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Swallow Sand Marine Conservation Zone (MCZ) Monitoring Report 2016

Curtis, M., Hawes, J., Noble-James, T., Mitchell, P., Mason, C. & Jones, L.

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Since 2010, offshore MPA surveys and associated reporting have been delivered by JNCC and Cefas through a JNCC\Cefas Partnership Agreement (which remained the vehicle for delivering the offshore survey work funded by MPAG between 2012 and 2020).

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Abbreviations

ANOSIM	Analysis of Similarity
BGS	British Geological Survey
BSH	Broadscale Habitats
Cefas	Centre for Environment, Fisheries and Aquaculture Science
CP2	Charting Progress 2
Defra	Department for Environment, Food and Rural Affairs
DEM	Digital Elevation Model
EUNIS	European Nature Information System
FOCI	Feature of Conservation Interest
GES	Good Environmental Status
ICES	International Council for the Exploration of the Sea
JNCC	Joint Nature Conservation Committee
NMBAQC	North East Atlantic Marine Biological Analytical Quality Control Scheme
MBES	Multibeam echosounder
MCZ	Marine Conservation Zone
MESH	Mapping European Seabed Habitats project
MPA	Marine Protected Area
MPAG	Marine Protected Areas Survey Coordination and Evidence Group
MSFD	Marine Strategy Framework Directive
NE	Natural England
NIS	Non-Indigenous Species
nMDS	Non-metric Multidimensional Scaling
OSPAR	The Convention for the Protection of the Marine Environment of the North-East Atlantic
PRIMER	Plymouth Routines in Multivariate Ecological Research
PSA	Particle Size Analysis
PSD	Particle Size Distribution
ROG	Recommended Operating Guidelines
RV	Research Vessel
SACFOR	Superabundant-Abundant-Common-Frequent-Occasional-Rare scale
SACO	Supplementary Advice on Conservation Objectives
SAD	Site Assessment Document
SIMPER	Similarity Percentages analysis

SIMPROF	Similarity Profile analysis
SNCB	Statutory Nature Conservation Body
WoRMS	World Register of Marine Species

Glossary

Definitions signified by an asterisk (*) have been sourced from Natural England and JNCC Ecological Network Guidance (Natural England & JNCC 2010).

Activity	A human action which may have an effect on the marine environment; e.g. fishing, energy production (Robinson *et al.* 2008).*
Anthropogenic	Caused by humans or human activities; usually used in reference to environmental degradation.*
Assemblage	A collection of plants and/or animals characteristically associated with a particular environment that can be used as an indicator of that environment. The term has a neutral connotation and does not imply any specific relationship between the component organisms, whereas terms such as ‘community’ imply interactions (Allaby 2015).
Benthic	A description for animals, plants and habitats associated with the seabed. All plants and animals that live in, on or near the seabed are benthos (e.g. sponges, crabs, seagrass beds).*
Biotope	The physical habitat with its associated, distinctive biological communities. A biotope is the smallest unit of a habitat that can be delineated conveniently and is characterised by the community of plants and animals living there.*
Broadscale Habitats	Habitats which have been broadly categorised based on a shared set of ecological requirements, aligning with level 3 of the EUNIS habitat classification. Examples of Broadscale Habitats are protected across the MCZ network.
Centre for Environment, Fisheries and Aquaculture Science (Cefas)	Executive Agency of the Department for Environment, Food and Rural Affairs (Defra)
Community	A general term applied to any grouping of populations of different organisms found living together in a particular environment; essentially the biotic component of an ecosystem. The organisms interact and give the community a structure (Allaby 2015).
Conservation Objective	A statement of the nature conservation aspirations for the feature(s) of interest within a site, and an assessment of those human pressures likely to affect the feature(s).*
Digital Elevation Model	A digital representation of ground surface topography or terrain.
Entropy	A non-hierarchical clustering method that groups large matrices of PSD datasets into a finite number of groups (see Stewart *et al.* 2009).
Epifauna	Fauna living on the seabed surface.

EUNIS	A European habitat classification system, covering all types of habitats from natural to artificial, terrestrial to freshwater and marine.*
Favourable Condition	When the ecological condition of a species or habitat is in line with the conservation objectives for that feature. The term ‘favourable’ encompasses a range of ecological conditions depending on the objectives for individual features.*
Feature	A species, habitat, geological or geomorphological entity for which an MPA is identified and managed.*
Feature attributes	Ecological characteristics defined for each feature within site-specific Supplementary Advice on Conservation Objectives (SACO). Feature attributes are monitored to determine whether condition is favourable.
Features of Conservation Importance (FOCI)	Habitats and species that are rare, threatened or declining in Secretary of State waters.*
Impact	The consequence of pressures (e.g. habitat degradation) where a change occurs that is different to that expected under natural conditions (Robinson *et al*. 2008).*
Infauna	Fauna living within the seabed sediment.
Joint Nature Conservation Committee (JNCC)	JNCC is the public body that advises the UK Government and devolved administrations on UK-wide and international nature conservation. JNCC has responsibility for nature conservation in the offshore marine environment, which begins at the edge of territorial waters and extends to the UK Continental Shelf (UKCS).
Marine Conservation Zone (MCZ)	MPAs designated under the Marine and Coastal Access Act (2009). MCZs protect nationally important marine wildlife, habitats, geology and geomorphology, and can be designated anywhere in English and Welsh inshore and UK offshore waters.*
Marine Protected Area (MPA)	A generic term to cover all marine areas that are ‘A clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values’ (Dudley 2008).*
Marine Strategy Framework Directive (MSFD)	The MSFD (EC Directive 2008/56/EC) aims to achieve Good Environmental Status (GES) of EU marine waters and to protect the resource base upon which marine-related economic and social activities depend.
Natural England	The statutory conservation advisor to Government, with a remit for England out to 12 nautical miles offshore.
Non-indigenous Species	A species that has been introduced directly or indirectly by human agency (deliberately or otherwise) to an area where it has not occurred in historical times and which is separate from and lies

	outside the area where natural range extension could be expected (Eno *et al*. 1997).*
Pressure	The mechanism through which an activity has an effect on any part of the ecosystem (e.g. physical abrasion caused by trawling). Pressures can be physical, chemical or biological, and the same pressure can be caused by a number of different activities (Robinson *et al*. 2008). *
Special Areas of Conservation (SAC)	Protected sites designated under the European Habitats Directive for species and habitats of European importance, as listed in Annex I and II of the Directive.*
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.

Executive Summary

This report is one of a series of Marine Protected Area (MPA) characterisation and monitoring reports delivered to the Department for Environment, Food and Rural Affairs (Defra) by the Marine Protected Areas Survey Coordination and Evidence Group (MPAG). The purpose of the report series is to provide the necessary information to allow Defra to fulfil its obligations in relation to MPA assessment and reporting, in accordance with current policy instruments. These include the Oslo-Paris (OSPAR) Convention, the Marine and Coastal Access Act (2009) and Community Directives (e.g. the Habitats and Birds Directives and the Marine Strategy Framework Directive).

The SNCB responsible for nature conservation offshore (between 12nm and 200nm from the coast) is the Joint Nature Conservation Committee (JNCC). JNCC utilise evidence gathered by targeted surveys and site-specific MPA reports in conjunction with other available evidence (e.g. activities, pressures, historical data, survey data collected from other organisations or data collected to meet different obligations). These data are collectively used to make assessments of the condition of designated features within sites, to inform and maintain up to date site-specific conservation advice and produce advice on operations and management measures for anthropogenic activities occurring within the site. This report, as a stand-alone document, **does not** therefore aim to assess the condition of the designated features or provide advice on management of anthropogenic activities occurring within the site. Anthropogenic pressures and their interaction with the data reported on here are considered by JNCC at a later stage as part of condition assessment and management advice.

This report includes recommendations that inform continual improvement and development of sample acquisition, analysis and data interpretation for future survey and reporting. Site and feature specific indicator metrics are not currently defined for this site. Potential indicators, where identified, will be evaluated and considered for inclusion in recommendations for future reporting.

Swallow Sand Marine Conservation Zone (MCZ) is an offshore MPA located approximately 100km offshore from the Northumberland coast in the north-east of England. It falls within the ‘Northern North Sea’ Charting Progress 2 (CP2) sea area. This report is primarily informed by data acquired in 2016, during the first dedicated monitoring survey at the MPA. The main aim of the report is to characterise and describe the listed feature attributes of the designated features 'A5.1 Subtidal coarse sediment’ and ‘A5.2 Subtidal sand’ (as defined in JNCC Supplementary Advice on Conservation Objectives (SACOs)) to enable future monitoring and assessment of feature condition. Temporal comparisons have also made between 2012 and 2016 data, in addition to other secondary reporting objectives detailed in Section 1.3.3.

The 2016 sediment data revealed that the distribution of Broadscale Habitats (BSH) was more complex than expected prior to the survey; agreement between the 2016 sediment classification and existing predicted habitat models was moderate. Samples were predominantly classified as ‘A5.2 Subtidal sand’ and ‘A5.3 Subtidal mud’, with a lower occurrence of ‘A5.1 Subtidal coarse sediment’ and ‘A5.4 Subtidal mixed sediments’. ‘A5.1 Subtidal coarse sediment’ was generally confined to the west of the site, whilst ‘A5.4 Subtidal mixed sediments’ occurred in the western and central areas. ‘A5.3 Subtidal mud’ was recorded in the centre and east of the site, whilst ‘A5.2 Subtidal sand’ occurred across the entire MCZ. The ‘A5.3 Subtidal mud’ observed at the centre of the site was associated with a newly discovered seabed feature, thought to be a glacial tunnel valley. A tidal model indicated that the habitats are subject to low hydrodynamic disturbance, as evidence by the comparable distribution of sediment cluster groups and BSH between 2012 and 2016.

Multivariate analysis of the 2016 infaunal data showed a single broad community, with no clear differentiation between BSH and characterising taxa generally occurring across the full dataset. The infaunal taxa were thought to vary in abundance along a gradient associated with sediment composition, whilst comprising the same broad community. The sediments classified as ‘A5.1 Subtidal coarse sediment’ showed a slightly higher degree of differentiation, particularly in the west of the site, due to the high gravel content. Where stations were revisited, a comparison of the 2012 and 2016 faunal assemblages indicated that the infaunal assemblages had remained relatively consistent.

The 2016 data showed that epifaunal assemblages were sparse and many taxa were only identifiable to a high taxonomic level. However, the phosphorescent sea-pen, *Pennatula phosphorea*, showed potential for development as an indicator of condition, being abundant, widely distributed, visually conspicuous and likely sensitivity to physical disturbance. Further studies would be required to determine whether this species has a sufficiently strong link to condition of the designated habitat features.

Habitat Features of Conservation Importance (FOCI) are not designated features of the MPA. However, data acquired in 2012, 2014 and 2016 have highlighted the presence of ‘Sea-pens and burrowing megafauna’ at nine stations (across the three surveys). Similarly, no species FOCI are designated as features of the MCZ, but the ‘Ocean quahog’ (*Arctica islandica*) has been recorded across all three surveys.

One non-indigenous species, the polychaete worm *Goniadella gracilis*, was identified at two stations: one sampled in 2012 and the other in 2016. Marine litter was observed at two locations in the 2016 imagery data. In addition, evidence of human activity was observed in the 2016 multibeam echosounder (MBES) data and these included demersal trawl marks, pipelines and a wreck.

A set of monitoring recommendations was developed and presented for future monitoring of the designated features within Swallow Sand MCZ (and other comparable sites).

1. Introduction

Swallow Sand Marine Conservation Zone (MCZ) is part of a network of sites designated to meet conservation objectives under the UK Marine and Coastal Access Act (2009). These sites will also contribute to an ecologically coherent network of Marine Protected Areas (MPAs) across the North-east Atlantic agreed under the Oslo-Paris (OSPAR) Convention and other international commitments to which the UK is a signatory.

Under the UK Marine and Coastal Access Act (2009), Defra is required to provide a report to Parliament every six years that includes an assessment of the degree to which the conservation objectives set for MCZs are being achieved. In order to fulfil its obligations, Defra has directed the Statutory Nature Conservation Bodies (SNCBs) to carry out a programme of MPA monitoring. The SNCB responsible for nature conservation offshore (between 12nm and 200nm from the coast) is the Joint Nature Conservation Committee (JNCC). Where possible, this monitoring will also inform assessment of the status of the wider UK marine environment; for example, assessment of whether Good Environmental Status (GES) has been achieved, as required under Article 11 of the Marine Strategy Framework Directive (MSFD).

This monitoring report primarily explores data acquired from the first dedicated monitoring survey of Swallow Sand MCZ in 2016. This dataset will allow a detailed characterisation of the MCZ and will form the initial point in a monitoring time series, against which site and feature condition can be assessed in the future. Data from previous surveys (2012 and 2014) have also been used to allow a qualitative temporal comparison. The specific aims and objectives of the report are discussed further in Section 1.3.

1.1 Site overview

Swallow Sand MCZ is an offshore site located approximately 100km from the Northumberland coast (including Berwick-upon-Tweed) in the north-east of England. Swallow Sand MCZ was recommended by the ‘Net Gain’ regional stakeholder group project and falls within the wider ‘Charting Progress 2’ (CP2) area ‘Northern North Sea’. The location of the site is displayed in Figure 1, in the context of surrounding MCZs, Special Areas of Conservation (SAC) and Nature Conservation Marine Protected Areas.

Swallow Sand MCZ covers an area of approximately 4,746km^2, with depths ranging from 50 to 150m below sea level (chart datum). Various different seabed habitats occur within the site, two of which have been designated as Broadscale Habitat (BSH) features of the MCZ; ‘A5.1 Subtidal coarse sediment’ and ‘A5.2 Subtidal sand’. The biological communities associated with ‘A5.1 Subtidal coarse sediment’ typically comprise fauna such as polychaete worms and bivalves which burrow within the sediments, or sea urchins and anemones which inhabit the sediment surface. The ‘A5.2 Subtidal sand’ habitats within the site support large numbers of worms, molluscs and crustaceans.

Table 1 lists the designated features of the site alongside those which are known to be present but are not designated, according to the Site Assessment Document (SAD) (Net Gain 2011) and the Site Verification Report (Curtis 2016). Swallow Sand MCZ also contains a designated geomorphological feature in the north-west of the site; the glacial tunnel valley known as Swallow Hole. Monitoring of this feature is not required, as the rate of change to geological features is far slower and the spatial variation greater, than seen in ecological features.

Table 1. Swallow Sand MCZ overview.

Charting Progress 2 Region[1]	Northern North Sea
Spatial Area (km^2)	4,746km^2
Water Depth Range (m)	50m – 150m (within the Swallow Hole glacial tunnel valley feature)
Current & Proposed Management Measures	The current management status of the site is: 'Progressing towards being well managed'. Progress is ongoing with the recommendation of fisheries management measures.
Features Present (BSH)	**Designated**
A5.1 Subtidal coarse sediment	✓
A5.2 Subtidal sand	✓
A5.3 Subtidal mud	✘
A5.4 Subtidal mixed sediments	✘
Features Present (Habitat FOCI)	
Sea-pen and burrowing megafauna communities	✘
Features Present (Species FOCI)	
Ocean quahog (*Arctica islandica*)*	✘
Geological Feature*	
North Sea glacial tunnel valleys (Swallow Hole)	✓

** Please note that the 2016 monitoring survey was not designed to target species features of conservation importance (FOCI), undesignated BSH features or the geological feature.*

[1] http://webarchive.nationalarchives.gov.uk/20141203170558tf_/http://chartingprogress.defra.gov.uk/

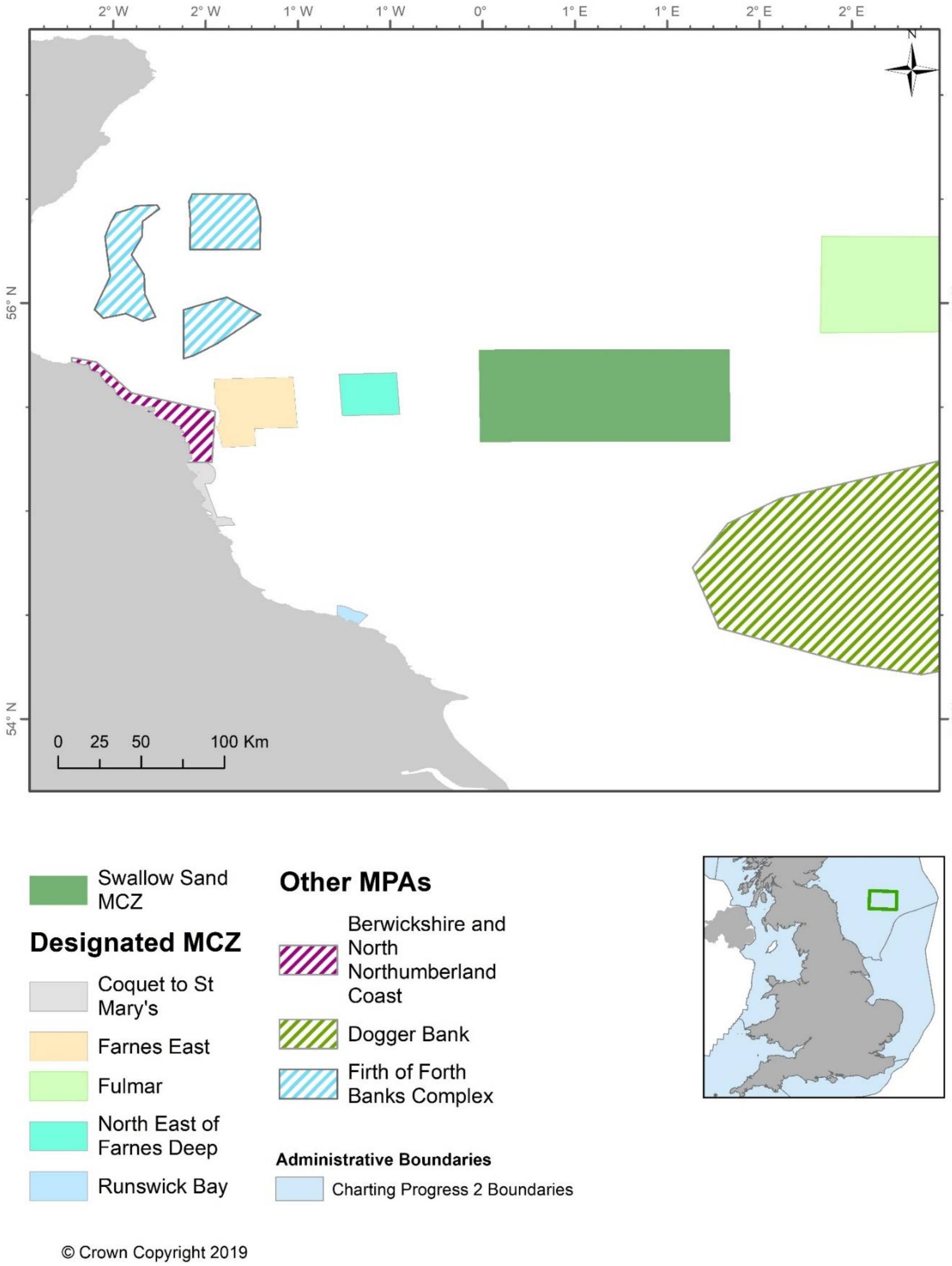

Figure 1. Location of the Swallow Sand MCZ in the context of Marine Protected Areas and management jurisdictions proximal to the site.

1.2 Existing data and habitat maps

Two verification surveys were conducted in May 2012 and 2014 (Ware 2013; McIlwaine 2014).

The 2012 survey acquired 103 0.1m^2 Hamon grab samples and imagery data from 38 camera sledge tows within the MCZ boundary, providing broad coverage of the site to support the verification of feature presence and distribution.

In March 2014, a further 65 stations were sampled using a 0.1m^2 Hamon grab and a subset of 15 stations using a drop-down camera, primarily to determine the extent of ‘A5.3 Subtidal mud’ within and near the Swallow Hole geomorphological feature.

A habitat model was produced by Stephens and Diesing (2015) for the Swallow Sand MCZ as part of a wider study area, utilising a bathymetry Digital Elevation Model (DEM), earth observation data, hydrodynamic model outputs and the existing sediment data. This model is displayed in Figure 2 (according to the BGS modified Folk classification; Long 2006) and Figure 3 (according to the Broadscale Habitat classification) , with the 2012 and 2014 sampling locations overlain.

A separate habitat model was also created by the British Geological Survey (BGS), which interpolated between sediment data points (Lark 2014). This model was used to inform fisheries management measures and conservation advice to Defra and is displayed in Figure 4.

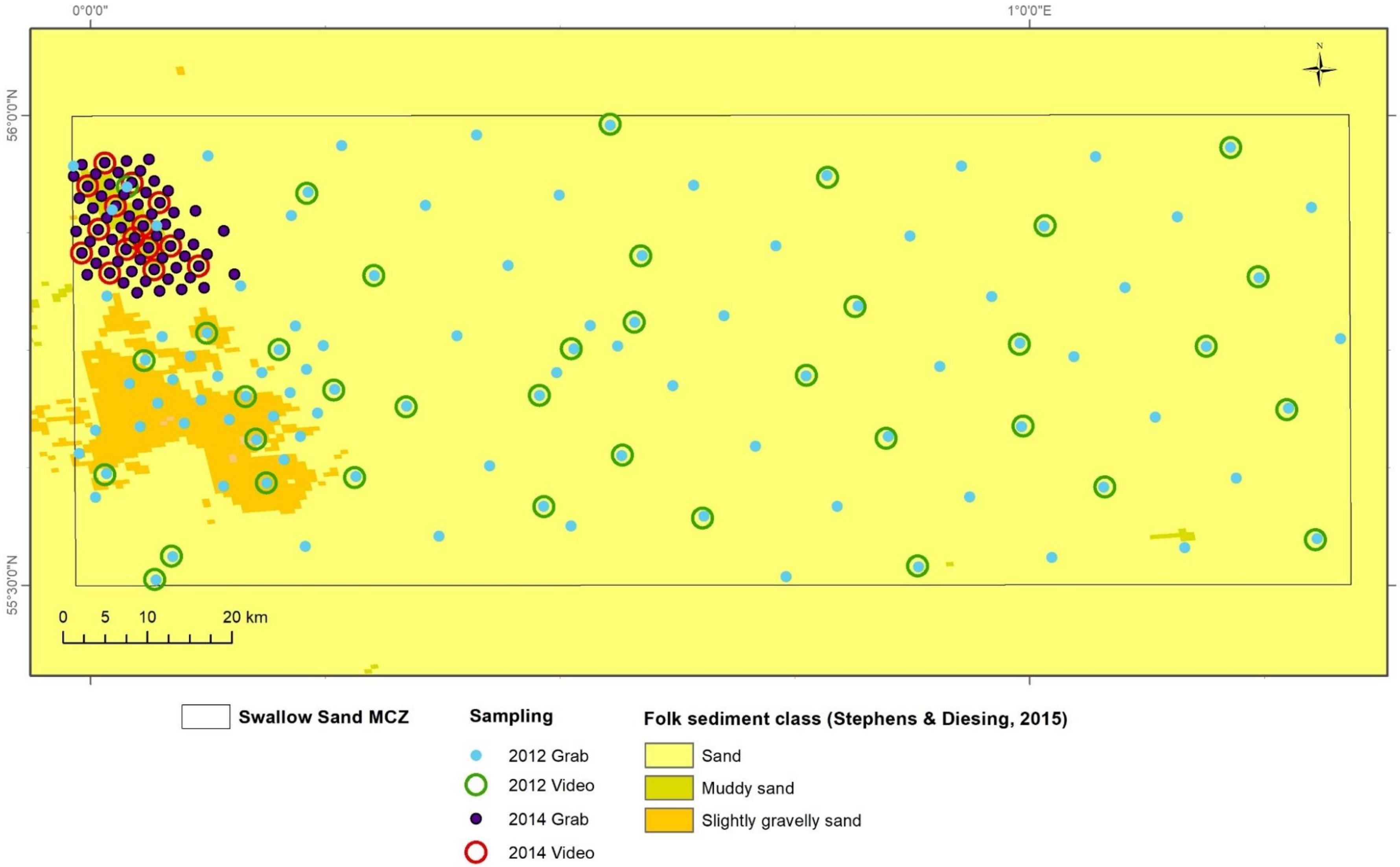

Figure 2. Imagery and 0.1m^2 Hamon grab samples collected at Swallow Sand MCZ in 2012 and 2014, displayed over the 2015 Stephens and Diesing model (BGS-modified Folk; Long 2006).

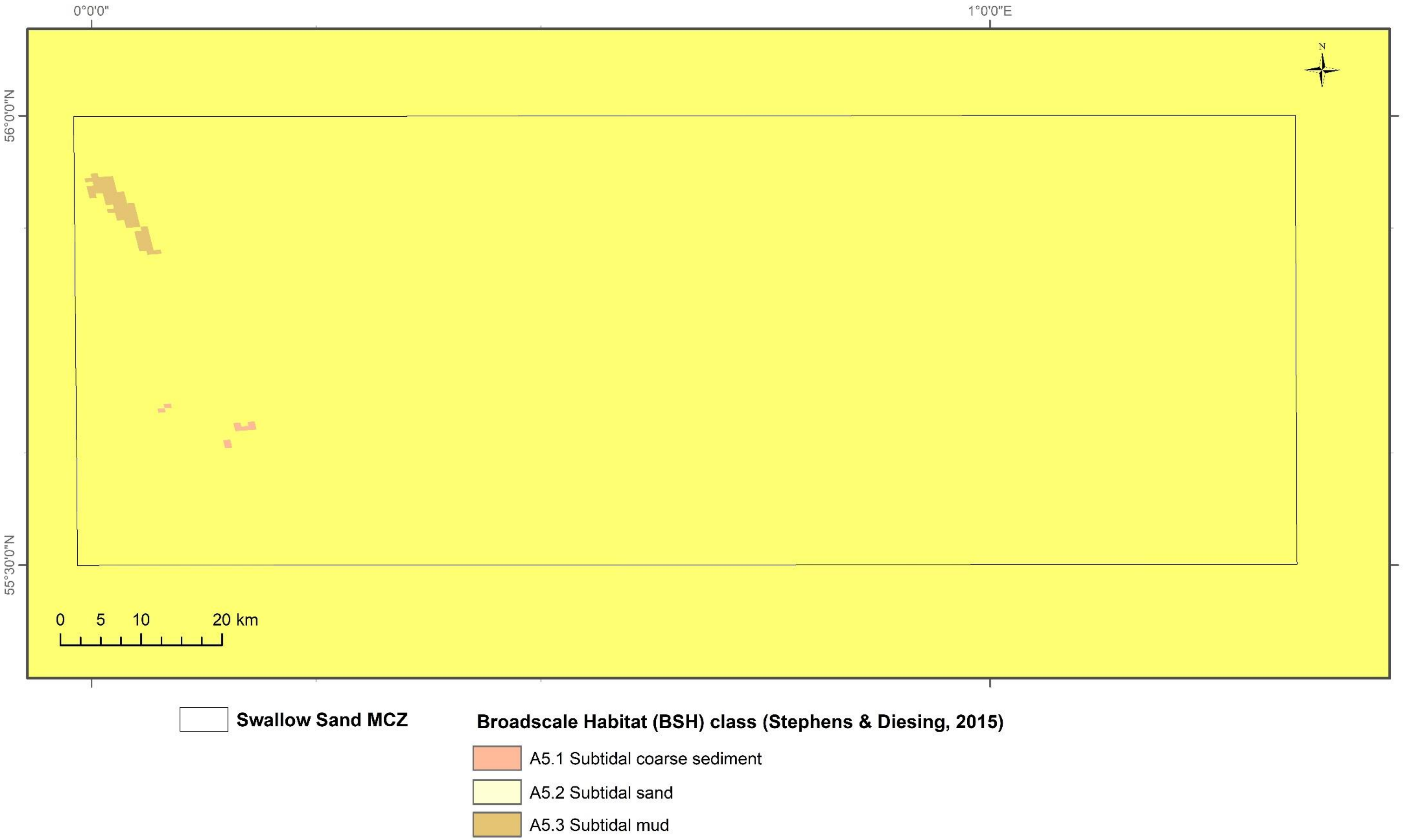

Figure 3. Stephens and Diesing habitat model (2015), classified according to Broadscale Habitat (as opposed to BGS-modified Folk class in Figure 2).

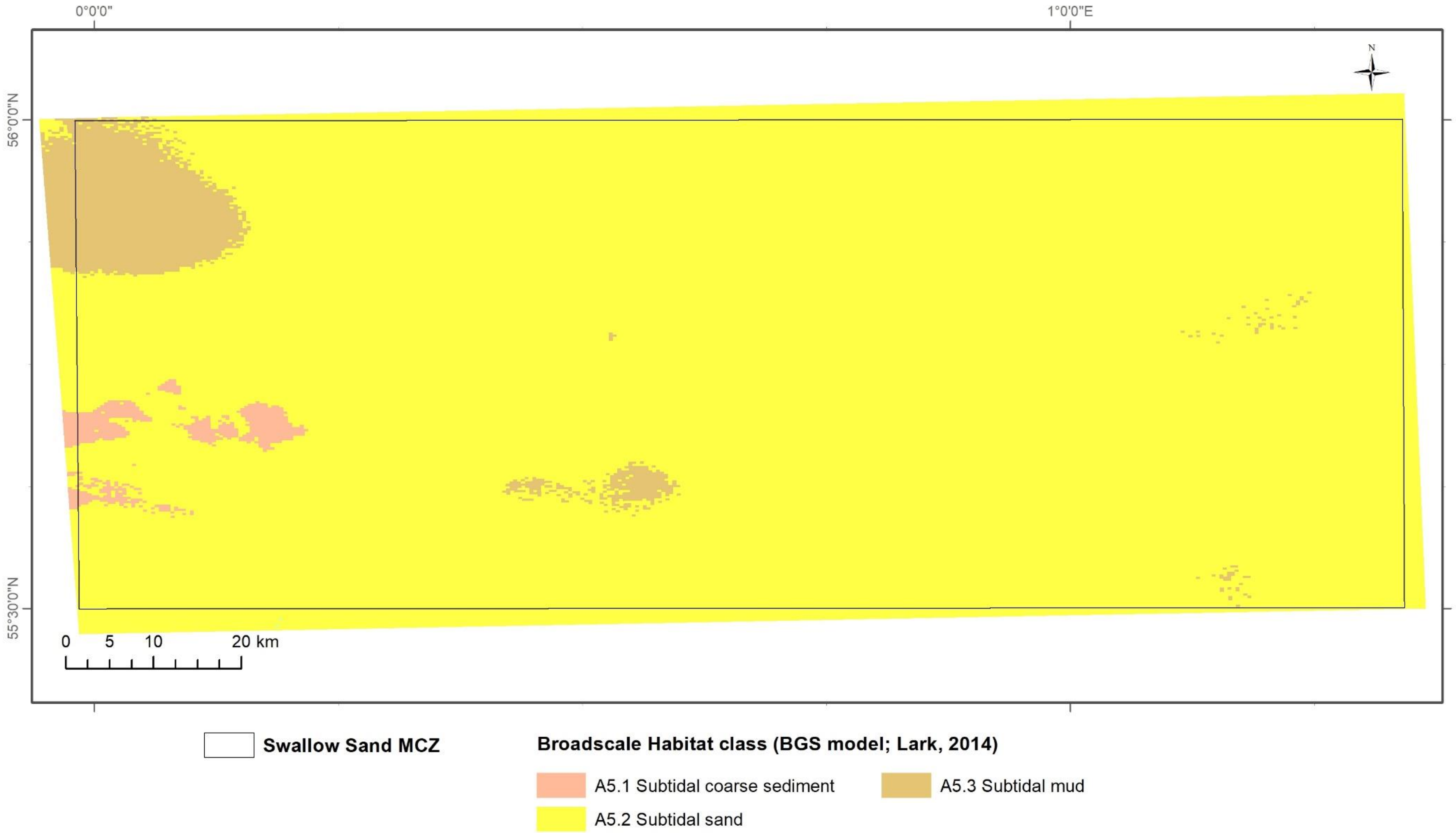

Figure 4. British Geological Survey (BGS) predicted Broadscale Habitats model used for fisheries management advice (Lark 2014).

1.3 Aims and objectives

1.3.1 High-level conservation objectives

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

As detailed in the conservation advice for the Swallow Sand MCZ (JNCC 2018a), the conservation objective for the site is that designated features:

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

1.3.2 Definition of favourable condition

Favourable condition, with respect to a habitat feature, means that:

a) Its **extent and distribution** are stable or increasing;
b) Its **structures and functions**, including its quality, and the composition of its characteristic biological communities, are such as to ensure that it remains in a condition which is healthy and not deteriorating; and
c) Its natural **supporting processes** are unimpeded.

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 (Elliott *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 2004).

Structure encompasses the physical 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 the hydrodynamic regime operating at varying spatial scales in the marine environment, as well as influencing the presence and distribution of associated biological communities (Elliott *et al*. 1998). The function of habitat features includes processes such as: sediment reworking (e.g. through bioturbation) and habitat modification, primary and secondary production and recruitment dynamics.

Habitat features rely on a range of supporting processes (e.g. hydrodynamic regime, water quality and sediment quality) which act to support their functioning as well as their resilience (e.g. the ability to recover following a negative impact).

1.3.3 Report aim and objectives

The primary aim of this monitoring report is to characterise and describe the designated features within Swallow Sand MCZ, to enable future assessment and monitoring of feature condition. The results presented will be used by JNCC to inform future condition assessments and develop recommendations for future monitoring.

The specific objectives of this monitoring report are:

1) Provide a characterisation of the benthic environment within the site from the 2016 data, including any available evidence on seabed features and **supporting processes**;

2) Provide a description of the **spatial extent**, **distribution** and **structural** feature attributes of the designated features 'A5.1 Subtidal coarse sediment' and 'A5.2 Subtidal sand' (see Table 2 for more detail) based on the 2016 data;
3) Conduct a qualitative temporal comparison of 2012 and 2016 data to evaluate whether sediment composition, BSH classifications and biological community structure have changed over time;
4) Note observations of any habitat or species features of conservation importance (FOCI) not designated as features of the site;
5) Present evidence on the abundance and distribution of non-indigenous species (Descriptor 2) and marine litter (Descriptor 10), to fulfil requirements of the MSFD;
6) Record any evidence of anthropogenic activities or impacts encountered during the 2016 survey;
7) Provide practical recommendations for appropriate future monitoring approaches for both the designated features and their natural supporting processes (e.g. metric selection, survey design, data collection approaches) with a discussion of their operational requirements.

1.3.4 Feature attributes and supporting processes

To achieve its objectives, this report will present evidence on selected attributes of the designated features and their supporting processes, as defined in the Supplementary Advice on Conservation Objectives (SACO) for the site (JNCC 2018b).

The list of selected feature attributes and supporting processes considered in this report is presented in Table 2 alongside the methods used to address each attribute.

Table 2. Feature attributes and supporting processes considered to achieve report objectives 1 and 2.

Feature attribute or supporting process	Features	Methods
Extent and distribution:		
Extent and distribution	A5.1 Subtidal coarse sediment A5.2 Subtidal sand	BSH point location maps (the available data do not support a full evaluation of extent and distribution).
Structure and function:		
Sediment composition	A5.1 Subtidal coarse sediment A5.2 Subtidal sand	PSA analysis derived from seabed sediment samples.
Characteristic biological communities Key and influential species	A5.1 Subtidal coarse sediment A5.2 Subtidal sand	Identify patterns in biological assemblages using multivariate analysis. Describe variance in biological assemblage structure across the site. Identify any key structural and influential species. Identify any potential indicator taxa (and evaluate them according to the criteria provided in Table 3).
Non-indigenous species (NIS)	Swallow Sand MCZ	Report and map abundance and distribution of non-indigenous species
Supporting processes:		
Energy/exposure	Swallow Sand MCZ	Present and describe a tidal model.

1.3.5 What is not covered by this report

The report **does not** aim to assess the condition of the designated features. 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.

2. Methods

2.1 Survey design

Prior to the survey four survey boxes were positioned to coincide with the ‘A5.1 Subtidal coarse sediment’ and ‘A5.2 Subtidal sand’ features within the MCZ. The placement of the survey boxes was informed by the results of sediment Particle Size Analysis (PSA) from the 2012 and 2014 verification surveys and the BGS-modified Folk habitat model generated by Stephens and Diesing (2015). The BGS-modified Folk model was used in preference to the Stephens and Diesing BSH model, as it appeared more effective for resolving differences in sediment types observed from PSA data. During the survey a fifth box was added to delineate and sample a geological feature identified from the newly acquired multibeam echosounder (MBES) data. Sample stations were positioned within the survey boxes using a 1.5km triangular lattice grid. Across the five survey boxes, a total of 216 stations were sampled using a 0.1m^2 Hamon grab, 31 stations by camera sledge and 16 by drop-down camera. The 2016 sampling locations are presented in Figure 5.

A number of grab sample stations from the 2012 survey were incorporated into the survey design to allow an indicative temporal comparison with those stations which were re-sampled in 2016. The 2012 sampling locations are presented in Figure 5, in context of the 2016 sample locations. Data acquired in 2014 were unsuitable for comparison, as the stations were concentrated in an area of ‘A5.3 Subtidal mud’ which was not included in the 2016 survey design (as this BSH is not a designated feature of the site).

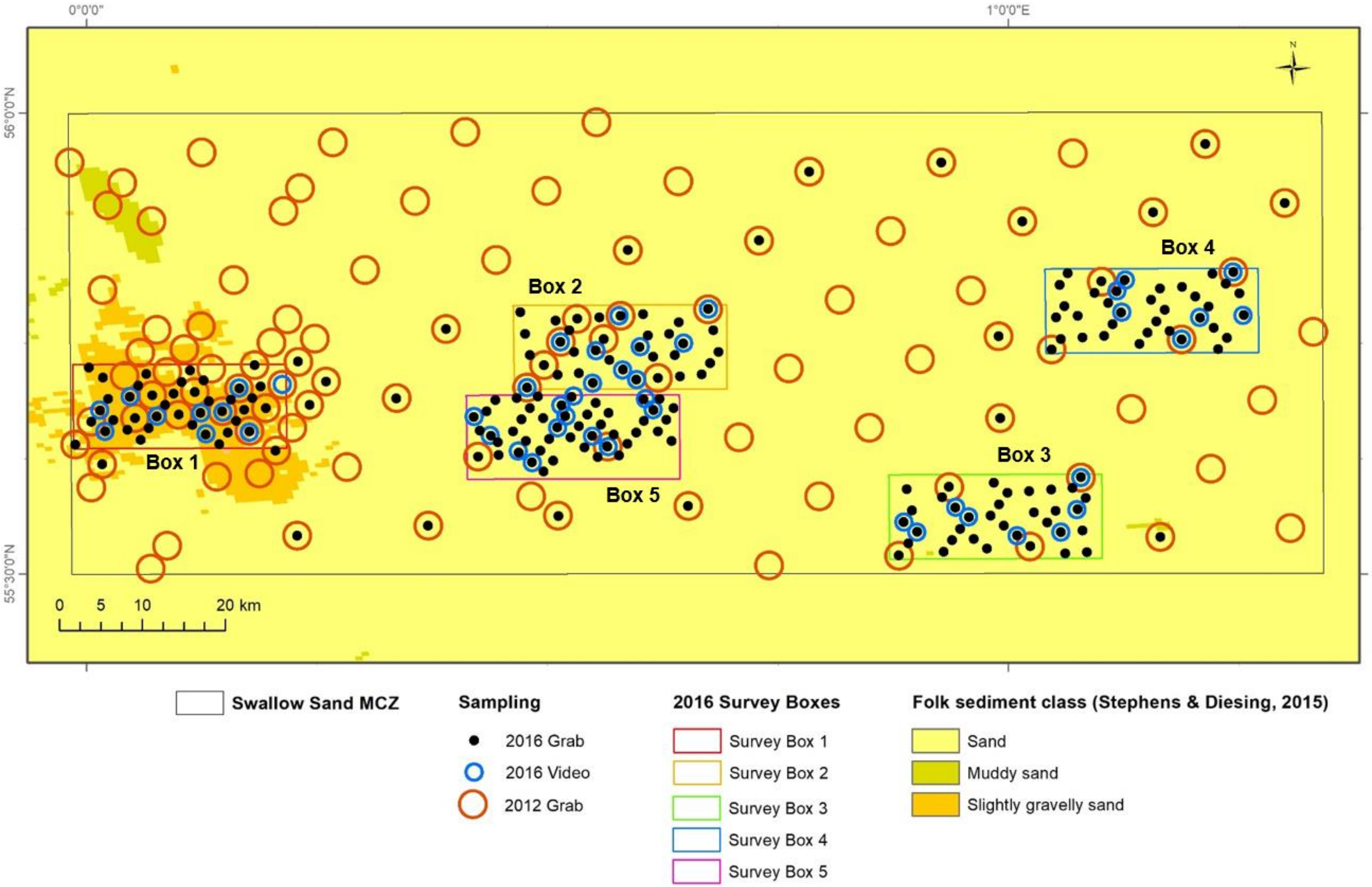

Figure 5. Imagery and 0.1m^2 Hamon grab samples collected at Swallow Sand MCZ in 2016, with 2012 0.1m^2 grab sample locations, displayed over the 2015 Stephens and Diesing model (BGS-modified Folk; Long 2006).

2.2 Data acquisition and processing

The May 2016 dedicated monitoring survey of the Swallow Sand MCZ was conducted onboard the RV *Cefas Endeavour* by Cefas and JNCC. A detailed account of data acquisition and processing methodologies is available in Whomersley *et al*. (2017).

2.2.1 Acoustic data

MBES bathymetry and backscatter data were acquired in survey boxes 2, 3 and 5 to target potential seabed features of interest. The first feature of interest, located in survey boxes 2 and 5, was a linear depression oriented north-south, and the second feature of interest (survey box 3) was thought to be a section of elevated seabed in an area of predominantly sandy substrate. A line spacing of approximately 1.3km was used to produce partial coverage bathymetry and backscatter layers (approximately 25% per box) for these features of interest. A total of 17 survey lines and two cross lines were acquired, with survey boxes 2 and 5 surveyed together.

2.2.2 Seabed samples

Seabed sediment samples were collected for PSA and benthic infaunal analyses using a 0.1m^2 Hamon grab.

A 500ml sub-sample was taken from each grab sample and stored at -20°C prior to determining the particle size distribution (PSD). Sediment samples were processed by Cefas following the recommended methodology of the North East Atlantic Marine Biological Analytical Quality Control (NMBAQC) scheme (Mason 2016). The less than 1mm sediment fraction was analysed using laser diffraction and the greater than 1mm fraction was dried, sieved and weighed at 0.5 phi (ϕ) intervals. Sediment particle size distribution data were then grouped according to the percentage contribution of gravel, sand and mud, as per the BGS-modified version (Long, 2006) of the classification proposed by Folk (1954). Gradistat software (Blott & Pye 2001) was used to produce sediment statistics.

The faunal fraction was sieved over a 1mm mesh, photographed then fixed in buffered 4% formaldehyde. Faunal samples were processed to extract all fauna present in each sample. Fauna were identified to the lowest taxonomic level possible, enumerated and weighed (blotted wet weight) to the nearest 0.0001g following the recommendations of the NMBAQC scheme (Worsfold *et al*. 2010).

2.2.3 Seabed imagery

Seabed imagery data were generally collected using a camera sledge system. A drop-down system was used to investigate the steep sides of a seabed feature encountered close to the centre of the MCZ. These data were collected to characterise the epifaunal communities associated with the sediment habitat features. All data were collected in accordance with Mapping European Seabed Habitats (MESH) Recommended Operating Guidelines (ROG) (Coggan *et al*. 2007). Images of the seabed were acquired every 10-15m over a distance of ~150m. Additional images were collected in heterogeneous areas of BSH and if particular habitats or species FOCI were observed.

2.3 Data preparation and analysis

2.3.1 Tidal modelling

Mean and maximum tidal current velocities (m s-1) at the seabed and direction of flow at the peak of the flood tide, were obtained from a high-resolution depth-averaged model of the North Sea. The model was built with an unstructured triangular mesh, using the software Telemac2D (v7p1). The model domain extended between 49.28°N – 60.69°N and 3.73°E – 9.57°W. The unstructured mesh was discretised with 240,000 nodes and 460,000 elements. The mesh had a resolution of 5km around the open boundary, reducing to ~500m along the coastline. Within the Swallow Sand MCZ the resolution was refined further to 200m. Bathymetry for the model was sourced from the Defra DEM (Astrium Oceanwise 2011). The resolution of the bathymetry dataset was 1 arc second (~30m). The hydrodynamics were forced along the open boundaries using 11 tidal constituents (M2, S2, N2, K2, K1, O1, P1, Q1, M4, MS4 and MN4) from the OSU TPXO European Shelf 1/30° regional model (OSU Tidal Data Inversion). After a spin-up period of 10 days, the model was run for 30 days to cover a full spring-neap cycle. The modelled mean and max tidal current velocities were calculated over the full spring-neap cycle, whereas the modelled peak flood and ebb directions were the instantaneous directions which occurred at the timestamp of peak flood and ebb tide in the centre of the MCZ.

2.3.2 Feature mapping

A large depression feature was resolved from the 2016 bathymetry data. The spatial extent of this feature was visually estimated and delineated based on the acoustic and sediment PSA data, with the boundary of the feature manually interpolated between acoustic survey lines.

2.3.3 Particle Size Analysis (PSA)

Each sediment sample was assigned to one of four sediment BSH using a modified version of the classification model produced during the MESH project (Long 2006).

Where sediment samples collected on the 2016 survey corresponded to the location of those acquired during the 2012 survey, they were analysed to investigate temporal changes in sediment composition. This temporal analysis was conducted using pooled data from the revisited stations (n = 51). The full-resolution PSA data (at 0.5 ϕ intervals) were grouped using Entropy analysis, a non-hierarchical clustering method that groups large matrices of PSA datasets into a finite number of groups (Stewart *et al.* 2009). The optimum number of clusters was achieved when the Calinski–Harabasz (C–H) statistic was at its maximum (Orpin & Kostylev 2006). In addition to this statistic, expert judgement determined that in cases where groups appeared to be very similar, they were numbered as members of the same group, being suffixed with an ‘a’ or ‘b’ to show the original groupings.

2.3.4 Infaunal data preparation and analysis

The 2012 and 2016 benthic infauna data sets were reviewed to ensure consistent nomenclature using the WORMS ‘match taxa’ tool[2]. The data were then truncated according to the truncation steps presented in Annex 1.

The truncated infaunal abundance data were imported into PRIMER v7 (Clarke & Gorley 2015) and square root transformed to reduce the dominance of species with higher

[2] http://www.marinespecies.org/aphia.php?p=match

abundance. Relevant factors and variables (sediment percentage composition, survey box membership and BSH) were assigned to the data prior to analysis.

A Bray-Curtis similarity matrix was generated, following which hierarchical cluster analysis and Similarity Profile (SIMPROF) testing were conducted (using group average linkage) and non-metric multidimensional scaling (nMDS) ordination plots were generated. The results of the cluster analysis were used to derive ecologically meaningful groups within the data. A Similarity Percentage (SIMPER) analysis was conducted to determine which taxa contributed the most to similarity within and dissimilarity between these groups. Analysis of Similarities (ANOSIM) was conducted to determine whether assemblages were different between the different survey boxes.

Indicative temporal comparisons of 2012 and 2016 data were conducted using jointly truncated data from revisited stations, which were fourth root transformed to down weight the effect of minor fluctuations over time. A SIMPER analysis was conducted to determine whether the assemblage composition was comparable between years.

2.3.5 Epifaunal data preparation and analysis

Epifaunal assemblage composition was investigated using still imagery data from the camera sledge which were assessed to be of 'Good' or 'Excellent' quality according to NMBAQC guidance (Turner *et al*. 2016). This allowed for the use of the abundance counts from the stills acquired from camera sledge tows, as this equipment has a fixed field of view when towed on the seabed. The raw epifaunal data were truncated as described in Annex 2. The combined percentage cover and count data were converted to a semi-quantitative SACFOR numerical scale (MNCR, 1990) allowing combination of solitary and colonial taxa in the same dataset (Superabundant = 6, Abundant = 5, Common = 4, Frequent = 3, Occasional = 2, Rare = 1).

Five still images (the maximum number of 'Good' or 'Excellent' quality images available from every transect) were randomly selected from each station for combination. Each still image covered an area of $0.27m^2$, resulting in a total area of $1.35m^2$ for each station. Where a transect intersected more than one BSH (as for stations SWS270 and SWS282), five stills were taken from each BSH and separated for analysis (e.g. from transect SWS270, five images were selected for 'A5.3 Subtidal mud' and five for 'A5.4 Subtidal mixed sediments'). The median SACFOR abundance value was taken for each set of five still image replicates. Where the median value was 0, but the mean was >0, a value of 0.1 was assigned to indicate presence.

Hierarchical cluster analysis and a SIMPROF test were conducted on a Bray-Curtis similarity matrix of the median SACFOR data. No transformation was required due to its ordinal nature. nMDS ordination plots were generated and overlain with BSH and survey box membership to explore small-scale variation within the epifaunal community.

Video data were used to investigate the distribution and relative abundance of the sea-pen *Pennatula phosphorea.* This was achieved by deriving a sea-pen abundance to transect length (m) ratio, using data from camera transects that were assigned 'Good' or 'Excellent' quality.

Epifaunal video segments and still images were each assigned a classification by the contracted imagery analysts, according to the EUNIS hierarchy.

2.3.6 Evaluating potential indictors

Any potential candidates for future monitoring of feature condition (e.g. a specific taxon) are evaluated against the criteria provided in Table 3.

These criteria were set out by OSPAR (2012) in advice on the selection of indicators for descriptors of marine biodiversity under the MSFD. They can, however, be broadly applied outside of this context, including in the selection of site or feature-specific indicators.

Table 3. OSPAR (2012) state indicator selection criteria (adapted from ICES and UK scientific indicator evaluation).

Criterion	Specification
Sensitivity	Does the indicator allow detection of change against background variation or noise?
Specificity	Does the indicator respond primarily to a specific human pressure, with low responsiveness to other causes of change?
Accuracy	Is the indicator measured with a low error rate?
Simplicity	Is the indicator easily measured?
Responsiveness	Is the indicator able to act as an early warning signal?
Spatial applicability	Is the indicator measurable over a large proportion of the geographical area to which it is to apply?
Management link	Is the indicator tightly linked to an activity which can be managed to reduce its negative effects on the indicator (i.e. are the quantitative trends in cause and effect of change well known?)
Validity	Is the indicator based on an existing body or time-series of data (either continuous or interrupted) to allow a realistic setting of objectives?
Communication	Is the indicator relatively easy to understand by non-scientists and those who will decide on their use?

2.3.7 Non-indigenous species

The raw infaunal and epifaunal data were cross-referenced against a list of 49 non-indigenous target species which have been selected for assessment of GES in UK waters under MSFD Descriptor 2 (Stebbing *et al.* 2014; Annex 3). The list includes two categories: species which are already known to be present within the assessment area (present) and species which are not yet thought to be present but have a perceived risk of introduction and impact (horizon). An additional list of taxa, which were identified as invasive in the 'Non-native marine species in British waters: a review and directory' (Eno *et al*. 1997) was also used to cross reference against the observed taxa (Annex 3).

2.3.8 Marine litter

Observations of marine litter from imagery data were categorised and recorded according to the MSFD list provided in Annex 4.

2.3.9 Anthropogenic activities and pressures

MBES data from the 2016 survey were reviewed for evidence of anthropogenic activities and pressures occurring within the site.

3. Results

3.1 Benthic and environmental overview

3.1.1 Tidal currents

Tidal currents were modelled as generally weak (< 0.5m s-1 maximum current velocity over a spring-neap tide) across the site, with currents flowing on a south-north axis (Figure 6). The tidal model highlights low variation in direction or strength of currents across the site, despite its bathymetric range. The maps in Figure 6 show depth and current conditions (the main direction of tidal flow during the flood phase) as well as maximum velocity and mean bed shear stress over a spring-neap tidal cycle.

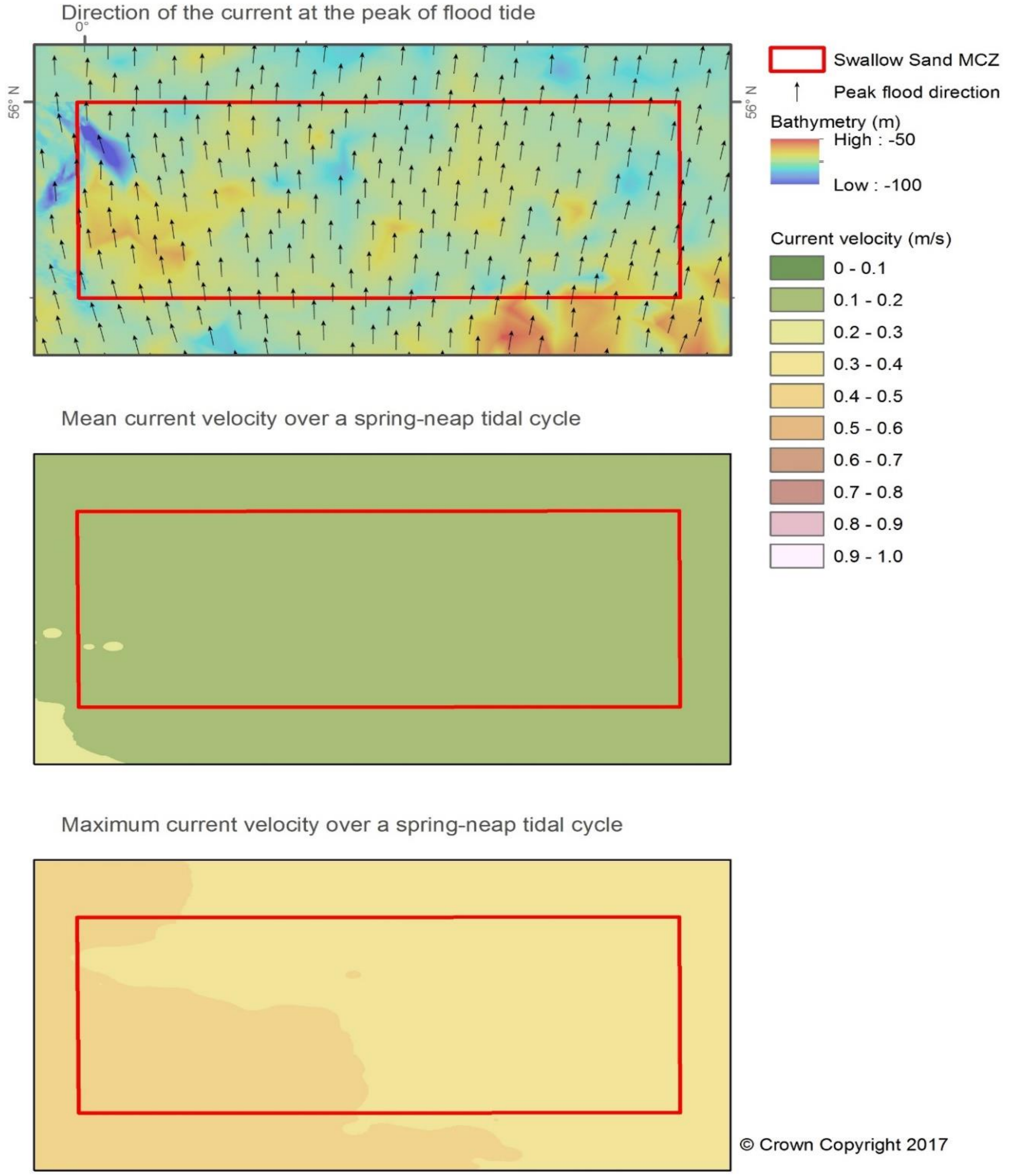

Figure 6. Tidal current velocity model for Swallow Sand MCZ.

It should be noted that the prevalent current direction as modelled (along the north-south axis) aligns with the active bedforms (megaripples) observed from the high resolution MBES and backscatter data acquired from survey boxes 2, 3 and 5. Survey box 1, where the results of PSA indicate a coarser substrate, was located in the area of stronger maximum current velocity to the east and south-east of the MCZ.

3.1.2 Particle Size Distribution and Broadscale Habitats (BSH)

With the exception of two stations in survey box 2, the vast majority of the 216 sediment samples were dominated by sand (comprising 36% to 97%), with varying proportions of mud (3% to 39%) and gravel (0.01% to 59%). Mud content was more evenly distributed across the site than gravel. Higher gravel percentage contributions were recorded in samples collected in survey boxes 1 and 5 in comparison to negligible gravel content elsewhere (Figure 7). Gravel comprised <1% of the sediment at 60% of stations.

Figure 7. Distribution of broad sediment fractions from $0.1m^2$ Hamon grab samples within 2016 survey boxes, displayed over the 2015 Stephens and Diesing model (BGS-modified Folk; Long 2006).

The trigon in Figure 8 shows the sediment BSH classes (coloured areas) plotted on a true scale sediment ternary diagram classified according to the modified classification for UKSeaMap (Long 2006).

The ‘A5.1 Subtidal coarse sediment’ BSH (the second designated feature) has a more limited distribution across the 2016 samples. Of particular note is the number of samples which fall within the ‘A5.3 Subtidal mud’ class, which was the second most frequently encountered BSH.

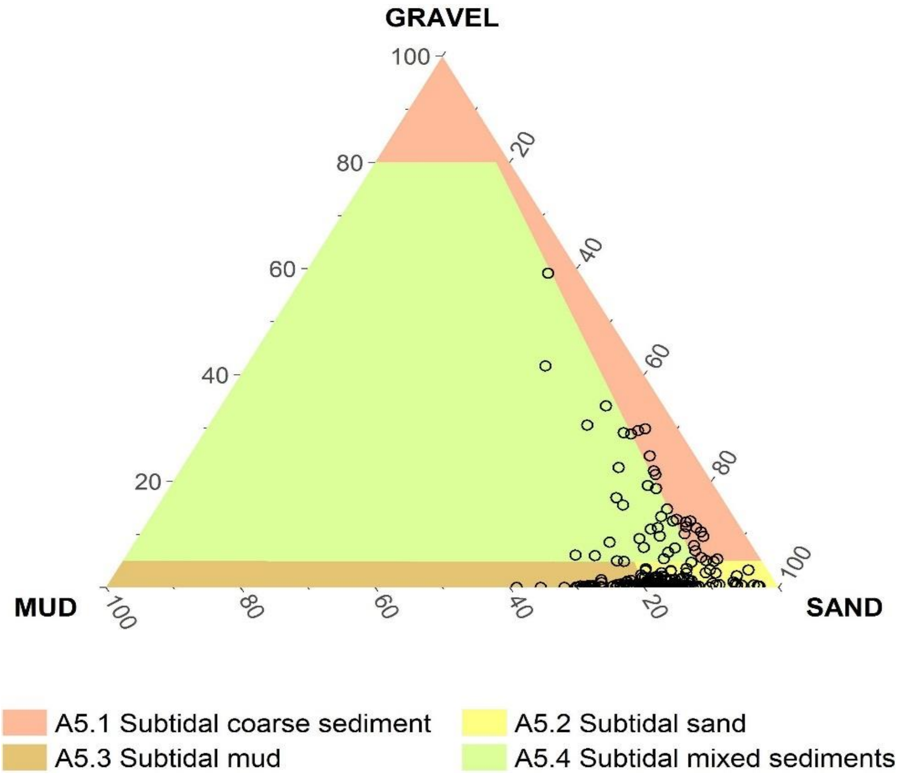

Figure 8. Classification of particle size distribution (half phi) data for 2016 0.1m^2 Hamon grab sampling points (black circles) into sediment BSH (coloured areas) plotted on a true scale sediment ternary diagram classified according to the BGS-modified Folk classification (Long 2006).

It should be noted that many samples fall on or close to the delineating boundaries of the BSH classes on the triangle. As displayed in Table 4, some textural sediment groups derived using the BGS-modified Folk method were attributable to more than one BSH, further illustrating the between-class similarities.

Table 4. Modified Folk textural sediment descriptions for 2016 0.1m^2 Hamon grab samples, with corresponding BSH classes.

BGS-modified Folk textural group (Long, 2006)	No. of samples	% of samples	Corresponding BSH
Gravelly sand	17	8	A5.1 Subtidal coarse sediment
Slightly gravelly sand	17	8	A5.2 Subtidal sand
Slightly gravelly muddy sand	155	72	A5.2 Subtidal sand A5.3 Subtidal mud
Gravelly muddy sand	23	11	A5.4 Subtidal mixed sediments
Muddy sandy gravel	4	2	A5.4 Subtidal mixed sediments

The 2016 imagery data also reflected a seabed composed of ‘A5.1 Subtidal coarse sediment’, ‘A5.2 Subtidal sand’, ‘A5.3 Subtidal mud’ and ‘A5.4 Subtidal mixed sediments’ (Table 5).

Table 5. Broadscale Habitat classification of 2016 imagery data.

Broadscale Habitat (BSH)	Number of video segments	Number of still images
A5.1 Subtidal coarse sediment	3	91
A5.2 Subtidal sand	8	76
A5.3 Subtidal mud	7	454
A5.4 Subtidal mixed sediments	5	133

The distribution of BSH point locations (from 2016 grab samples) is displayed in Figure 9 and Figure 10, overlying the Stephens and Diesing BGS-modified Folk (2015) and BGS (Lark 2014) predictive habitat models. The agreement between the habitat models and the 2016 samples is moderate, with neither model providing a fully accurate delineation of the different sediment types across the site.

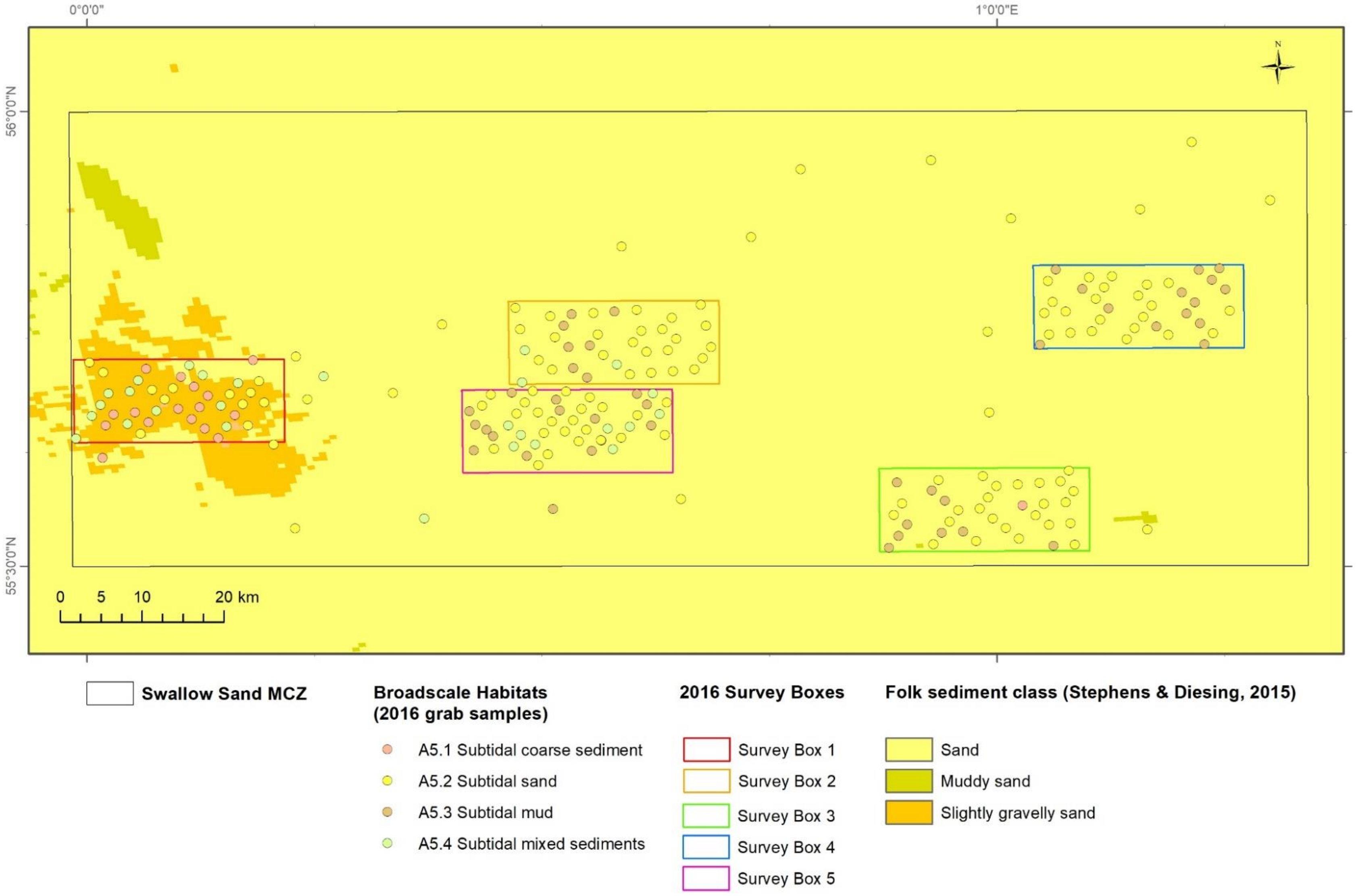

Figure 9. Distribution of BSH assigned to 0.1m^2 Hamon grab samples within the Swallow Sand MCZ, displayed over the 2015 Stephens and Diesing model (BGS-modified Folk; Long 2006).

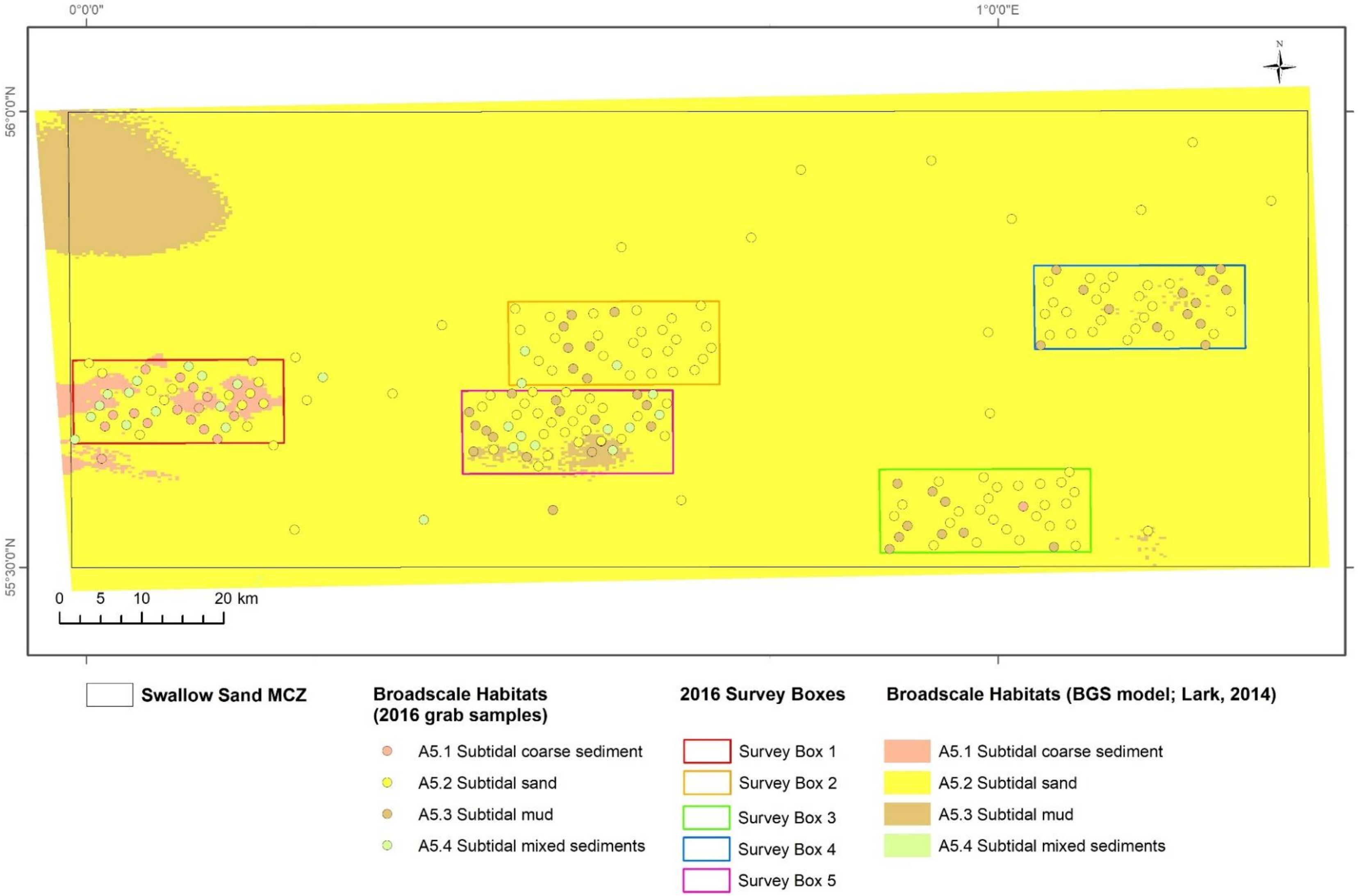

Figure 10. Distribution of BSH assigned to 0.1m^2 Hamon grab samples within the Swallow Sand MCZ, displayed above the British Geological Survey model (Lark 2014).

3.1.3 Seabed features

The MBES bathymetry data acquired from survey boxes 2 and 5 revealed the presence of a submerged valley feature, which was expressed as a large depression on the seabed. The associated groundtruth sampling revealed the presence of mud within the deeper areas of the depression. The extent of the feature was estimated, with interpolation applied between acoustic lines to allow the feature to be delineated (Figure 11). The acoustic data and grab samples suggest that an additional glacial tunnel valley feature may be located in the south-west corner of box 5, however the full extent of this feature could not be delineated using the data available. Also of note is the orientation and nature of large-scale megaripple features between 80 and 100m (crest to crest) and orientated north-south (see Figure 11), aligned with the predominant tidal current direction.

The submerged valley feature was not reflected by either the Stephens and Diesing BGS-modified Folk (2015) or the BGS (Lark 2014) predictive habitat models (see Figure 12), although the latter modelled an area of mud to the south of the feature, which the former did not.

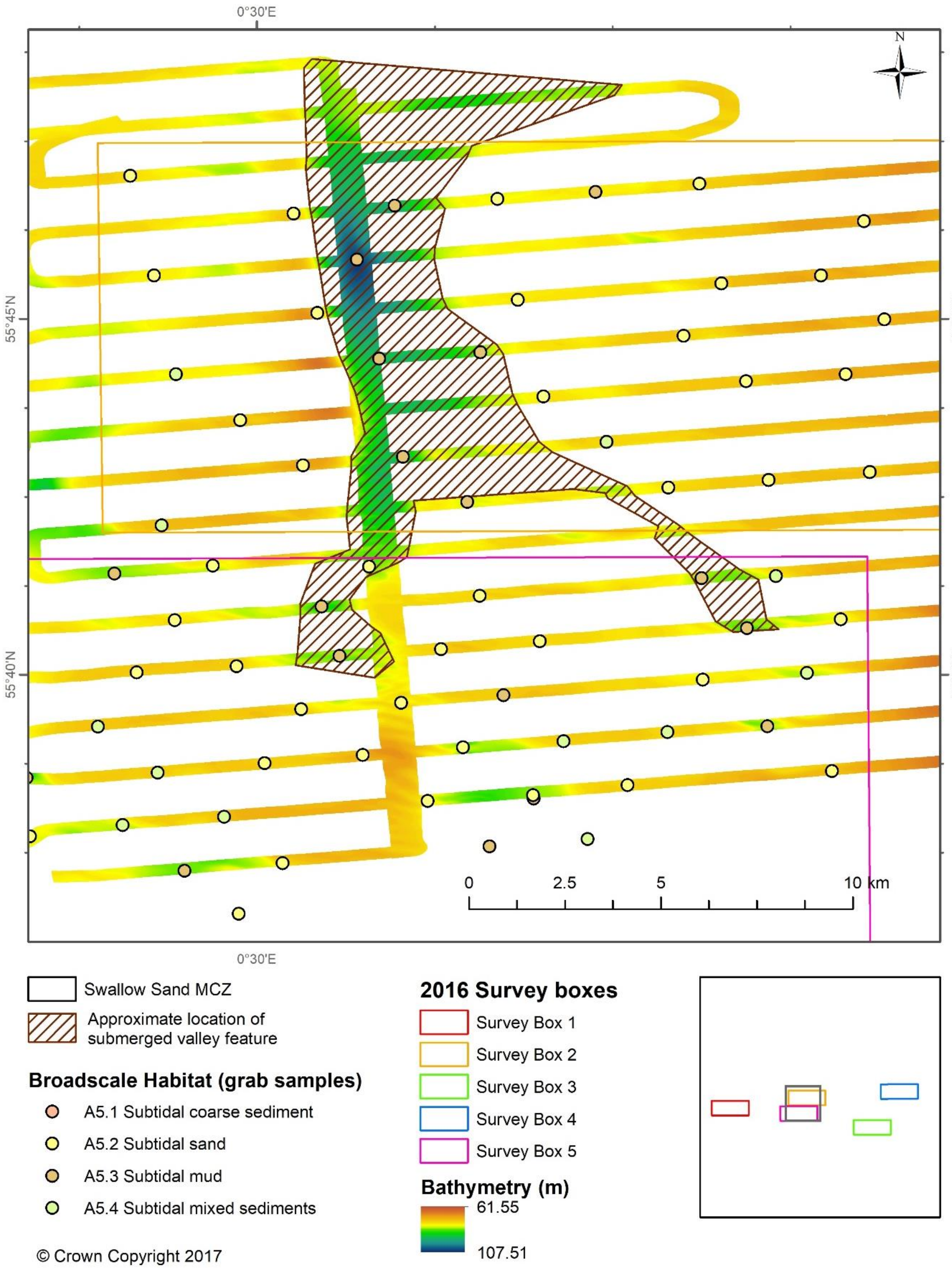

Figure 11. Approximate extent of the submerged valley feature and large megaripple bedforms (at the centre of survey box 5) observed from the 2016 acoustic data, overlain by Broadscale Habitat class points derived from 2016 0.1m[2] Hamon grab samples.

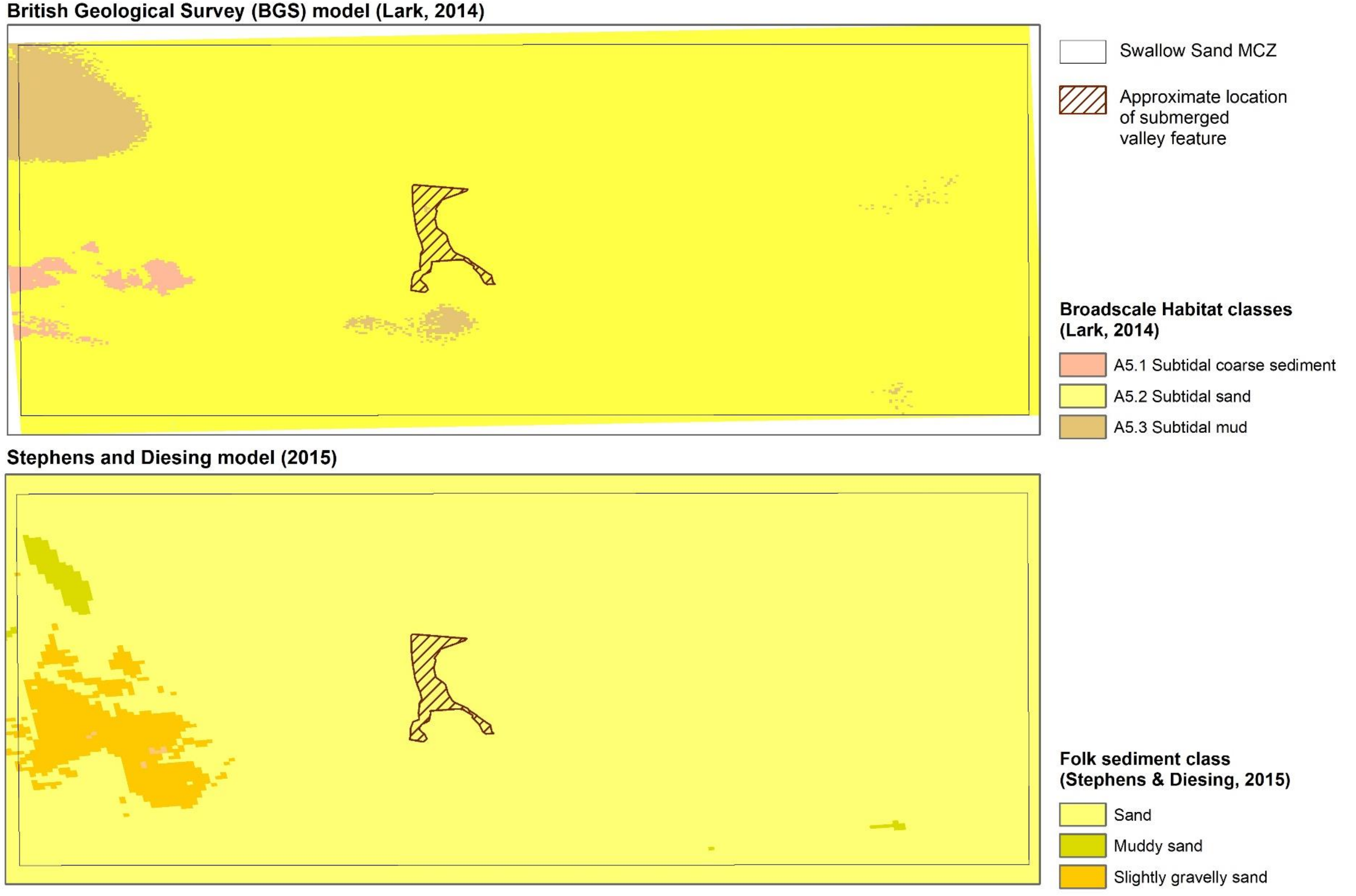

Figure 12. Submerged valley feature displayed over the BGS model (Lark, 2014) and 2015 Stephens and Diesing model (BGS-modified Folk; Long 2006).

3.2 Infaunal communities (2016 data)

Hierarchical cluster analysis of the square root transformed infaunal data was initially performed alongside a SIMPROF test, with a significance level of 5%. This analysis yielded a large number of clusters (illustrated in Figure 14). Detailed exploration of these clusters showed that the majority were dominated by similar taxa, with minor differences in abundance or assemblage composition driving statistically significant splits in the dataset.

An nMDS ordination of the infaunal samples overlain with cluster membership is displayed in Figure 13. The high 2D stress (0.24) indicates that distances between points may have been distorted in the reduction from three to two dimensions (Clarke & Warwick 2001). The ordination should therefore be interpreted with a high degree of caution and has been used simply to provide a broad visualisation of patterns noted from multivariate analyses, as opposed to a basis for interpretation.

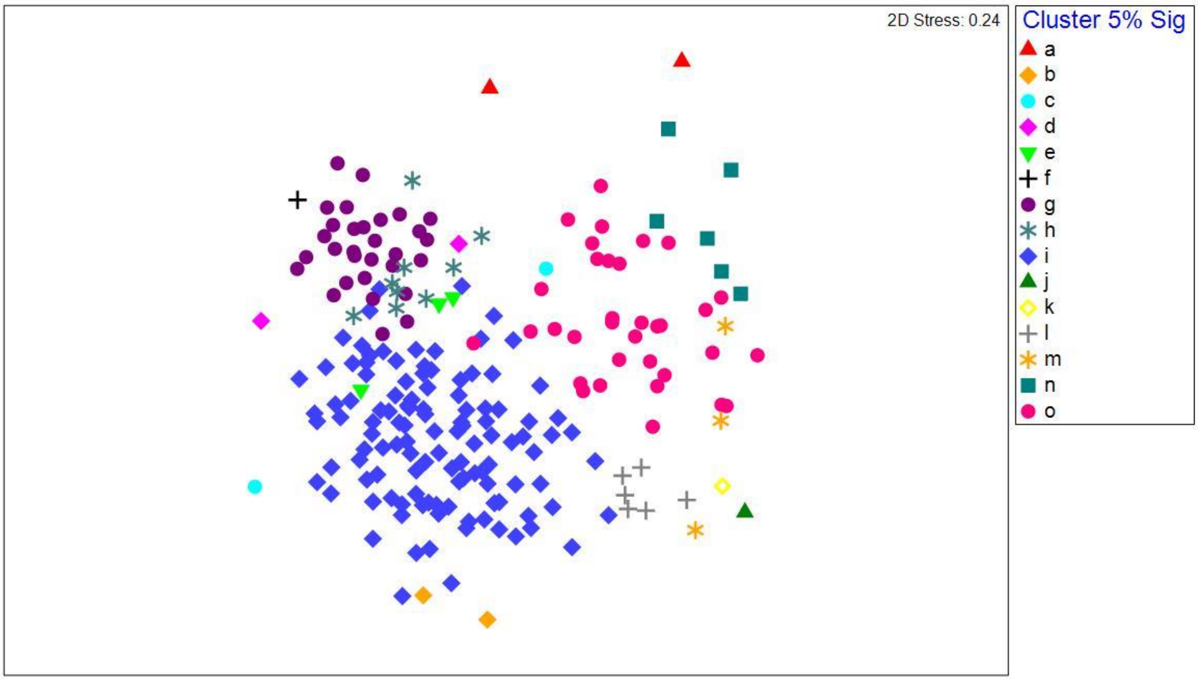

Figure 13. nMDS ordination of square root transformed infauna data (from 0.1m^2 Hamon grab samples), overlain with hierarchical cluster groups derived at the 5% significance level.

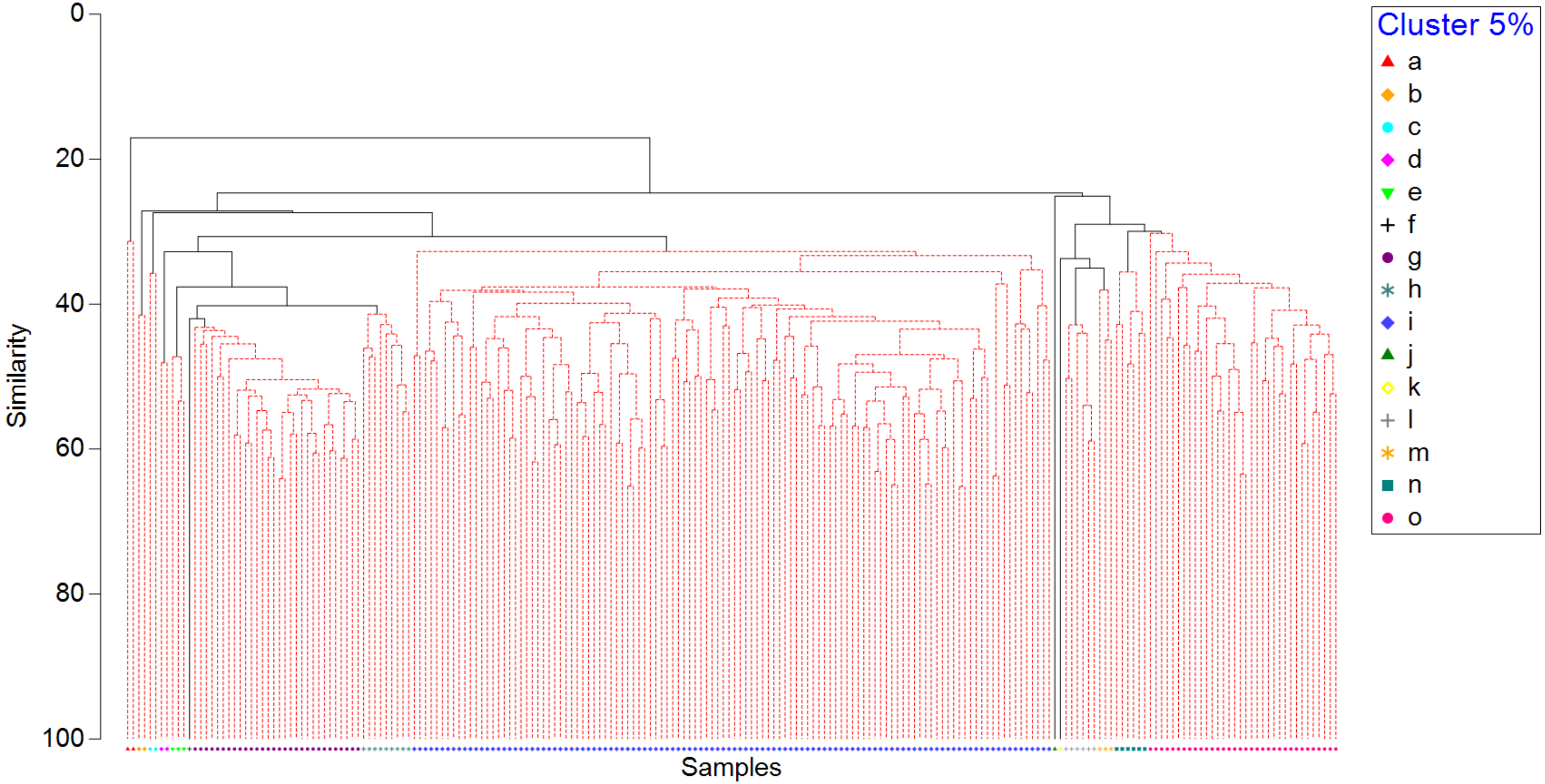

Figure 14. Dendrogram of showing statistically significant infaunal clusters derived at 5% similarity using SIMPROF analysis.

Expert judgement was used to determine a level of similarity (30%) which would allow variation in assemblage composition to be explored at a more ecologically meaningful level (see Figure 15).

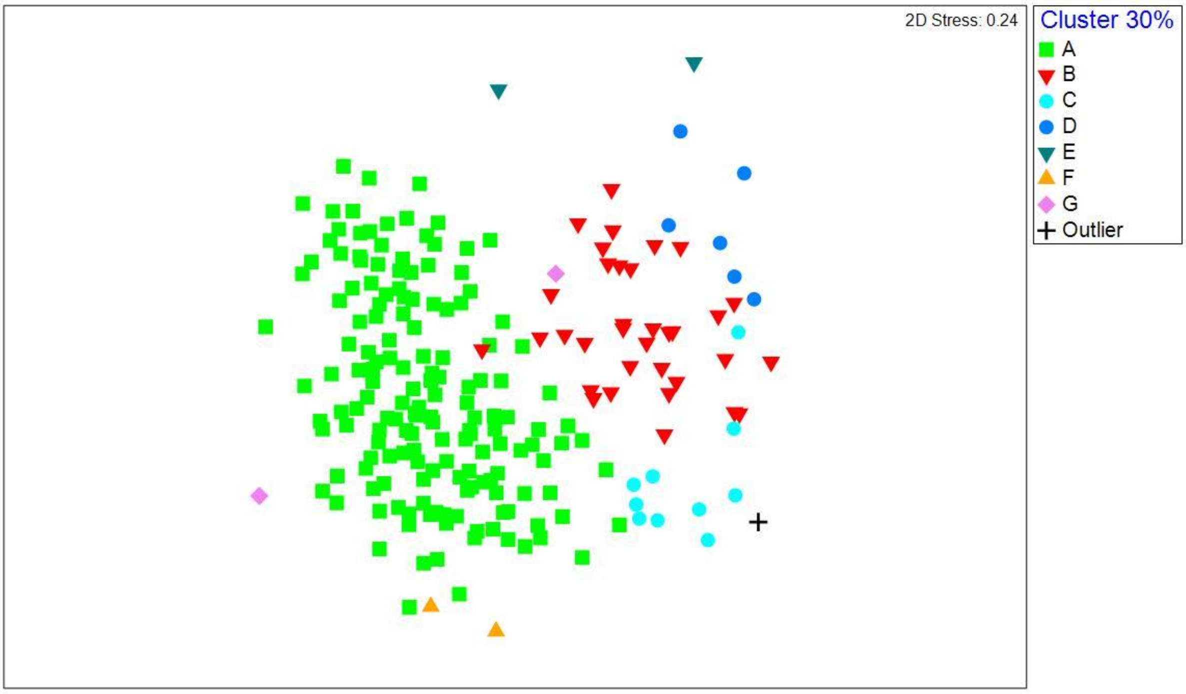

Figure 15. nMDS ordination of square root transformed infauna data (from 0.1m^2 Hamon grab samples), overlain with hierarchical cluster groups derived at 30% similarity.

SIMPER analysis was performed on the infaunal dataset, using the 30% similarity cluster grouping as a factor. Groups with <3 member stations (E, F, G and an outlying station) were excluded from further analysis due to the very small group size, low numbers of fauna contributing to within-group similarity, and the subsequent limitations for using these groups in future monitoring comparisons.

Similarity within groups A, B, C and D was moderate (36 – 39%) and dissimilarity between groups was high (71 – 82%). The ten highest contributors to within-group similarity are listed in Table 6, alongside sediment characteristics, BSH and survey box membership.

The SIMPER results support the existence of an assemblage gradient, as suggested by the ordination in Figure 15, with various dominant characterising taxa occurring across multiple cluster groups and within a number of BSH. The common sand-dwelling spionid polychaete *Spiophanes bombyx* dominated group B, being ubiquitous across the ten highest contributors of all groups, reflecting the primarily sandy composition of most sampling locations. The amphinomid polychaete *Paramphinome jeffreysii* was dominant in group A, and influential within groups B and C, also being present at a similar average abundance in group D. The pea urchin *Echinocyamus pusillis,* horseshoe worms belonging to the genus *Phoronis*, burrowing anemones of the family Edwardsiidae, the sabellid polychaete *Owenia fusiformis* and genus *Notomastus*, and the scaphopod mollusc *Antalis entalis* also made a notable contribution to similarity across either two or three groups. These taxa are typical of sandy or muddy sand habitats.

Table 6. SIMPER analysis results: ten highest infaunal contributors to similarity within cluster groups (>30% similarity, >2 member stations).* Average square root abundance. ** Cumulative contribution to within-group similarity. S = No. of taxa, N = No. of taxa, H = Shannon diversity (loge).

Group A				**Group B**				**Group C**				**Group D**			
Average similarity: 36%		**n = 159**		**Average similarity: 38%**		**n = 34**		**Average similarity: 39%**		**n = 10**		**Average similarity: 39%**		**n = 6**	
Sediment %	**Min**	**Max**	**Median**	**Sediment %**	**Min**	**Max**	**Median**	**Sediment %**	**Min**	**Max**	**Median**	**Sediment %**	**Min**	**Max**	**Median**
Gravel	0.01	30.55	0.36	**Gravel**	0.49	59.15	10.85	**Gravel**	0.09	24.74	0.54	**Gravel**	0.23	6.60	0.74
Sand	56.29	89.70	81.09	**Sand**	36.16	93.86	80.94	**Sand**	68.49	96.11	88.99	**Sand**	80.30	97.05	93.18
Mud	10.23	38.92	17.54	**Mud**	2.87	12.78	8.38	**Mud**	3.45	14.31	7.94	**Mud**	2.72	13.10	5.53
Broadscale Habitats (BSH)		**Survey Box**		**BSH**		**Survey Box**		**BSH**		**Survey Box**		**BSH**		**Survey Box**	
A5.2, A5.3, A5.4		1, 2, 3, 4, 5, outside boxes		A5.1, A5.2, A5.4		1, 5 & outside boxes		A5.1, A5.2		1, 2 & 3		A5.2, A5.4		1 & outside boxes	
	S	**N**	**H'**		**S**	**N**	**H'**		**S**	**N**	**H'**		**S**	**N**	**H'**
Min	14	20	2.48	**Min**	12	18	2.37	**Min**	16	28	2.56	**Min**	31	53	3.15
Max	46	174	3.52	**Max**	47	86	3.61	**Max**	30	63	3.12	**Max**	43	110	3.30
Median	27	49	3.06	**Median**	28	48	2.98	**Median**	23	40	2.88	**Median**	34	64	3.23
Taxon		**Abun***	**Cum.%****	**Taxon**		**Abun***	**Cum.%**	**Taxon**		**Abun***	**Cum.%**	**Taxon**		**Abun***	**Cum.%**
Paramphinome jeffreysii		1.87	8.68	*Spiophanes bombyx*		2.43	15.43	*Echinocyamus pusillus*		2.14	15.47	Edwardsiidae		3.00	12.25
Spiophanes bombyx		1.42	15.89	*Phoronis*		1.46	23.44	*Spiophanes bombyx*		1.82	28.71	*Echinocyamus pusillus*		2.41	21.53
Antalis entalis		1.15	22.58	*Owenia fusiformis*		1.36	31.35	*Bathyporeia elegans*		1.91	41.73	*Aricidea (Acmira) cerrutii*		1.98	30.40
Harpinia antennaria		1.26	29.18	*Edwardsiidae*		1.79	39.22	*Paramphinome jeffreysii*		1.35	52.05	*Notomastus* sp.		1.63	37.53
Scoloplos armiger		1.07	34.92	*Urothoe elegans*		1.25	46.26	*Phoronis*		1.23	58.54	*Spiophanes bombyx*		1.69	44.56
Spiophanes kroyeri		1.02	40.10	*Paramphinome jeffreysii*		1.31	51.81	*Sthenelais limicola*		0.92	64.87	*Antalis entalis*		1.30	49.05
Phoronis		1.01	45.26	*Spiophanes kroyeri*		1.12	56.76	*Amphiura filiformis*		0.82	69.19	*Aricidea (Acmira) simonae*		1.15	53.27
Amphictene auricoma		1.18	50.36	*Goniada maculata*		0.96	61.31	*Goniada maculata*		0.78	72.59	Nemertea		1.04	57.44
Amphiura filiformis		0.98	55.13	*Echinocyamus pusillus*		1.22	65.44	*Nephtys longosetosa*		0.64	75.90	*Owenia fusiformis*		1.16	61.39
Goniada maculata		0.90	59.70	*Notomastus* sp.		0.90	69.36	*Spiophanes kroyeri*		0.54	78.39	*Ophelia borealis*		0.97	65.22

Dissimilarity ranking between groups showed that the taxa contributing the most to similarity were also those contributing to dissimilarity. This further indicates that the cluster groups are variants of a single broad assemblage, as opposed to separate communities. The groupings are therefore likely to be driven by natural variation in abundance and patchiness in distribution, due to small-scale differences in sediment composition and ecological drivers such as competition. It is clear from the results presented in Table 6 that the infaunal cluster groups do not correspond to the BSH classes. The BSH are shown overlying the nMDS ordination in Figure 16.

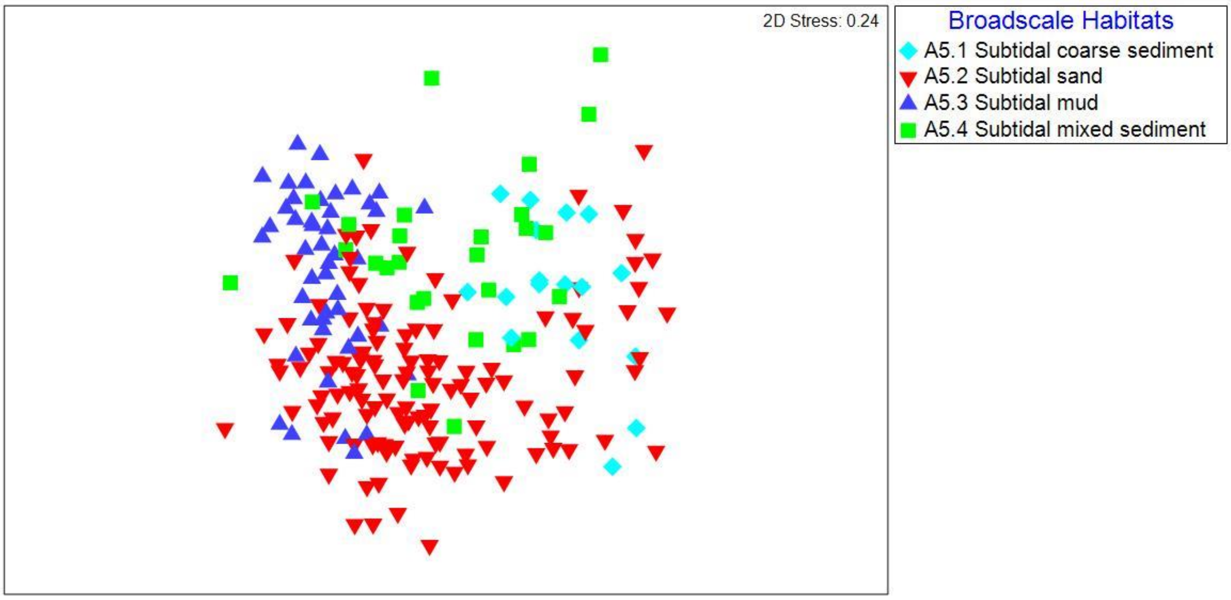

Figure 16. nMDS ordination of square root transformed 2016 infauna data (from 0.1m^2 Hamon grab samples), overlain with BSH classes.

SIMPER analysis of the infaunal data using BSH as a factor revealed some differences between 'A5.1 Subtidal coarse sediment' and 'A5.3 Subtidal mud'. The bivalve *Parathyasira equalis* (formerly *Thyasira equalis*) and the polychaete *Amphictene auricoma* were reasonably abundant in 'A5.3 Subtidal mud' but were absent from 'A5.1 Subtidal coarse sediment'. The pea urchin *Echinocyamus pusillis* was present in 'A5.1 Subtidal coarse sediment' and absent from 'A5.3 Subtidal mud'. *Parathyasira equalis* and *Amphictene auricoma* preferentially inhabit sediments with approximately 10% mud and above. *Echinocyamus pusillis* appears preferential of gravelly sand with a lower mud component. With the exception of these species, the characterising taxa listed Table 6 also contributed the most to dissimilarity between BSH.

ANOSIM analysis was conducted to determine whether differences existed between the infaunal assemblages of each survey box. The global test indicated a statistically significant difference between boxes ($p = 0.001$), whilst the associated R value (0.367) was moderate. Pairwise comparisons between survey boxes showed that, although a statistically significant difference was calculated ($p < 0.005$), the assemblages of survey boxes 2, 3, 4 and 5 appeared to be similar in terms of composition (see R values in Table 7). Conversely, the assemblages of survey box 1 (the most easterly of the five boxes) showed moderate to high levels of dissimilarity to those of boxes 2, 3, 4 and 5. The particle size data showed an increased gravel component in survey box 1 (Figure 7), which was thought likely to drive this separation. Survey box membership and gravel percentage content are overlain on the nMDS plot in Figure 17 to further explore this relationship.

Table 7. Results of pairwise ANOSIM analysis on 2016 infaunal data (0.1m^2 Hamon grab), using survey box membership as a factor.

Survey Boxes		R value	P value
1	2	0.465	0.001
1	3	0.646	0.001
1	4	0.762	0.001
1	5	0.614	0.001
2	3	0.173	0.001
2	4	0.166	0.001
2	5	0.264	0.001
3	4	0.068	0.005
3	5	0.176	0.001
4	5	0.271	0.001

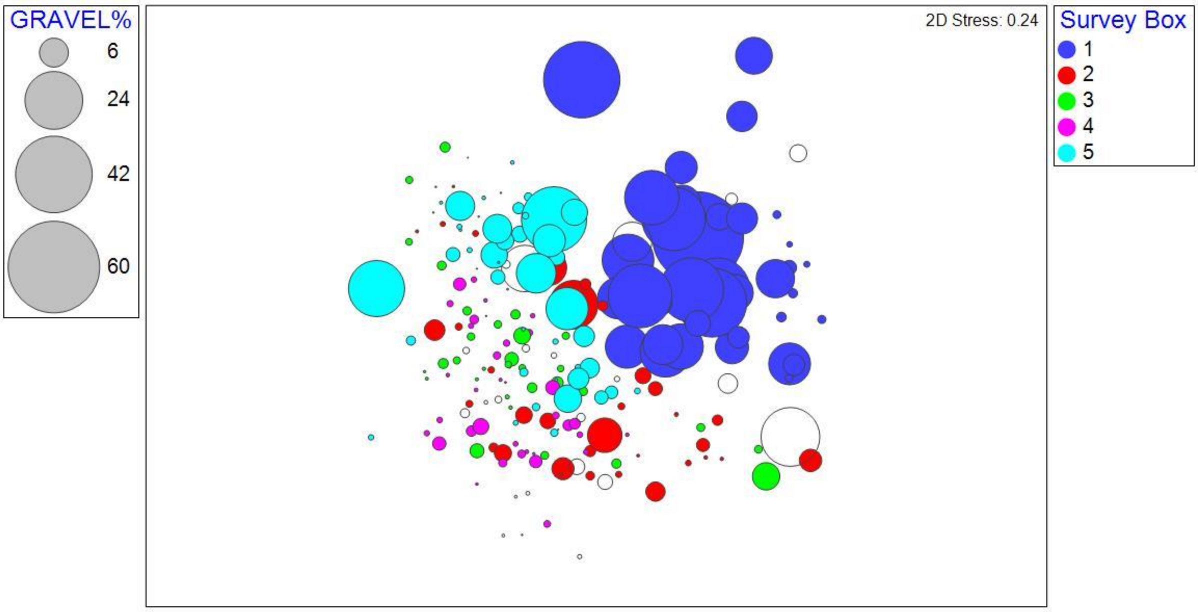

Figure 17. nMDS ordination of 2016 infaunal data (from 0.1m^2 Hamon grab samples) with survey box membership and gravel content overlain.

3.3 Epifaunal communities (2016 data)

Epifaunal video segments and still images were each assigned a classification according to the EUNIS hierarchy. Where possible the data were classified to biotope level (EUNIS level 5), however in most cases the data did not support this level of classification and samples were instead assigned a level 4 habitat. The EUNIS habitat classification for the 2016 data is presented in Table 8 (as assigned by the imagery analyst), although it should be noted that differences between level 4 sediment classes (e.g. between Circalittoral muddy sand, sandy mud and fine mud) can be difficult to discern from imagery data alone.

Table 8. EUNIS habitat classification hierarchy for Swallow Sand MCZ 2016 still image and video data.

Level 3	Level 4	Level 5
A5.1 Subtidal coarse sediment	A5.14 Circalittoral coarse sediment	
A5.2 Subtidal sand	A5.26 Circalittoral muddy sand	
A5.3 Subtidal mud	A5.35 Circalittoral sandy mud	
	A5.36 Circalittoral fine mud	A5.361 Sea-pens and burrowing megafauna in circalittoral fine mud
A5.4 Subtidal mixed sediment	A5.44 Circalittoral mixed sediment	

Epifaunal data from 207 still images were analysed from a total of 39 transects. Median SACFOR abundance data from five ‘Good’ or ‘Excellent’ quality images (Turner et al., 2016) was combined for each transect[3]. Following truncation of the data matrix, 26 epifaunal taxa of varying taxonomic resolution were retained in the dataset (Annex 2). This low taxon richness is likely to be a result both of the typically sparse epifauna associated with predominantly soft sediments, and the limitations associated with identifying epifauna to a low taxonomic resolution (i.e. genus or species) from imagery.

Hierarchical cluster analysis of the numerical SACFOR abundance data showed that all stations belonged to a single cluster, with no differentiation observed at the 5% significance level (SIMPROF test). SIMPER analysis showed 39% similarity within the cluster, with just three taxa (the phosphorescent sea-pen *Pennatula phosphorea*, polychaete tubes and unidentified faunal turf) contributing 95% of within-cluster similarity.

The epifauna were ranked by summed median SACFOR score (Table 9); only two taxa *P. phosphorea* and Polychaeta (tubes) had an overall median score >0, providing a further indication of the paucity of faunal diversity and the patchy distribution of most taxa. Median abundance of *P. phosphorea* was 4 (‘Common’) with a maximum score of 5 (‘Abundant’), whilst polychaete tubes recorded a median score of 3 (‘Frequent’) and a maximum of 4 (‘Common’). These two taxa were highly uniform in terms of spatial distribution, with *P. phosphorea* being present in 85% and polychaete tubes in 90% of transects. The almost ubiquitous nature of *P. phosphorea* is illustrated in Figure 18, where it can be seen in example images of each BSH (polychaete tubes are too small to discern). Other taxa (e.g. unidentified faunal turf, Asteroidea and Paguridae) occurred in moderate or high numbers of transects, however at low or very low densities (as evidenced by the median score of 0). Sixteen of the remaining 24 taxa were only recorded as ‘present’ (denoted as 0.1 in the dataset) as opposed to being allocated a SACFOR score of 1 or above. This is due to these taxa not being recorded in sufficient density in the five selected images for each transect (i.e. the taxon was present in one or two of the five images, yet the median score per transect was 0). These taxa were present in <15% of transects.

[3] With the exception of SWSD270 and 282, which both intersected two BSH. Five images were therefore combined for each BSH per transect.

Table 9. Epifaunal taxa ranked by summed SACFOR abundance across 39 transects.

Taxon*	**Summed SACFOR score**	**Median**	**Minimum**	**Maximum**	**Occurrence frequency (% of transects)**
Pennatula phosphorea	102.0	4 (Common)	0	5 (Abundant)	85
Polychaeta (tubes)	76.3	3 (Frequent)	0	4 (Common)	90
Unidentified faunal turf	23.6	0	0	2 (Occasional)	87
Asteroidea	21.5	0	0	4 (Common)	51
Spatangus purpureus	12.6	0	0	4 (Common)	23
Paguridae	9.6	0	0	4 (Common)	46
Nudibranchia	6.2	0	0	3 (Frequent)	10
Alcyonium digitatum	4.4	0	0	1 (Rare)	44
Bryozoa (encrusting)	3.4	0	0	1 (Rare)	18
Serpulidae (encrusting)	1.8	0	0	1 (Rare)	23
Zoantharia	0.6	0	0	0.1	15
Spatangoida	0.6	0	0	0.1	15
Gracilechinus acutus	0.5	0	0	0.1	13
Hydrozoa	0.4	0	0	0.1	10
Hyalinoecia	0.4	0	0	0.1	10
Pectinidae	0.3	0	0	0.1	8
Actiniaria	0.2	0	0	0.1	5
Urticina eques	0.2	0	0	0.1	5
Scaphander lignarius	0.2	0	0	0.1	5
Alcyonidium diaphanum	0.2	0	0	0.1	5
Abietinaria abietina	0.1	0	0	0.1	3
Aphrodita aculeata	0.1	0	0	0.1	3
Oxydromus flexuosus	0.1	0	0	0.1	3
Ditrupa arietina	0.1	0	0	0.1	3
Janolus cristatus	0.1	0	0	0.1	3
Ophiocten affinis	0.1	0	0	0.1	3

* Grey denotes taxa which are present (indicated in the dataset by a score of 0.1), but do not have a transect median SACFOR score >0 (i.e. for five images combined).

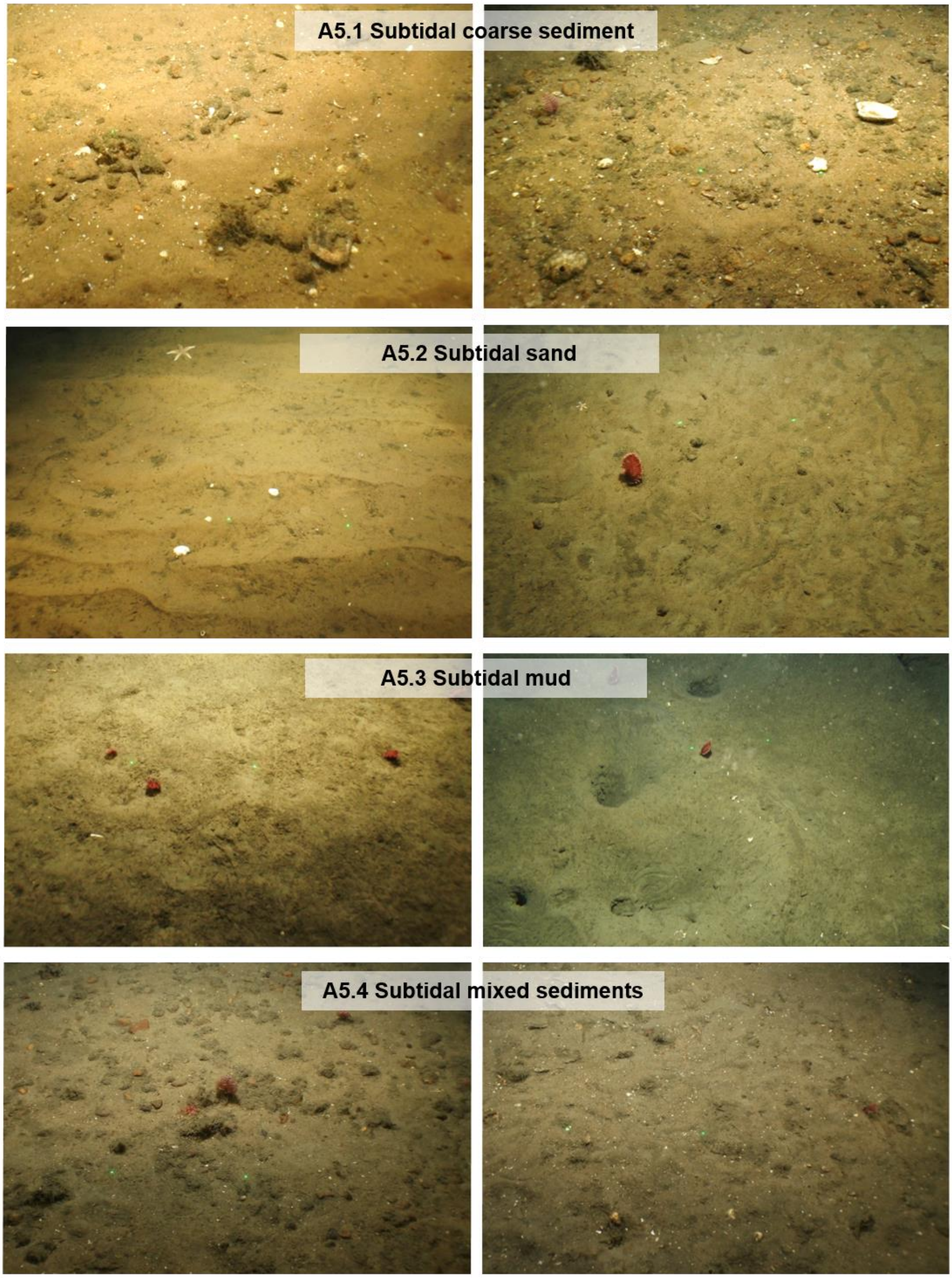

Figure 18. Example still images of BSH and associated epifauna (including the pink / red phosphorescent sea-pen, *Pennatula phosphorea*).

Following the identification of *P. phosphorea* as an abundant, widely distributed and easily identifiable taxon, further exploration of this species was undertaken.

P. phosphorea was recorded as present in 47 of 51 video segments (92%), a number of which were considered to be of insufficient quality for a qualitative comparison of relative sea-pen density. Where video segments were determined to be of ‘Good’ or ‘Excellent’ quality (according to Turner *et al*. 2016), the ratio of *P. phosphorea* abundance to video segment length was calculated. Of these ‘Good’ and ‘Excellent’ segments, *P. phosphorea* was present in 34 of 36 (94%). The relative density of the species was extremely variable across the site. In the video segments where *P. phosphorea* were present, the abundance to segment length ratio ranged from 3.76 (452 individuals over 120.3m) to 0.01 (1 individual over 85.4m).

When aggregated by BSH, the highest mean ratios of *P. phosphorea* to segment length was recorded for segments described as ‘A5.3 Subtidal mud’ (1.25 ± 0.74, n = 16) and ‘A5.2 Subtidal sand’ (1.08 ± 1.26, n = 9), whilst comparably low and extremely low ratios were recorded for ‘A5.4 Subtidal mixed sediments’ (0.45 ± 0.49, n = 5) and ‘A5.1 Subtidal coarse sediment’ (0.05 ± 0.04, n = 4).

As shown in Table 10 and Figure 19, the highest relative abundances of *P. phosphorea* were observed in survey boxes 2 and 5, at the centre of the site. These boxes covered the mud-filled submerged valley feature identified from the 2016 MBES data.

Table 10. Relative density of *Pennatula phosphorea* from ‘Good’ or ‘Excellent’ video segments (Turner *et al*. 2016) where the species was recorded as present.

Survey Box	No. of video segments	*Pennatula phosphorea* abundance		Segment length (m)		*P. phosphorea* abundance : segment length	
		Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.
1	8	4	3	66.5	27.7	0.08	0.07
2	7	94	69	89.1	7.4	1.05	0.76
3	1	29	-	87.9	-	0.33	-
4	7	58	27	89.0	15.9	0.65	0.27
5	11	202	119	113.7	24.4	1.75	0.99

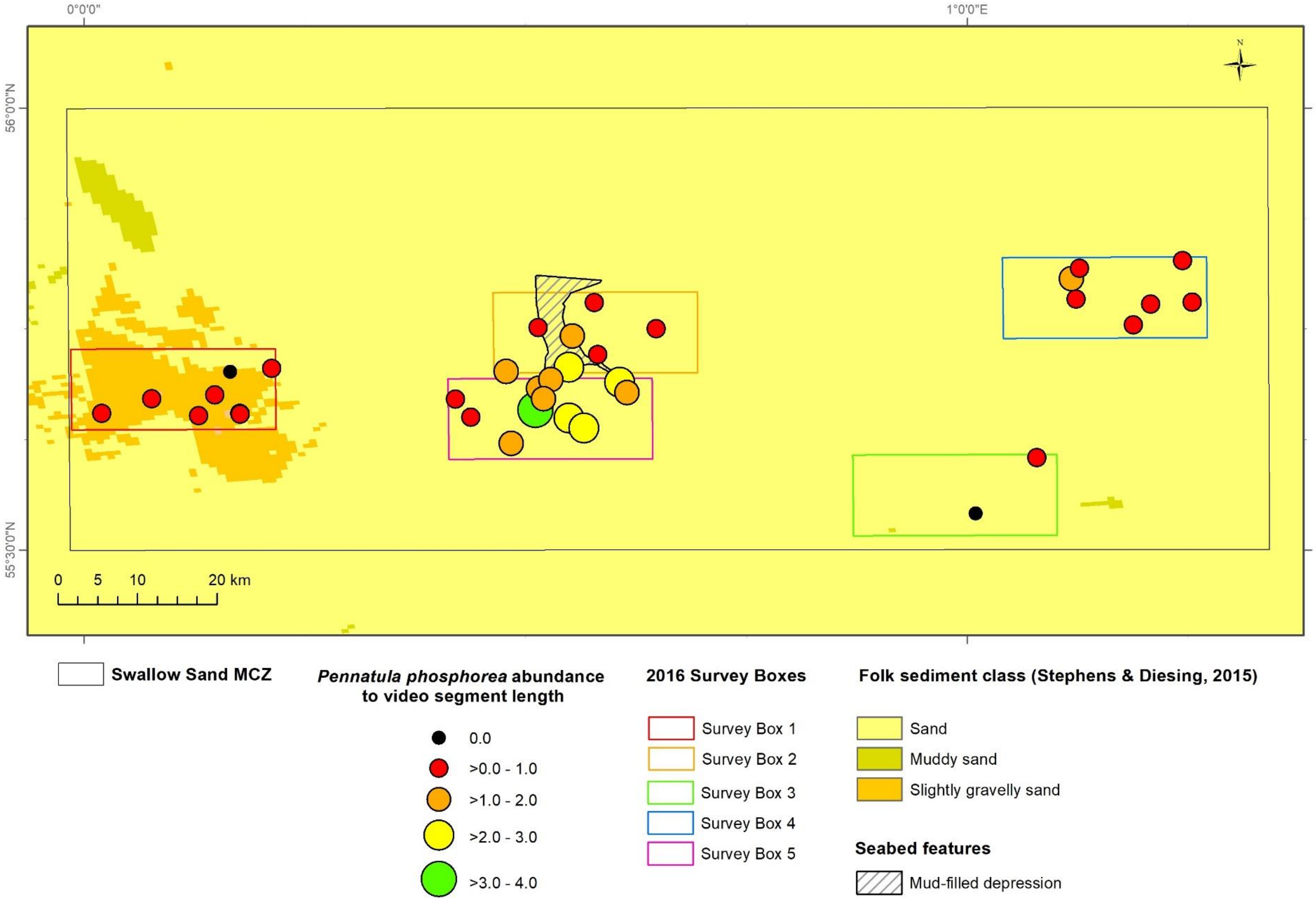

Figure 19. The distribution and density of *P. phosphorea* from 'Good' and 'Excellent' quality video segments, shown as the ratio of abundance to segment length, displayed over the 2015 Stephens and Diesing model (BGS-modified Folk; Long 2006).

3.4 Temporal comparisons (2012 and 2016 data)

3.4.1 BSH comparison

The spatial distribution and number of grab samples collected per BSH in 2012 and 2016 is presented in Figure 20 and the number of samples collected from each is given in Table 11. Similar to the Entropy results in the previous section, only minor differences in BSH between 2012 and 2016 were noted. A degree of variation between grab stations over time would be expected due to small scale variation and the marginal nature of some stations (in terms of BSH membership).

Table 11. Number of $0.1m^2$ Hamon grab samples collected per BSH, overall and for the 51 comparable grab stations.

Broadscale Habitat (BSH)	2012	2016
A5.1 Subtidal coarse sediment	8	5
A5.2 Subtidal sand	29	31
A5.3 Subtidal mud	9	8
A5.4 Subtidal mixed sediments	5	7

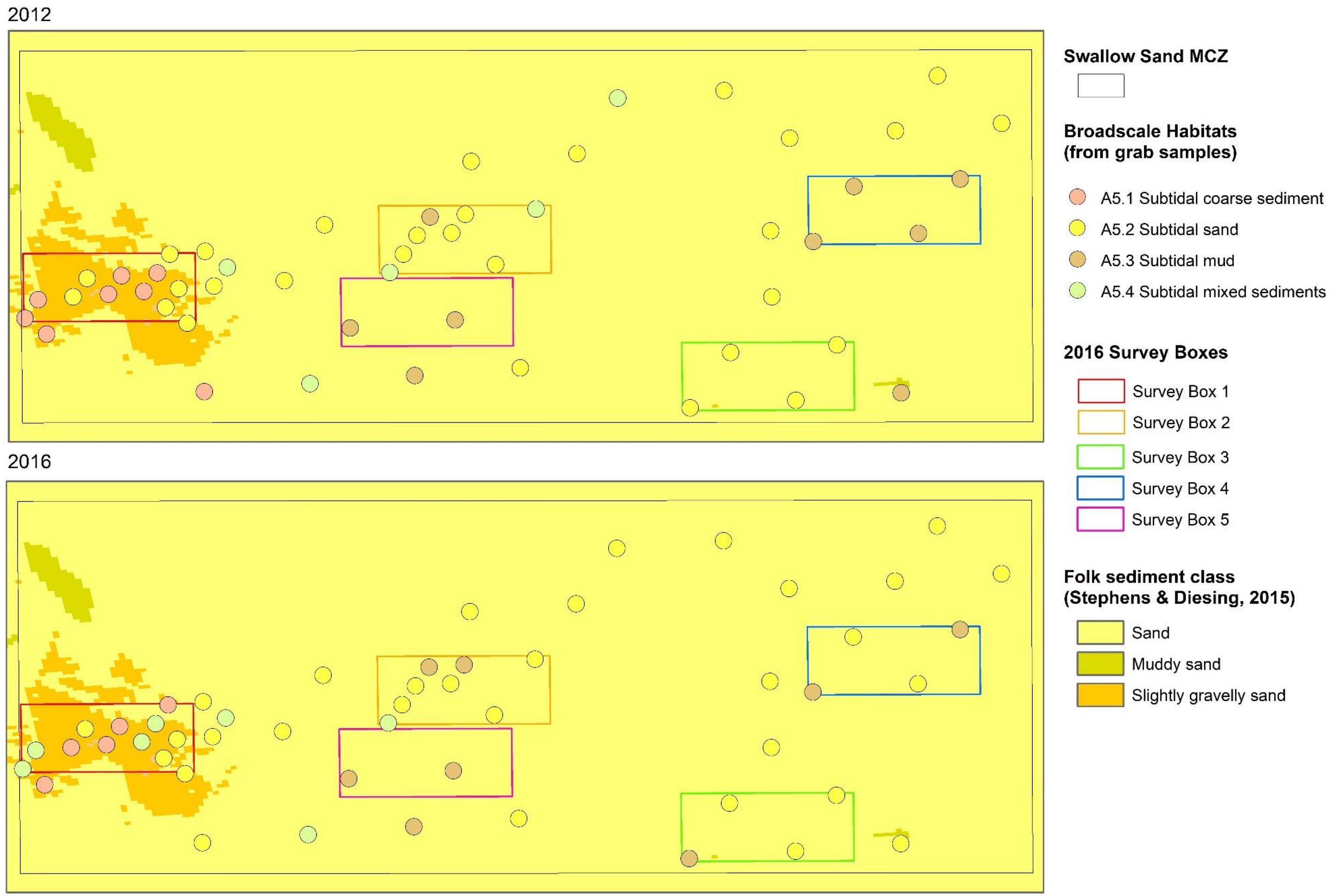

Figure 20. BSH classifications from 0.1m^2 Hamon grab stations sampled in both 2012 and 2016, displayed over the 2015 Stephens and Diesing model (BGS-modified Folk; Long 2006).

3.4.2 Sediment composition comparison

Where grab samples were collected at the same location in 2012 and 2016, an Entropy sediment analysis was carried out to compare particle size distribution (PSD) between the two sampling events. The PSD datasets were pooled as per the methodology described in Section 2.3.3, allowing Entropy group membership to be compared in a standardised manner.

Four Entropy groups were derived from the pooled 2012 and 2016 data. Sediment characteristics and profiles for each of the groups are given in Figure 21, with summary particle size data presented in Table 12.

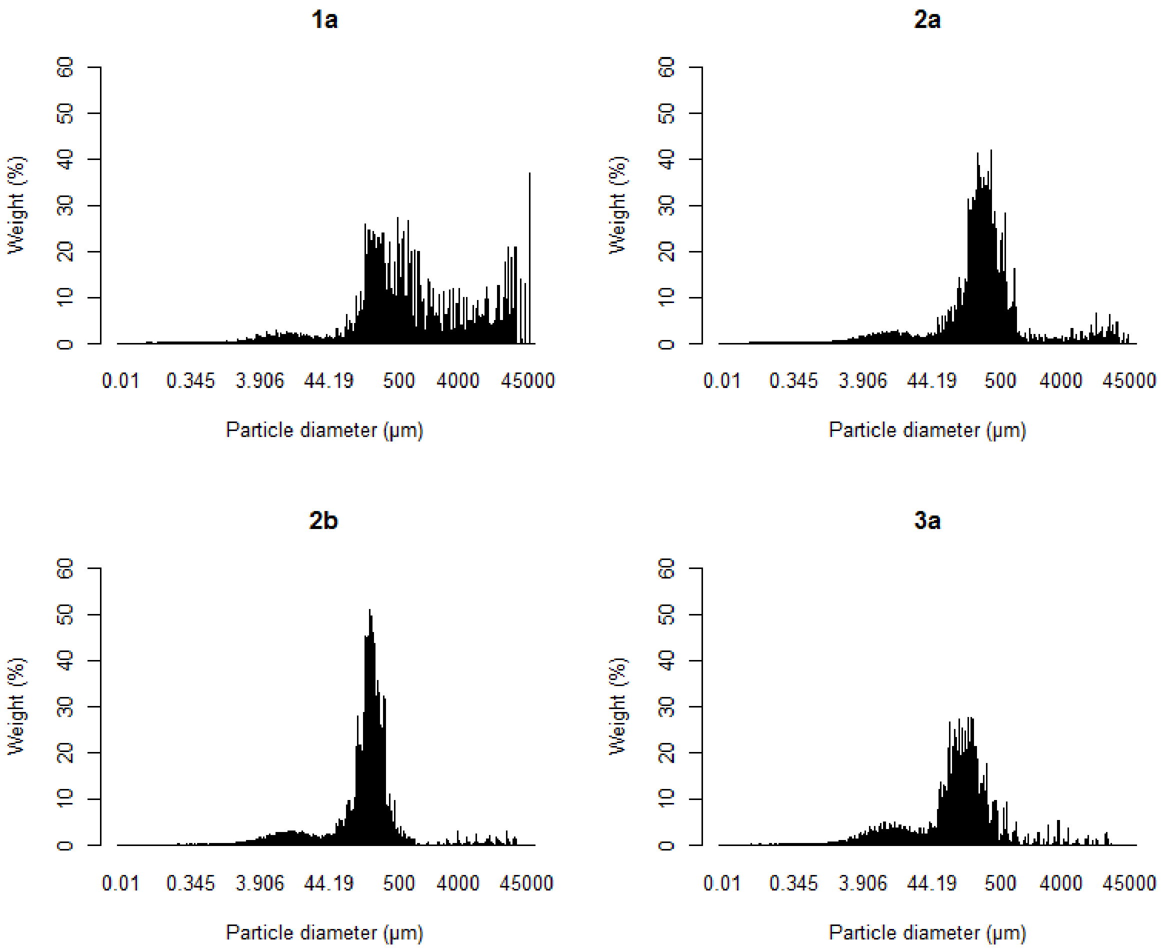

Figure 21. Particle size distribution histograms for each Entropy group (pooled 2012 and 2016 0.1m^2 Hamon grab data).

Table 12. Sediment characteristics of the four Entropy groups derived from pooled 2012 and 2016 0.1m^2 Hamon grab data (Blott & Pye 2001).

Sediment group	Number of samples	Sediment description	Mode 1 (µm)	Mode 2 (µm)
1a	52	Gravelly Muddy Sand	301.8	9600.0
2a	97	Slightly Gravelly Muddy Sand	301.8	
2b	124	Slightly Gravelly Muddy Sand	213.4	
3a	46	Slightly Gravelly Muddy Sand	150.9	13.3

Sediment group	Gravel (%)	Very coarse sand (%)	Coarse sand (%)	Medium sand (%)	Fine sand (%)	Very fine sand (%)	Silt/clay (%)
1a	23.58	5.75	13.90	24.44	19.85	3.35	9.14
2a	2.63	0.69	10.72	41.26	27.77	5.33	11.60
2b	0.81	0.08	1.07	22.48	51.37	8.10	16.09
3a	1.19	0.31	2.46	10.96	34.79	24.18	26.11

Comparison of Entropy group membership between 2012 and 2016 shows that the particle size distribution has largely remained consistent between the two sampling events at revisited stations (see Table 13). Overall, agreement between 2012 and 2016 Entropy group membership is very high, with only five of 51 stations showing a change in membership over this time period. These five stations were observed to have similar PSD profiles, with slight differences in gravel or silt/clay content being responsible for changes in Entropy group membership. This is likely to reflect the small-scale variation in sediment composition within the site.

Table 13. Comparison of Entropy group membership between 0.1m^2 Hamon grab samples collected in 2012 and 2016.

Sample code (2016 code/2012 code)	Sediment group_2016	Sediment group_2012
SWSD030/SWSD02	2a	2a
SWSD029/SWSD03	2b	2b
SWSD250/SWSD05	2b	2b
SWSD258/SWSD06	2a	2a
SWSD257/SWSD08	1a	1a
SWSD255/SWSD09	3a	3a
SWSD254/SWSD10	2a	2a
SWSD244/SWSD102	2b	2b
SWSD031/SWSD12	2b	2b
SWSD028/SWSD13	2b	2b
SWSD238/SWSD17	3a	3a
SWSD239/SWSD18	3a	3a
SWSD245/SWSD21	2a	2a
SWSD016/SWSD22	2a	2a
SWSD237/SWSD25	2b	2b
SWSD006/SWSD26	1a	1a
SWSD025/SWSD27	2a	2a
SWSD026/SWSD30	2b	2b
SWSD027/SWSD31	2b	2b
SWSD218/SWSD33	2b	2b
SWSD003/SWSD34	2b	2a
SWSD002/SWSD38	2b	2b
SWSD001/SWSD40	2b	3a
SWSD210/SWSD43	2a	2a
SWSD211/SWSD44	2b	2b
SWSD213/SWSD46	2b	2b
SWSD214/SWSD48	2b	2b
SWSD215/SWSD50	2b	2b
SWSD204/SWSD54	2b	2b
SWSD203/SWSD56	2b	2b
SWSD201/SWSD59	2b	2b
SWSD225/SWSD67	1a	1a
SWSD233/SWSD68	2a	2a
SWSD018/SWSD69	1a	1a
SWSD024/SWSD70	2a	2a
SWSD017/SWSD72	1a	1a
SWSD015/SWSD73	2a	1a
SWSD019/SWSD74	1a	1a
SWSD023/SWSD75	2a	2a
SWSD235/SWSD76	1a	1a
SWSD011/SWSD77	2a	2a
SWSD014/SWSD78	1a	1a
SWSD020/SWSD79	1a	1a
SWSD236/SWSD81	2a	1a
SWSD021/SWSD85	2a	2a
SWSD007/SWSD86	2a	2a
SWSD229/SWSD87	2a	2a
SWSD008/SWSD92	2b	2b
SWSD005/SWSD94	2b	2a
SWSD009/SWSD98	3a	3a
SWSD004/SWSD99	2b	2b

3.4.3 Infaunal community comparison

A comparison of infaunal assemblages was conducted between the stations sampled in 2012 and 2016. This comparison should be considered indicative only, due to the lack of information (from both survey years) on within-station small-scale variability (and therefore the degree of variance that can be attributed to change over time, as opposed to spatial variance).

SIMPER analysis was conducted to determine which taxa contributed to the apparent assemblage dissimilarity between 2012 and 2016. The average dissimilarity between the two groups was 73%, although scrutiny of the contributions of individual taxa to dissimilarity indicated that minor fluctuations in abundance were responsible, as opposed to presence or absence of taxa between years. The percentage contribution of individual taxa to overall dissimilarity was very low (as displayed in Table 14). The highest ranked contributer to dissimilarity, *Galathowenia oculata,* contributed just 2.17%.

Table 14. Ten highest ranked contributors to dissimilarity in assemblage composition between 2012 and 2016 (fourth root transformed data from 0.1m^2 Hamon grab samples).

Taxon	2012 Average abundance	2016 Average abundance	Average dissimilarity	Contribution to dissimilarity (%)	Cumulative contribution (%)
Galathowenia oculata	1.07	0.21	1.59	2.17	2.17
Paramphinome jeffreysii	1.16	0.96	1.36	1.85	4.02
Harpinia antennaria	0.10	0.73	1.28	1.74	5.76
Spiophanes kroyeri	0.37	0.89	1.25	1.71	7.47
Nemertea	1.05	0.57	1.25	1.70	9.17
Spiophanes bombyx	0.72	1.12	1.19	1.63	10.79
Scoloplos armiger	1.07	0.69	1.16	1.59	12.38
Chaetozone setosa	0.71	0.44	1.14	1.56	13.94
Trichobranchus roseus	0.63	0.38	1.12	1.53	15.47
Amphiura filiformis	0.65	0.76	1.10	1.50	16.97

3.5 Habitat Features of Conservation Importance (FOCI)

3.5.1 Sea-pens and burrowing megafauna

No habitat FOCI have been designated as features of the MCZ, however burrows and *P. phosphorea* observed in the 2016 data indicated that the ‘Sea-pens and burrowing megafauna’ habitat FOCI may occur within the site.

According to JNCC guidance (Robson, 2014) ‘Sea-pens and burrowing megafauna’ is identified by the exceedance of a threshold density of burrows (1-9 per 10m^2) which are attributable to burrowing species through positive identification from video or infaunal sampling. The presence of sea-pens is not considered crucial, as they may have been removed by demersal trawling or other human activities. As such, the density of burrows was calculated per transect (standardised by transect length) at three stations where burrows were recorded in 2016. As a result of this burrow density analysis, the ‘Sea-pens and burrowing megafauna’ FOCI has been assigned to two stations surveyed in 2016 (SWSD263 and SWSD265) which had burrow densities of 1 and 7 per 10m^2 respectively. Data from previous surveys has allowed for identification of this FOCI (according to the

Robson 2014 criteria) at four locations in the north-west of the site; at Swallow Hole in 2014 and at three locations in the east of the site in 2012. Figure 22 shows the locations of all stations which have been classified as the ‘Sea-pens and burrowing megafauna’ FOCI.

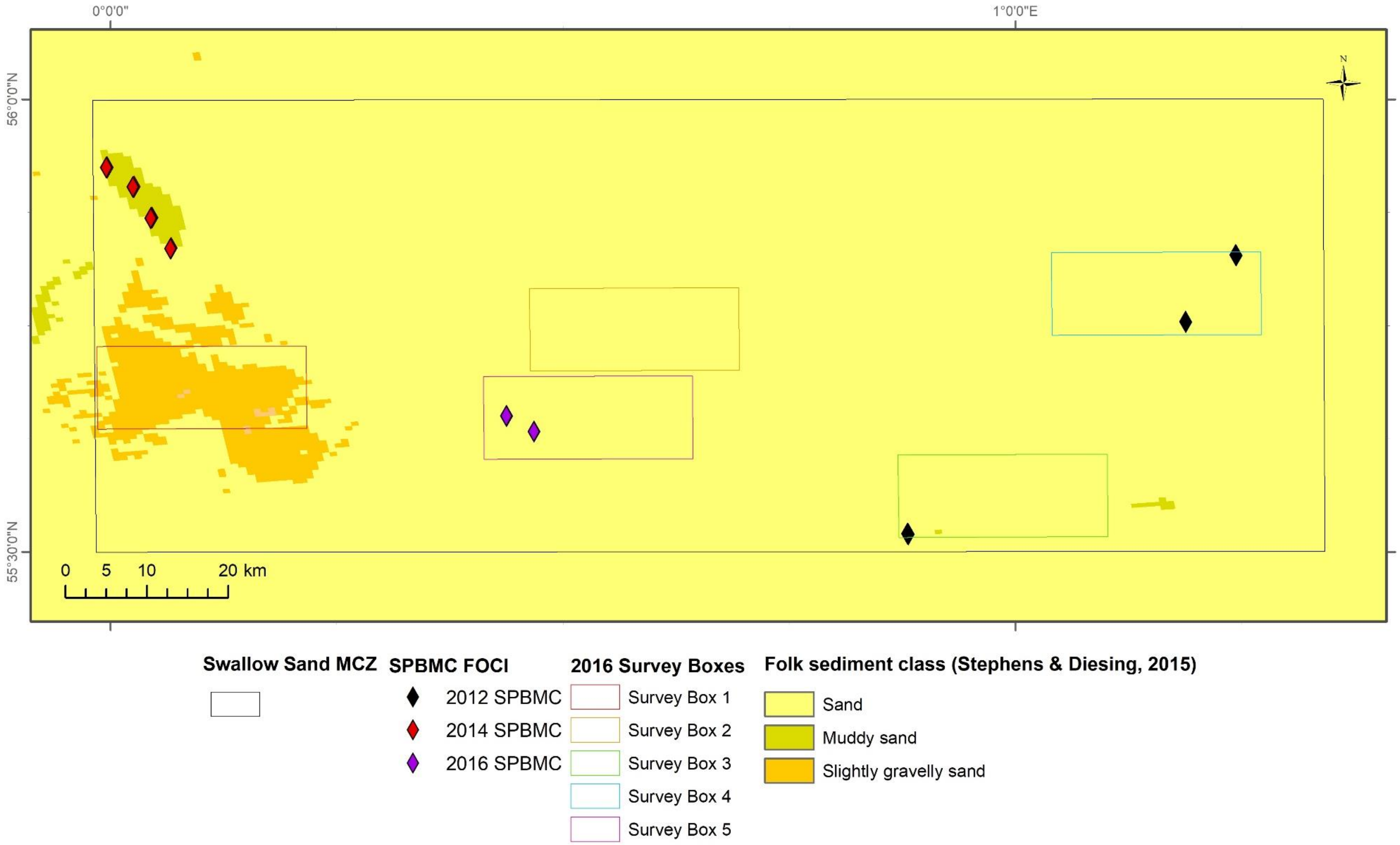

Figure 22. Location of the habitat FOCI 'Sea-pens and burrowing megafauna communities' (SPBMC) observed from 2012, 2014 and 2016 imagery, displayed over the 2015 Stephens and Diesing model (BGS-modified Folk; Long 2006).

3.6 Species Features of Conservation Importance (FOCI)

3.6.1 Ocean Quahog

No species FOCI are designated as features of the MCZ. However, the species FOCI 'Ocean quahog' (*Arctica islandica*) was recorded from 57 grab samples in 2016, having previously been recorded from 31 grab samples in 2012, and 40 grab samples in 2014. It should be noted, however, that targeted quantitative sampling of this species was not undertaken in any of these surveys (in terms of equipment used or sampling strategy). The abundance and distribution of *A. islandica* displayed in Figure 23 should therefore be considered an underestimate.

Although *A. islandica* were observed in samples from all four BSH, their relative abundance appeared to be higher in the muddy sediments of the Swallow Hole feature in the north-west of the site.

3.7 Non-indigenous species (NIS)

All taxa identified in grab and imagery samples collected in the 2012, 2014 and 2016 surveys were cross-referenced against a list of 49 non-indigenous target species which have been selected for assessment of GES in UK waters under MSFD Descriptor 2 (Stebbing *et al.* 2014) and a list of taxa identified in 'Non-native marine species in British waters: a review and directory' (Eno *et al*.1997; Annex 3).

The non-indigenous infaunal species *Goniadella gracilis*, was found to occur at low abundance within the site, with four individuals recorded in 2012 and one in 2016. Figure 24 shows the location of grab samples containing *G. gracilis*.

3.8 Marine litter

Two items of litter were observed on the seabed from 2016 imagery data. A piece of plastic fishing line (A5. Plastic fishing line - monofilament) was observed at one station in the south-east of the site, whilst an item appearing to be a piece of ceramic plate (D4. Glass/ceramics – other) was observed at a station in the centre of the site (see Figure 25).

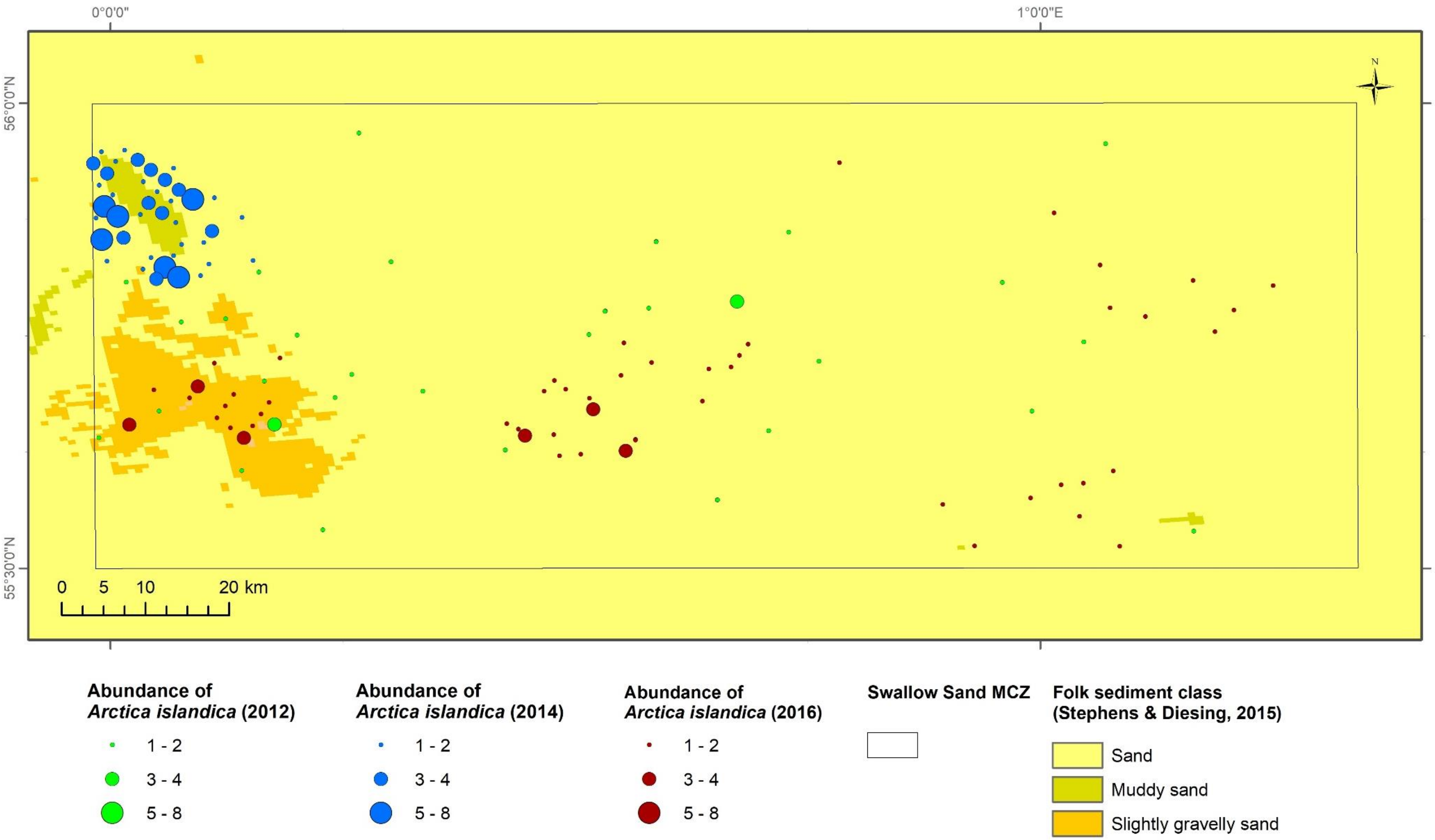

Figure 23. Distribution and abundance of species FOCI 'Ocean Quahog' *Arctica islandica* from 2012, 2014 and 2016 0.1m^2 Hamon grab samples, displayed over the 2015 Stephens and Diesing model (BGS-modified Folk; Long 2006).

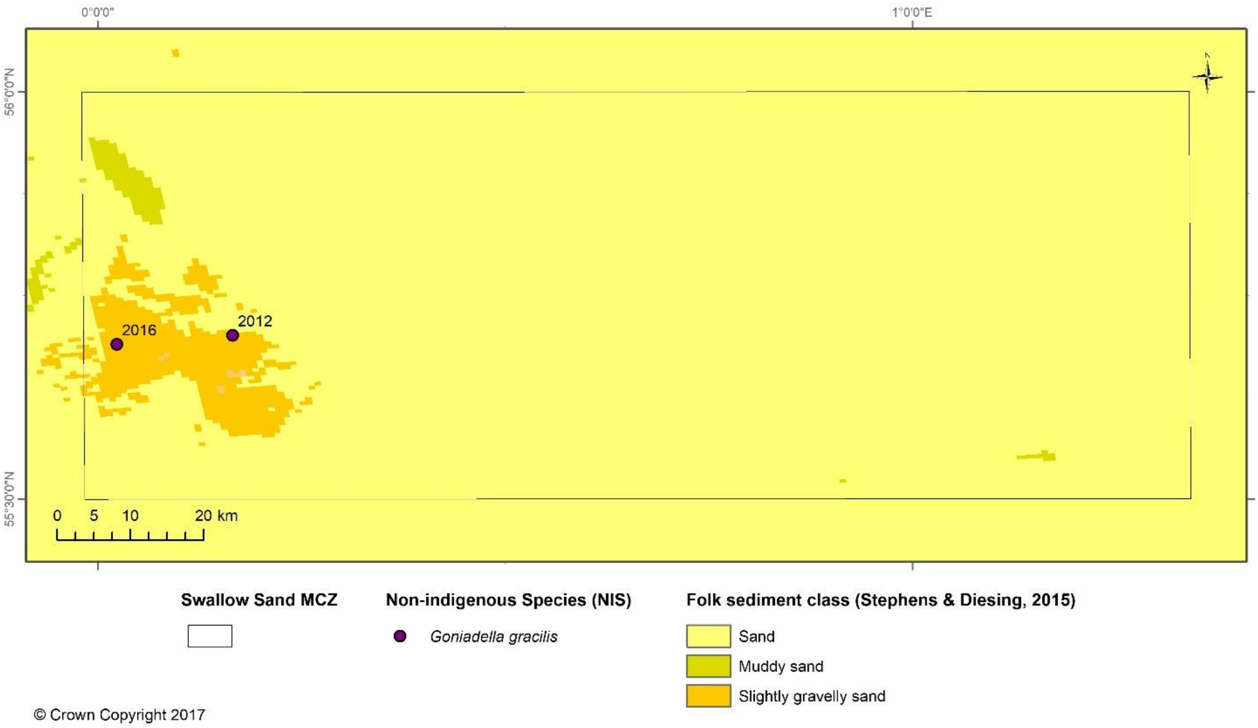

Figure 24. Location of 0.1m^2 Hamon grab samples containing the non-indigenous species *Goniadella gracilis,* displayed over the 2015 Stephens and Diesing model (BGS-modified Folk; Long 2006).

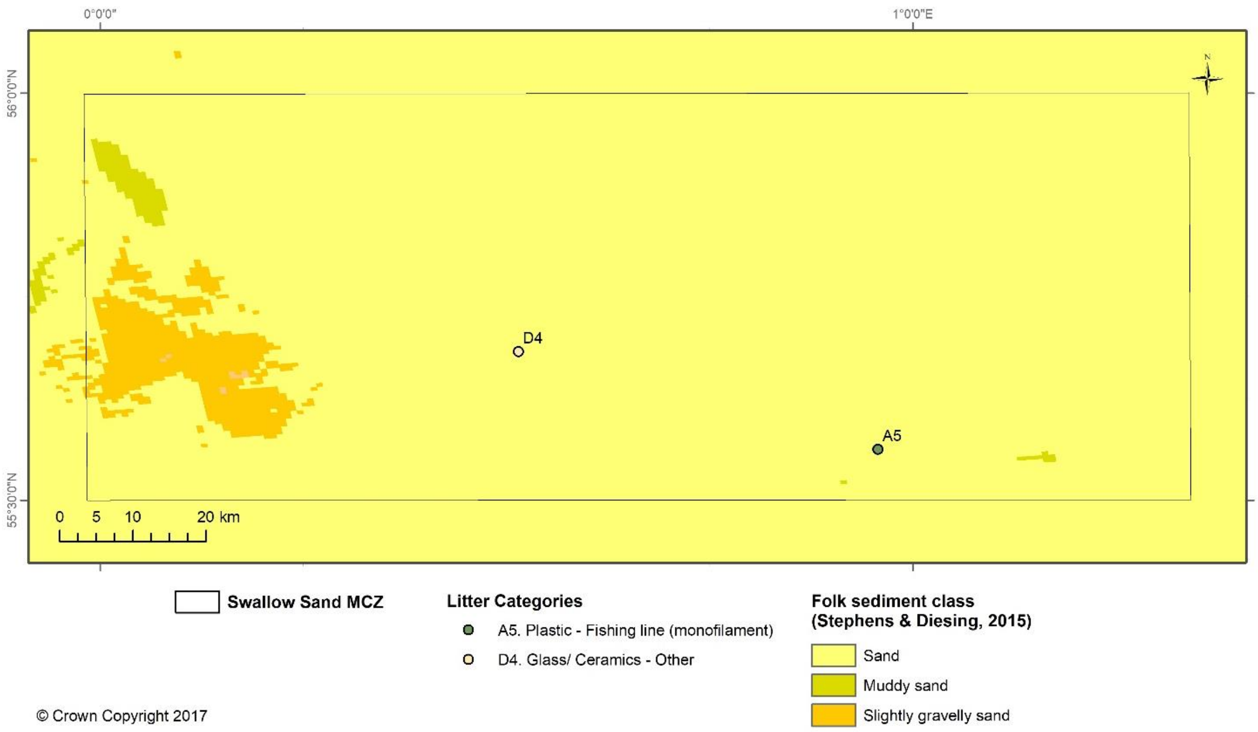

Figure 25. Items of marine litter observed from 2016 imagery data, displayed over the 2015 Stephens and Diesing model (BGS-modified Folk; Long 2006).

3.9 Observed anthropogenic activities and pressures

Parallel marks were observed in the 2016 MBES data, potentially created by demersal mobile fishing gear (Figure 26). Pipelines were also present within the site (Figure 27), and an unknown wreck was observed in survey box 3. The wreck was estimated to be 100m in length, 13m wide and 5m tall, with sediment scour pits noted along the starboard side (Figure 28).

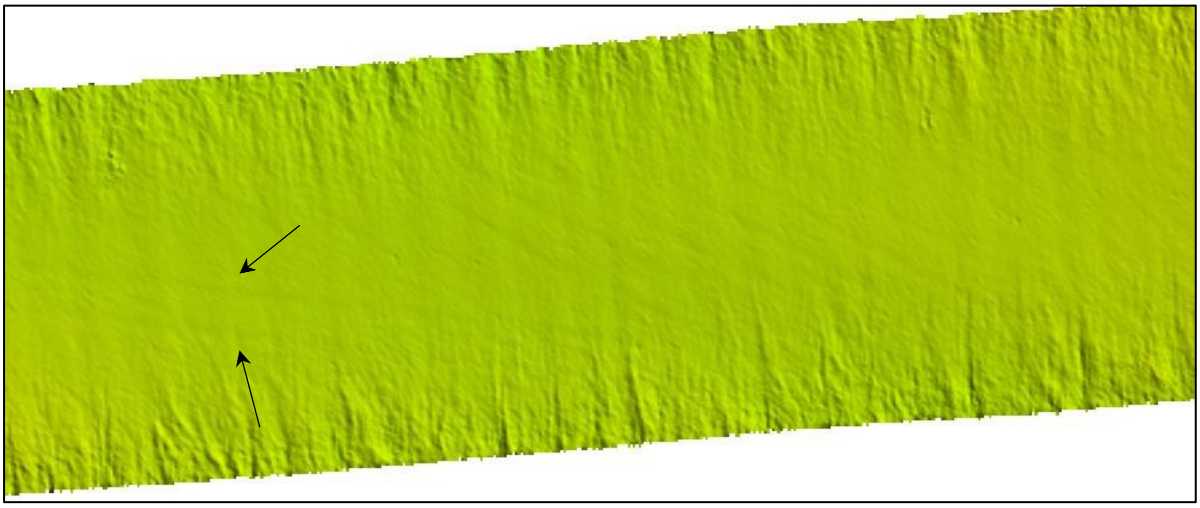

Figure 26. Linear 'trawl' marks on the seabed within survey box 3.

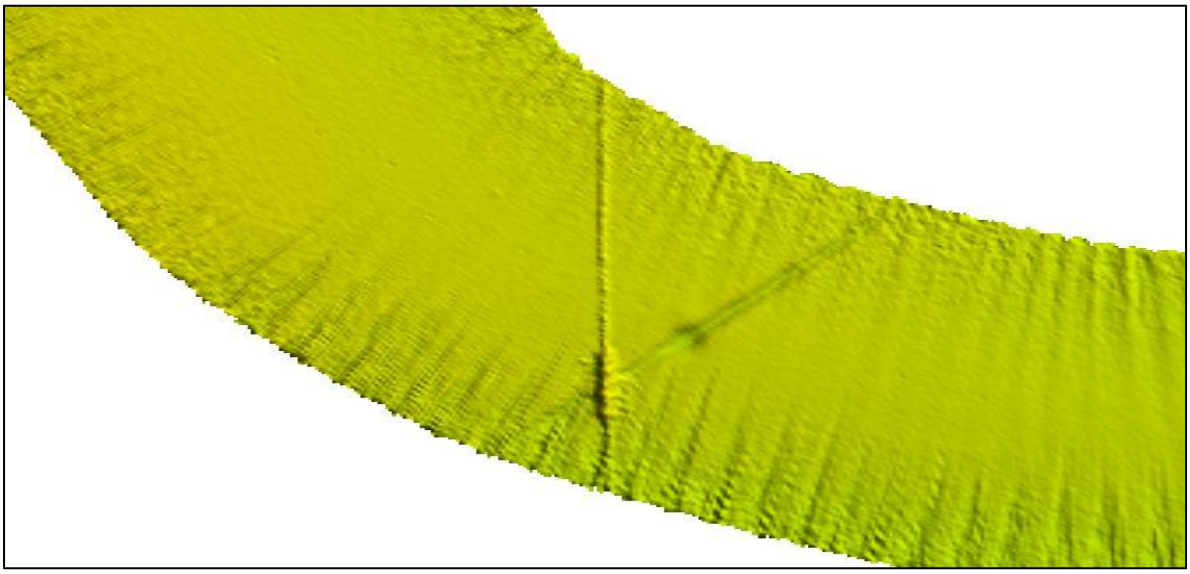

Figure 27. Pipelines observed crossing the seabed during the MBES survey of survey box 3.

Figure 28. Unknown wreck observed in survey box 3.

4. Discussion

4.1 Benthic environment and supporting processes (Objective 1)

The seabed within the Swallow Sand MCZ was more heterogeneous than previously indicated by the Stephens and Diesing (2015) habitat model. ‘A5.3 Subtidal mud’, ‘A5.4 Subtidal mixed sediment’ and ‘A5.1 Subtidal coarse sediment’ were more widely distributed than predicted, although the dominant BSH was confirmed as ‘A5.2 Subtidal sand’. ‘A5.1 Subtidal coarse sediment’ was generally confined to the western-most survey box (1), whilst ‘A5.4 Subtidal mixed sediments’ occurred in the western and central survey boxes (1, 2 and 5). ‘A5.3 Subtidal mud’ was recorded in the central and eastern boxes (2, 3, 4 and 5) and ‘A5.2 Subtidal sand’ occurred across the entire MCZ. The ‘A5.3 Subtidal mud’ observed in the central survey boxes (2 and 5) was associated with a newly discovered seabed feature, similar to the Swallow Hole feature in the north-east of the MCZ. This is thought to be a glacial tunnel valley, based on work undertaken in this area by Stewart *et al*. (2013). The overall distribution of BSH was not obviously attributable to the weak tidal regimes within the site, which showed little variation in current strength or direction across the site, despite variation in seabed depth.

4.2 Designated BSH feature attributes (Objectives 2 and 3)

4.2.1 Sediment composition

The 2016 grab samples were almost uniformly dominated by sand fractions, with a lower but consistently present proportion of mud. Gravel was also present at all stations; however, the proportion was negligible at the majority. The gravel component was notably increased in survey box 1 in the west of the site, with one station being dominated by it. Higher proportions were also noted in survey box 5 at the centre of the site.

Variation within each survey box and within each BSH class is high. As shown in Figure 8, the samples exist on a gradient with the sediment composition of some being more similar between BSH classes than within them. In places, stations classified as non-designated (i.e. those classified as ‘A5.3 Subtidal mud’ and ‘A5.4 Subtidal mixed sediments’) are extremely similar to those which as classified as designated features of the site (A5.1 Subtidal coarse sediment’ and A5.2 Subtidal sand’). This indicates that subtle changes within the sediment composition over time could result in a station being considered ‘non-designated’ in terms of the site features, when in fact no meaningful change had occurred.

Only one grab sample was acquired per station, therefore the degree of small-scale variation at each sampling station is unknown. The temporal comparisons of 2012 and 2016 data do, however, indicate that the broad particle size composition (corresponding to Entropy cluster groups) and BSH membership have remained reasonably stable though time. Given that small-scale variation is unquantified and that small changes in sediment composition can result in a change in BSH membership (with many samples existing close to the boundaries between classes) any change in BSH membership should not automatically be interpreted as meaningful in future assessments.

4.2.2 Extent and distribution

The 2016 sample data have substantially improved the known distribution of the designated BSH following the 2012 and 2014 surveys. As expected, ‘A5.2 Subtidal sand’ was ubiquitous across the site, being recorded from 58% of the 216 grab samples. ‘A5.1 Subtidal coarse sediment' was more widespread than predicted, being recorded from approximately a third of stations in survey box 1, and one station in survey box 3.

There was moderate agreement between the designated BSH recorded from 2016 data, both the Stephens and Diesing BGS-modified Folk and BSH models (2015; Figure 2 and Figure 3) and the BGS predictive habitat model (Lark 2014; Figure 4). Although some agreement was found with areas of coarse gravelly sediment and mud, none of the models accurately predicted the distribution of BSH across the site. All models underestimated the distribution of 'A5.1 Subtidal coarse sediment', 'A5.3 Subtidal mud' and 'A5.4 Subtidal mixed sediments' and overestimated 'A5.2 Subtidal sand'. This may be in part due to them being created using limited empirical groundtruth data (i.e. legacy PSA and low-resolution bathymetry data). Also, the resolution of the Stephens and Diesing model is limited due to its very large scale (having been produced for the entire UK continental shelf). The predictive models should therefore not be used for further sampling design or management decisions, unless considered alongside the new sediment data.

Given that the sediments exist on a gradient, and cannot be meaningfully differentiated along BSH boundaries, it is extremely unlikely that future acquisition of acoustic data would allow the extent of the designated BSH to be mapped with confidence. Extent should not therefore be pursued as an indicator of condition for this site. Continued monitoring of distribution will, however, give an indication of relative extent over time (within the constraints discussed in Section 4.2.1). Targeted acquisition of multibeam bathymetry data within areas of designated BSH known to have been underrepresented by the predictive models – notably the coarse sediments in survey box 1 – would be beneficial for informing future survey designs.

4.2.3 Biological communities

As expected, given the results of the PSA, multivariate analysis of the 2016 infaunal data showed a single broad community, with no clear differentiation between BSH. Although there was reasonable variation within the dataset (as evidenced by statistically significant groupings derived by cluster analysis and SIMPROF testing) the cluster groupings were found to be driven by variation in abundance and patchiness in distribution. Presence and absence of limited number of species were shown to contribute to dissimilarity between 'A5.1 Subtidal coarse sediment' and 'A5.3 Subtidal mud', however the majority of characterising taxa occurred across BSH. Ordinations of dissimilarity within the infaunal assemblage indicated some differentiation between the infaunal composition between survey box 1 and other survey boxes, as expected given the substantially higher gravel component within this box. Again, this differentiation was thought likely to represent a slight variant of the single broad assemblage observed within the site. No specific taxa or groups of taxa were identified as specific targets for future monitoring.

Qualitative comparison of 2012 and 2016 data suggested that infaunal assemblage composition was broadly comparable between the two survey years, with fluctuations in abundance of co-occurring taxa being responsible for variation observed. Further exploration of the data revealed that a change in the relative abundance of a single taxon (*Galathowenia oculata*) was sufficient to 'split' the multivariate community structure on the nMDS ordination. *G. oculata* is not known to indicate disturbance, therefore it is reasonable to assume that this abundance fluctuation is the result of natural variation over time. A number of the highest ranked taxa contributing to dissimilarity between years appeared to have declined in abundance since 2012 (although some increased). This is unlikely to indicate a general decline in condition, potentially being attributable to factors such as environmental conditions, recruitment and life cycles of the infauna, in addition to possible sampling artefacts.

The epifaunal analyses revealed no statistical differentiation in the sparse faunal assemblages. Just two taxa, the phosphorescent sea-pen *Pennatula phosphorea* and Polychaeta (tubes), had an overall median SACFOR abundance >0 and were uniformly distributed across the site. The conspicuous, abundant and widely distributed *P. phosphorea* shows potential as a condition indicator for the site (particularly for designated BSH 'A5.2 Subtidal sand', although the highest abundances were recorded in association with non-designated 'A5.3 Subtidal mud'), as there is some evidence that it may be sensitive to abrasion pressures such as demersal trawling (Murray *et al.* 2016). According to the OSPAR criteria (Table 3) this metric shows potential in terms of 'Accuracy', 'Simplicity', 'Spatial applicability' and 'Communication'. Further studies would be required to establish whether it would fulfil the 'Sensitivity', 'Specificity', 'Responsiveness', 'Management link' and 'Validity' criteria. It should be noted that if comparisons of the full epifaunal community are to be made for monitoring purposes, the combination of five still images per transect is unlikely to represent the true occurrence frequency, particularly for rare or sparsely distributed taxa. As shown in the epifaunal truncation (see Annex 2), a number of taxa present in the wider dataset were not captured in the sub-set extracted for statistical analysis. The number of still images acquired should therefore be increased, to ensure a higher number of good quality images for analysis.

When considering the overall impact of survey box membership on the dataset, the nMDS showed that biological communities broadly overlapped between all boxes, except survey box 1 (which was associated with higher occurrence of gravel, classifications of 'A5.1 Subtidal coarse sediment' and a slightly shallower area of seabed). This indicates that samples from box 1 should not be pooled with those from elsewhere in the site for future analyses.

4.3 Undesignated FOCI (Objective 4)

4.3.1 Habitat FOCI

No habitat FOCI have been designated as features of the Swallow Sand MCZ. However, data from the 2012, 2014 and 2016 surveys have highlighted the presence of the habitat FOCI 'Sea-pens and burrowing megafauna'.

Sea-pens and burrows were not fully quantified in this study, as the survey was not designed to assess burrow density in a quantitative manner. As such, the method outlined in Section 3.5.1 is the most robust method for assessment of this FOCI available, given the data limitations. The use of the semi-quantitative burrow to transect length ratio provides an indication of FOCI distribution across the MCZ. Two stations in 2016 were found to have the requisite density of burrows (1 and 7 burrows per $10m^2$) and were therefore assigned this FOCI, following guidance from Robson (2014).

Stations sampled in 2016 which have been assigned were associated with the sea-pen species *P. phosphorea*, however the presence of any sea-pen species does not implicitly result in the assignment of the FOCI.

According to the JNCC criteria (Robson 2014), the 'Sea-pens and burrowing megafauna' habitat FOCI was observed at nine stations across the three surveys. These observations include two stations sampled in 2016 (within survey box 5), three stations identified in the east of the site in 2012 (survey boxes 3 and 4), and four stations in 2014 (within the glacial tunnel valley Swallow Hole).

4.3.2 Species FOCI

No species FOCI are designated as features of the MCZ, as such the survey was not designed to target any specific FOCI. However, the species FOCI 'Ocean quahog' (*Arctica islandica*) was recorded in 31 grab samples in 2012, 40 grab samples in 2014 and 57 grab samples in 2016.

In total, 221 individuals were collected across the three survey years, with a maximum of eight individuals collected in a single grab sample. *Arctica islandica* were found in association with all four BSH although the highest abundances were associated with the Swallow Hole glacial tunnel valley, and the possible glacial tunnel valley feature located within survey boxes 2 and 5.

4.4 MSFD Descriptors (Objective 5)

4.4.1 Non-indigenous species

One non-indigenous species, the polychaete worm *Goniadella gracilis*, was identified at two stations, one sampled in 2012 and the other in 2016 (Figure 24).

4.4.2 Marine litter

Marine litter was observed in underwater images at two stations sampled in 2016. A piece of plastic fishing line was observed at a station in the south-east of the site, and an apparent piece of ceramic plate was recorded at a station in the centre of the site.

4.5 Anthropogenic activities (Objective 6)

The evidence acquired from this survey (demersal trawl marks, pipelines and a wreck) reflect the high levels of human activity occurring within the North Sea. It should be noted that this summary is qualitative only, and the survey was not designed to provide quantitative evidence on prevalence of human activities.

4.6 Recommendations for future monitoring (Objective 7)

The 2016 monitoring survey (in combination with the available previous data) has allowed a thorough characterisation of the Swallow Sand MCZ and provided evidence for evaluation of the monitoring approaches used.

The following recommendations are made in relation to future monitoring within the site:

- The 2016 data have illustrated that the distribution of BSH within the site is far more complex than indicated by the existing predictive habitat models, therefore the new sediment data should be used in conjunction with these predictive models for any future sampling design or management decisions
- Due to the large size of the MCZ, the resource-intensive nature of acoustic survey and the difficulty in discriminating the BSH from backscatter data, a full acoustic survey of the site and production of a full-site habitat map from acoustic data is unlikely to be cost-effective or to provide a robust means of monitoring extent of the designated BSH. It will therefore not be possible to monitor the full extent of the BSH at the site level.
- Although a full-scale habitat map for the site is unlikely to be feasible, additional MBES data could be acquired within survey box 1, which may improve delineation of the area of high gravel content 'A5.1 Subtidal coarse sediment'. This sediment is likely to be

more easily distinguishable from backscatter data than soft sediments, due to higher reflectance, and is already partially represented in the Stephens and Diesing and BGS models.

- In the absence of a reliable habitat map or model, future sampling for the two designated BSH should be targeted towards areas where their presence was confirmed by the 2016 samples (e.g. survey box 1 for ‘A5.1 Subtidal coarse sediment’ and specific areas of the other survey boxes for ‘A5.2 Subtidal sand’).
- Given the unknown composition of the seabed throughout the majority of the MCZ, future sampling should be continued within the 2016 sampling boxes, although it is noted that not all boxes or all stations will necessarily be revisited. Sampling stations could remain fixed or be re-randomised, although fixing stations would provide a more accurate means of targeting the designated features given the demonstrated variability in sediment composition (and BSH) within survey boxes.
- Additional stations should be located within survey box 1 to better sample the ‘A5.1 Subtidal coarse sediment’ feature.
- Given the notable occurrence of undesignated features in some boxes (e.g. A5.3 Subtidal mud and A5.4 Subtidal mixed sediments in boxes 2 and 5), future surveys could consider exploring other areas (e.g. in the north of the site), to position new boxes with a higher incidence of designated features.
- If possible, multiple replicates should be acquired per station. This would control for (and allow assessment of) small-scale within-station small-scale variability, providing greater context on the natural variability of the sediments and increasing the robustness with which assessments of condition can be made.
- The overall recorded epifaunal assemblage appeared to be sparse and did not appear likely to provide robust evidence for assessing change over time. Based on the current (albeit limited) data for this BSH, enumeration of the full epifaunal assemblage is not thought to represent a cost-effective approach to monitoring the designated features.
- Density of the phosphorescent sea-pen, *P. phosphorea,* should be considered for development as a potential indicator of condition within the site. Further studies should be conducted to establish whether it would fulfil the ‘Sensitivity’, ‘Specificity’, ‘Responsiveness’, ‘Management link’ and ‘Validity’ indicator criteria specified by OSPAR (Table 3). Future surveys should target sea-pens to allow a quantitative comparison of density through time, using video data with a standardised field of view, analysed to a standard video segment length.
- The SACO for the site lists nutrition as a key ‘function’ feature attribute (JNCC 2018a). If this feature attribute was determined to be a priority for future monitoring surveys, the abundance and distribution of key taxa such as the Norway lobster (*N. norvegicus*), and sand eel species, amongst others, could be quantitatively sampled using appropriate methods. Secondary productivity could be monitored across the site with repeated acquisition of biomass data for both infauna and epifauna. Biomass data for epifauna could be acquired using scientific beam trawls, although the benefits of bottom-contacting methods must be assessed against the potential for damage to the designated features of the site.
- Climate regulation is also listed as a key ‘function’ feature attribute. Future surveys could assess the role of the sedimentary habitats in providing a long-term sink for carbon. If this is a priority total organic carbon (TOC) should be measured from grab samples.
- Marine litter was recorded from seabed imagery data only. If required, further evidence on this MSFD Descriptor could be derived by analysing sediment sub-samples for microplastics.

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6. Annex 1. Infauna data truncation protocol

Raw taxon abundance and biomass matrices can often contain entries that include the same taxa recorded differently, erroneously or differentiated according to unorthodox, subjective criteria. Therefore, ahead of analysis, data are checked and truncated to ensure that each row represents a legitimate taxon and they are consistently recorded within the dataset. An artificially inflated taxon list (i.e. one that has not had spurious entries removed) risks distorting patterns in assemblage structure.

Some taxa may require merging to a level in the taxonomic hierarchy that is higher than the level at which they were identified. In such situations, a compromise must be reached between the level of information lost by discarding recorded detail on a taxon's identity and the potential for error in analyses, results and interpretation if that detail is retained.

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

- If abundance was reported to genus as well as at species level, and within a sample both the genus and at least one other species occurs, the genus was treated as a different taxon (i.e. do not truncate to genus level).
- If abundance was reported to genus as well as at species level, but within each sample there was only one occurrence of either, the sample data were combined to the genus level.
- Taxa are often assigned as 'juveniles' during the identification stage with little evidence for their actual reproductive natural history (except some well-studied molluscs and commercial species). Many truncation methods involve the removal of all 'juveniles.' However, a decision must be made on whether removal of all juveniles from the dataset is appropriate, or whether they should be combined with the adults of the same species where present. In this instance, where 'juvenile' records were recorded at the same taxonomic level as 'adult' records the two records were combined, whereas if juveniles were recorded at a higher taxonomic level than adults then the 'juvenile' records were removed to avoid having to reduce the taxonomic resolution of the 'adult' records.
- Records of meiofauna (i.e. nematodes) were removed.
- Records of fish species were removed.

The same approach was applied to the truncation of the temporal comparison data set (2012 and 2016), however additional stages were incorporated to ensure that taxon name changes were accounted for. The full protocol is displayed in below.

Infaunal truncation protocol for merged 2012 and 2016 data.

Step	Action
1	**2012 data extracted from Unicorn and import error name changes reverted to correct (WoRMS) name. 2016 merged with 2012 using PRIMER merge tool**
2	**All merged data put through WoRMS name check and exported - see 'Species classification info_All'**
	CANNOT IMPORT - ERRORS LOGGED
	The following taxa or Qualifiers failed validation:
	Taxon: Astrorhizidae "type 3" = Astrorhizidae 3
	Taxon: FILIFERA = ANTHOATHECATA
	Taxon: *Phyllodoce groenlandica = Anaitides groenlandica*
	Taxon: *Oxydromus flexuosus = Ophiodromus flexuosus*
	Taxon: *Parexogone hebes = Exogone hebes*
	Taxon: *Lumbrineris aniara/cingulata = Lumbrineris cingulata*
	Taxon: *Pseudopolydora* cf. *paucibranchiata = Pseudopolydora paucibranchiata*
	Taxon: *Mediomastus pilis = Mediomastus fragilis*
	Taxon: *Pterolysippe vanelli = Eclysippe vanelli*
	Taxon: *Terebellides stroemii = Terebellides stroemi*
	Taxon: *Pontocrates* "species B" = *Pontocrates* 2
	Taxon: *Astacilla dilatata = Arcturella dilatata*
	Taxon: *Araphura brevimanus = Araphura brevimana*
	Taxon: *Hemilamprops roseus = Hemilamprops rosea*
	Taxon: MESOGASTROPODA = added to GASTROPODA
	Taxon: *Melanella polita = Polygireulima polita*
	Taxon: *Curtitoma trevelliana = Oenopota trevelliana*
	Taxon: *Thyasira biplicata = Thyasira polygona*
	Taxon: CAMARODONTA = ECHINOIDEA
	Taxon: *Oestergrenia digitata = Labidoplax digitata*
3	'All' data name ordering - data ordered on hierachy-alphabetical
4	All names checked against WoRMS list and corrected. Inappropriate taxa removed. Obvious merges (nomenclature between lists) highlighted. Final name decided
5	All P converted to 1 and highlighted yellow in 'All Abundance' tab. All fragments changed to '0' and highlighted red; not removed from biomass
6	Truncation 1 completed to all Trunc.1 tabs. Red deleted. Orange merged by inserting row below and summing the contents above an over righting the 1st record
7	Truncation 2
8	If abundance is reported to genus as well as at species level and within a sample, both the genus and at least one other species occurs, then the genus is treated as a different species (i.e. do not truncate everything to genus level).
9	If abundance is reported to genus as well as at species level, but within each sample there is only one occurrence of either, then the sample data are combined to the genus level.
10	Case-by-case treatment:

	Nephtys, Cirratulus, Ascidiacea, Spatangoida, Cucumariidae, Amphiuridae, Astartidae, M*odiolus*, *Spisula*, – removed in accordance with 2016 data procedure.
	Sthenelais - Merged with *Sthenelais limicola*
	Owenia - merged with *Owenia fusiformis*
	Jasmineira - merged with *Jasmineira caudata* as most abundant
	Apistobranchus tullbergi - merged with *Apistobranchus* as this id dominant. Probable difference between contractors
	Laonice - merged with *Laonice sarsi*. Only 1 counted
	Aphelochaeta and *Aphelochaeta* "species A" kept separately. Possible difference between contractors
	Chaetozone - added to *Chaetozone zetlandica* as this is dominant. Only 1 counted
	Cirratulus - could not split. 3 species listed
	Terebellides - added to *Terebellides stroemii*. Only 1 counted
	Ampelisca - Left as is as only 3 counted and 8 species listed
	Cheirocratus - 3 species listed so could not split. Left as is
	Pontocrates (Type A) and *Pontocrates* (Type B) left in
	Diastylis - 5 species listed so could not split. Only 1 counted, left as is
	Astacilla dilatata - merged with *Astacilla*
	Gnathia oxyuraea - merged with *Gnathia*
	Nebaliidae - *Sarsinebalia typhlops* and *Sarsinebalia* merged with Nebaliidae
	Sagittidae - merged with Chaetognatha
	Edwardsia claparedii - merged with Edwardsiidae
	Camarodonta - merged with Echinidea
	Thyasira - merged with *Thyasira flexuosa* as most abundant
	Dosinia - merged with *Dosinia lupinus*
	Thracia - merged with *Thracia phaseolina*. Only 1 counted
11	*Arctica islandica* - on 2016 cruise specimens found in samples were removed, measured and put over the side. These have been added back into the data - only for abundance

7. Annex 2. Epifaunal data standardisation and truncation protocol

The 2016 epifauna were truncated for the imagery sub-set used for statistical analysis, with due consideration of each truncation in terms of taxon abundance and implications for the dataset (see below). Truncation actions are colour coded as per the key given.

All epifaunal taxa recorded in 2016, highlighted by truncation action type.

Taxon	Notes
Nephrops burrows	Removed - not epifauna
Egg mass	Removed - not epifauna
U. faunal turf	
Porifera	Removed - present in wider data but not sub-set.
Suberites	Removed - present in wider data but not sub-set.
Hydrozoa	
Hydractinia echinata	Removed - too small for reliable ID
Abietinaria abietina	Not merged with Hydrozoa as distinctive
Nemertesia antennina	Removed - present in wider data but not sub-set.
Nemertesia ramosa	Removed - present in wider data but not sub-set.
Anthozoa	Removed - present in wider data but not sub-set.
Alcyonium digitatum	
Pennatulacea	Removed - present in wider data but not sub-set.
Pennatula phosphorea	
Zoantharia	
Actiniaria	
Urticina eques	Not merged with Actiniaria as visually distinctive
Hormathiidae	Removed - present in wider data but not sub-set.
Polychaeta	
Polychaeta	Removed - present in wider data but not sub-set.
Aphrodita aculeata	
Oxydromus flexuosus	
Hyalinoecia	
Ditrupa arietina	
Serpulidae (encrusting)	
Decapoda	Removed - resolution too high
Caridea	Removed - present in wider data but not sub-set.
Paguridae	
Maja brachydactyla	Removed - present in wider data but not sub-set.
Gastropoda	Removed - present in wider data but not sub-set.
Buccinidae	Removed - present in wider data but not sub-set.
Buccinum undatum	Removed - present in wider data but not sub-set.
Scaphander lignarius	
Nudibranchia	
Janolus cristatus	Not merged with Nudibranchia as visually distinctive.
Pectinidae	
Aequipecten opercularis	Removed - present in wider data but not sub-set.

Sepiola atlantica	Removed - cephalopod
Eledone cirrhosa	Removed - cephalopod
Bryozoa (encrusting)	
Bryozoa	Removed - present in wider data but not sub-set.
Alcyonidium diaphanum	
Asteroidea	Merged - unclear whether juvenile from imagery
Asteroidea (juv.)	
Asterias rubens	Merged with Asteroidea - unclear whether other Asteroidea are Asterias.
Luidia ciliaris	Removed - present in wider data but not sub-set.
Astropecten irregularis	Removed - present in wider data but not sub-set.
Solaster endeca	Removed - present in wider data but not sub-set.
Crossaster papposus	Removed - present in wider data but not sub-set.
Stichastrella rosea	Removed - present in wider data but not sub-set.
Ophiura	Removed - present in wider data but not sub-set.
Ophiocten affinis	
Echinoidea	Removed - resolution too high
Gracilechinus acutus	
Spatangoida	
Spatangus purpureus	
Holothuroidea	Removed - present in wider data but not sub-set.
Psolus phantapus	Removed - present in wider data but not sub-set.
ASCIDIACEA	Removed - present in wider data but not sub-set.
Myxine glutinosa	Remove - fish
Rajidae	Remove - fish
TELEOSTEI	Remove - fish
Lophius piscatorius	Remove - fish
Callionymus	Remove - fish
Pleuronectiformes	Remove - fish
Microstomus kitt	Remove - fish
Pleuronectes platessa	Remove - fish

Epifaunal truncation action key.

Step	Colour and Taxa	Rationale
1	Taxa not in image sub-set	Taxa present in wider dataset, but not the five image sub-set.
2	All fish, cephalopods and eggs, plus selected fauna.	Removed - mobile species or irrelevant to report objectives.
2	Very high-resolution taxa (e.g. Anthozoa)	High generality and overlapping nature of classification.
3	Asteroidea juv. and *Asterias rubens* merged with Asteroidea	Juvenile status unclear, also unclear whether '*Asterias rubens*' distinct from 'Asteroidea'.

8. Annex 3. Non-indigenous species

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

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)**
Thalassiosira punctigera	
Thalassiosira tealata	
Coscinodiscus wailesii	
Odontella sinensis	
Pleurosigma simonsenii	
Grateloupia doryphora	
Grateloupia filicina var. luxurians	*Grateloupia subpectinata*
Pikea californica	
Agardhiella subulata	
Solieria chordalis	
Antithamnionella spirographidis	
Antithamnionella ternifolia	
Polysiphonia harveyi	*Neosiphonia harveyi*
Colpomenia peregrine	
Codium fragile subsp. Atlanticum	
Codium fragile subsp. tomentosoides	*Codium fragile* subsp. *atlanticum*
Gonionemus vertens	
Clavopsella navis	*Pachycordyle navis*
Anguillicoloides crassus	
Goniadella gracilis	
Marenzelleria viridis	
Clymenella torquata	
Hydroides dianthus	
Hydroides ezoensis	
Janua brasiliensis	
Pileolaria berkeleyana	
Ammothea hilgendorfi	
Elminius modestus	*Austrominius modestus*
Eusarsiella zostericola	
Corophium sextonae	
Rhithropanopeus harrissii	

Species name (1997)	**Updated name (2017)**
Potamopyrgus antipodarum	
Tiostrea lutaria	*Tiostrea chilensis*
Mercenaria mercenaria	
Petricola pholadiformis	
Mya arenaria	

9. Annex 4. Marine litter

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

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: ≤ 5*5 cm = 25 cm^2
B: ≤ 10*10 cm = 100 cm^2
C: ≤ 20*20 cm = 400 cm^2
D: ≤ 50*50 cm = 2500 cm^2
E: ≤ 100*100 cm = 10000 cm^2
F: ≥ 100*100 cm = 10000 cm^2

10. Annex 5. Acknowledgement

Swallow Sand
Marine Conservation Zone (MCZ)
Monitoring Report 2016

MPA Monitoring Programme

Contract Reference: MB0129

Report Number: 14

Version 3

January 2020

Marine Protected Areas Survey Coordination & Evidence Delivery Group

This work was delivered by Cefas and JNCC on behalf of the Marine Protected Areas Survey Coordination & Evidence Delivery Group (MPAG) and sponsored by Defra. MPAG was established in November 2012 and continued until March 2020. MPAG, was originally established to deliver evidence for Marine Conservation Zones (MCZs) recommended for designation. In 2016, the programme of work was refocused towards delivering the evolving requirements for Marine Protected Area (MPA) data and evidence gathering to inform the assessment of the condition of designated sites and features by SNCBs, in order to inform Secretary of State reporting to Parliament. MPAG was primarily comprised of members from Defra and its delivery bodies which have MPA evidence and monitoring budgets and/or survey capability. Members included representatives from Defra, JNCC, Natural England, Cefas, the Environment Agency, the Inshore Fisheries Conservation Authorities (IFCAs) and the Marine Management Organisation (MMO)).

Since 2010, offshore MPA surveys and associated reporting have been delivered by JNCC and Cefas through a JNCC\Cefas Partnership Agreement (which remained the vehicle for delivering the offshore survey work funded by MPAG between 2012 and 2020).

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