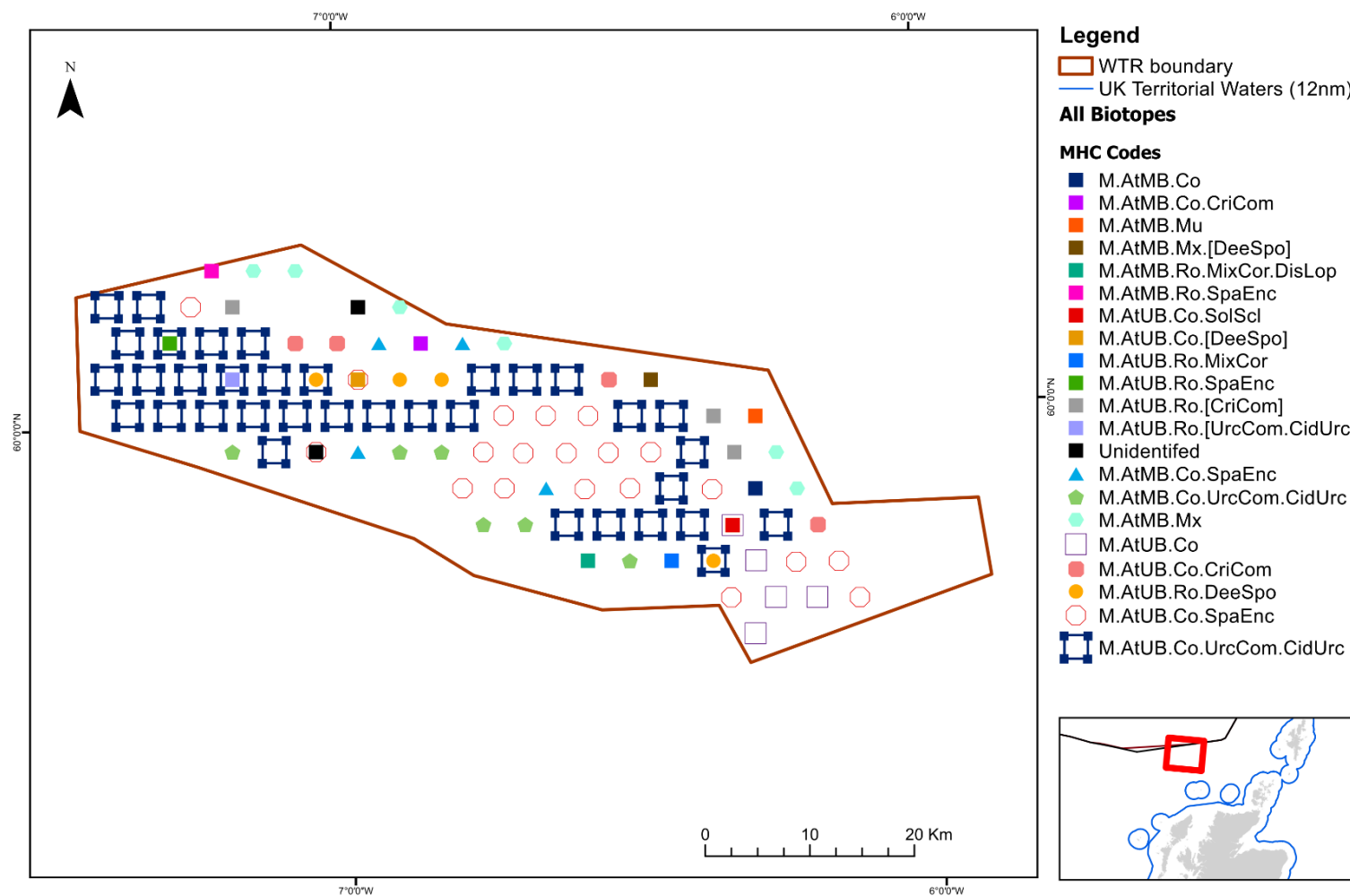
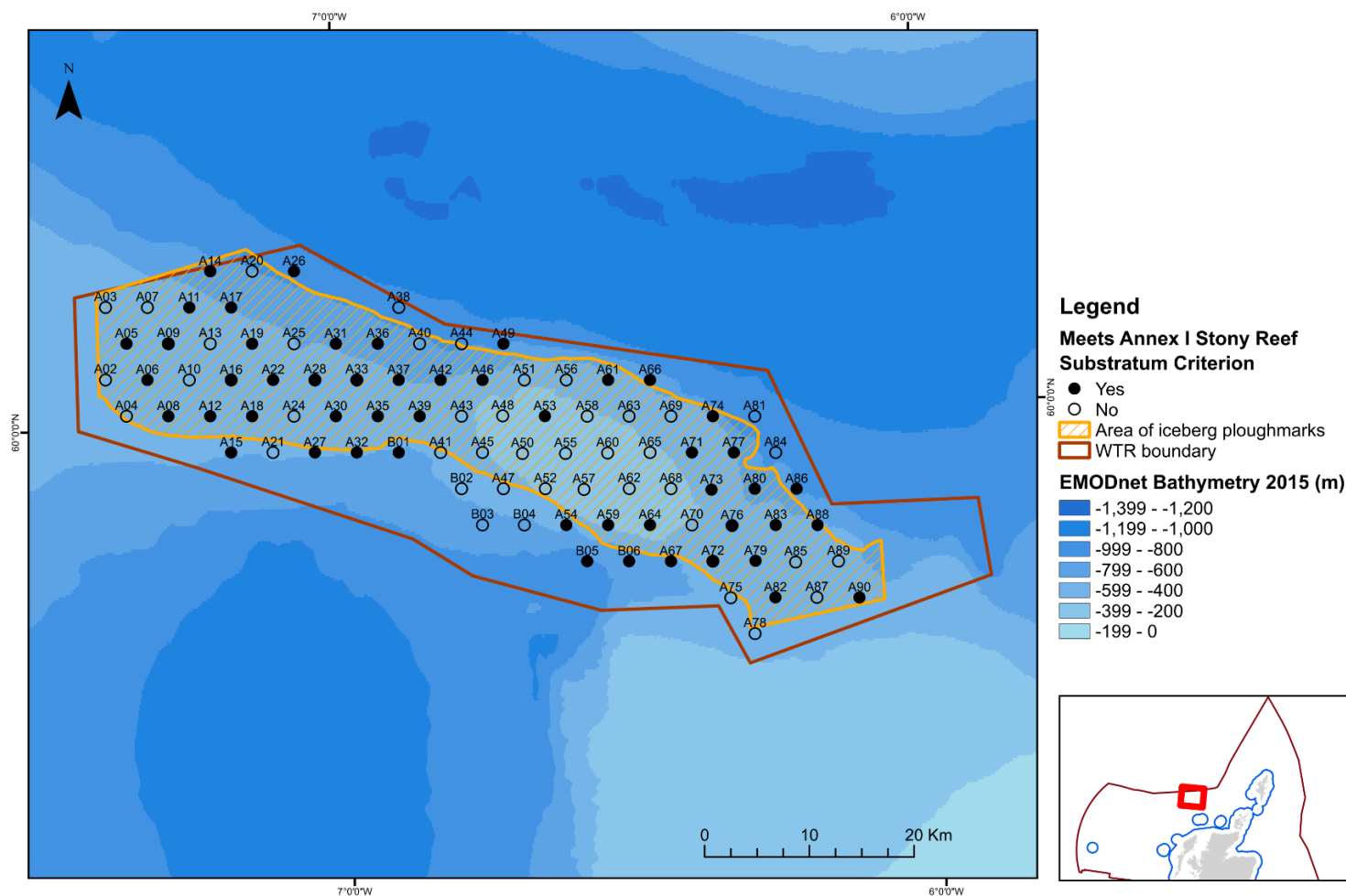


Figure 17. Map of Wyville-Thomson Ridge Special Area of Conservation (WTR) showing the occurrence of biotopes and habitat types. Data is based on video analysis from survey 1517S and 1218S. For habitat abbreviation description see Table 4 and for biotope description see Marine Habitat Classification of Britain and Ireland (JNCC 2022b).

3.6 Extent and distribution of Annex I stony reef

The extent and distribution of Annex I stony reef is described below. It should be noted that although the stony reef criteria can be applied (Irving 2009), iceberg ploughmark Annex I Reef is a special case of Annex I stony reef. This means that regardless of the substrate present, the area identified as iceberg ploughmark is Annex I Reef. The patchy nature of stony substrate within the wider iceberg ploughmark area results in a small-scale mosaic of stony and non-stony substrate of the seabed. Hence, small scale variation in the presence or absence of stony reef substratum can occur within the wider Annex I Reef area. Because of the highly patchy nature of iceberg ploughmarks, apparent changes in Stony Reef extent and distribution within the ploughmark area over time should be interpreted with a high degree of 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.

Following the Annex I stony reef definition (Irving 2009), stating a minimum of 10% contribution of cobble or boulder to the seabed substratum matrix, 50 out of the 91 stations investigated met this threshold (Appendix 9; Figure 18) for at least one of its video segments. Of those, 12 stations (A15, A27, A28, A32, A49, A54, A66, A67, A86, B01, B05 and B06) fell outside the attributed Annex I stony reef – iceberg ploughmark area as per Annex I reef layer v8.3 2022 (Figure 18).



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Figure 18. Map of Wyville-Thomson Ridge Special Area of Conservation (WTR) showing stations that met Annex I stony reef substratum criterion of $\geq 10\%$ coverage (filled circles) and those with $< 10\%$ coverage of cobbles and/or boulders (open circles). The wider Annex I stony reef – iceberg ploughmark area (yellow shaded area). Annex I stony reef substratum analysis is based on video sampling from surveys 1517S and 1218S.

3.7 Extent and distribution of deep-sea sponge aggregations

The previously selected 45 sampling stations were also assessed for the density, habitat and ecological function criteria for DSSA outlined by Henry and Roberts (2014) using still imagery data. Based on these results, a confidence score was assigned to each station outlining the likelihood that DSSA are present according to OSPAR (2010).

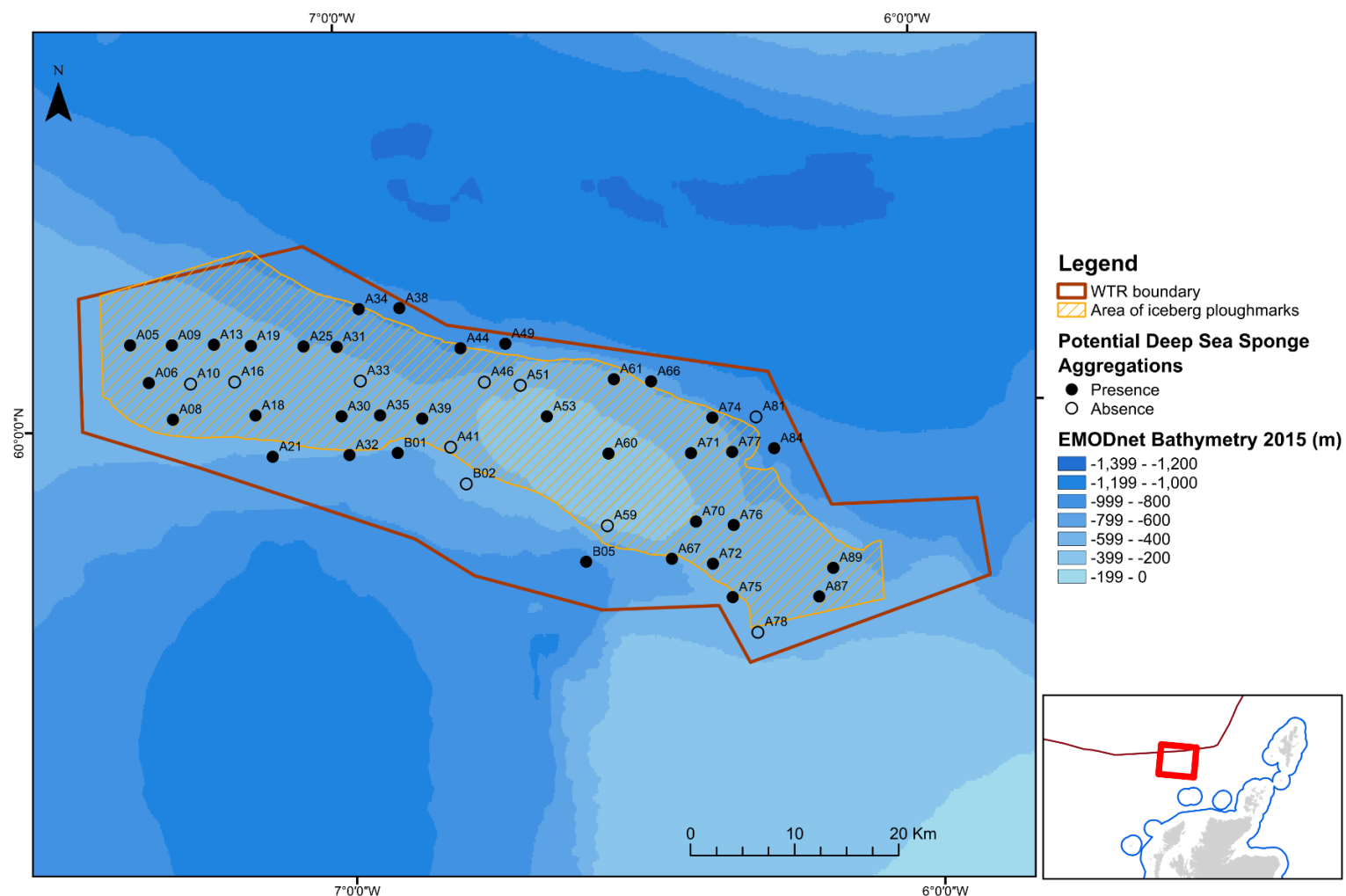
At WTR, sponge densities ranged from 0 (eight stations) to 18.7 individuals m^{-2} (station A74) for solitary morpho-taxa (counts) and 0% (four stations) to 37.3% (station A77) for encrusting and colonial morpho-taxa (% cover) (Appendix 10). 35 out of 45 stations analysed met the DSSA density criterion for solitary and/or encrusting morpho-taxa (Table 7). Of those, 19 stations met the density threshold for both solitary and encrusting taxa (Appendix 10; Figure 19; Table 7).

To investigate whether the above stations also met the habitat criterion, the results from the multi-level pattern analysis were examined, which identified the characterising taxa in each cluster group. In clusters B, D and H, structure-forming sponges were identified as characterising taxa, meaning that the stations in these clusters met the habitat criterion (Table 7).

However, in cluster H the soft coral taxa, *Octocorallia*, was also identified as a characterising taxon, suggesting that it could potentially be identified as a coral garden. According to Henry and Roberts (2014), there must be evidence that sponges are the dominant habitat-forming taxa across these stations. Only one coral taxon was identified as characteristic of the epifaunal assemblages at stations in this cluster, while three sponge taxa were identified. This suggests that sponges are the dominant taxa, meaning that these stations met the requirements for the habitat criterion. As a result, a total of 14 stations were deemed to meet the habitat criterion.

Finally, ecological function was also determined from the multi-level pattern analysis results. The characterising taxa that were identified in cluster D included fauna typically associated with DSSA. Therefore, a total of five stations were identified as having a biological assemblage typical of a DSSA and therefore met the ecological function criterion (Table 7).

Based on the three above criteria, 35 out of the 45 stations included in the analysis were found to have potential DSSA present. Of these, 13 stations were assigned a 'high' confidence of DSSA presence, while the remaining 22 stations were assigned 'low' or 'medium' confidence (Table 7).



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Figure 19. Map of Wyville-Thomson Ridge Special Area of Conservation (WTR) showing the presence (filled circles) and absence (open circles) of potential Deep Sea Sponge Aggregations based on the density criterion. Analysis is based on selected images from surveys 1517S and 1218S.

Table 7. Deep-sea sponge aggregations confidence assessment for stations at Wyville-Thomson Ridge Special Area of Conservation. Analysis is based on criteria outlined in Henry and Roberts (2014) and makes use of selected images from surveys 1517S and 1218S.

Cluster	Station	Density (counts)	Density (cover)	Ecological Function	Habitat	Confidence
A	A08	✓	✓	✗	✗	Low
	A21	✗	✓	✗	✗	Low
	A32	✗	✓	✗	✗	Low
	A70	✗	✓	✗	✗	Low
	B05	✓	✓	✗	✗	Low
B	A53	✓	✗	✓	✓	High
	A60	✗	✓	✓	✓	High
	A75	✓	✓	✓	✓	High
	A76	✓	✓	✓	✓	High
	A78	✗	✗	✓	✓	Medium
	A87	✓	✗	✓	✓	High
C	A39	✗	✓	✗	✗	Low
	A49	✓	✓	✗	✗	Low
	A61	✓	✓	✗	✗	Low
	A89	✓	✗	✗	✗	Low
D	A25	✓	✓	✓	✓	High
	A31	✗	✓	✓	✓	High
	A66	✓	✓	✓	✓	High
	A74	✓	✓	✓	✓	High
	A77	✓	✓	✓	✓	High
E	A10	✗	✗	✗	✗	No
	B02	✗	✗	✗	✗	No
F	A30	✗	✓	✗	✗	Low
	A35	✗	✓	✗	✗	Low
	A67	✓	✓	✗	✗	Low
	A71	✓	✓	✗	✗	Low
	A72	✗	✓	✗	✗	Low
	B01	✓	✓	✗	✗	Low
G	A81	✗	✗	✗	✗	No
	A84	✓	✗	✗	✗	Low
H	A34	✓	✓	✓	✓	High
	A38	✓	✓	✓	✓	High

Cluster	Station	Density (counts)	Density (cover)	Ecological Function	Habitat	Confidence
H	A44	✓	✓	✓	✓	High
I	A05	✗	✓	✗	✗	Low
	A06	✓	✓	✗	✗	Low
	A09	✓	✓	✗	✗	Low
	A13	✓	✗	✗	✗	Low
	A16	✗	✗	✗	✗	No
	A18	✗	✓	✗	✗	Low
	A19	✓	✓	✗	✗	Low
J	A33	✗	✗	✗	✗	No
	A41	✗	✗	✗	✗	No
	A46	✗	✗	✗	✗	No
	A51	✗	✗	✗	✗	No
	A59	✗	✗	✗	✗	No

3.8 Other Priority Marine Features

Several species were observed that could be considered 'features of interest' in terms of protection or conservation status during 1517S and 1218S at WTR (Benson & Sotheran 2018; Benson *et al.* 2020).

Observations from 1517S included the Scottish Priority Marine Feature *Molva dypterygia* (Blue Ling), which was observed throughout the footage. Some species of cup corals and other possible scleractinians were observed, however most were uncertain identifications. Soft corals were recorded, potentially *Drifa glomerata* and *Anthomastus grandiflorus* species.

Observations from 1218S included the seapen of the genus 'Umbellula' (seen in one image and one video segment), the ping pong sponge of the genus 'Chondrocladia' seen in five images and within the six segments of the video footage and rays observed which were in two images and eight video segments, however the rays could not be identified confidently to ascertain if they were species of specific conservation interest. Cup corals were frequently seen (350 images and 36 video segments), which are often a component of coral or reef habitats and features. Cold water corals (potentially *Lophelia pertusa*, *Madrepora oculata*, *Solenosmilia*) were observed in 19 images and two video segments (at stations A67 and A83). These corals occurred as scattered colonies. Soft corals were observed in 237 images (including 'Soft corals', 'Branching Octocorals' and '*Anthomastus grandiflorus*') and approximately 40 video segments which are also components of the habitat features above. The density of corals observed across WTR MPA were deemed by expert opinion to not be high enough to be considered coral garden or cold-water coral reef and no further analyses were conducted.

3.9 Anthropogenic evidence: Marine litter and Anthropogenic activities and pressures

Non-natural materials were observed at 11 stations at WTR during surveys 1517S and 1218S (Figure 20; Table 8). Further detail on the MSFD litter categories (EU Commission 2013b) can be found in Appendix 11.

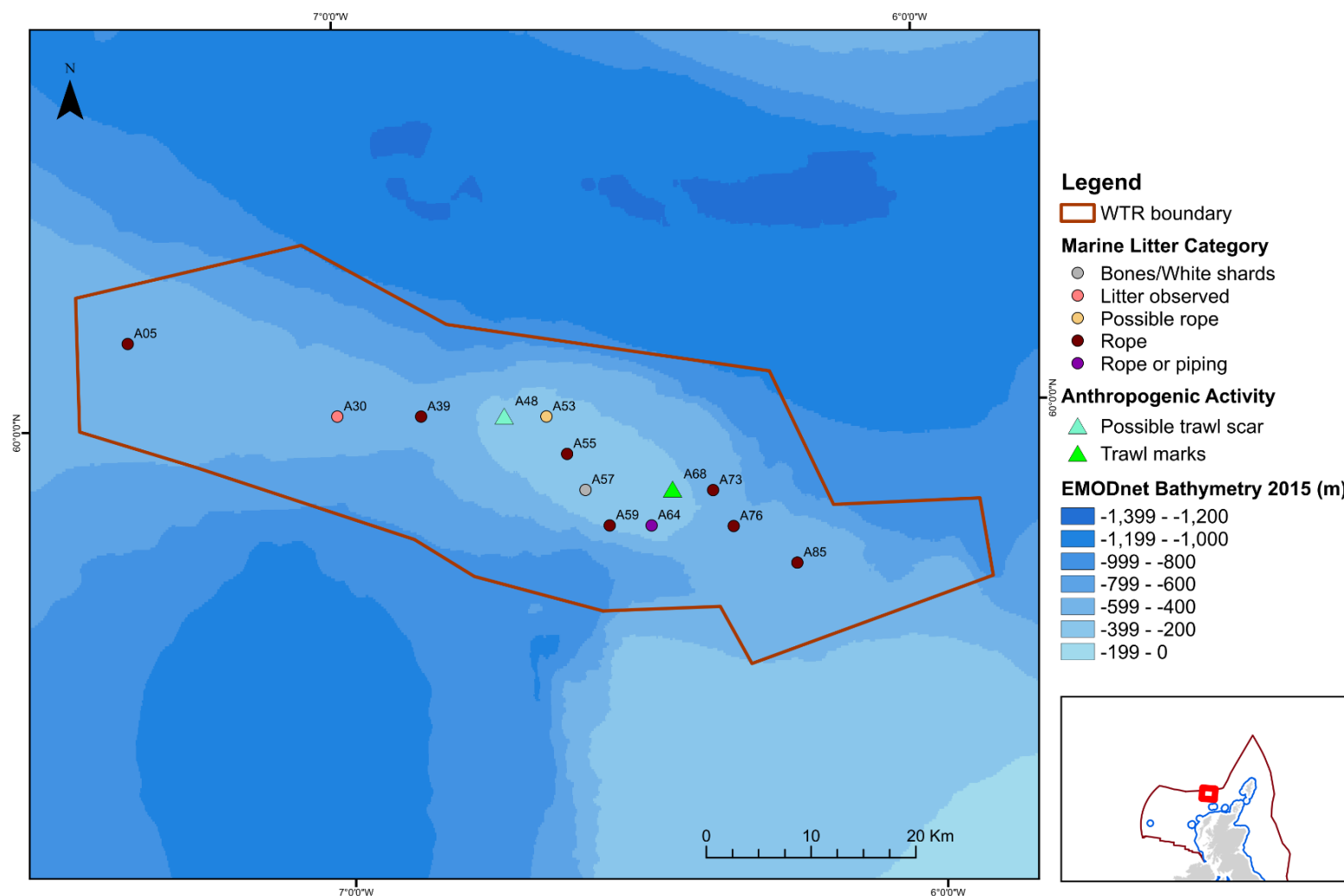
Table 8. Non-natural materials and Potential anthropogenic impacts observed at stations at Wyville-Thomson Ridge SAC. Based on video data from surveys 1517S and 1218S.

Station	Marine Litter Category
53	Possible rope
A55	Rope
A57	Bones / white shards
A73	Rope
A76	Rope
A85	Rope
A05	Rope
A30	Litter observed
A39	Rope
A59	Rope
A64	Rope or piping

Potential anthropogenic activity and pressures were observed at two stations at WTR (Figure 20; Table 9).

Table 9. Anthropogenic activities and pressures observed at stations at Wyville-Thomson Ridge SAC. Based on video data from surveys 1517S and 1218S.

Station	Anthropogenic activity
48	Possible trawl scar
A68	Trawl marks



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UK Territorial Sea Limit. Contains UKHO data © Crown copyright. All rights reserved. UK Exclusive Economic Zone © Crown copyright. The exact limits of the EEZ are set out in The Exclusive Economic Zone Order 2013. World Vector Shoreline © US Defence Mapping Agency. Not to be used for navigation. Map and Inset Projection: WGS84 UTM Zone 29N.

Figure 20. Map of locations of Wyville-Thomson Ridge SAC showing anthropogenic evidence. Based on surveys 1517S and 1218S.

3.10 Non-Indigenous Species

The epifaunal taxon lists generated from the seabed imagery data were cross-referenced against lists of target NIS which have been selected for assessment of Good Environmental Status in UK waters under MSFD Descriptor 2 and identified as significant by the GB Non-Native Species Secretariat. None of the identified taxa at WTR were listed on the NIS list (Stebbing *et al.* 2014) (Appendix 12).

4 Discussion

4.1 Biological communities, potential drivers and supporting processes

The oceanographic regime is key in shaping large scale patterns in epifauna communities at WTR. This can be divided into two regions which are separated by the ridge. Warm North Atlantic water can cross the ridge and enter the Faroe-Shetland Channel. Colder Norwegian Sea deep water can flow out of the channel across the ridge and into the Ymir trough (McKenna *et al.* 2016 and references therein).

Benthic communities found at the NE flank of the ridge (cluster groups D, G and H) appear influenced by Norwegian Sea water masses flowing via the Faroe Shetland Channel that meet the Wyville-Thomson Ridge (McKenna *et al.* 2016 and references therein), as also indicated by the associated cold temperatures observed. More precisely, cluster group D, with observed *in situ* temperatures around zero degrees, is potentially affected by Norwegian Sea Arctic intermediate water (water temperature $-0.5 - 0.5$ °C). And cluster groups G and H, at larger depth and with lowest temperatures, by Norwegian Sea Deep Water (water temperature < -0.79 °C) (McKenna *et al.* 2016 and references therein).

In contrast, warm water associated cluster groups (i.e. cluster groups A, B, E, F, I and J) were found on the SW flank of the ridge, on top of the ridge, and at the NE end of the ridge. Based on the *in situ* temperatures and the near-bottom water flows estimates presented in this report, stations belonging to those clusters are likely influenced by the comparatively warm, saline and nutrient poor poleward flow of North Atlantic water (McKenna *et al.* 2016 and references therein).

Within the large-scale spatial community variation linked to oceanographic patterns, we found further separation of communities associated to a change in substrate composition. For example, for the cluster groups found in cool Arctic waters, cluster group D was associated to a large contribution of hard substrate (boulder), with cluster group F its counterpart in warmer North Atlantic waters. In contrast, cluster groups G and H were associated to an increase in soft sediment of sand and/or mud in cold Arctic waters. A similar but less distinct observation can be made for cluster groups B and C in warm North Atlantic waters.

Community composition among cluster groups can be better understood when considering the associated changes in environmental conditions. For example, Crinoidea, Porifera, Bryozoa and Anthozoa (including sea anemones and stony- and soft corals) are typically associated to hard substratum in deep water (Masson *et al.* 2000; Henry & Roberts 2004; Howell *et al.* 2007). Those taxa were characteristic for cluster groups D and F linked to a high contribution of hard substrate (boulder and cobble).

In contrast, cluster groups linked to a large proportion of soft sediment (e.g. cluster groups G and H) contained characteristic taxa that are often associated with soft sediment. These include polychaetes of the family Terebellidae which contains many species living in soft sediment burrows; Holothuroidea including sea cucumbers, often found burrowing into soft sediments; and sea anemones of the genus *Halcampoides*, which also contains burrowing members.

The observed patterns of large-scale spatial separation by oceanographic variation and small-scale spatial separation associated to changes in substrate composition as important variables to describe community variation at WTR was confirmed by the BIOENV analysis. Our findings mostly agree with earlier observations of differing species composition between

the two sides of the ridge, with water temperature, depth, and sediment type previously indicated as key drivers for community composition (Howell *et al.* 2007). Our findings differed in that water depth was not associated to changing communities, but water current velocity was. Driven by both large- and small-scale environmental variation, WTR supports a great variety of epifauna communities across a relatively small spatial area.

It should be noted that the separation of cluster group B, which solely and exclusively contained stations sampled during survey 1517S, may be an artefact of the sampling and/or analytical methods. For example, observed community differences may be driven by the influence of the distinct area of sampling of 1517S with its own unique environmental properties. Similarly, samples from 1517S may differ from 1218S samples due to a potential temporal effect of surveys occurring in subsequent year. Thirdly, observed differences may be a result of the different analytical methods used for both sets of samples, for example Faunal turf and Faunal crust were only identified for 1517S. Clustering of group B may even be driven by a combination of the three above mentioned possible explanations. It is not possible to tease apart the underlying mechanism of the distinct clustering of 1517S samples with high confidence. Interestingly, the RDA analysis did not show 'survey ID' to be a significant contribution to shaping benthic communities, suggesting that any observed differences are explained by a change in environmental conditions included in the analysis. The identification of cluster group B in this work demonstrates a potential issue arising when data from across multiple surveys are combined or compared and should be considered when comparing different time points in long-term monitoring studies.

Cluster group J was another outlier. This relatively large cluster group contains five stations; all found in the central region of WTR. The Multi-level Pattern analysis did not identify any key characteristic taxa associated to this group. This indicates that no taxa were uniquely associated to this group and/or taxa had a low specificity across stations within the group. This may be interpreted as group J functioning as a transitioning community between its neighbouring communities, with no taxa being consistently and uniquely present here.

The under-sampling of epifauna communities at a station, as demonstrated by the TVA requirements analysis, may have contributed to the inability to explain 40% of the community variation, as indicated by the RDA results. Alternatively, environmental abiotic or biotic variables not investigated in these surveys could also account for some of the unexplained community variation. For future surveys, one could consider increasing the environmental variables sampled, for example including sedimentation rates; nutrient concentration; and/or fluctuation of temperature as a measure of environmental dynamics including turbulent mixing and the potential occurrence of internal waves linked to increased sponge density (see e.g. Davison *et al.* 2019).

4.2 Annex I Reef extent and distribution

Results of the substrate matrix analysis suggest an extent and distribution of Annex I reef largely in agreement with previous Annex I reef v3.8 2022 information. Within the delineated iceberg ploughmark area, some stations did not meet the stony reef substrate composition threshold value according to the still image - substrate analysis. However, according to Irving (2009), these stations should still be considered Annex I reef due to the highly variable nature of substrate within this area. Some stations outside of the previously identified Annex I reef (v3.8 2022), however, did meet the threshold values, indicating that Annex I reef may extend further south than previously thought.

In this report, it was only possible to assess for the presence of stony reef based on the 'composition' criterion outlined by Irving (2009). The inability to assess based on the remaining criteria (elevation and biota thresholds) means that all stony reef identified in this report have been done so to a low degree of certainty. To accurately comment on the

distribution and the extent of stony reef at WTR, we recommend future work should also consider the measurement of reef elevation to comment on I) the elevation of stony reef threshold and the measurement of relative density of epifauna to comment on II) the stony reef biota threshold. Together, these characteristics will increase our confidence in describing the distribution and extent of stony reef and will help to accurately qualify the resemblance of WTR to being a stony reef (i.e. low, medium, high; Golding *et al* 2020).

4.3 Sponge morpho-type variation, associated communities and distribution

Sponges were abundant and diverse in their morphology at WTR. Sponge morpho-taxa were also identified as characteristic for certain epifauna community cluster groups. Interestingly, differences in key morpho-taxa across those cluster groups appear linked to the respective environmental conditions where they were found. For example, cluster group D, characterized by a large contribution of hard substrate and high near-bottom water current velocity, was associated to encrusting Porifera and Simple morphological forms. Those morphologies are commonly associated to those environmental conditions (Schönberg 2021). Similarly, cluster group H, characterised by increased substratum contribution of soft sediment and lower near-bottom water current velocity, was associated to Simple, tubular, massive and “massive balls” Porifera (Schönberg 2021).

It should be noted, however, that sponges are highly plastic in their morphology, both shape and colour, and the patterns observed may merely a representation of their differing growth forms rather than differences in species ID (Schönberg 2021). Porifera species ID is rarely possible from benthic images as it requires physical samples. Therefore, benthic imagery data alone cannot tease apart differences in Porifera species ID, their morphology, or a combination of the two.

Similar to our findings, extensive sponge growth in the Faroe-Shetland region has been previously associated with associated faunal communities that include the presence of Galatheaidea squat lobsters, *Cidaris cidaris*, Asteroidea including cushion stars *Ceramaster* spp., brittlestars Ophiuroidea, Sabellidae polychaetes and brachiopods (Bett & Axelsson 2000; Axelsson 2003; Bett & Jacobs 2007; Henry & Roberts 2014).

Environmental conditions of the observed Ostur-type communities such as depth range, substrate composition and oceanographic conditions were also comparable to others found in the area, including at the Faroe Shetland Sponge Belt MPA (Bett 2001; Henry & Roberts 2014; JNCC, *in prep*). Although in our analysis Ostur-type sponge communities, represented by cluster group D, were similar in environmental conditions, stations belonging to this cluster were not grouped in space. This adds to our understanding of the patchy nature of DSSA (Henry & Roberts 2014), particularly when associated to iceberg ploughmarks.

5 Recommendations

5.1 Data quality

- Species accumulation curves demonstrated that none of the stations from surveys 1517S and 1218S were sufficiently sampled. The induced increased potential error has very likely limited our ability to detect community patterns across space and can similarly affect our ability to detect and describe community changes over time. To avoid such issues during long-term MPA monitoring, we stress the importance of an adequate sampling size.
- This report demonstrated the large effect of FoV range on both our ability to detect (presence absence) and quantify (% cover and count abundance) benthic taxa. Conspicuous taxa such as erect and massive Porifera were not excluded from this finding. It is recommended to:
 - aim for a constant height above the seabed and camera settings to reduce FoV variation across images, but also across surveys when obtaining time series information and
 - based on the hardware used for surveys 1517S and 1218S, maintain a FoV range of around $<5 \text{ m}^2$. This should be reconsidered when camera specs and associated ground pixel size and/ or visibility change.
 - The appropriate still image FoV range should be considered for future surveys. We suggest considering the hardware (e.g. pixels, light, focus range); the identity of taxa present and the potential influence of FoV on the ability to detect their presence and/or abundance; and finally, the required sampling size (seabed covered) by the image depending on the site (e.g. habitats present, taxa present, species density and distribution). We advise to maintain a high consistency across images due to the demonstrated influence of a changing FoV on taxa abundance observations.
- This report demonstrated a mostly negative effect of reduced image quality on both our ability to detect (presence absence) and quantify (abundance) benthic taxa. We recommend that poor and very poor-quality images should be removed in the final datasets for benthic community analysis.
- Even though images were identified as of “good” image quality by the analysts, a large FoV may still result in poor quality data. Vice versa, a small FoV did not necessarily warrant “good” quality images. Therefore, image quality classification or FoV should not be the sole identifier for data quality and both variables should be included in the decision making to include or exclude images for community analysis.
- Analysis showed that both observed species abundance *and* occurrence are affected by reduced image quality. Data transformation to presence/absence information, as sometimes suggested for poor quality data, does not therefore avoid introducing uncertainty/ bias in community analysis and should be considered carefully.
- The presented research on data quality impact could be expanded and would provide valuable and novel information for the international benthic monitoring community. For example, the data can be used to investigate if bias is more pronounced for inconspicuous or smaller taxa, or taxa with a patchy distribution by comparing their respective model estimates. Similarly, the potential of image quality bias can be investigated for univariate biodiversity by running similar models as in this report, but with different response variables. It can also be used to explore bias in the taxonomic identity by comparing multivariate community results. This work would be suitable for peer reviewed scientific publication.

5.2 Future monitoring at WTR

- This study showed the key role of water temperature (resulting from the different water bodies present at the site and presumed mixing on top of the ridge) and substrate composition as drivers of community composition. These factors should be focused on when designing future surveys that will contribute to time series information.
- For future surveys, one could consider increasing the environmental variables sampled to better understand community patterns. We suggest measuring sedimentation rates; nutrient concentration; and/or fluctuation of temperature as a measure of environmental dynamics including turbulent mixing and the potential occurrence of internal waves linked to increased sponge density.
- WTR is characterised by a large variability in environmental conditions driven by the hydrographic conditions, which is reflected in the number of epifauna communities supported. When monitoring WTR, it is key to consider that these communities may show different patterns over time driven, for example, by differing changes or rates of change in abiotic conditions of the different water bodies that converge at WTR, or by different vulnerabilities of the associated faunal communities to those changes. This is especially pertinent when considering expected impacts of climate change (including impacts on seawater temperature, ocean acidification, nutrient concentrations, etc.).
- Because of the diverse physical characteristics of the MPA and likely variable rates of environmental change in relation to those, we recommend installing environmental data logger fixed to the seabed. This will allow long-term monitoring of environmental conditions across the site as changes in oceanographic conditions will likely affect communities present. Single observations in time linked to epifauna surveys, as per current monitoring strategy, are unlikely to provide sufficient information to fully understand abiotic changes and the environmental drivers of biotic change.
- This report found that cluster group B consisted entirely of stations from the 1517S survey, suggesting that this result may be an analytical or sampling artefact. However, the RDA analysis did not find “survey ID” to be a significant driver of the observed variation in community structure. It is recommended that further exploration of the data (e.g. by running the analyses with and without the 1517S data) could provide a better insight into whether this is the case. Alternatively, the analysis of future data collected in WTR will reveal whether the patterns in community composition observed in this report are truly representative of the site or are a result of sampling/analytical methods.
- The optimal sampling size per station at WTR was calculated using a sample stopping algorithm devised by Chao and Jost (2012) to provide 95% sample coverage, giving a value of 38 images per sample unit. As such, it is recommended that a minimum of 38 high quality images should be obtained per sample unit in future surveys of WTR. In this case, 95% coverage was chosen instead of the usual 90% to compensate for any errors induced by the low number of images available. To improve this estimate and confidence, we also suggest re-running this analysis on future epifauna data collected from WTR.
- Morpho-taxa such as the varying colour of different sponge-morphologies were important in community clustering. This level of detail in species identification should be maintained. A dedicated species tree should be used (including morpho-taxa) to ensure consistency and comparability across datasets, such as the global standardised marine taxon reference image database SMaTaR-ID (Howell *et al.* 2019).
- As colour variation for certain morpho-taxa appeared important in separating benthic communities, we stress the importance of considering the effect of image post-

processing on colour changes and the associated altered ability to ID morpho-taxa correctly.

- It is important that assessments of stony reef can be made with higher confidence than they have been in the current report, particularly as stony reef appears to be more widespread across WTR than previously reported.

5.3 General recommendations on analysis and interpretation

- Ensure consistency in abundance measurements per species across surveys (e.g. count or % cover) to ensure data comparability. This is especially crucial for time series data when analysing species abundances over time.
- The dataset contained % cover data with unrealistic values > 100 for some cells. Additionally, the sum of substrate type contributions was sometimes below or above 100%. Data ingestion processes should be improved to pick up those errors.
- Include appropriate metadata in the metadata log or survey report. For example, model of CTD used was unknown. And the units for conductivity and temperature were not provided in the data logs.

5.4 Site management

- Results indicate that the distribution of the rocky reef extends beyond the current polygon. This should be updated to reflect those results.
- Although not a designated feature of the site, sponges were abundant and a key component of benthic communities at WTR, with potential DSSA present. This should be considered as part of the site management.

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Appendix 1. Glossary

Term	Description
Activity	A human action which may have an effect on the marine environment; (e.g. fishing, energy production) (Robinson <i>et al.</i> 2008).
Anthropogenic	Caused by humans or human activities; usually used in reference to environmental degradation. (NE & JNCC 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.
Community	A general term applied to any grouping of populations of different organisms found living together in a specific 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.
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.
Impact	The consequence of pressures (e.g. habitat degradation) where a change occurs that is different to that expected under natural conditions (Robinson <i>et al.</i> 2008)
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).

Term	Description
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).
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 <i>et al.</i> 1997).
Pressure	The mechanism through which an activity influences 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 <i>et al.</i> 2008).
Priority Marine Feature (PMF)	Priority marine features are habitats and species that are marine nature conservation priorities in Scottish 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.
Sentinel Monitoring of long-term trends (Type 1 monitoring)	Objective: to measure rate and direction of long-term change. This type of monitoring provides the context to distinguish directional trends from short-scale variability in space and time by representing variability across space at any one time and documenting changes over time. To achieve this objective efficiently, a long-term commitment to regular and consistent data collection is necessary; this means time-series must be established as their power in identifying trends is far superior to any combination of independent studies (Kröger & Johnston 2016).

Appendix 2. Data preparation and analysis

Epifaunal Truncation

Raw taxon abundance matrices can often contain entries that include the same taxa recorded differently, erroneously or differentiated according to unorthodox, subjective criteria. Therefore, prior to analysis, data should be checked and truncated to ensure that each row represents a legitimate taxon, and they are consistently recorded within the dataset. Employing an artificially inflated taxon list (i.e. one that has not had spurious entries removed) risks distorting the interpretation of pattern contained within the sampled assemblage. It is often the case that some taxa must be merged to a level in the taxonomic hierarchy that is higher than the level at which they were identified (i.e. from species to genus level). In such cases, 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. Due to the nature of the imagery identification, many identifications were made at a high taxonomic level. As such, the truncation carried out on epifaunal datasets was minimal. Details of the data preparation and truncation protocols applied to the 1517S and 1218S epifaunal datasets pre-analysis are provided below:

- records of fish and mobile species were removed,
- records of 'eggs' and 'juveniles' were removed,
- where recorded, meiofauna (i.e. nematodes) and fauna that cannot be accurately resolved from imagery at resolution were removed,
- unidentifiable fauna (e.g. Species B, unidentified faunal turf) were removed.

Epifauna community analysis

Epifauna community analysis followed multiple preparation and processing steps. An overview is provided in the figure below (Figure A1). This is followed by further explanation for key steps as indicated in the figure. All statistical analyses were undertaken in R version 4.1.0 (R Core Team 2021).

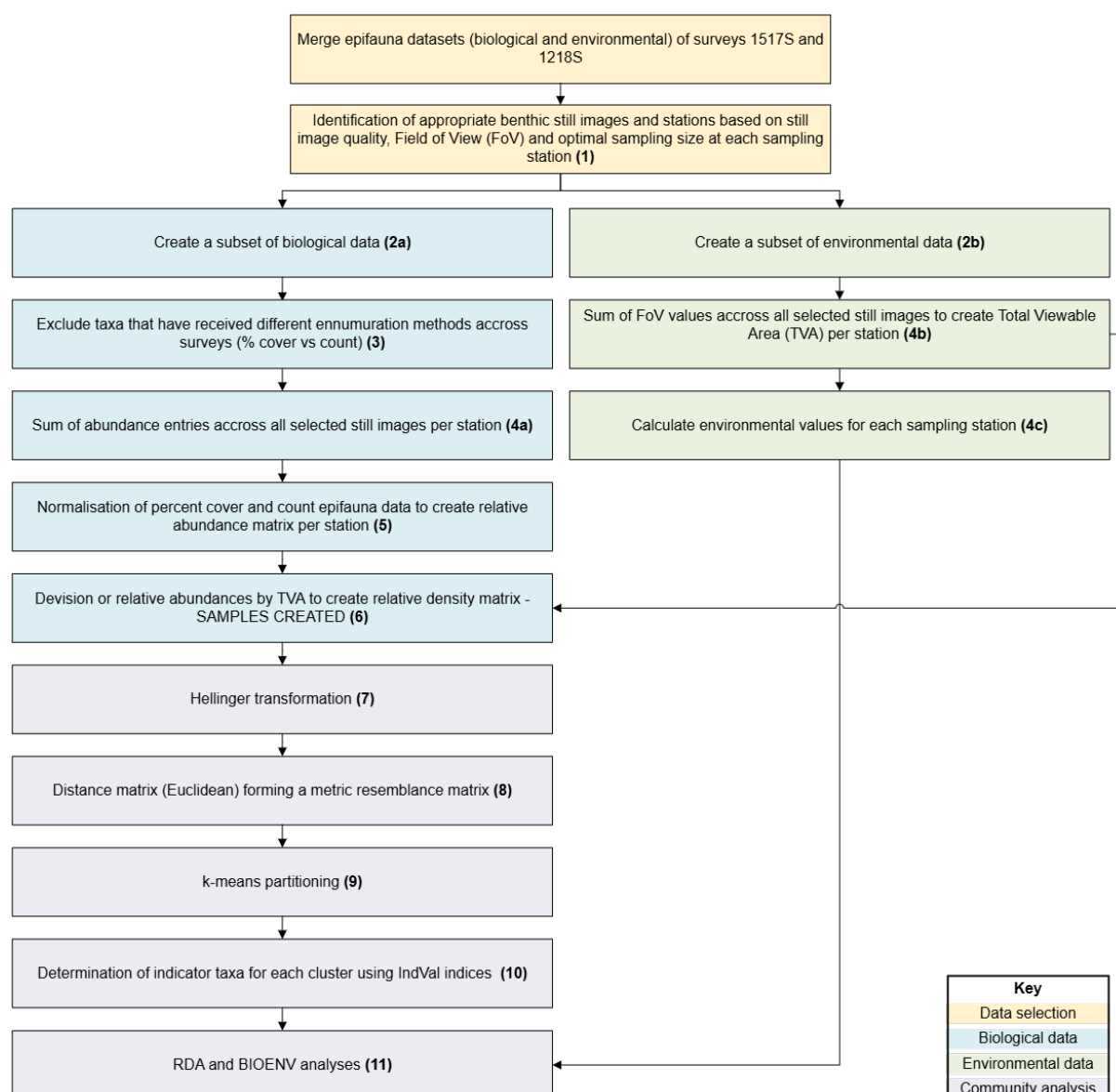


Figure A1. Schematic overview of preparation and processing steps for seabed still imagery data for epifauna community analysis. Numbers indicate key steps that are further explained below.

1) Identification of appropriate still images and stations

To identify a dataset that is best able to describe the biological community accurately and precisely. This considers image quality and FoV, their respective impact on identification of key morpho-taxa and required sampling size at a station. See Appendix 4, 5 and 6 for further detail.

2) Creation of subset of biological and environmental data.

To create the best available dataset.

3) Exclusion of samples with different processing methods

To ensure samples are comparable.

4) Sum of epifauna abundance, FoV and environmental values

To obtain one value per sampling station.

5) Creation of relative abundance matrix

To enable community analysis across methods of epifauna abundance enumeration (count and cover).

6) Creation of relative density matrix

To ensure differences in sampling size (TVA) across stations is considered.

7) Hellinger transformation

Abundance data as derived from seabed imagery are often skewed strongly by the prevalence of a limited number of highly abundant (and/or easily observed) entries, contrasted against the zero-inflation typical of faunal community matrices. The option of using k-means clustering routines meant that the relative density data required further transformation into a metric distance matrix: the Hellinger Distance matrix (Legendre and Gallagher, 2001). This step was performed using the *decostand()* function in the R package 'Vegan' (Oksanen *et al.* 2019).

Hellinger distance is asymmetric (meaning it handles double zeros as effectively as the possibly better-known Bray Curtis distance); however, it provides further standardisation of the data by sample vector. This means that it assesses sample importance and if samples are of equal importance, then rare or abundant taxa will contribute the same amount to the distance between those samples. If the samples are of differing importance, then rare taxa will contribute more.

8) Creation of resemblance matrix

To prepare the data for ordination methods including Redundancy Analysis (RDA; step 10).

9) K-means partitioning

K-means partitioning (a non-hierarchical method) was undertaken for the relative density data using the 'cascadeKM' package in R. Understanding assemblage distribution and links to environmental drivers are perhaps most aided by single partitions which most accurately describe the direct relationship among samples. This is best achieved by non-hierarchical methods where samples are not fixed in a branch and can therefore swap between clusters as the process progresses (Legendre & Legendre 2018). Non-hierarchical methods are more computationally intensive than hierarchical clustering (as e.g. used in the PRIMER cluster routine) but were deemed preferred. The selection of the optimum partition was then performed using the Simple Structure Index (SSI) method (Dolnicar *et al.* 1999).

The cluster groups defined using k-means partitioning in non-metric space were represented in a nMDS plot. This was undertaken using the *ordiplot()* function in the R package 'Vegan' (Oksanen *et al.* 2019).

10) Identification of indicator (morpho-)taxa

To better investigate taxa which characterise the defined cluster group, the *multipatt()* function of the R package 'indicspecies' (De Cáceres *et al.* 2012) was used.

This is a permutational testing routine which permutes the input clusters and compares these combinations against presence of the taxon in the raw matrix, using the IndVal index as a test statistic (Dufrêne & Legendre 1997) to measure association between individual taxa clusters. For each taxon, the routine chooses the combination with the highest association value per cluster. The patterns which best match are tested for statistical significance (permutational testing) of the associations, providing the IndVal test statistic and a p. value for each taxon within each cluster. Higher values of the test statistic indicate a greater value of the taxon as an indicator of that cluster. The two components of the IndVal index, A and B, provide information on the specificity and fidelity (respectively) of the taxon as characteristic of that cluster group (De Cáceres *et al.* 2012). The specificity (IndVal A) is the probability that the sample belongs to the cluster group, given presence of the taxon in question. The fidelity (IndVal B) is the probability of finding the taxon in samples belonging to the cluster group. The indicator value is the product of those two. This means that if prevalence in a group is low, the indicator value will be low even if a species is only found in that group, because it is not present regularly.

11) RDA and BIOENV analyses

Redundancy Analysis (RDA) was used to investigate any association between the environmental variables and the epifauna community groups defined using k-means partitioning. The RDA was undertaken using the *rda()* function in the R package 'Vegan' (Oksanen 2008).

A BIOENV analysis was performed to identify the best subset of environmental variables to describe the epifauna community data. This was undertaken using the *bioenv()* function in the R package 'Vegan' (Oksanen *et al.* 2019).

Appendix 3. Optimal sampling size

An assessment of the 'optimum' seabed area was undertaken through the creation and comparison of species accumulation curves. Species Accumulation Curves were created using two functions within two separate R packages; the non-metric (sample accumulation by accumulate seabed area surveyed) using the *specaccum()* function in the R package 'Vegan' (Oksanen *et al.* 2019). The metric (sample accumulation by summed field of view) was undertaken using the *accumcomp()* function in the R package 'BiodiversityR' (Kindt & Coe 2005).

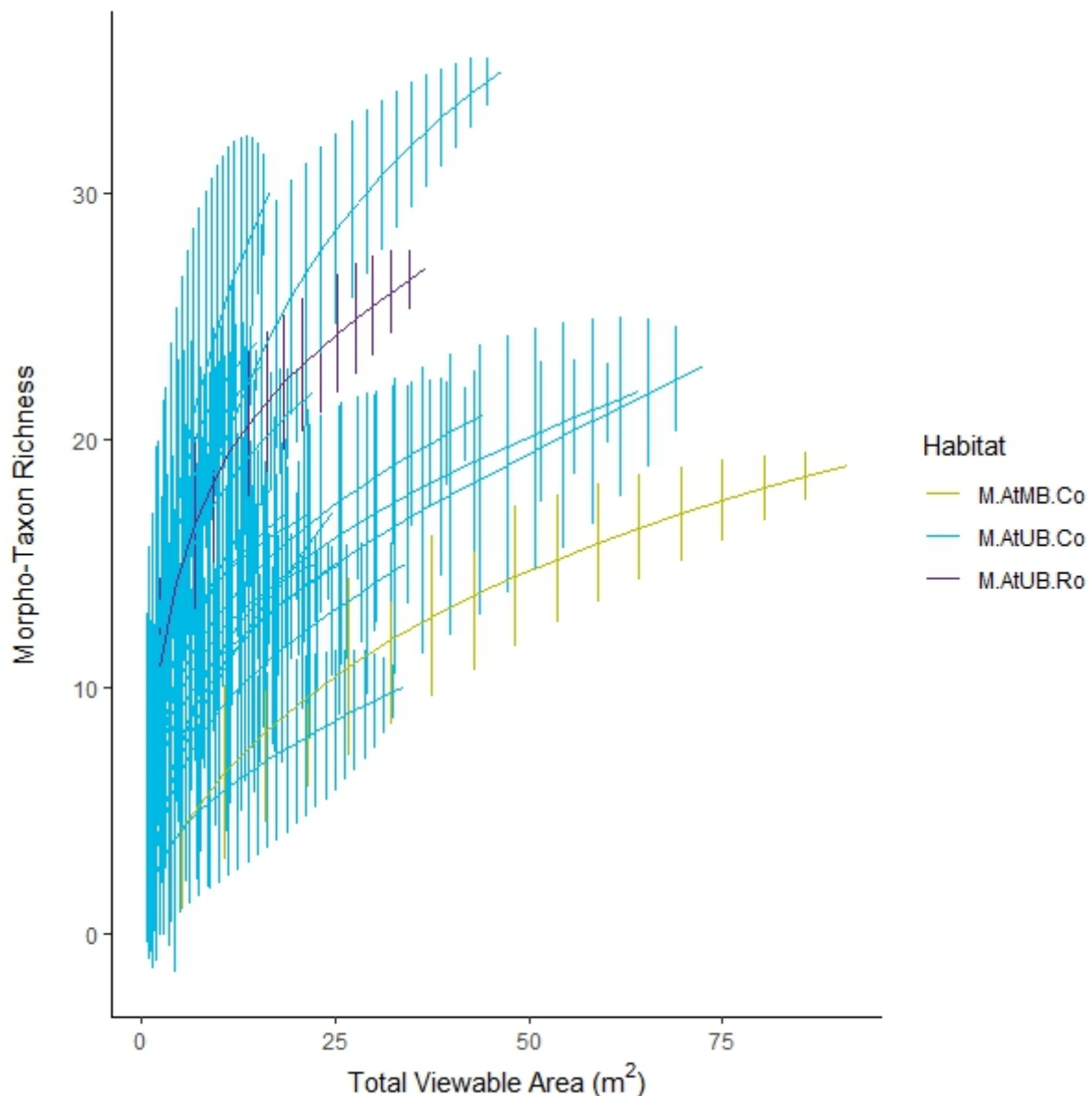


Figure A2. Species accumulation curves per broad scale habitat at Wyville-Thomson Ridge Special Area of Conservation. Different lines represent different sampling stations. Error bars represent confidence intervals. Levels of BSH abbreviations are detailed in Table 4. Only station x Habitat combinations with $n \geq 20$ images have been included. Data from surveys 1517S and 1218S combined.

Appendix 4. Image FoV and Quality epifauna abundance bias

The role of Field of View and Image quality on data quality

Image FoV and its variability can impact data quality and consequently our ability to adequately and precisely identify epifauna communities. For example, increased FoV and associated increased ground pixel size may negatively impact the taxonomic resolution to which epifauna can be identified. Similarly, the ability to detect small or inconspicuous species may be inhibited with increased ground pixel size. In contrast, the ability to detect rare species or species with a patchy distribution may be positively impacted by increased FoV as a larger area is sampled.

Secondly, image quality may also impact data quality. Low Image quality scores can be caused by the seabed being obscured with disturbed sediment; insufficient illumination; image overexposure; or the angle or height of the camera system result in a restricted view of the substrate (Benson & Sotheran 2018; see Turner *et al.* 2016 for Quality level definitions). Similar to the impact of altered FoV, this can negatively impact the taxonomic resolution to which epifauna can be identified and the ability to detect small or inconspicuous species (Turner *et al.* 2016).

Abundance bias of Porifera morphological forms

Whilst accounting for differences in habitat and image quality, the relationship between the abundance of different Porifera morphological forms and image FoV was best described by negative binomial and zero-inflated negative binomial models (Table A1).

Table A1. Comparison of different model families describing the relationship between Porifera abundance and image Field of View (FoV) and Quality, with Broad Scale Habitat added to the model as covariate. Relationships are investigated for different morphological forms. Best models (indicated with the lowest AIC value) are indicated in bold. Abundances are given as density (m^{-2}) for massive and erect morphologies, and as % cover for the encrusting morphology.

Porifera morphological form	Model	dAIC	df
Massive	Nbm2	0	6
	Poisson	4548.4	5
	Glm	6171.0	6
	ZI Nbm2	NA	11
	ZI Poisson	2520.4	10
Erect	Nbm2	0	6
	Poisson	19.2	5
	Glm	570.3	6
	ZI Nbm2	NA	11
	ZI Poisson	19.8	10

Porifera morphological form	Model	dAIC	df
Encrusting	Nbm2	164.7	6
	Poisson	17661.3	5
	Glm	3957.4	6
	ZI Nbm2	0	11
	ZI Poisson	9362.5	10

There was a significant negative relationship with FoV and the abundance of massive and erect morphological forms, as indicated by the negative model estimates (Figure A3a - b; Table A2). This indicates that, irrespective of image quality, one is more likely to underestimate massive and erect sponge density when image FoV increases.

The negative relationship between Porifera abundance and FoV was not observed for the encrusting morphology, as indicated by the conditional model component (Table A2; Figure A3c). There was, however, a significant negative association between encrusting Porifera and FoV for the zero-inflation model component (Table A2). This indicates that whilst abundance estimates of encrusting Porifera may not be affected, images with a larger FoV are less likely to detect the presence of encrusting Porifera *per se*.

Apart from image FoV, Image Quality was also important in shaping Porifera abundance for all morphologies investigated (Table A2). The significant negative estimates of the conditional models indicates that when image quality is reduced (from “Good+” to “Poor” or “Very poor”), sponge abundances are underestimated. Moreover, there was an increasingly negative relationship associated with an increasingly reduced image quality for the conditional model in general (Table A2). This indicates that “Very poor” quality images result in an increased undervaluation of Porifera abundances compared to “Poor” quality images. One exception to this was the relationship for the Porifera erect morphology, where the relationship with “Very poor” quality images was not significant (Table A2).

The significant positive association of encrusting Porifera with reduced image quality for the zero-inflation model was surprising (Table A2). This result indicates that with a lower image quality, the encrusting Porifera are more likely to be detected. Again, this relationship was stronger the poorer the image quality got, as indicated by the higher estimate for ‘Very poor’ quality in relation to ‘Poor’ quality images.

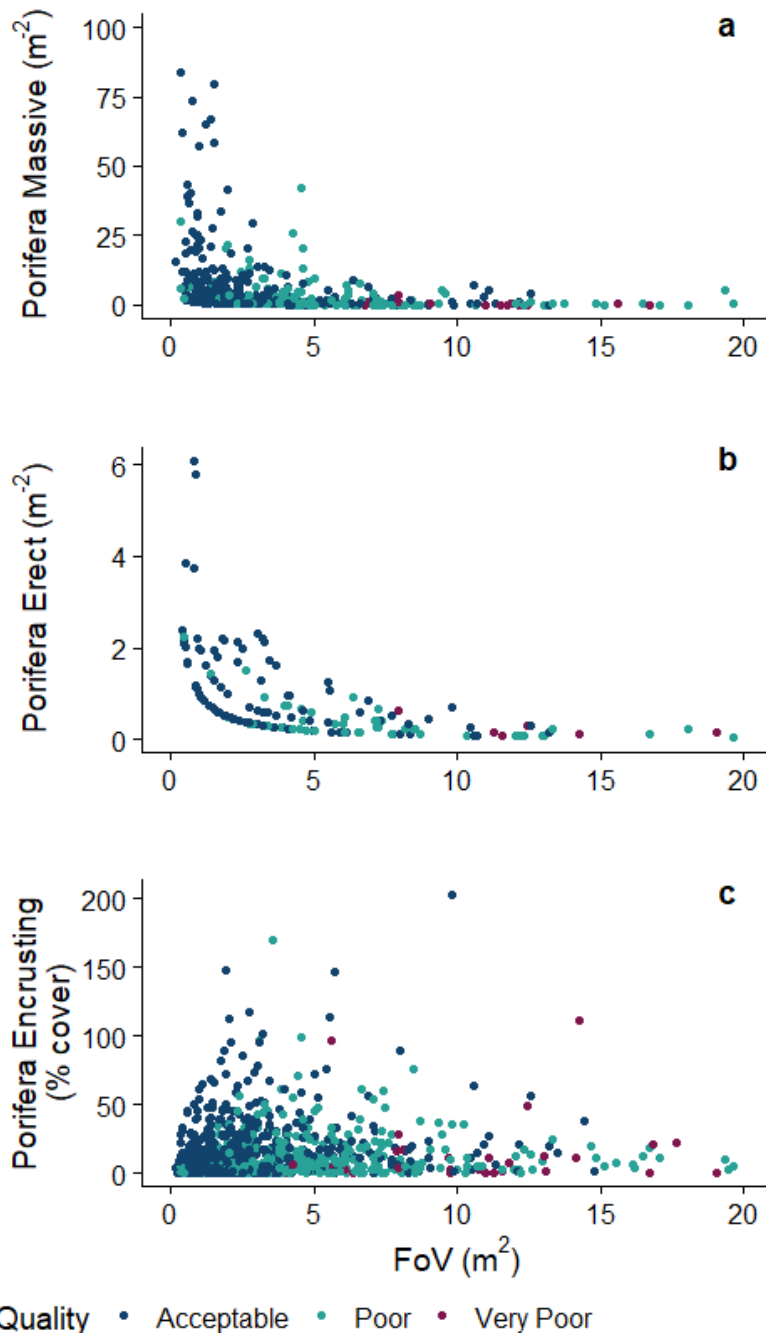


Figure A3. Scatter plots showing the relationship between Porifera abundance and image Field of View (FoV) for different morphological groups at Wyville-Thomson Ridge Special Area of Conservation. A - b: Porifera' density calculated from count abundance data of solitary individuals for massive and erect morphologies. C: Porifera' percentage cover for Porifera of encrusting and bioeroding morphological forms combined. Data points are coloured by image quality. Note the different units of the y-axes. Zero abundances are not shown for image clarity. Only images from 1218S have been included in the analysis.

Table A2. Negative Binomial and zero-inflated Negative Binomial model details exploring the association between Porifera abundance (density or % cover) of different morphologies and FoV and image Quality at Wyville-Thomson Ridge Special Area of Conservation. Habitat (as per MHC; JNCC, 2022b) was added as a random effect to the model. Significant effects ($p < 0.05$) are indicated in bold. Quality estimates are calculated in relation to category level “Good+” (“Good” and “Excellent” quality combined). The conditional model explores the relationship with Porifera abundances whilst the zero-inflation model explores the relationship with Porifera detection (presence-absence). Only images from 1218S have been included for analysis. N = 1412.

Porifera massive (m ⁻²)	Conditional model			Zero-inflation model			Full model	
	Estimate	SE	Pr	Estimate	SE	Pr	AIC	Df (resid)
intercept	0.51	0.67	0.45	-	-	-	3701.9	1406
FoV (m ²)	-0.19	0.024	< 0.001	-	-	-	-	-
Quality: Poor	-0.66	0.14	< 0.001	-	-	-	-	-
Quality: Very poor	-0.99	0.41	0.015	-	-	-	-	-

Porifera erect (m ⁻²)	Conditional model			Zero-inflation model			Full model	
	Estimate	SE	Pr	Estimate	SE	Pr	AIC	Df (resid)
intercept	-1.9	0.36	< 0.001	-	-	-	871.7	1406
FoV (m ²)	-0.1	0.042	0.014	-	-	-	-	-
Quality: Poor	-1.1	0.25	< 0.001	-	-	-	-	-
Quality: Very poor	-1.2	0.86	0.15	-	-	-	-	-

Porifera encrusting (%)	Conditional model			Zero-inflation model			Full model	
	Estimate	SE	Pr	Estimate	SE	Pr	AIC	Df (resid)
intercept	2.4	0.27	< 0.001	-1.8	1.6	0.17	7891.5	1401
FoV (m ²)	0.0051	0.0098	0.60	-0.24	0.058	< 0.001	-	-
Quality: Poor	-0.35	0.090	< 0.001	0.43	0.19	0.025	-	-
Quality: Very poor	-0.59	0.21	0.005	2.66	0.56	< 0.001	-	-

Abundance bias of Abundant Taxa

Similar patterns in species density and FoV were observed for the 12 most abundant morpho-taxa (excluding Porifera) at the site (Figure A4). Again, negative binomial models or zero inflated negative binomial models best described the abundance for all investigated taxa, with the exception of *Cidaris cidaris* for which a Poisson model was deemed the best fit (Table A3).

The models indicate a significant negative effect of FoV as part of the conditional and often also the zero-inflated component (when included in the model) for all morpho-taxa

investigated (Figure A4; Table A4). This is similar to the observations for Porifera morphologies. This indicates that for images with a larger FoV, it is less likely to identify the taxon present, and if a taxon is present, the observed density will be lower. This means that with a larger FoV both the occurrence *and* the abundance of taxa are likely to be underestimated.

The analyses also revealed a predominantly negative effect of reduced image quality on taxon abundances, although a significant association was not observed for all comparisons (Table A4). When a significant relationship was detected, “Very poor” quality images generally affected species densities more negatively than “Poor” quality images did (Table A4). Surprisingly, a positive association between the abundance of the morpho-taxa white branching Bryozoa and Echinodea was found with reduced image quality.

Image quality showed mixed results as a driver for the zero-inflation component of the respective models (Table A4). For two out of the four zero-inflated negative binomial models investigated (i.e. for Galattheoidea and Echinoidea), no significant association with Image Quality was observed. This may suggest that image quality is less important when exploring species presence-absences compared to their abundances for solitary taxa. Surprisingly however, and like the observation for encrusting Porifera, a positive association was observed between image quality and the *presence* of Scleractinia and of the morpho-taxa white branching Bryozoa. Here, the zero-inflation model component indicated an increasingly positive relationship between taxon presence and increasingly reduced image quality (i.e. from “Poor” to “Very poor” Quality; Table A4). This indicates that when image quality is reduced, one is more likely to observe (falsely or not) those morpho-taxa present.

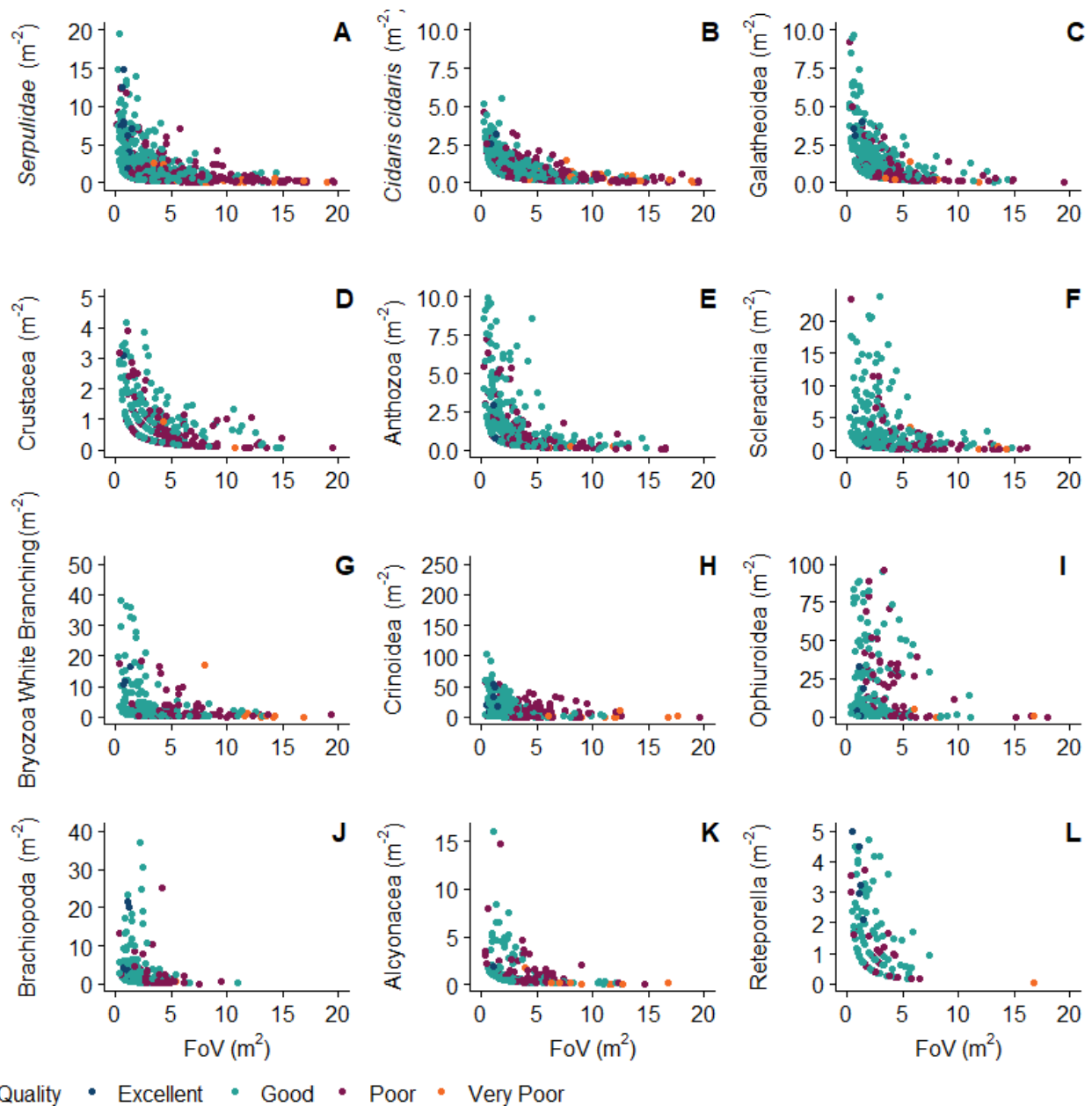


Figure A4. Scatter plots showing the relationship between taxon abundance and image Field of View (FoV) for the 12 most abundant taxa (Porifera excluded) at Wyville-Thomson Ridge Special Area of Conservation. Data points are coloured by image quality. Note: zero abundances are not shown, and x-axes have been restricted to 0 - 10 m² for figure clarity. Only images from 1218S have been included. Taxa are presented in order of their abundance with the most abundant taxon presented first.

Table A3. Comparison of different model families describing the relationship between the density (m^{-2}) of the 12 most abundant taxa (excluding Porifera) and image FoV and Quality, with Broad Scale Habitat added to the model as covariate. Best model (indicated with the lowest AIC value) are indicated in bold. NA if the model could not be computed thus no dAIC could be calculated. Taxa are presented in order of their abundance with the most abundant taxon presented first.

Taxon	Model	dAIC	df
Serpulidae	Nbm2	0.0	6
	Poisson	751.2	5
	Glm	2705.4	6
	ZI Nbm2	NA	11
	ZI Poisson	491.0	10
<i>Cidaris cidaris</i>	Nbm2	NA	6
	Poisson	0	5
	Glm	723.6	6
	ZI Nbm2	NA	11
	ZI Poisson	NA	10
Galatheaidea	Nbm2	9.0	6
	Poisson	101.3	5
	Glm	1850.2	6
	ZI Nbm2	0	11
	ZI Poisson	28.4	10
Crustacea	Nbm2	16.3	6
	Poisson	42.5	5
	Glm	12112	6
	ZI Nbm2	0	11
	ZI Poisson	10.4	10
Anthozoa	Nbm2	7.3	6
	Poisson	3541.1	5
	Glm	6903.8	6
	ZI Nbm2	0	11
	ZI Poisson	1978.4	10
Scleractinia	Nbm2	22.9	6
	Poisson	1679.0	5
	Glm	4131.1	6
	ZI Nbm2	0	11
	ZI Poisson	513.7	10

Taxon	Model	dAIC	df
Bryozoa White Branching	Nbm2	38.2	6
	Poisson	2329.3	5
	Glm	5720.6	6
	ZI Nbm2	0	11
	ZI Poisson	825	10
Ophiuroidea	Nbm2	0	6
	Poisson	24598.6	5
	Glm	9559.6	6
	ZI Nbm2	0	11
	ZI Poisson	0	10
Crinoidea	Nbm2	0	6
	Poisson	11320.6	5
	Glm	7257.1	6
	ZI Nbm2	NA	11
	ZI Poisson	NA	10
Brachiopoda	Nbm2	0	6
	Poisson	2809.6	5
	Glm	6308.4	6
	ZI Nbm2	NA	11
	ZI Poisson	1149.0	10
Echinoidea	Nbm2	14.7	6
	Poisson	75.9	5
	Glm	1139.2	6
	ZI Nbm2	0	11
	ZI Poisson	5.7	10
Alcyonacea	Nbm2	0	6
	Poisson	135.6	5
	Glm	2684.9	6
	ZI Nbm2	NA	11
	ZI Poisson	NA	10

Table A4. Negative Binomial, zero-inflated Negative Binomial and poisson model details exploring the association between the density (m⁻²) of the 12 most abundant taxa (excluding Porifera) and Field of View (FoV) and image Quality at WTR Special Area of Conservation. Habitat (as per Marine Habitat Classification of Britain and Ireland; JNCC 2015) was added as a random effect to the model. Significant effects ($p < 0.05$) are indicated in bold. Quality estimates are calculated in relation to Quality level “Good+” (“Good” and “Excellent” quality combined). Only images from 1218S have been included for analysis. N = 1412.

Taxon	Field of View / Image Quality	Conditional model			Zero-inflation model			Full model	
		Estimate	SE	Pr	Estimate	SE	Pr	AIC	Df (resid)
<i>Serpulidae</i>	intercept	0.28	0.35	0.43	-	-	-	3,907.8	1,406
	FoV (m ²)	-0.19	0.017	< 0.001	-	-	-	-	-
	Quality: Poor	-0.39	0.083	< 0.001	-	-	-	-	-
	Quality: Very poor	-0.78	0.28	0.006	-	-	-	-	-
<i>Cidaris cidaris</i>	intercept	-1.6	0.58	0.006	-	-	-	2,046.8	1,407
	FoV (m ²)	-0.10	0.019	< 0.001	-	-	-	-	-
	Quality: Poor	-0.23	0.096	0.017	-	-	-	-	-
	Quality: Very poor	-0.0084	0.27	0.98	-	-	-	-	-
<i>Galatheaidea</i>	intercept	-0.99	0.84	0.24	1.2	0.88	0.18	32,102.8	1,401
	FoV (m ²)	-0.35	0.035	< 0.001	-2.0	0.63	0.0018	-	-
	Quality: Poor	-0.64	0.12	< 0.001	-0.41	1.0	0.68	-	-
	Quality: Very poor	-0.85	0.61	0.16	-10	3,070	1.0	-	-
<i>Crustacea</i>	intercept	-1.8	0.50	< 0.001	-	-	-	1,732.3	1,406
	FoV (m ²)	-0.15	0.0.7	< 0.001	-	-	-	-	-
	Quality: Poor	-0.30	0.12	0.014	-	-	-	-	-
	Quality: Very poor	-1.8	0.80	0.025	-	-	-	-	-

Taxon	Field of View / Image Quality	Conditional model			Zero-inflation model			Full model	
		Estimate	SE	Pr	Estimate	SE	Pr	AIC	Df (resid)
Anthozoa	intercept	1.1	0.11	< 0.001	-	-	-	2,590.8	1,406
	FoV (m ²)	-0.43	0.038	< 0.001	-	-	-	-	-
	Quality: Poor	-0.86	0.15	< 0.001	-	-	-	-	-
	Quality: Very poor	-1.7	0.76	0.026	-	-	-	-	-
Scleractinia	intercept	-0.14	0.82	0.86	0.96	0.34	0.004	2,204.2	1,401
	FoV (m ²)	-0.22	0.034	< 0.001	-0.82	0.21	< 0.001	-	-
	Quality: Poor	-1.1	0.20	< 0.001	0.69	0.48	0.16	-	-
	Quality: Very poor	-1.2	0.64	0.061	3.6	1.7	0.036	-	-
Bryozoa White Branching	intercept	-2.5	1.6	0.11	0.77	0.53	0.15	2,124.5	1,401
	FoV (m ²)	-0.26	0.035	< 0.001	-1.0	0.19	< 0.001	-	-
	Quality: Poor	-0.17	0.22	0.45	1.8	0.49	< 0.001	-	-
	Quality: Very poor	0.98	0.49	0.044	5.4	1.4	< 0.001	-	-
Ophiuroidea	intercept	3.2	0.61	< 0.001	-	-	-	3,158.3	1,406
	FoV (m ²)	-0.78	0.059	< 0.001	-	-	-	-	-
	Quality: Poor	-0.22	0.26	0.39	-	-	-	-	-
	Quality: Very poor	-2.2	0.92	0.015	-	-	-	-	-
Crinoidea	intercept	-0.25	0.82	0.76	-	-	-	2,954.0	1,406
	FoV (m ²)	-0.20	0.045	< 0.001	-	-	-	-	-
	Quality: Poor	0.051	0.28	0.85	-	-	-	-	-
	Quality: Very poor	-0.087	0.70	0.90	-	-	-	-	-

Taxon	Field of View / Image Quality	Conditional model			Zero-inflation model			Full model	
		Estimate	SE	Pr	Estimate	SE	Pr	AIC	Df (resid)
Brachiopoda	intercept	-8.9	4.3	0.036	-	-	-	1,687.0	1,406
	FoV (m ²)	-0.59	0.078	< 0.001	-	-	-	-	-
	Quality: Poor	-0.66	0.26	0.012	-	-	-	-	-
	Quality: Very poor	-1.6	1.6	0.31	-	-	-	-	-
Echinoidea	intercept	-0.67	0.67	0.32	3.3	0.69	< 0.001	613.4	1,401
	FoV (m ²)	-0.96	0.15	< 0.001	-2.1	0.45	< 0.001	-	-
	Quality: Poor	0.31	0.32	0.33	-0.36	0.90	0.69	-	-
	Quality: Very poor	2.5	0.86	0.004	3.5	2.5	0.16	-	-
Alcyonacea	intercept	-1.7	0.73	0.018	-	-	-	869.3	1,406
	FoV (m ²)	-0.23	0.054	< 0.001	-	-	-	-	-
	Quality: Poor	0.16	0.21	0.15	-	-	-	-	-
	Quality: Very poor	-1.1	0.71	0.13	-	-	-	-	-

Appendix 5. Data size following image selection

Table A5. Consequences of data quality selection steps for image pool size. Data has been pooled across surveys 1517S and 1218S.

Image selection step	Images removed (#) (sequential)	Residual Image pool size (#)
Raw data	-	2,052
Key metadata absent	304	1,748
Insufficient image quality	755	993
Outside preset FoV range	179	814
Unselected images to meet minimum TVA per station.	150	664
Excluded stations (those that did not meet minimum TVA threshold)	303	361

Table A6. Trade-off analysis to identify the number of stations available for analysis as a consequence of image Field of View (FoV) range (table rows) and minimum Total Viewable Area (TVA) at a station (table columns) for images grouped by Station * Habitat combination and separated by survey. The consequences of the selected 'best' solution of a FoV range of 0.5 – 5 m² and a minimum TVA of 15 m² is highlighted in bold.

Survey	FoV range (m ²)	TVA ≥ 5 m ²	TVA ≥ 10 m ²	TVA ≥ 15 m ²	TVA ≥ 20 m ²
1517S	0–3	13	12	8	4
1517S	0–4	13	12	8	4
1517S	0–5	13	12	8	4
1517S	0.5–3	13	12	6	4
1517S	0.5–4	13	12	6	4
1517S	0.5–5	13	12	6	4
1218S	0–3	55	35	21	9
1218S	0–4	71	46	33	20
1218S	0–5	77	58	39	24
1218S	0.5–3	55	35	21	8
1218S	0.5–4	71	46	33	20
1218S	0.5–5	76	58	39	24

Appendix 6. K-means partitioning results

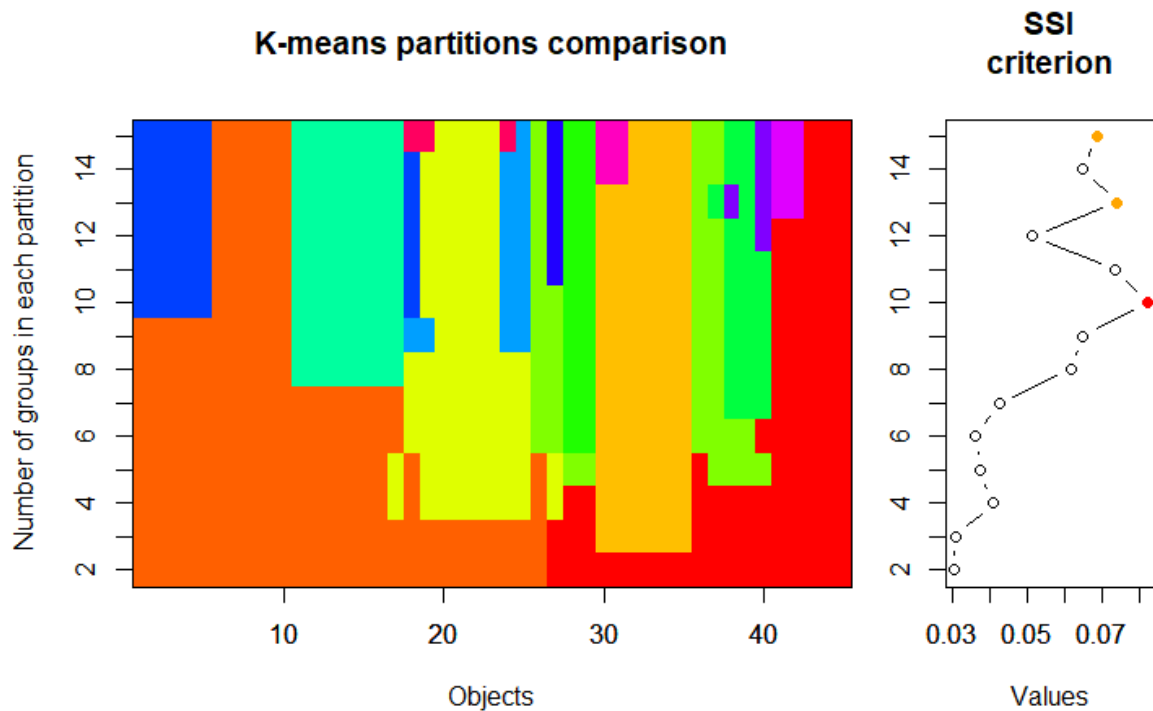


Figure A5. Partition diagram with corresponding SSI criterion values based on Hellinger transformed relative abundance epifauna data of Wyville-Thomson Ridge Special Area of Conservation. Left panel: stations grouped in the same cluster share the same indicator colour. Right panel: the red point indicates the highest SSI value within the investigated possible number of groupings range; orange points indicate subsequent highest values. This figure was created using *cascadeKM* (Oksanen *et al.* 2025) in R. Data from 1517S and 1218S.

Appendix 7. Environmental data

Table A7. Environmental data per station at Wyville-Thomson Ridge Special Area of Conservation from surveys 1517S and 1218S combined. Temperature, Depth and Conductivity were measured in situ. This information is based on selected images from 1517S and 1218S. Water current magnitude information is based on the nearest available datapoint.

Station	Temperature (°C)	Depth (m)	Conductivity (mS cm ⁻¹)	Near-bed current magnitude (ms ⁻¹)
A05	8.39	474.51	36.91	0.29
A06	8.49	488.30	37.01	0.20
A08	8.54	547.94	37.09	0.36
A09	8.19	471.93	36.70	0.20
A10	8.46	471.24	36.97	0.20
A13	7.75	478.77	36.26	0.38
A16	8.42	460.85	36.92	0.38
A18	8.46	468.11	36.97	0.29
A19	7.16	500.92	35.71	0.29
A21	8.55	566.65	37.11	0.36
A25	0.82	553.10	29.88	0.43
A30	8.52	437.82	37.01	0.43
A31	-0.60	592.67	28.67	0.43
A32	8.72	657.43	37.31	0.33
A33	8.49	503.31	37.01	0.38
A34	-0.67	764.33	28.68	0.38
A35	8.57	424.59	37.07	0.35
A38	-0.68	848.01	28.72	0.04
A39	8.58	433.73	37.07	0.35
A41	8.90	510.44	37.43	0.35
A44	-0.69	795.11	28.68	0.43
A46	8.26	485.16	36.77	0.43
A49	-0.70	831.52	28.70	0.38
A51	8.39	438.24	36.88	0.38
A53	9.65	342.31	38.11	0.05
A59	9.01	390.33	37.49	0.11
A60	9.73	358.45	38.19	0.07
A61	6.45	545.62	35.04	0.33
A66	-0.66	697.86	28.67	0.38

Station	Temperature (°C)	Depth (m)	Conductivity (mS cm ⁻¹)	Near-bed current magnitude (ms ⁻¹)
A67	8.97	637.19	37.57	0.07
A70	9.30	408.43	37.80	0.13
A71	9.09	449.19	37.61	0.19
A72	9.13	431.46	37.64	0.15
A74	-0.55	625.33	28.73	0.33
A75	9.58	500.22	38.10	0.15
A76	9.53	463.04	38.03	0.19
A77	-0.57	617.28	28.71	0.07
A78	9.95	472.12	38.48	0.01
A81	-0.65	879.88	28.76	0.16
A84	-0.64	837.63	28.75	0.07
A87	9.37	475.52	37.87	0.15
A89	9.16	516.05	37.71	0.15
B01	8.75	648.17	37.35	0.43
B02	8.74	565.96	37.29	0.35
B05	8.64	861.30	37.33	0.05

Table A8. Summary of environmental data for each cluster group at Wyville-Thomson Ridge Special Area of Conservation. Temperature, Depth and Conductivity were measured *in situ*. Water current magnitude information is based on the nearest available datapoint. N = 5, 6, 4, 5, 2, 6, 2, 3, 7 and 5 stations for cluster groups A – J, respectively.

Cluster group	Variable	Min	Max	Mean	Standard Error
A	Temperature.CTD	8.54	9.30	8.75	0.14
A	Depth.CTD	408.43	861.30	608.35	74.75
A	Conductivity.CTD	37.09	37.80	37.33	0.13
A	nearest.annual.mag	0.05	0.36	0.24	0.07
B	Temperature.CTD	9.37	9.95	9.64	0.08
B	Depth.CTD	342.31	500.22	435.28	27.39
B	Conductivity.CTD	37.87	38.48	38.13	0.08
B	nearest.annual.mag	0.01	0.19	0.10	0.03
C	Temperature.CTD	-0.70	9.16	5.87	2.27
C	Depth.CTD	433.73	831.52	581.73	86.56
C	Conductivity.CTD	28.70	37.71	34.63	2.06
C	nearest.annual.mag	0.15	0.38	0.30	0.05
D	Temperature.CTD	-0.66	0.82	-0.31	0.28
D	Depth.CTD	553.10	697.86	617.25	23.75

Cluster group	Variable	Min	Max	Mean	Standard Error
D	Conductivity.CTD	28.67	29.88	28.93	0.24
D	nearest.annual.mag	0.07	0.43	0.33	0.07
E	Temperature.CTD	8.46	8.74	8.60	0.14
E	Depth.CTD	471.24	565.96	518.60	47.36
E	Conductivity.CTD	36.97	37.29	37.13	0.16
E	nearest.annual.mag	0.20	0.35	0.28	0.08
F	Temperature.CTD	8.52	9.13	8.84	0.11
F	Depth.CTD	424.59	648.17	504.74	43.77
F	Conductivity.CTD	37.01	37.64	37.37	0.11
F	nearest.annual.mag	0.07	0.43	0.27	0.06
G	Temperature.CTD	-0.65	-0.64	-0.64	0.00
G	Depth.CTD	837.63	879.88	858.75	21.13
G	Conductivity.CTD	28.75	28.76	28.76	0.01
G	nearest.annual.mag	0.07	0.16	0.12	0.05
H	Temperature.CTD	-0.69	-0.67	-0.68	0.01
H	Depth.CTD	764.33	848.01	802.48	24.44
H	Conductivity.CTD	28.68	28.72	28.69	0.01
H	nearest.annual.mag	0.04	0.43	0.28	0.12
I	Temperature.CTD	7.16	8.49	8.12	0.19
I	Depth.CTD	460.85	500.92	477.63	5.05
I	Conductivity.CTD	35.71	37.01	36.64	0.18
I	nearest.annual.mag	0.20	0.38	0.29	0.03
J	Temperature.CTD	8.26	9.01	8.61	0.15
J	Depth.CTD	390.33	510.44	465.50	22.62
J	Conductivity.CTD	36.77	37.49	37.12	0.15
J	nearest.annual.mag	0.11	0.43	0.33	0.06

Table A9. Summary of substrate composition data for each cluster group at WTR.

Cluster group	Variable	Min	Max	Mean	Standard Error
A	Boulders (256–512 mm)	0.0	1.1	0.2	0.2
A	Cobbles	4.7	16.8	10.4	2.1
A	Pebbles	73.2	86.1	79.5	2.3
A	Sand (0.063–2 mm)	10.0	11.6	10.3	0.3
B	Boulders (512–1,024 mm)	0.0	2.1	0.3	0.3
B	Boulders (256–512 mm)	0.0	1.6	0.7	0.3
B	Cobbles	0.3	8.8	3.4	1.3
B	Pebbles	42.9	71.4	56.8	5.0
B	Shells (Empty)	0.0	0.1	0.0	0.0
B	Granule (2–4 mm)	0.0	7.6	3.6	1.2
B	Shell (2–16 mm)	1.0	8.0	4.4	0.9
B	Sand (0.063–2 mm)	20.4	48.6	30.1	4.7
B	Mud (< 0.063 mm)	0.0	1.5	0.6	0.3
C	Boulders (256–512 mm)	0.0	2.0	0.5	0.5
C	Cobbles	2.6	6.7	3.8	1.0
C	Pebbles	53.3	90.0	67.5	8.6
C	Sand (0.063–2 mm)	10.0	42.4	26.7	6.7
C	Mud (< 0.063 mm)	0.0	10.0	2.5	2.5
D	Boulders (256–512 mm)	0.0	13.1	4.5	2.8
D	Cobbles	2.8	38.2	18.9	7.4
D	Pebbles	38.8	74.8	57.3	6.9
D	Sand (0.063–2 mm)	10.0	25.8	17.5	3.2
D	Mud (< 0.063 mm)	0.0	10.0	2.0	2.0
E	Cobbles	2.4	10.0	6.2	3.8
E	Pebbles	80.0	86.5	83.3	3.3
E	Coarse sand with shell fragments	0.0	1.0	0.5	0.5
E	Sand (0.063–2 mm)	10.0	10.0	10.0	0.0
F	Boulders (256–512 mm)	0.0	4.6	0.9	0.7
F	Cobbles	4.3	50.3	15.1	7.3
F	Pebbles	35.2	84.0	74.6	7.9
F	Coarse sand with shell fragments	0.0	0.4	0.1	0.1
F	Sand (0.063–2 mm)	0.0	16.2	10.1	2.3

Cluster group	Variable	Min	Max	Mean	Standard Error
G	Cobbles	1.3	4.1	2.7	1.4
G	Pebbles	5.0	35.1	20.1	15.1
G	Coarse sand with shell fragments	0.0	5.0	2.5	2.5
G	Sand (0.063–2 mm)	30.0	60.0	45.0	15.0
G	Mud (< 0.063 mm)	30.8	40.0	35.4	4.6
H	Cobbles	8.0	11.1	9.4	0.9
H	Pebbles	51.6	60.0	56.9	2.6
H	Sand (0.063–2 mm)	20.0	39.3	26.4	6.4
H	Mud (< 0.063 mm)	5.0	12.7	9.2	2.2
I	Boulders (256–512 mm)	0.0	2.3	0.5	0.3
I	Cobbles	3.4	18.1	7.0	2.0
I	Pebbles	71.9	84.3	80.2	1.8
I	Coarse sand with shell fragments	0.0	3.3	0.5	0.5
I	Sand (0.063–2 mm)	7.8	15.5	12.1	0.9
J	Boulders (256–512 mm)	0.0	5.2	1.0	1.0
J	Cobbles	0.0	7.6	3.4	1.5
J	Pebbles	54.5	89.0	77.0	6.1
J	Coarse sand with shell fragments	0.0	4.6	0.9	0.9
J	Sand (0.063–2 mm)	11.0	35.1	18.1	4.6

Appendix 8. Univariate biodiversity indices

Table A10. Univariate biodiversity indices per station at Wyville-Thomson Ridge Special Area of Conservation from surveys 1517S and 1218S. Analysis is based on selected images from 1517S and 1218S and excludes morpho-taxa that had multiple abundance measurement methods (i.e. count vs % cover).

STN No	Solitary (count data) morpho-taxa			Encrusting and colonial (% cover data) morpho-taxa		Total
	H' biodiversity	Abundance (m ⁻²)	Richness	Abundance (% cover)	Richness	Richness
A53	1.585	8.498	11	3.750	4	15
A60	0.840	3.709	7	3.237	5	12
A75	1.781	3.435	9	4.100	5	14
A76	1.895	12.987	11	5.541	4	15
A78	1.094	1.325	5	1.904	3	8
A87	1.708	1.296	7	2.321	4	11
A05	2.210	4.701	13	1.990	4	17
A06	1.824	11.825	11	4.961	5	16
A08	1.720	6.792	9	25.837	3	12
A09	1.943	10.071	11	3.937	2	13
A10	1.499	4.806	7	0.203	1	8
A13	2.200	6.555	14	0.412	2	16
A16	1.630	3.851	8	0.874	2	10
A18	1.660	7.746	10	9.614	4	14
A19	2.302	7.035	14	6.014	2	16
A21	1.871	3.254	12	11.844	3	15
A25	1.139	36.032	17	13.512	3	20
A30	1.497	22.391	10	14.026	3	13
A31	0.773	32.196	9	31.026	3	12
A32	1.992	0.698	8	2.029	4	12
A33	1.373	1.713	5	0.000	0	5
A34	1.834	16.169	16	6.444	3	19
A35	1.743	16.167	11	4.545	3	14
A38	2.357	10.156	21	5.123	4	25
A39	1.588	10.480	10	28.476	5	15
A41	1.623	2.523	7	0.887	2	9
A44	2.284	4.662	17	1.882	4	21

STN No	Solitary (count data) morpho-taxa			Encrusting and colonial (% cover data) morpho-taxa		Total
	H' biodiversity	Abundance (m ⁻²)	Richness	Abundance (% cover)	Richness	Richness
A46	1.835	1.502	8	0.327	2	10
A49	2.152	5.556	18	33.008	3	21
A51	1.949	1.859	10	0.821	1	11
A59	1.358	1.954	6	0.000	0	6
A61	1.988	5.959	13	8.862	5	18
A66	0.924	66.451	16	15.294	5	21
A67	1.490	31.265	17	32.366	4	21
A70	1.898	6.000	11	22.738	3	14
A71	1.808	13.631	15	4.469	3	18
A72	1.631	5.790	9	1.362	2	11
A74	1.185	87.500	17	27.769	3	20
A77	1.234	81.420	16	37.340	3	19
A81	0.847	14.160	9	0.000	0	9
A84	1.899	11.558	18	0.145	1	19
A89	2.079	4.528	13	0.448	1	14
B01	1.190	9.701	10	9.557	5	15
B02	0.956	0.421	3	0.000	0	3
B05	1.790	4.061	12	10.880	3	15

Table A11. Summary of epifaunal diversity indices for each cluster group at Wyville-Thomson Ridge Special Area of Conservation. Analysis is based on ONLY count data (density per m²). Analysis is based on selected images from 1517S and 1218S and excludes morpho-taxa that had multiple abundance measurement methods (i.e. count vs % cover). N = 5, 6, 4, 5, 2, 6, 2, 3, 7 and 5 stations for cluster groups A – J, respectively.

Cluster group	Index	Min	Max	Mean	Standard Error
A	H' diversity	1.720	1.992	1.854	0.046
A	Abundance (m ⁻²)	0.698	6.792	4.161	1.075
A	Richness	8	12	10.400	0.812
B	H' diversity	0.840	1.895	1.484	0.172
B	Abundance (m ⁻²)	1.296	12.987	5.208	1.890
B	Richness	5	11	8.333	0.989
C	H' diversity	1.588	2.152	1.952	0.126
C	Abundance (m ⁻²)	4.528	10.480	6.631	1.318
C	Richness	10	18	13.500	1.658
D	H' diversity	0.773	1.234	1.051	0.087
D	Abundance (m ⁻²)	32.196	87.500	60.720	11.405
D	Richness	9	17	15.000	1.517
E	H' diversity	0.956	1.499	1.227	0.271
E	Abundance (m ⁻²)	0.421	4.806	2.614	2.192
E	Richness	3	7	5.000	2.000
F	H' diversity	1.190	1.808	1.560	0.091
F	Abundance (m ⁻²)	5.790	31.265	16.491	3.750
F	Richness	9	17	12.000	1.317
G	H' diversity	0.847	1.899	1.373	0.526
G	Abundance (m ⁻²)	11.558	14.160	12.859	1.301
G	Richness	9	18	13.500	4.500
H	H' diversity	1.834	2.357	2.158	0.164
H	Abundance (m ⁻²)	4.662	16.169	10.329	3.323
H	Richness	16	21	18.000	1.528
I	H' diversity	1.630	2.302	1.967	0.104
I	Abundance (m ⁻²)	3.851	11.825	7.398	1.064
I	Richness	8	14	11.571	0.841
J	H' diversity	1.358	1.949	1.627	0.119
J	Abundance (m ⁻²)	1.502	2.523	1.910	0.171
J	Richness	5	10	7.200	0.860

Table A12. Summary of epifaunal diversity indices for each cluster group at Wyville-Thomson Ridge Special Area of Conservation. Analysis is based on ONLY % cover data of encrusting and colonial morpho-taxa. Analysis is based on selected images from 1517S and 1218S and excludes morpho-taxa that had multiple abundance measurement methods (i.e. count vs % cover). N = 5, 6, 4, 5, 2, 6, 2, 3, 7 and 5 stations for cluster groups A – J, respectively.

Cluster group	Index	Min	Max	Mean	Standard Error
A	Abundance (% cover)	2.0	26	14	4.3
A	Richness	3	4	3.2	0.20
B	Abundance (% cover)	1.9	5.5	3.5	0.54
B	Richness	3	5	4.2	0.31
C	Abundance (% cover)	0.45	33	18	7.8
C	Richness	1	5	3.5	0.96
D	Abundance (% cover)	14	37	25	4.6
D	Richness	3	5	3.4	0.40
E	Abundance (% cover)	0.0	0.20	0.10	0.10
E	Richness	0	1	0.50	0.50
F	Abundance (% cover)	1.4	32	11	4.6
F	Richness	2	5	3.3	0.42
G	Abundance (% cover)	0.0	0.15	0.072	0.072
G	Richness	0	1	0.50	0.50
H	Abundance (% cover)	1.9	6.4	4.5	1.4
H	Richness	3	4	3.7	0.33
I	Abundance (% cover)	0.41	9.6	4.0	1.2
I	Richness	2	5	3.0	0.49
J	Abundance (% cover)	0.0	0.89	0.41	0.19
J	Richness	0	2	1.0	0.45

Appendix 9. Annex I Reef substratum analysis results

Table A13. Results of Annex I Reef substratum criterion analysis at stations at Wyville-Thomson Ridge Special Area of Conservation. Analysis is based on video imagery from surveys 1517S and 1218S.

Survey Code	Station Code	Video Sample Ref	% Reef Substrate	Meets Annex I stony reef substratum criterion
1517S	A48	1517S_WTR_A48_S86	6	no
1517S	A50	1517S_WTR_A50_S84	7	no
1517S	A53	1517S_WTR_A53_S85	12	yes
1517S	A55	1517S_WTR_A55_S83	4	no
1517S	A57	1517S_WTR_A57_S81	4	no
1517S	A60	1517S_WTR_A60_S82	2	no
1517S	A62	1517S_WTR_A62_S80	5	no
1517S	A73	1517S_WTR_A73_S79	14	yes
1517S	A75	1517S_WTR_A75_S75	9	no
1517S	A76	1517S_WTR_A76_S78_SEG01	6	no
1517S	A76	1517S_WTR_A76_S78_SEG02	42	yes
1517S	A76	1517S_WTR_A76_S78_SEG03	13	yes
1517S	A78	1517S_WTR_A78_S72	2	no
1517S	A79	1517S_WTR_A79_S77	15	yes
1517S	A82	1517S_WTR_A82_S74	16	yes
1517S	A85	1517S_WTR_A85_S76	6	no
1517S	A87	1517S_WTR_A87_S73	1	no
1218S	A02	1218S_A02_39_1_H1	2.9	no
1218S	A03	1218S_A03_22_1_H1	5.7	no
1218S	A04	1218S_A04_81_1_H1	10	no
1218S	A05	1218S_A05_38_1_H1	12.3	yes
1218S	A06	1218S_A06_40_1_H1	11.5	yes
1218S	A07	1218S_A07_24_1_H1	10	no
1218S	A08	1218S_A08_80_1_H1	20	yes
1218S	A09	1218S_A09_37_1_H1	0	no
1218S	A09	1218S_A09_37_1_H2	41.7	yes
1218S	A10	1218S_A10_41_1_H1	9.7	no
1218S	A11	1218S_A11_25_1_H1	22.3	yes
1218S	A12	1218S_A12_79_1_H1	12.6	yes

Survey Code	Station Code	Video Sample Ref	% Reef Substrate	Meets Annex I stony reef substratum criterion
1218S	A13	1218S_A13_36_1_	10	no
1218S	A14	1218S_A14_26_1_H1	32	yes
1218S	A15	1218S_A15_82_1_H1	22.3	yes
1218S	A16	1218S_A16_42_1_H1	30	yes
1218S	A16	1218S_A16_42_1_H2	0	no
1218S	A17	1218S_A17_35_1_H1	41.7	yes
1218S	A18	1218S_A18_78_1_H1	22.3	yes
1218S	A19	1218S_A19_34_1_H1	22.3	yes
1218S	A20	1218S_A20_27_1_H1	10	no
1218S	A21	1218S_A21_83_1_H1	10	no
1218S	A22	1218S_A22_77_1_H1	22.3	yes
1218S	A24	1218S_A24_48_1_H1	10	no
1218S	A25	1218S_A25_33_1_H1	10	no
1218S	A26	1218S_A26_28_1_H1	22.3	yes
1218S	A27	1218S_A27_92_1_H1	NA	NA
1218S	A27	1218S_A27_92_2_H1	22.3	yes
1218S	A28	1218S_A28_43_1_H1	5	no
1218S	A28	1218S_A28_43_1_H2	35	yes
1218S	A30	1218S_A30_47_1_H1	22.3	yes
1218S	A31	1218S_A31_32_1_H1	12.6	yes
1218S	A32	1218S_A32_93_1_H1	22.3	yes
1218S	A33	1218S_A33_44_1_H1	12.6	yes
1218S	A33	1218S_A33_44_1_H2	0	no
1218S	A34	1218S_A34_29_1_H1	NA	NA
1218S	A35	1218S_A35_46_1_H1	22.3	yes
1218S	A36	1218S_A36_31_1_H1	21.7	yes
1218S	A37	1218S_A37_45_1_H1	32	yes
1218S	A38	1218S_A38_30_1_H1	10	no
1218S	A39	1218S_A39_76_1_H1	20	yes
1218S	A40	1218S_A40_74_1_H1	9.7	no
1218S	A41	1218S_A41_95_1_H1	10	no
1218S	A42	1218S_A42_75_1_H1	30	yes
1218S	A43	1218S_A43_84_1_H1	10	no
1218S	A44	1218S_A44_73_1_H1	10	no

Survey Code	Station Code	Video Sample Ref	% Reef Substrate	Meets Annex I stony reef substratum criterion
1218S	A45	1218S_A45_85_1_H1	10	no
1218S	A46	1218S_A46_72_1_H1	22.3	yes
1218S	A47	1218S_A47_86_1_H1	5.7	no
1218S	A49	1218S_A49_71_1_H1	15	yes
1218S	A51	1218S_A51_70_1_H1	2.9	no
1218S	A52	1218S_A52_87_1_H1	5.7	no
1218S	A54	1218S_A54_88_1_H1	12.6	yes
1218S	A56	1218S_A56_69_1_H1	0	no
1218S	A58	1218S_A58_68_1_H1	0	no
1218S	A59	1218S_A59_89_1_H1	17.5	yes
1218S	A61	1218S_A61_67_1_H1	22.3	yes
1218S	A63	1218S_A63_65_1_H1	5.7	no
1218S	A64	1218S_A64_90_1_H1	12.6	yes
1218S	A65	1218S_A65_64_1_H1	5.7	no
1218S	A66	1218S_A66_66_1_H1	22.3	yes
1218S	A67	1218S_A67_52_1_H1	60	yes
1218S	A68	1218S_A68_91_1_H1	0	no
1218S	A69	1218S_A69_63_1_H1	5.7	no
1218S	A70	1218S_A70_51_1_H1	5.7	no
1218S	A71	1218S_A71_62_1_H1	12.6	yes
1218S	A72	1218S_A72_53_1_H1	5.7	no
1218S	A72	1218S_A72_53_1_H2	32	yes
1218S	A74	1218S_A74_61_1_H1	40	yes
1218S	A77	1218S_A77_58_1_H1	50	yes
1218S	A80	1218S_A80_57_1_H1	19.4	yes
1218S	A81	1218S_A81_60_1_H1	5.5	no
1218S	A83	1218S_A83_54_1_H1	12.6	yes
1218S	A84	1218S_A84_59_1_H1	7.8	no
1218S	A86	1218S_A86_56_1_H1	21.7	yes
1218S	A88	1218S_A88_55_1_H1	25	yes
1218S	A89	1218S_A89_50_1_H1	2.9	no
1218S	A90	1218S_A90_49_1_H1	12.6	yes
1218S	B01	1218S_B01_94_1_H1	20	yes
1218S	B02	1218S_B02_96_1_H1	10	no

Survey Code	Station Code	Video Sample Ref	% Reef Substrate	Meets Annex I stony reef substratum criterion
1218S	B03	1218S_B03_97_1_H1	7.8	no
1218S	B04	1218S_B04_98_1_H1	10	no
1218S	B05	1218S_B05_99_1_H1	35	yes
1218S	B06	1218S_B06_100_1_H1	12.5	yes

Appendix 10. Deep-sea sponge aggregation analysis results

Table A14. Results of potential Deep-sea sponge aggregation (DSSA) occurrence analysis at Wyville-Thomson Ridge Special Area of Conservation. Analysis is based on sponge density criteria for solitary (count) and encrusting (% cover) morpho-taxa. TVA = Total Viewable Area. Analysis is based on selected images from surveys 1517S (2017) and 1218S (2018).

Year	Station number	Broad Scale Habitat	TVA	Density solitary Porifera (m ⁻²)	Density encrusting Porifera (%)	Solitary Porifera ≥ DSSA threshold	Encrusting Porifera ≥ DSSA threshold	DSSA Summary
2017	A53	M.AtUB.Co	15.7	2.0	0.8	yes	no	count only
2017	A60	M.AtUB.Co	15.1	0.0	1.4	no	yes	cover only
2017	A75	M.AtUB.Co	15.1	0.5	1.0	yes	yes	count and cover
2017	A76	M.AtUB.Co	15.4	6.3	1.9	yes	yes	count and cover
2017	A78	M.AtUB.Co	15.1	0.1	0.1	no	no	no DSSA
2017	A87	M.AtUB.Co	15.4	0.6	0.5	yes	no	count only
2018	A05	M.AtUB.Co	15.5	0.0	2.0	no	yes	cover only
2018	A06	M.AtUB.Co	15.7	5.2	5.0	yes	yes	count and cover
2018	A08	M.AtUB.Co	15.5	1.9	25.8	yes	yes	count and cover
2018	A09	M.AtUB.Co	15.4	2.0	3.9	yes	yes	count and cover
2018	A10	M.AtUB.Co	15.2	0.0	0.2	no	no	no DSSA
2018	A13	M.AtUB.Co	17.4	1.7	0.4	yes	no	count only
2018	A16	M.AtUB.Co	15.6	0.1	0.9	no	no	no DSSA

Year	Station number	Broad Scale Habitat	TVA	Density solitary Porifera (m ⁻²)	Density encrusting Porifera (%)	Solitary Porifera ≥ DSSA threshold	Encrusting Porifera ≥ DSSA threshold	DSSA Summary
2018	A18	M.AtUB.Co	18.5	0.1	9.6	no	yes	cover only
2018	A19	M.AtUB.Co	15.2	1.2	6.0	yes	yes	count and cover
2018	A21	M.AtUB.Co	18.1	0.1	11.8	no	yes	cover only
2018	A25	M.AtUB.Co	16.4	2.1	13.5	yes	yes	count and cover
2018	A30	M.AtUB.Co	15.8	0.1	14.0	no	yes	cover only
2018	A31	M.AtUB.Co	17.6	0.2	31.0	no	yes	cover only
2018	A32	M.AtMB.Co	18.6	0.1	2.0	no	yes	cover only
2018	A33	M.AtUB.Co	15.8	0.1	0.0	no	no	no DSSA
2018	A34	M.AtMB.Mx	16.1	4.7	6.4	yes	yes	count and cover
2018	A35	M.AtUB.Co	16.0	0.2	4.5	no	yes	cover only
2018	A38	M.AtMB.Mx	15.4	4.3	5.1	yes	yes	count and cover
2018	A39	M.AtUB.Co	16.9	0.0	28.2	no	yes	cover only
2018	A41	M.AtUB.Co	16.3	0.0	0.9	no	no	no DSSA
2018	A44	M.AtMB.Co	15.2	0.7	1.9	yes	yes	count and cover
2018	A46	M.AtUB.Co	16.7	0.1	0.3	no	no	no DSSA
2018	A49	M.AtMB.Mx	17.1	2.7	33.0	yes	yes	count and cover

Year	Station number	Broad Scale Habitat	TVA	Density solitary Porifera (m ⁻²)	Density encrusting Porifera (%)	Solitary Porifera ≥ DSSA threshold	Encrusting Porifera ≥ DSSA threshold	DSSA Summary
2018	A51	M.AtUB.Co	15.1	0.1	0.8	no	no	no DSSA
2018	A59	M.AtUB.Co	16.9	0.0	0.0	no	no	no DSSA
2018	A61	M.AtUB.Co	16.8	1.1	8.9	yes	yes	count and cover
2018	A66	M.AtMB.Mx	15.5	3.1	15.3	yes	yes	count and cover
2018	A67	M.AtUB.Ro	16.3	0.7	32.1	yes	yes	count and cover
2018	A70	M.AtUB.Co	17.0	0.3	22.7	no	yes	cover only
2018	A71	M.AtUB.Co	15.7	0.9	4.5	yes	yes	count and cover
2018	A72	M.AtUB.Co	17.3	0.1	1.4	no	yes	cover only
2018	A74	M.AtUB.Ro	15.1	18.7	27.8	yes	yes	count and cover
2018	A77	M.AtUB.Ro	15.1	12.1	37.3	yes	yes	count and cover
2018	A81	M.AtMB.Mu	16.0	0.0	0.0	no	no	no DSSA
2018	A84	M.AtMB.Mx	15.9	0.5	0.1	yes	no	count only
2018	A89	M.AtUB.Co	15.9	0.8	0.4	yes	no	count only
2018	B01	M.AtMB.Co	16.4	0.5	9.6	yes	yes	count and cover
2018	B02	M.AtUB.Co	16.6	0.0	0.0	no	no	no DSSA

Year	Station number	Broad Scale Habitat	TVA	Density solitary Porifera (m⁻²)	Density encrusting Porifera (%)	Solitary Porifera ≥ DSSA threshold	Encrusting Porifera ≥ DSSA threshold	DSSA Summary
2018	B05	M.AtMB.Co	15.0	0.7	10.9	yes	yes	count and cover

Appendix 11. Marine litter categories

Table A15. Categories and sub-categories of litter items for Sea-Floor (European Commission 2013b).

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				
A8. Fishing net	B8. Other				
A9. Cable ties					
A10. Strapping band					
A11. Crates and containers					
A12. Plastic diapers					
A13. Sanitary towels/ tampons					
A14. Other					

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: $\geq 100*100 \text{ cm} = 10000 \text{ cm}^2$

Appendix 12. Non-indigenous species lists

Table A16. 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 *et al.* 2014).

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>Crassostrea angulata</i>	Present	<i>Celtodoryx ciocalyptoides</i>	Horizon
<i>Crassostrea gigas</i>	Present	<i>Chama sp.</i>	Horizon
<i>Crepidula fornicata</i>	Present	<i>Dendostrea frons</i>	Horizon
<i>Diadumene lineata</i>	Present	<i>Gracilaria vermiculophylla</i>	Horizon
<i>Didemnum vexillum</i>	Present	<i>Hemigrapsus penicillatus</i>	Horizon
<i>Dyspanopeus sayi</i>	Present	<i>Hemigrapsus sanguineus</i>	Horizon
<i>Ensis directus</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>Ocenebra inornata</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 townsendii</i> var. <i>anglica</i>	Present		
<i>Styela clava</i>	Present		
<i>Undaria pinnatifida</i>	Present		
<i>Urosalpinx cinerea</i>	Present		
<i>Watersipora subatra</i>	Present		

Table A17. Additional taxa listed as non-indigenous species in the JNCC 'Non-native marine species in British waters: a review and directory' report by (Eno *et al.* 1997) which have not been selected for assessment of Good Environmental Status in GB waters under MSFD.

Species name (1997)	Updated name (2017)
<i>Thalassiosira punctigera</i>	-
<i>Thalassiosira tealata</i>	-
<i>Coscinodiscus wailesii</i>	-
<i>Odontella 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>Neosiphonia harveyi</i>
<i>Colpomenia peregrine</i>	-
<i>Codium fragile</i> subsp. <i>atlanticum</i>	-
<i>Codium fragile</i> subsp. <i>tomentosoides</i>	<i>Codium fragile</i> subsp. <i>atlanticum</i>
<i>Gonionemus vertens</i>	-
<i>Clavopsella navis</i>	<i>Pachycordyle navis</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>Pileolaria berkeleyana</i>	-
<i>Ammothea hilgendorfi</i>	-
<i>Elminius modestus</i>	<i>Austrominius modestus</i>
<i>Eusarsiella zostericola</i>	-
<i>Corophium sextonae</i>	-
<i>Rhithropanopeus harrissii</i>	-

Species name (1997)	Updated name (2017)
<i>Potamopyrgus antipodarum</i>	-
<i>Tiostrea lutaria</i>	<i>Tiostrea chilensis</i>
<i>Mercenaria mercenaria</i>	-
<i>Petricola pholadiformis</i>	-
<i>Mya arenaria</i>	-



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