Dover to Deal Marine Conservation Zone (MCZ) Characterisation Report 2016

MPA Monitoring Programme

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Foreword

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

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Executive Summary

This report is one of a series of Marine Protected Area (MPA) characterisation and monitoring reports delivered to Defra by the Marine Protected Areas 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 relation to current policy instruments, including the Oslo-Paris (OSPAR), the UK Marine & Coastal Act (2009) and other relevant Directives (e.g., Marine Strategy Framework Directive). This characterisation report is informed by data acquired during a dedicated Day grab survey carried out within the Dover to Deal Marine Conservation Zone (MCZ) in 2016 and will form part of the ongoing time series data and evidence for this MPA.

Dover to Deal MCZ is an inshore site, covering a 10 km^2 area, adjacent to the Kent coast. This report provides a characterisation of the subtidal sedimentary Broadscale Habitats (BSHs) 'A5.2 Subtidal sand' and 'A5.4 Subtidal mixed sediments', designated within the MCZ. The site was surveyed between the 17^{th} and 25^{th} August 2016.

The survey reconfirms confirms the presence of 'A5.4 Subtidal mixed sediments' across the site, but the previously recorded sand habitats in the east of the MCZ had changed composition and were assigned as 'A5.3 Subtidal mud'. This BSH had a significantly lower taxa richness and abundance of infauna species than the dominant 'A5.4 Subtidal mixed sediments'.

There was a minimal difference in the infauna communities sampled inside and outside the MCZ, and overall the infauna were considered to be ecologically healthy, supported by generally low contaminant measurements across most of the MCZ. However, the 'A5.4 Subtidal mixed sediment' communities had significantly changed in structure since the 2012 verification survey. This was predominately due to an increase in the abundance of the tube-building amphipod *Ampelisca diadema* and biogenic reef-building polychaete *Sabellaria spinulosa* since 2012. This was reflected in assignment of the biotope SS.SBR.PoR.SspiMx (*Sabellaria spinulosa* on stable circalittoral mixed sediment) in all but one sample of 'A5.4 Subtidal mixed sediments' inside the MCZ. At most stations *S. spinulosa* was observed as small-scale 'crusts' but at two stations to the north of the MCZ more extensive 'tube-like' structures were observed. Although the MCZ is designated for Native oyster (*Ostrea edulis*), no specimens were recovered in this survey. A tailored dive survey is recommended to detail the distribution of oysters across the MCZ.

Future surveys could also consider using alternative sampling methods – a freshwater lens camera could provide viable results in a site at which the visibility is unpredictable. Similarly, a Hamon grab could be used as an alternative to the Day grab to sample coarser areas of sediment.

1 Introduction

Dover to Deal Marine Conservation Zone (MCZ) is part of a network of sites designed to meet conservation objectives under the Marine and Coastal Access Act (2009). These sites 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 & 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 inshore (between 0 nm and 12 nm from the coast) is Natural England (NE) and the SNCB responsible for nature conservation offshore (between 12 nm and 200 nm 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 characterisation report primarily explores data acquired from the first dedicated monitoring survey of Dover to Deal MCZ, which will form the initial point in a monitoring time series against which feature (and site) condition can be assessed in the future. The specific aims of the report are detailed in Section 1.1.3.

1.1 Site overview

Dover to Deal MCZ is an inshore site, covering a 10.4 km^2 area, adjacent to the Kent coast (Figure 1). The site extends from the East Dover Harbour wall to almost Deal further north. The MCZ was proposed by the Balanced Seas regional stakeholder project (Balanced Seas, 2011) and designated in January 2016. The site is neighboured by Dover to Folkestone MCZ to the south (Figure 1: Location of the Dover to Deal MCZ in the context of Marine Protected Areas and management jurisdictions proximal to the site., and sits within Kent and Essex Inshore Fisheries and Conservation Authority (KEIFCA) district and the 'Kent South' Water Framework Directive (WFD) waterbody. There is a single WFD and Environmental Quality Standards Directive (EQSD) sampling station outside the site, and a Bathing Waters sampling station within the site at St Margaret's Bay (Figure 1). At the time of writing, there were no byelaws in place restricting fishing activity within the site, although inshore sightings maps show there is some low intensity mobile and static gear fishing taking place over and close to the site (Vanstaen and Breen, 2014).

The west of the site sits within the Dover Harbour Authority area. The Dover dredge disposal site is to the southwest of the site, just south of the Dover harbour entrance.

Due to the proximity of the site to the port, the western end of the site is subject to high levels of shipping passaging over or close to the site, with an estimated annual average of >10,000 vessels passaging over the western site boundary. This decreases to an annual average of up to 200 vessels in the north east of the site at Deal (MMO, 2014). A historic subsea telegraph cable passes through the site and makes landfall at St Margaret's Bay (Figure 1).

The Dover to Deal MCZ extends ca. 1 km from the shoreline, ranging from the intertidal to a water depth of ca. 50 m below chart datum. Erosion of the chalk cliffs in the area, has created boulders and flat areas at the base of the cliffs that supports unique seaweed and animal communities, with the chalk foreshore at St Margaret's Bay having one of the richest algal communities in the area (Dover to Deal MCZ Factsheet, 2016). This site is one of only a few sites designated to protect intertidal underboulder communities in the UK MPA network. These boulders provide shaded areas which offer refuge to sea squirts, sea mats, and sponges. The undersides of these boulders provide habitats for animals like sea slugs, long-clawed porcelain crabs and brittlestars, which shelter and feed in the damp shaded conditions. Crabs, fish and young lobsters also scavenge for food and seek shelter amongst the boulders. The site also includes archetypes of unique littoral chalk communities of seaweeds and associated fauna. The area also includes regional exemplars of wave-cut platforms - planar intertidal surfaces formed by wave erosion of the bedrock. Below these platforms lie gullies and rock pools, which support several types of seaweed.

The site was designated in January 2016 owing to the presence of high quality habitats. The Dover to Deal MCZ designation order[1] protects several Broadscale Habitats (BSH), habitat Features Of Conservation Importance (FOCI) and a single species FOCI in accordance with a General Management Approach (GMA) which applies to each protected feature (Table 1: Dover to Deal MCZ site overview, including General Management Approach (GMA) for designated features.). A further two BSH and two habitat FOCI were added to the designated features as part of the third tranche of designations in May 2019 (Table 1: Dover to Deal MCZ site overview, including General Management Approach (GMA) for designated features.).

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[1] Dover to Deal Marine Conservation Zone Designation Order 2016 : http://www.legislation.gov.uk/ukmo/2016/5/contents/created

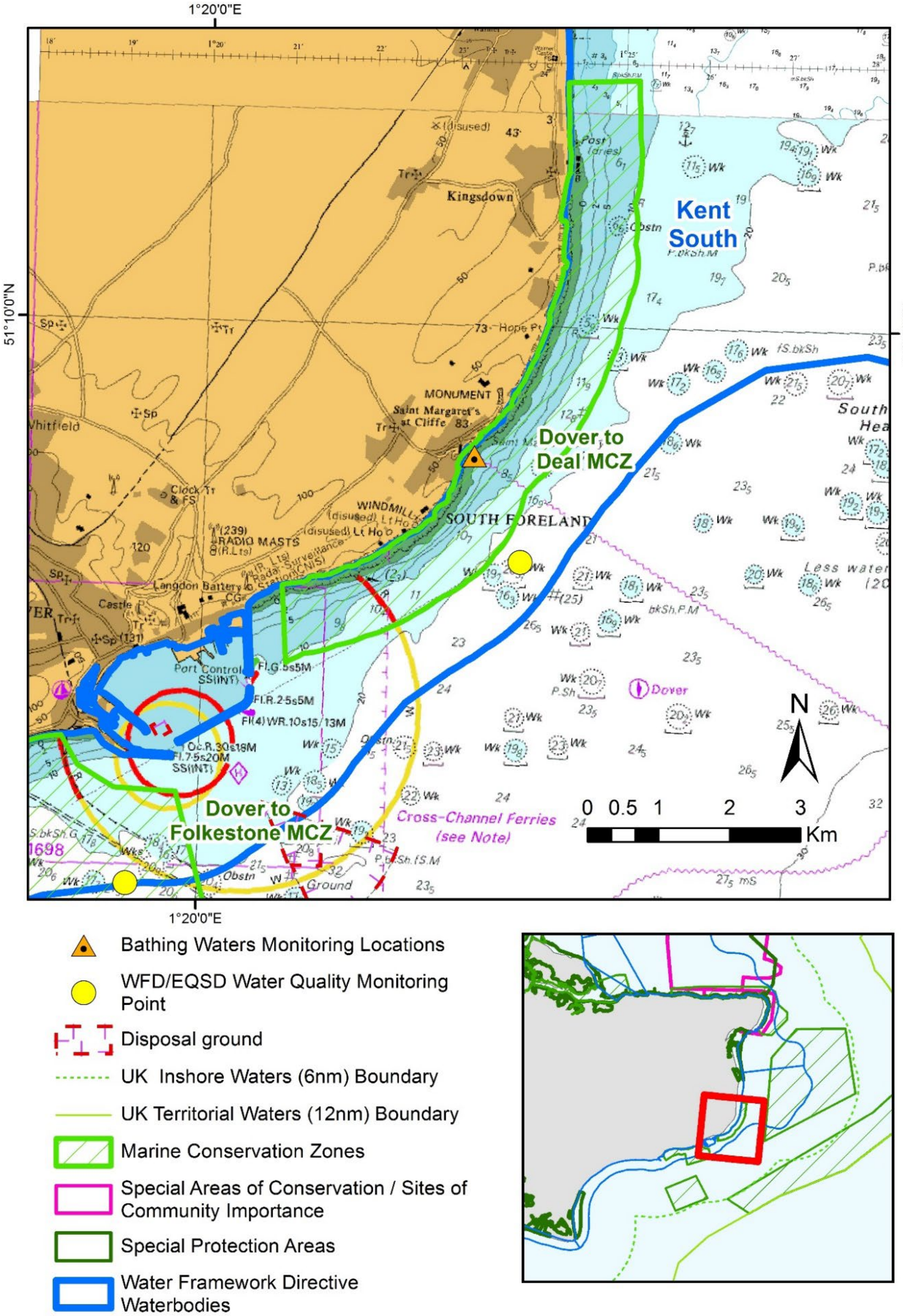

Figure 1. Location of the Dover to Deal MCZ in the context of Marine Protected Areas and management jurisdictions proximal to the site. EQSD = Environmental Quality Standards Directive. Contains information from the Ordnance Survey Crown

Table 1. Dover to Deal MCZ site overview, including General Management Approach (GMA) for designated features (© Natural England and Environment Agency 2022). Some cells left intentionally blank.

Site Details		
Charting Progress 2 Region[2]	Eastern Channel	
Spatial Area (km^2)	10.4	
Water Depth Range (m)	0-50	
Existing Data & Information	**Godsell, N., Meakins, B., Fraser, M. and Jones, N.** (2013) Dover to Deal rMCZ Survey Report. 50 pp. **Fraser, M. and Easter, J (2017)** Dover to Deal MCZ 2016 Baseline Survey Report. 94pp	
Current & Proposed Management Measures	None	
Features Present (BSH)	**Designated**	**GMA**
A1.1 High energy intertidal rock*	**Yes**	Maintain
A1.2 Moderate energy intertidal rock*	**Yes**	Maintain
A1.3 Low energy intertidal rock*	**Yes**	Maintain
A2.1 Intertidal coarse sediment*	**Yes**	Maintain
A2.2 Intertidal sand and muddy sand*	**Yes**	Maintain
A3.2 Moderate energy infralittoral rock	**Yes**	Maintain
A4.1 High energy circalittoral rock	Yes (May 2019)	Recover
A4.2 Moderate energy circalittoral rock	Yes (May 2019)	Recover
A5.1 Subtidal coarse sediment	**No**	N/A
A5.2 Subtidal sand	**Yes**	Maintain
A5.3 Subtidal mud	**No**	N/A
A5.4 Subtidal mixed sediments	**Yes**	Maintain
Features Present (Habitat FOCI)		
Blue Mussel Beds	**Yes** (May 2019)	Recover
Intertidal Underboulder Communities	**Yes**	Maintain
Littoral Chalk Communities	**Yes**	Maintain
Ross Worm (*Sabellaria spinulosa*) Reefs	**Yes** (May 2019)	Recover
Subtidal Chalk	**Yes**	Maintain
Features Present (Species FOCI)		
Native Oyster (*Ostrea edulis*)**	**Yes**	Maintain

** The characterisation survey reported here did not extend into the intertidal.*

***The characterisation survey was not specifically designed to target species FOCI.*

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

1.1.1 High-level conservation objectives

High-level site-specific conservation objectives serve as benchmarks against which the efficacy of the GMA in achieving the conservation objectives (i.e., maintaining designated features at, or recovering them to, 'favourable condition') can be assessed and monitored.

As detailed in the Dover to Deal MCZ designation order[1], the conservation objectives for the site are that the designated features:

a) So far as already in favourable condition, remain in such condition; and

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

It should be noted that the 'maintain' GMAs have been applied based on a proxy assessment, as opposed to being based on empirical monitoring evidence (i.e., direct observations). As such, the vulnerability assessment took into account the level of exposure of the features to those pressures to which they are perceived to be sensitive.

1.1.2 Definition of favourable condition

For habitat features, a number of attributes[3] are assessed and monitored to determine whether or not features are in favourable condition.

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

a) Its extent and distribution is 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 sedimentary 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).

The assessment and monitoring of extent is only appropriate for those features with a discrete boundary, which are likely to be affected by pressures that can be regulated as part of the management approach. Examples of such features are,

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[3] Dover to Deal MCZ Conservation Advice Package : https://designatedsites.naturalengland.org.uk/Marine/MarineSiteDetail.aspx?SiteCode=UKMCZ0032&SiteName=dover&countyCode=&responsiblePerson=&SeaArea=&IFCAArea=

among others, biogenic reefs and maerl beds. The spatial extent of most Broadscale Habitats is not likely to change in response to most pressures. Exceptions to this include activities such as dredging and disposal of dredged materials, which can directly impact the type of seabed habitat present (OSPAR, 2004). The other assessed attributes (i.e., feature structure and function) are more appropriate measures of favourable condition for most habitat features. Natural England are currently in the process of developing a Conservation Advice package for the Dover to Deal MCZ. Upon publication, feature and sub-feature specific targets (and details of their supporting processes) will be available within the Designated Sites System[3].

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., ability to recover following impact).

For species features, favourable condition means that:

a) The quality and quantity of its habitat are such as to ensure that the population is maintained in numbers which enable it to thrive;

b) the composition of its population in terms of number, age and sex ratio are such as to ensure that the population is maintained in numbers which enable it to thrive; and

c) its natural supporting processes are unimpeded.

1.1.3 Report aims and objectives

The primary aim of this characterisation report is to describe the attributes of the designated features within the Dover to Deal MCZ in order to enable future assessment and monitoring of feature condition. The results presented will be used to inform recommendations for future monitoring, including the operational testing of specific metrics which may indicate whether the condition of the feature has been maintained, is improving, or is in decline.

The broad objectives of this monitoring report are provided below:

1) Provide a description of the **extent**[4]**, distribution, structural** and (where possible) **functional** attributes, and the **supporting processes**, of the designated features within the site (see Table 2 for more detail), to enable subsequent condition monitoring and assessment;

2) Note observations of any Habitat or Species FOCI not covered by Designation Order as features of the site;

3) Present evidence relating to marine litter (Descriptor 10), to satisfy requirements of the Marine Strategy Framework Directive;

4) 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 requirements

1.2 Survey elements: feature attributes and supporting processes

To achieve report objective 1, the report will present evidence on a number of feature attributes and supporting processes, as defined in supplementary advice on conservation objectives developed by Natural England for the designated features within the Dover to Deal MCZ[3]. It should be noted that it was not possible to address all feature attributes in the characterisation survey, given the comprehensive nature of the attribute lists for each feature. The feature attributes were therefore rationalised and prioritised, resulting in a smaller sub-set.

The list of selected feature attributes and supporting processes considered in this report is presented in Table 2, alongside the generated outputs for each.

Table 2. Feature attributes and supporting processes addressed to achieve report objective 1, for the Mounts Bay MCZ (© Natural England and Environment Agency 2022).

Feature attributes	Features	Outputs
Extent and distribution	A5.1 Subtidal coarse sediment* A5.2 Subtidal sand A5.3 Subtidal mud* A5.4 Subtidal mixed sediments	Maps of locations of biotopes & substrates sampled & Habitat map
Sediment composition and distribution	A5.1 Subtidal coarse sediment* A5.2 Subtidal sand A5.3 Subtidal mud** A5.4 Subtidal mixed sediments	Habitat map and PSA derived from seabed sediment samples
Presence and spatial distribution of biological communities **Presence and abundance of key structural and influential species** **Species composition of component communities**	A5.1 Subtidal coarse sediment* A5.2 Subtidal sand A5.3 Subtidal mud* A5.4 Subtidal mixed sediments	Biological communities (and derived biotopes) derived from ground truth samples Assessment of temporal change comparing communities sampled in 2012 and 2016.
Non-indigenous species (NIS)	Dover to Deal MCZ	Location of samples where NIS were recorded
Supporting processes:		
Sediment contaminants	Dover to Deal MCZ	Results of analysis of surface sediment scrapes
Water quality parameters	Dover to Deal MCZ	Summary of water column salinity
Additional monitoring		
Marine Litter	Dover to Deal MCZ	Map of location of marine litter sampled and description

*** Not a designated feature of the MCZ**

2 Methods

2.1 Data sources

Data used to inform this characterisation report have been compiled from surveys carried out at the Dover to Deal MCZ in 2012 and 2016 by the Environment Agency (Godsell *et al*., 2013; Fraser and Easter, 2019). Locations of grab samples collected during the 2016 Dover to Deal MCZ survey are shown in Figure 2.

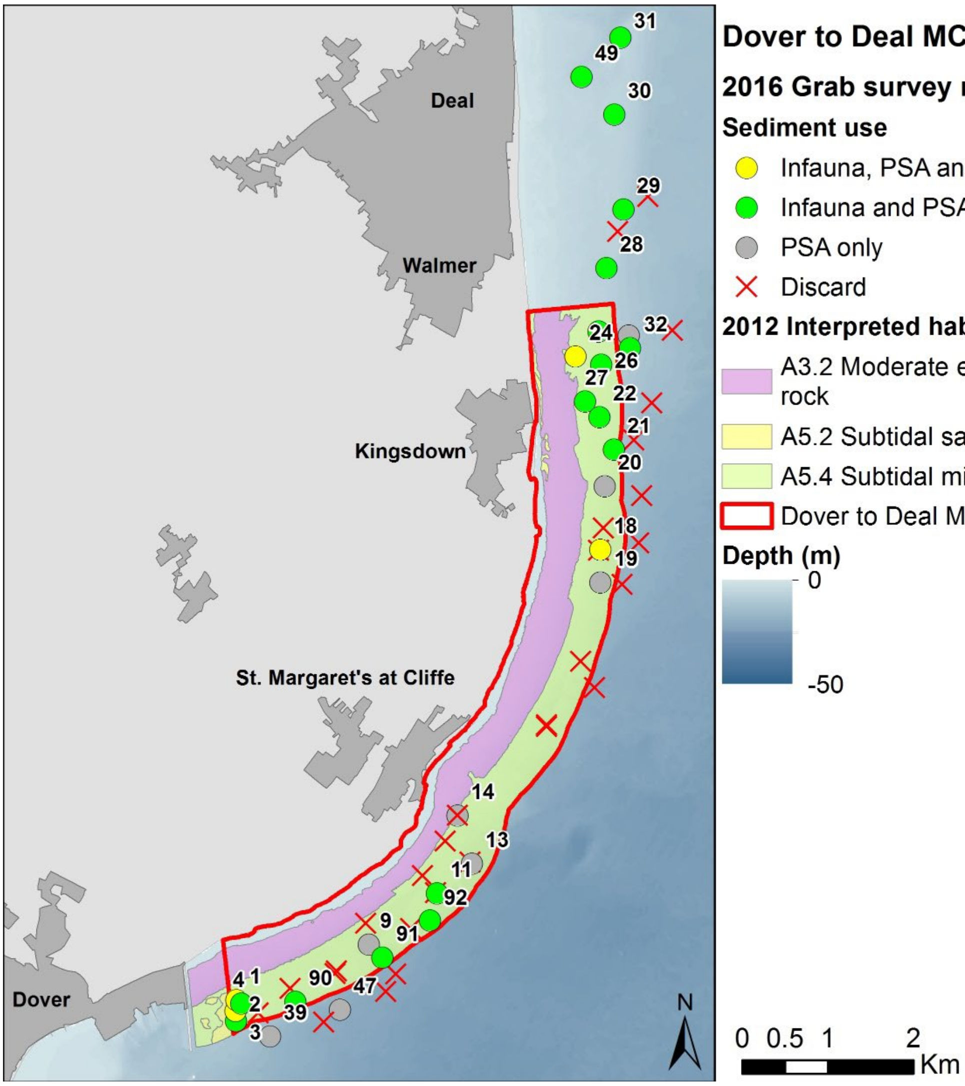

Figure 2. Location of Day grab samples, and their use, collected inside and outside the Dover to Deal MCZ in 2016 (© Natural England and Environment Agency 2022).

2.2 Survey design

In 2012, 32 stations located within the Dover to Deal MCZ boundary were surveyed to support the verification of feature presence and distribution (Colenutt *et al*., 2015; Godsell *et al.,* 2013). These sampling stations were revisited and expanded upon during a second survey in 2016 to support a more detailed characterisation of the features designated within the MCZ along with comparable features present within the wider environment adjacent to the site. The results of the 2012 survey were used to inform the target station locations for the 2016 characterisation survey design (Fraser and Easter, 2019). The 2016 survey design comprised of 53 planned stations (19 of which were resamples of the 2012 stations) within the MCZ boundary. In order to collect additional habitat data beyond the MCZ boundary**,** an additional 35 stations were planned based on existing bathymetric (within the 0-25 m depth contour (Figure 2)) and sediment data. Of the 88 target stations for the 2016 survey, 29 viable grab samples were acquired (Fraser and Easter, 2019). Data collected during the 2016 survey are intended for the first time interval of a baseline characterisation of the site.

2.3 Data acquisition and processing

2.3.1 Seabed imagery

Seabed imagery data were collected using a drop down video system which consisted of a digital stills and video camera mounted on a frame. The seabed imagery data were intended to contribute to the characterisation of epifaunal communities associated with both the rock and sedimentary habitat features. All data were collected following MESH Recommended Operating Guidelines (ROG) (Coggan *et al*.**,** 2007). Video and still images were collected using an STR Seaspyder drop camera system. Real time navigation data acquisition and manual position fixing was captured via Trimble® HYDRO*pro*™ software. Full details can be found in the survey reports (Godsell *et al.,* 2013; Fraser and Easter, 2019). Images of the seabed were acquired every 10-15 m over a distance of ~150 m. Additional images were collected in heterogeneous areas of BSH and if particular habitats or species FOCI were observed to ensure, as far as possible, that the habitats and species were adequately sampled and accurately identified. The video footage was annotated with time and position using a SIMRAD MX512 DGPS referenced video overlay (uncorrected position data).

2.3.2 Seabed sediments

Seabed sediment samples for particle size distribution and benthic infauna analyses were collected using a 0.1 m^2 Day grab.

A 500 ml sub-sample was taken from each grab sample and stored at -20°C prior to determining the particle size distribution. Sediment samples were processed by the National Laboratory Service (NLS) following the recommended methodology of the North East Atlantic Marine Biological Analytical Quality Control (NMBAQC) scheme (Mason, 2011). The less than 1 mm sediment fraction was analysed using laser diffraction and the greater than1 mm fraction was dried, sieved and weighed at 0.5 phi (ϕ) intervals. Sediment distribution data were merged and used to classify samples into sedimentary Broadscale Habitats.

The faunal fraction was sieved over a 1 mm mesh, photographed then fixed in buffered 8% formaldehyde. Faunal samples were processed by APEM Ltd. to extract all fauna present in each sample. Fauna were identified to the lowest taxonomic level possible, enumerated and weighed (blotted wet weight) to the nearest 0.0001 g following the recommendations of the NMBAQC scheme (Worsfold *et al.,* 2010). To achieve report objective 3, any marine litter fragments >1 mm present in the residues were extracted and counted for each sample.

2.4 Data preparation and analysis

2.4.1 Sediment particle size distribution

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

2.4.2 Biological community data preparation

Benthic infauna data sets were checked to ensure consistent nomenclature and identification policies. Any discrepancies identified were resolved using expert judgement following the truncation steps presented in Annex 1. Invalid taxa and fragments of countable taxa were removed from the dataset while the presence of colonial taxa was changed to a numerical value of one. Records were combined where a species was identified correctly both by using its binomial name and by using its binomial name with a qualifier e.g. *Lumbrinereis cingulata* 'aggregate'. Records labelled as 'juvenile' were combined with adults of the same genus/species/family.

Temporal community analysis of the infauna data (2016 data compared to the 2012 verification survey) was undertaken at the genus level in order to remove any potential species identification errors resulting from the infauna samples from the two surveys being analysed by two different contractors.

The infaunal species abundance data (generated from the infaunal samples data) were cross-referenced against a list of 49 non-indigenous target species which have been selected for assessment of Good Environmental Status in GB waters under MSFD Descriptor 2 (Stebbing *et al.,* 2014; Annex 4). 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 all taxa observed (Annex 4).

2.4.3 Statistical analyses

The truncated macrofaunal abundance and biomass data were imported into PRIMER v6 (Clarke and Gorley, 2006) to enable multivariate analysis and the derivation of various metrics for univariate analysis. Species classification information and a number of relevant factors/indicators were also assigned to the data at this stage, as follows. Species diversity metrics were derived for each sample using the DIVERSE function within PRIMER v6 (Table 5). These metrics can be considered as a standard suite of ecologically meaningful measures of diversity and were selected to assess differences between designated habitat features and biological community characteristics of comparable features located inside and outside of the MCZ boundary.

Nonmetric multidimensional scaling (nMDS) ordination, analysis of similarity (abundance square-root transformed species data and Bray-Curtis similarity) between (ANOSIM) and dissimilarity within (SIMPROF with associated SIMPER) groups were conducted in PRIMER v6 to explore differences in biological community composition for (a) between the habitat features; (b) between examples of comparable features located within and outside of the MCZ boundary and (c) between examples of comparable features collected inside the MCZ boundary from the 2016 survey and the 2012 verification survey (Colenutt *et al.* 2015). The infaunal quality index (IQI), an assessment of benthic faunal condition, was calculated using the latest version of the Environment Agency's IQI Excel workbook (Phillips *et al.,* 2014).

2.4.4 Contaminants sampling

At four stations inside the MCZ boundary, additional grabs were collected for sediment contaminant analysis (two from the BSH 'A5.4 Subtidal mixed sediments' and two from the 'A5.2 Subtidal sand' BSHs of the 2012 interpreted habitat map), providing a record of the most recent contaminant levels deposited in these sediments. Surficial sediment scrapes were sampled to a maximum depth of 1 cm (or to the depth of the apparent redox potential discontinuity (aRPD) if shallower), following the methodology described in the Environment Agency Operational Instruction 10_07 (2016).

Sediment dry weight contaminant concentrations were normalised to 5% aluminium (for heavy metals) and 2.5% total organic carbon content (for organics) to take account of the variation between sediment types (OSPAR Commission, 2008) for comparison.

Results were compared against OSPAR Background Assessment Concentrations (BAC) considered to be background level thresholds and Environmental Assessment Criteria (EAC) / Effects Range Low (ERL) thresholds for heavy metals, polycyclic aromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs) - above which concentrations may chronically impact marine fauna (OSPAR Commission, 2008).

3 Results and Interpretation

3.1 Site overview

The Dover to Deal MCZ 2016 subtidal characterisation survey was completed between the 17th and 25th August 2016. The survey within the MCZ boundary targeted two BSHs: 'A5.2 Subtidal sand' and 'A5.4 Subtidal mixed sediments' based on the 2012 interpreted habitat map (Figure 2). Table 3 shows the number of samples collected and their BSH designations based on the associated PSA results. The spatial distribution of sediment samples and assigned BSHs collected during the Dover to Deal MCZ 2016 and 2012 surveys is illustrated in Figure 4. No samples were assigned to the BSH 'A5.2 Subtidal sand' in 2016, preventing comparisons with these features observed in 2012 (Fraser and Easter, 2019). The BSHs 'A5.1 Subtidal coarse sediment' and 'A5.3 Subtidal mud' were observed in 2016 but not in the 2012 survey. Owing to poor visibility no viable video or still images were captured in 2016. A summary of the designated subtidal sediment BSH features identified during this (2016) and previous surveys is given in Table 3.

Because the camera survey, which targeted subtidal rock habitats, produced no viable data this report focusses solely on subtidal sedimentary habitats. The results presented in this report for the 29 subtidal sediment grab samples collected are used to explicitly fulfil objective a) for the designated BSH 'A5.4 Subtidal mixed sediments' of the Dover to Deal MCZ. Whilst the sampling in this survey detected differences in abundance, species richness, IQI and multivariate species composition between different BSHs sampled in the 2016 Dover to Deal MCZ survey, the imbalance in the survey design means that, at best, only the sample size within the 'A5.4 Subtidal mixed sediments' was sufficient enough to elucidate statistically significant differences within this BSH. Power analysis (Annex 2) suggested that sampling effort within the 'A5.4 Subtidal mixed sediments' BSH should not be decreased in future surveys if the BACI approach is to be applied to univariate indices of community structure.

Table 3. Number of 0.1m2 Day grab samples collected during the 2016 Dover to Deal MCZ survey in each BSH (© Natural England and Environment Agency 2022). In = within MCZ boundary, Out = outside MCZ boundary and D = protected feature listed in the site designation order[1]. Some cells left intentionally blank.

Broadscale Habitat (BSH)	D	grab – PSA & Infauna		grab – PSA only		Video		Stills	
		In	Out	In	Out	In	Out	In	Out
A5.1 Subtidal coarse sediment		3	-	2	2	-	-	-	-
A5.2 Subtidal sand	Yes	-	-	-	-	-	-	-	-
A5.3 Subtidal mud		3	-	-	-	-	-	-	-
A5.4 Subtidal mixed sediments	Yes	9	6	3	1	-	-	-	-

Table 4. Subtidal sediment Broadscale Habitat (BSH) features identified from the 2016 survey of Dover to Deal MCZ (© Natural England and Environment Agency 2022). Summary of presence recorded by the Site Assessment Document (SAD, Balanced Seas, 2011) and subsequent surveys (PSA = particle size analysis sample). D = protected feature listed in the site designation order[1].

Broadscale Habitat (BSH)	D	Extent km^2 (SAD)	Extent km^2 (2012)	Presence in 2012 survey	Presence in 2016 survey
A5.1 Subtidal coarse sediment		1.8	N/A	Not recorded	7 PSA
A5.2 Subtidal sand	Yes	N/A	0.15	1 PSA	Not recorded
A5.3 Subtidal mud		N/A	N/A	Not recorded	3 PSA
A5.4 Subtidal mixed sediments	Yes	5.07	5.48	8 PSA	19 PSA

3.1.1 Subtidal sediment BSH: Sediment composition and biological communities

This classification of PSA samples analysed from the Dover to Deal MCZ survey is illustrated in Figure 3. The distribution and relative abundances of gravel, sand and mud for the 2016 PSA samples is illustrated in Figure 5. In both surveys, 'A5.4 Subtidal mixed sediments' were dominant, contributing to 89% of samples (n=8) in 2012 and 66% of samples (n=19) in 2016. Overall, there were significant differences between infaunal community species composition and sediment type (ANOSIM, Global R = 0.62, $p < 0.01$). This is further demonstrated by the the nMDS plot (Figure 6) where infaunal communites are generally grouped in ordination space in relation to the BSH from which they were sampled. Finer, less heterogenous sediments, were relatively species poor and lower in biomass than coarser sediments (Figure 7 and Figure 9). The most pronounced difference between the 2012 and 2016 survey results are around the southern boundary of the MCZ, close to Dover harbour. In 2012 this area was interpreted as comprising entirely of 'A5.2 Subtidal sand' BSH, but in 2016 was classified as 'A5.3 Subtidal mud' (75% of samples) and 'A5.1 Subtidal coarse sediment' (25% of samples). No presence of the BSH 'A5.1 Subtidal coarse sediment' was observed in 2012, while in 2016 this BSH contributed to 24% (n=7) of all samples collected in 2016, and 36% (n=4) of samples collected within the area interpreted as 'A5.4 Subtidal mixed sediments' in 2012. Despite this, all the stations sampled for PSA within the area interpreted as 'A5.4 Subtidal mixed sediments' in 2012 were consistently classified as A5.4 Subtidal mixed sediments' in 2016.

In total, 316 taxa were identified from sediment samples collected in 2016 (279 from 'A5.4 Subtidal mixed sediments', 30 from 'A5.3 Subtidal mud' and 179 from 'A5.4 Subtidal coarse sediment' samples). Table 5 shows the mean (± standard error) infaunal species abundance, richness and other univariate statistics calculated for the infaunal samples collected using a Day grab within the BSHs sampled during the 2016 survey. The spatial pattern of species richness, the biotopes (EUNIS level 5) assigned to each 0.1 m^2 Day grab sample, and biomass can be found in Figure 7,

Figure 8 and Figure 9, respectively. The infaunal quality of benthic communities sampled inside and outside the MCZ is presented in Figure 11. Multivariate analyses indicated the infaunal community compositions of each of the three BSHs sampled in the 2016 survey were statistically different from one another (ANOSIM Global R = 0.62, p = 0.03).

Several species of taxonomic interest were noted in the samples. The most interesting being potentially the first record of the photid amphipod *Megamphopus longicornis* (nine individuals inside and one individual outside the MCZ boundary) from the British Isles, a species so far only recorded as far north as the Bay of Biscay. Several specimens of *Megamphopus longicornis* were sent for expert verification. Other species of note include: the rarely recorded boring flask shell, *Rocellaria dubia*, a species generally regarded as being limited to the south west coasts of the British Isles; the sporadically recorded nestling bivalve *Thracia distorta*; and the southerly distributed mussel *Gibbomodiola adriatica*.

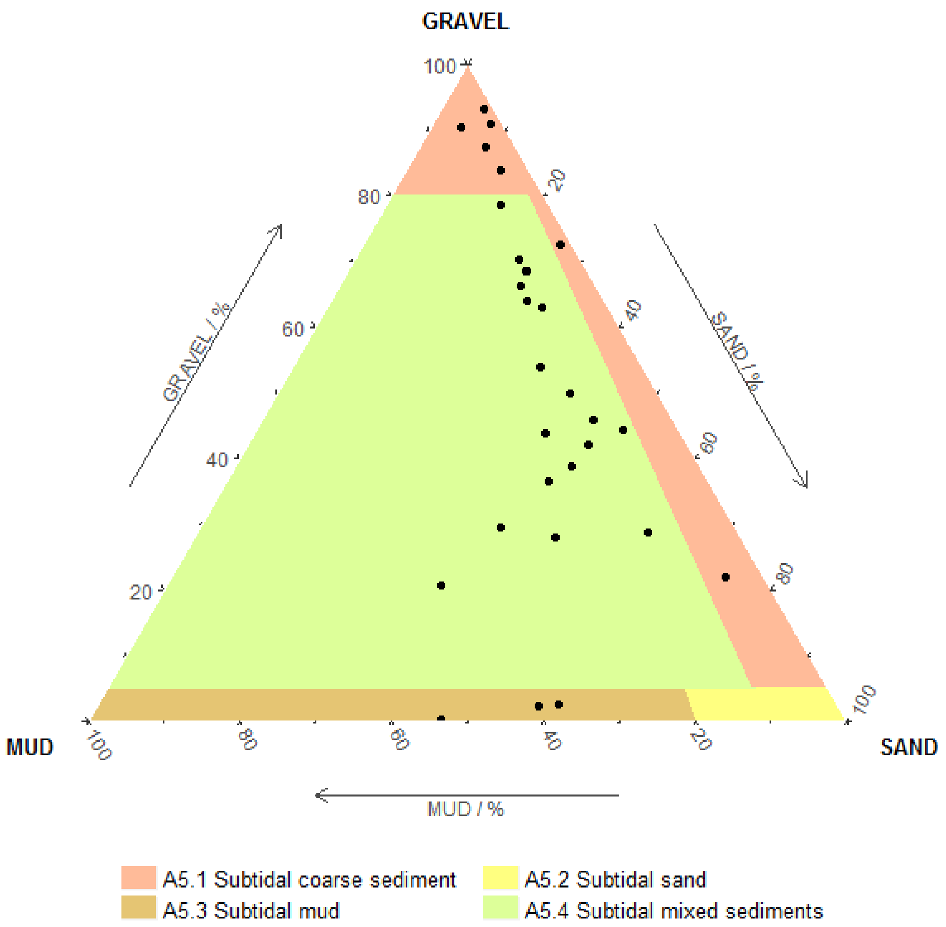

Figure 3. Classification of particle size distribution (half phi) information for each sampling point (black points) into one of the sedimentary Broadscale Habitats (coloured areas) plotted on a true scale subdivision of the Folk triangle (Folk, 1954) into a simplified classification for UKSeaMap (Long, 2006) (© Natural England and Environment Agency 2022).

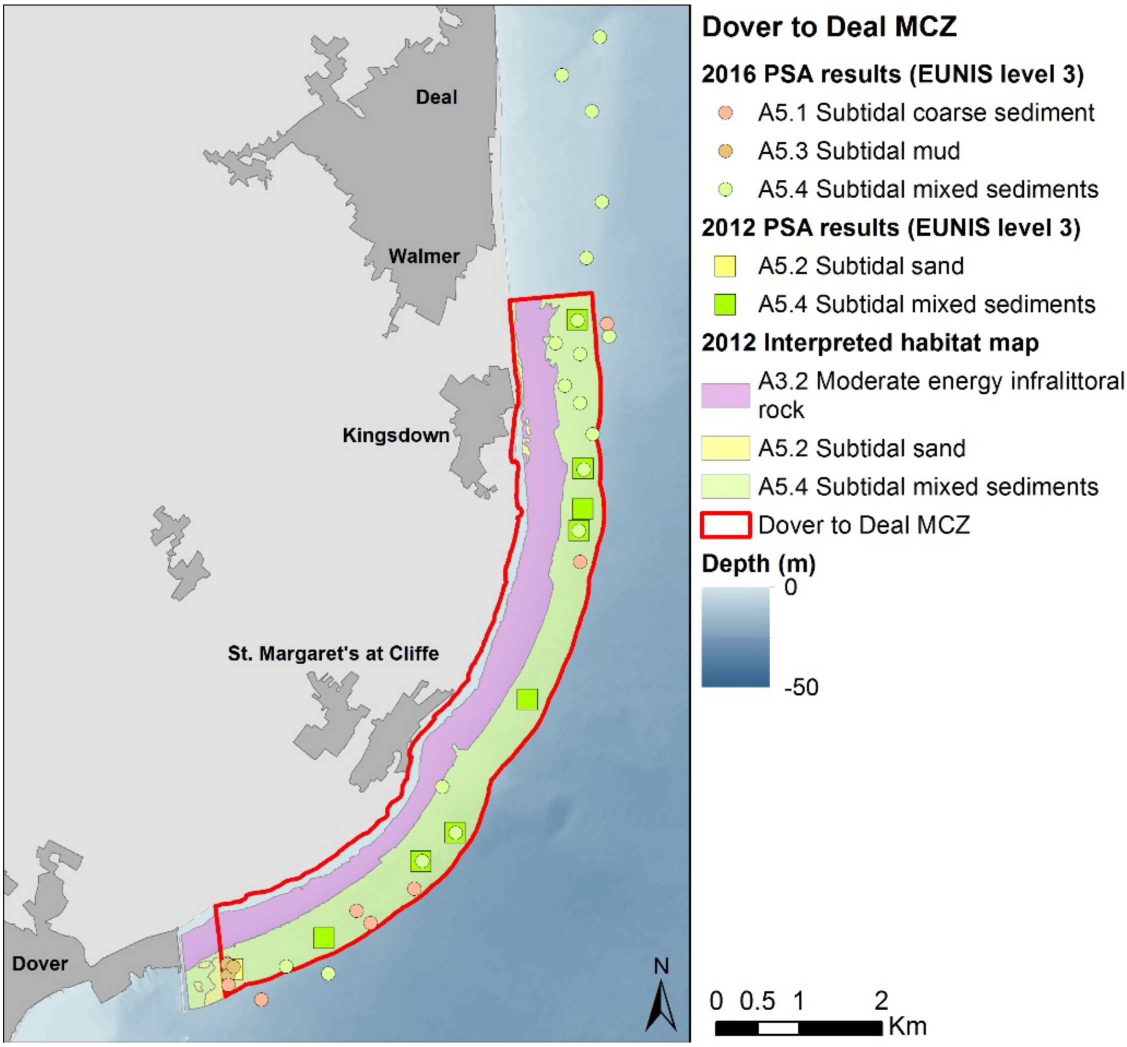

Figure 4. Broadscale habitat classifications of subtidal particle size analysis (PSA) samples collected during the 2016 and 2012 surveys of Dover to Deal MCZ surveys (© Natural England and Environment Agency 2022).

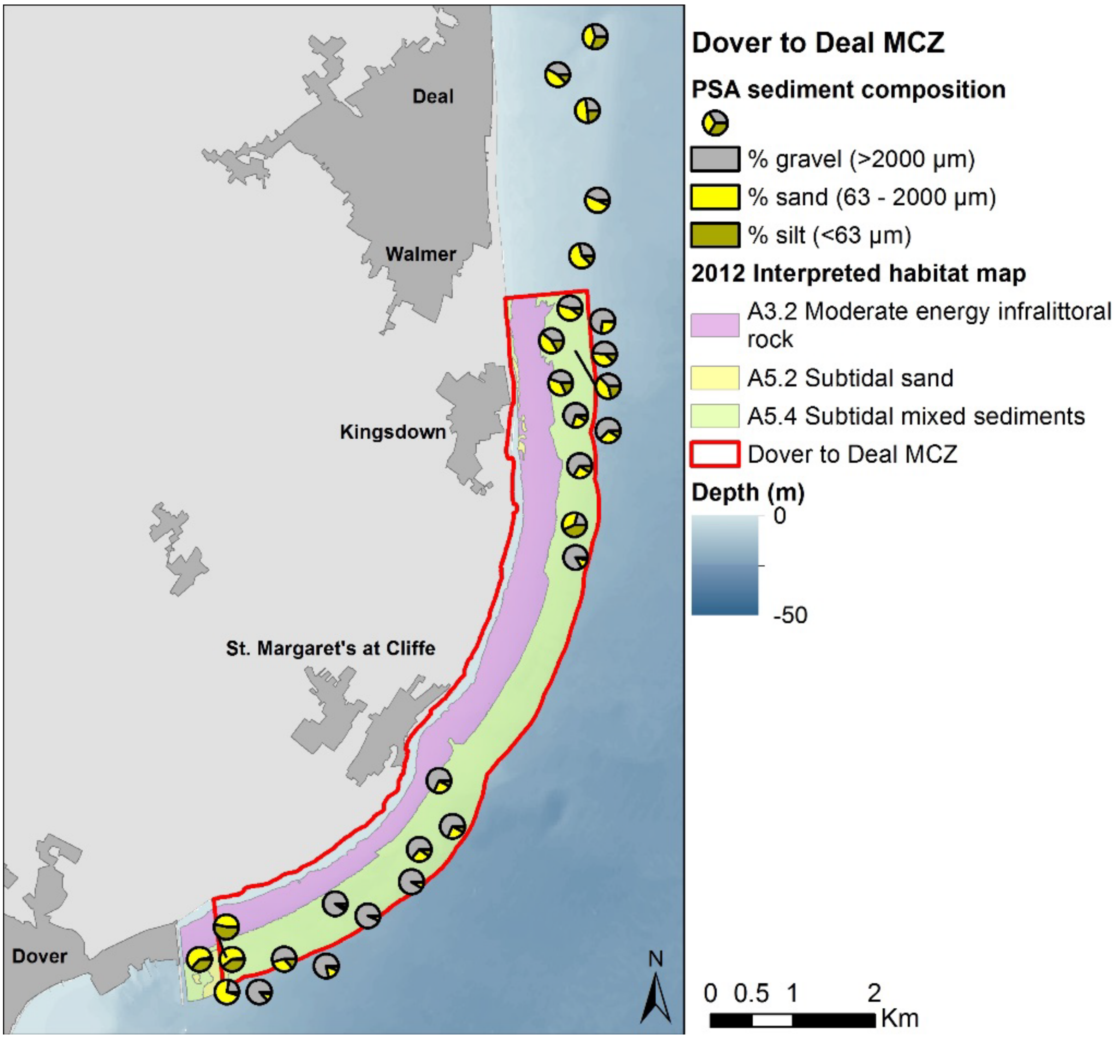

Figure 5. Relative proportions of gravel, sand and mud of subtidal particle size analysis (PSA) samples collected during the 2016 Dover to Deal MCZ survey (© Natural England and Environment Agency 2022).

Table 5. Mean (± standard error) macrobenthic species abundance, richness, total biomass, infaunal quality index (IQI) and other univariate indices of the 0.1 m^2 Day grab samples for the four different Broadscale Habitats (BSHs) collected outside and within the Dover to Deal MCZ in 2016 (sieved to 1 mm) (© Natural England and Environment Agency 2022).

		Sample number	Total taxa	Abundance (n sample^{-1})		Taxa Richness (S sample^{-1})		Biomass (wet wt, g)		Shannon Index H'(log^e)		Simpson's Evenness (1-λ')		Hill's N1		Infaunal Quality Index (IQI)	
				Mean	±S.E.	Mean	±S.E.	Mean	±S.E.	Mean	±S.E.	Mean	±S.E.	Mean	±S.E.	Mean	±S.E.
'A5.1 Subtidal coarse sediment'	Inside	3	179	593	159	93.30	35.70	4.98	2.19	3.07	0.46	0.87	0.04	25.65	8.67	0.86	0.00
	Outside	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
'A5.3 Subtidal mud'	Inside	3	30	140	17	14.33	3.93	7.26	1.88	1.60	0.33	0.68	0.09	5.47	1.59	0.66	0.02
	Outside	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
'A5.4 Subtidal mixed sediments'	Inside	9	246	1625	687	98.56	6.34	5.80	1.26	2.45	0.27	0.71	0.07	14.49	2.85	0.84	0.01
	Outside	6	231	1200	350	102.50	9.79	9.93	5.37	2.57	0.30	0.76	0.04	16.37	5.02	0.85	0.02

Table 6. The top five species that characterise each BSH (sampled inside and outside the Dover to Deal MCZ site boundary), assessed using SIMPER analysis on untransformed abundance data (© Natural England and Environment Agency 2022).

A5.1 Subtidal coarse sediment		**A5.3 Subtidal mud**	
Species	**% contribution to characterisation**	**Species**	**% contribution to characterisatio n**
Sabellaria spinulosa	34.57	*Abra alba*	38.36
Spisula sp.	5.35	*Nucula nitidosa*	24.73
Dendrodoa grossularia	4.39	*Lagis koreni*	14.44
Pisidia longicornis	2.78	*Nephtys hombergii*	13.42
Nephasoma minutum	2.64	*Mediomastus fragilis*	2.54
A5.4 Subtidal mixed sediments – inside MCZ		**A5.4 Subtidal mixed sediments – outside MCZ**	
Sabellaria spinulosa	51.04	*Sabellaria spinulosa*	40.27
Dendrodoa grossularia	7.67	*Balanus crenatus*	7.72
Lumbrineris aniara/cingulata	3.35	*Dendrodoa grossularia*	7.67
Jasmineira elegans	3.35	*Spisula sp.*	6.81
Ampelisca diadema	2.83	*Dipolydora flava*	3.68

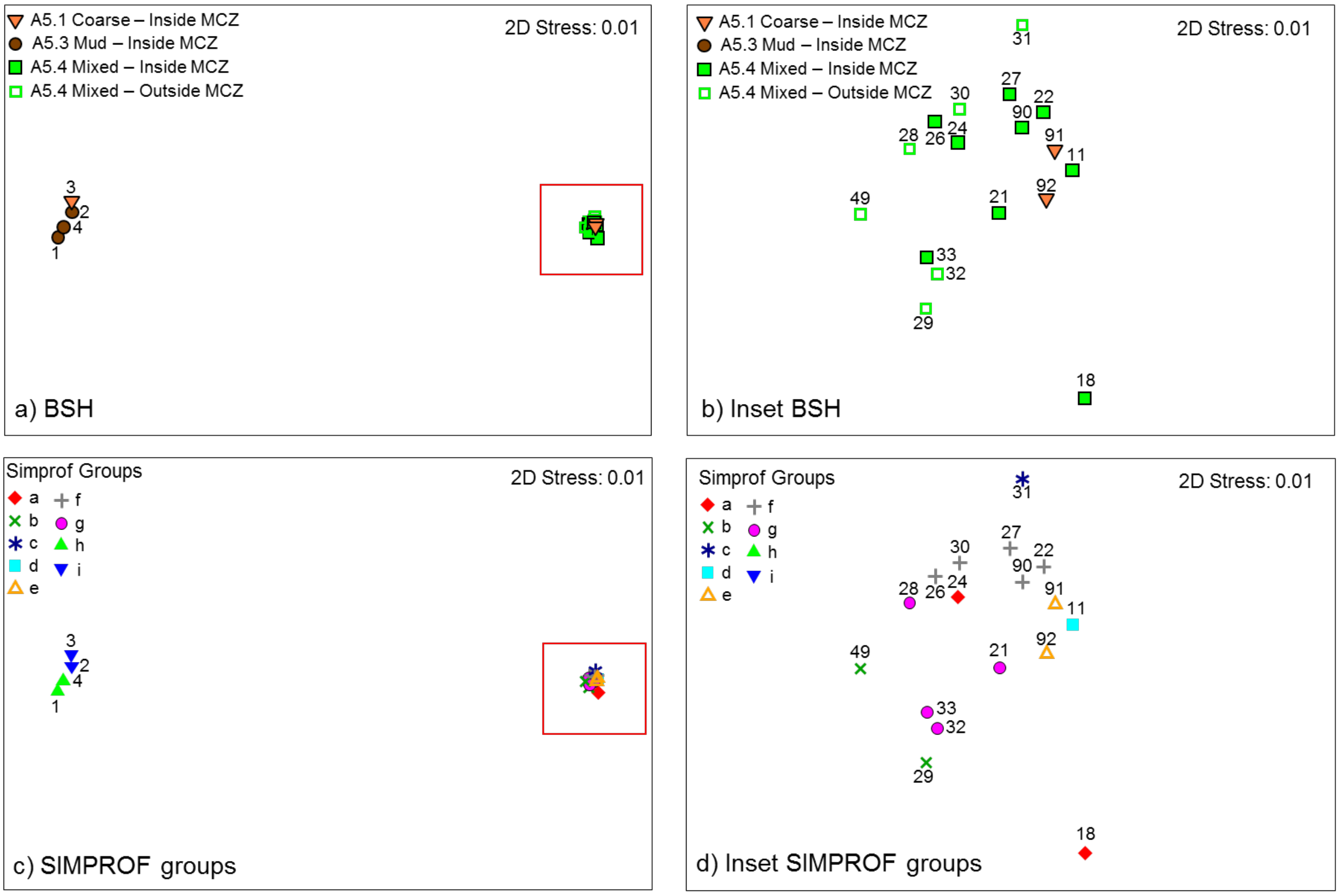

Figure 6. Nonmetric multidimensional scaling (nMDS) plot of infaunal communities (sieved to 1.0 mm) sampled in the 2016 Dover to Deal MCZ survey, grouped by (a, and inset, b) assigned sediment Broadscale Habitats, and (c, and inset d) groupings of stations with significantly different community structure, derived from SIMPROF analysis (© Natural England and Environment Agency 2022). The point labels indicates the station number (minus the DVDL prefix).

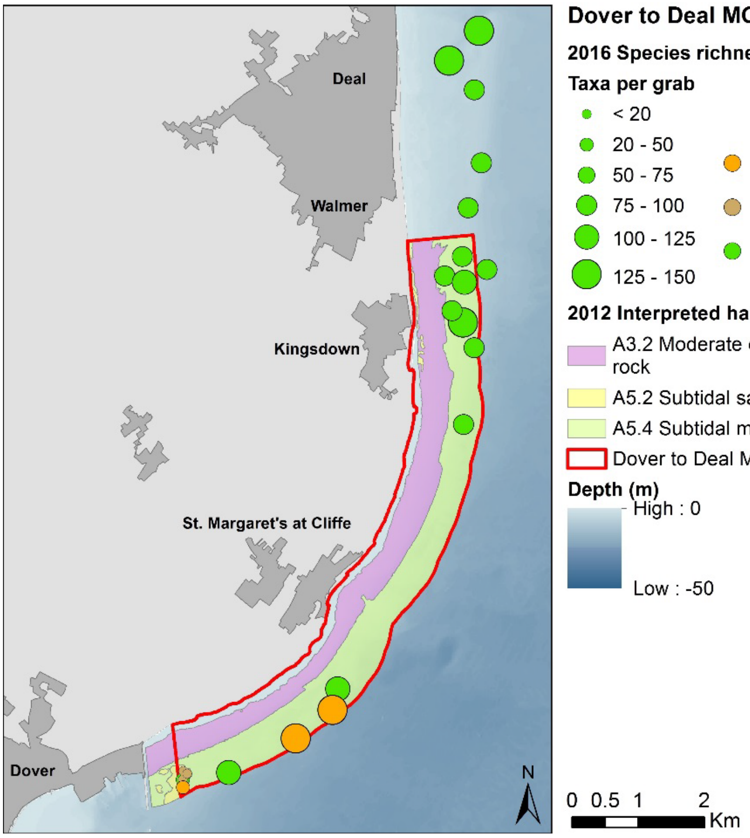

Figure 7. Spatial pattern of species richness (number of taxa per grab) by Broadscale Habitat for Day grabs sampled in the 2016 Dover to Deal MCZ survey (© Natural England and Environment Agency 2022).

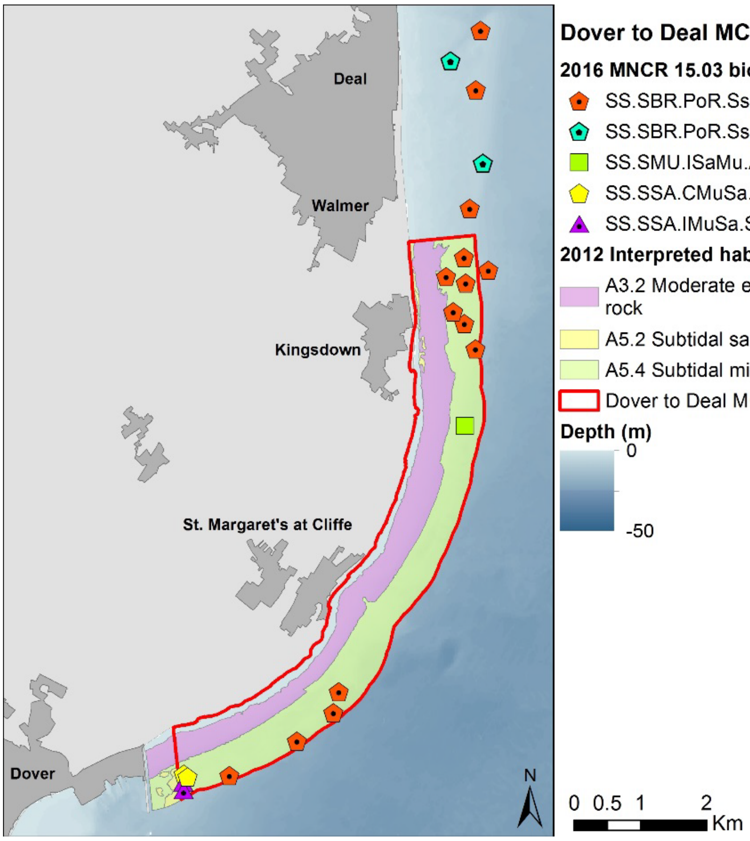

Figure 8. Assigned EUNIS level 5 biotopes for Day grabs sampled in the 2016 Dover to Deal MCZ survey (© Natural England and Environment Agency 2022).

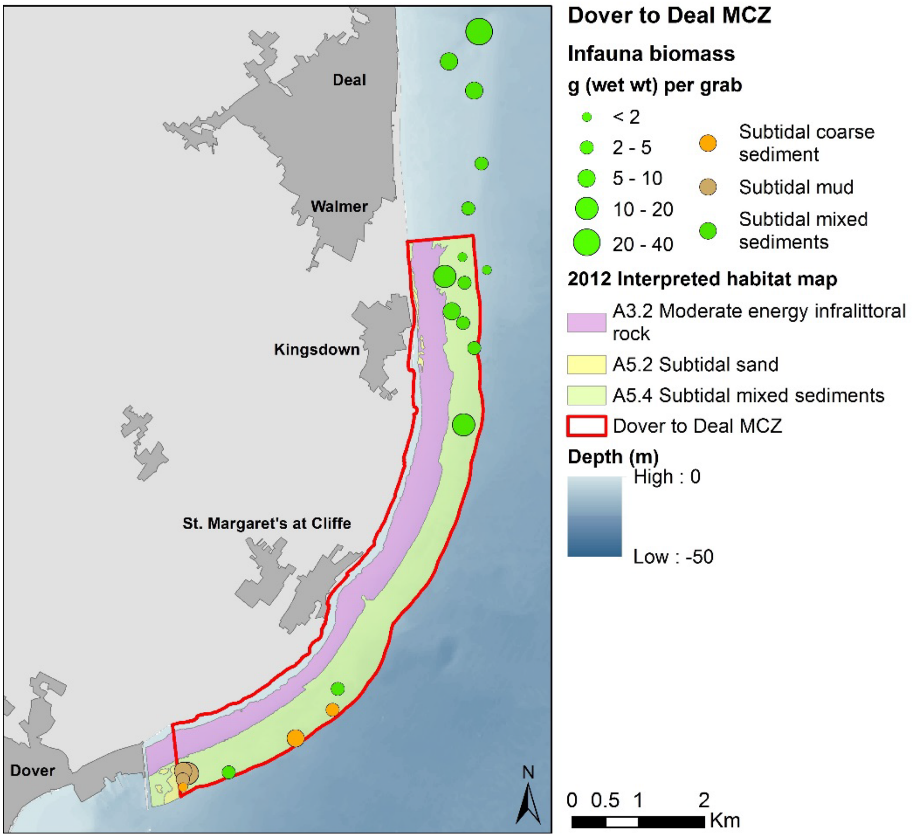

Figure 9. Spatial pattern of biomass (g wet weight) by Broadscale Habitat for Day grabs sampled in the 2016 Dover to Deal MCZ survey (© Natural England and Environment Agency 2022).

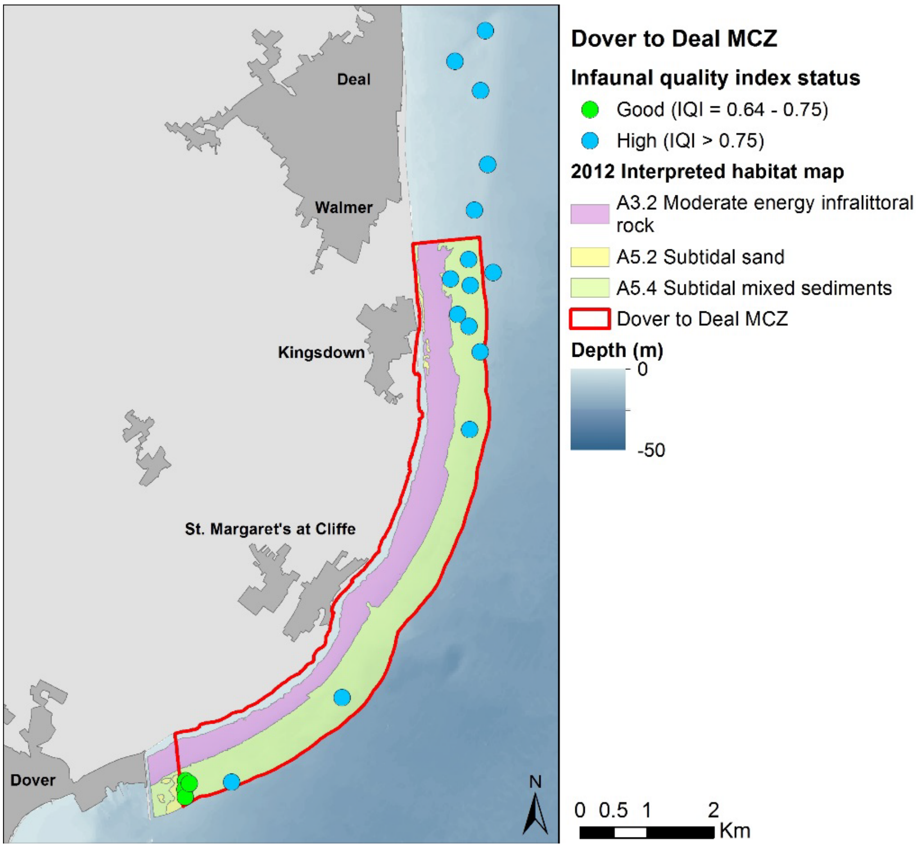

Figure 10. Infaunal Quality Index (IQI) status of infaunal Day grab samples collected in the 2016 Dover to Deal MCZ survey (© Natural England and Environment Agency 2022).

3.1.2 Subtidal coarse sediment

All benthic infaunal samples assigned to the 'A5.1 Subtidal coarse sediment' BSH (n=3) in the 2016 survey were collected within the MCZ boundary. The coarse sediment BSH had a higher mean abundance of macrofauna (1779) than the 'A5.3 Subtidal mud' BSH (421), but it was much lower than abundances observed in the 'A5.4 Subtidal mixed sediments' BSH (21,822). The mean percentage mud, sand and gravel of samples in this BSH was 3%, 29% and 69% respectively. Example images of the 2016 infaunal samples assigned to the 'A5.1 Subtidal coarse sediment' BSH can be found in Figure 12.

Mean similarity between benthic communities assigned to this BSH was the lowest of all BSHs sampled at 29%. Mean total biomass was 4.98 ± 2.19 g wet weight. The 'A5.1 Subtidal coarse sediment' communities were the most diverse (mean Hill's N1 = 25.65) of all the BSHs surveyed. This diversity is reflected in the SIMPER results where only the Ross worm, *Sabellaria spinulosa*, had a >6% relative contribution, and 31 taxa had between 1-5% relative contributions, to the mean similarity between communities assigned to this BSH (Table 6). Notably *S. spinulosa* was the most abundant taxon in two of the samples assigned to this BSH (27% relative abundance in DVDL 91 and 29% relative abundance in DVDL 92) but not present in the other sample from this BSH (DVDL 3). SIMPROF analysis showed that there were two sub-communities of ‘A5.1 Subtidal coarse sediment’ with DVDL 3 having a community similar to the adjacent ‘A5.3 Subtidal Mud’ station DVDL 2 (Figure 6, Table 7).

Table 7. The top five species that characterise each community defined by SIMPROF analysis, assessed using SIMPER analysis on untransformed abundance data from the 2016 Dover to Deal MCZ survey (© Natural England and Environment Agency 2022). SIMPROF-defined communities composed of one sample are not listed.

Group ‘a’ (Mixed sediments, inside MCZ)		**Group ‘b’ (Mixed sediments, outside MCZ)**	
Species	**% contribution to characterisation**	**Species**	**% contribution to characterisation**
Ampelisca diadema	65.55	*Balanus crenatus*	40.98
Sabellaria spinulosa	7.32	*Sabellaria spinulosa*	16.39
Jasmineira elegans	5.52	*Spisula sp.*	7.58
Lumbrineris aniara/cingulata	3.60	*Mytilus edulis*	6.56
Polycirrus sp.	2.28	*Dipolydora flava*	4.51
Group ‘e’ (Coarse sediments, outside MCZ)		**Group ‘f’ (Mixed sediments, inside & outside MCZ)**	
Sabellaria spinulosa	38.44	*Sabellaria spinulosa*	40.27
Dendrodoa grossularia	4.89	*Dendrodoa grossularia*	7.72
Pisidia longicornis	3.09	*Spirobranchus lamarckii*	7.67
Nephasoma minutum	2.93	*Jasmineira elegans*	6.81
Sphenia binghami	2.93	*Lumbrineris aniara/cingulata*	3.68
Group ‘g’ (Mixed sediments, inside & outside MCZ)		**Group ‘h’ (Mud, inside MCZ)**	
Sabellaria spinulosa	37.87	*Abra alba*	46.67
Dendrodoa grossularia	11.98	*Nucula nitidosa*	40.00
Spisula sp.	5.58	*Nephtys hombergii*	8.89
Dipolydora flava	5.23	*Lagis koreni*	3.33
Lumbrineris aniara/cingulata	3.83	*Spiophanes bombyx*	1.11
Group ‘i’ (Mud and Coarse sediment, inside MCZ)			
Spisula sp.	51.11		
Lagis koreni	31.11		
Abra alba	6.67		
Eteone longa	2.22		
Nephtys hombergii	2.22		

Subtidal coarse sediment (SS.SBR.PoR.SspiMx)
Sabellaria spinulosa **on stable circalittoral mixed sediments**

Subtidal coarse sediment (SS.SSA.IMuSa.SsubNhom)
Spisula subtruncata **and** ***Nephtys hombergii*** **in shallow muddy sand.**

Figure 11. Example images from the 2016 Dover to Deal MCZ survey of faunal samples in 0.1m^2 Day grabs (left) and on the 1mm sieve (right) associated with the 'A5.1 Subtidal coarse sediment' Broadscale Habitat (© Environment Agency and Natural England 2016).

The top 16 most abundant taxa in DVDL 91 and DVDL 92 are not present in DVDL3 and if DVDL3 is removed from the analysis then the similarity increases by 40% (to 69%). With the exception of *Sabellaria spinulosa* no taxa have a relative abundance >7% or >4% in DVDL 91 and DVDL 92 respectively. Whereas 76% of the relative abundance of DVDL 3 is accounted for by five taxa: the bivalve *Spisula* (40%), the polychaete *Lagis koreni* (19%), the polychaete *Spiophanes bombyx* (8%), the bivalve *Abra alba* (4%) and the mysid *Gastrosaccus spinifer* (4%). The mean infaunal quality index score within this BSH was classified as 'Good' for all samples according to their IQI scores (Table 5).

3.1.3 Subtidal mud

All infaunal benthic samples assigned to the 'A5.3 Subtidal mud' BSH (n=3) in the 2016 survey were collected within the MCZ boundary. These samples accounted for 1.75 % (n=421) of all taxa (n=24022) observed from all BSHs. The mean percentage mud, sand and gravel content of samples in this BSH were 43%, 55% and 2%

respectively. Example images of the 2016 infaunal samples assigned to the ‘A5.3 Subtidal mud’ BSH can be found in Figure 15.

The subtidal mud communities were the least diverse (Hill’s N1 = 5.47) of all the BSHs surveyed. Mean similarity between benthic communities assigned to this BSH was 42% and mean total biomass was 7.26 ± 1.88 g wet weight. SIMPER analyses indicated that no taxon particularly dominated the subtidal mud benthic communities with the most abundant taxon, the bivalve mollusc *Abra alba*, having a relative mean abundance of 1% of all taxa within this BSH (Table 6). However, *Abra alba* along with the associated bivalve *Nucula nitidosa,* the catworm *Nephtys hombergii,* the polychaete *Spiophanes bombyx* and the polychaetes *Lagis koreni* and *Mediomastus fragilis* account for 92% of the similarity between the benthic communities in the BSH. Notably, the bivalves *Abra alba* and *Nucula nitidosa* account for a combined 91% and 66% of the relative abundance in the samples from stations DVDL1 (*A. alba* = 66%, *N. nitidosa* = 24%) and DVDL4 (*A. alba* = 27%, *N. nitidosa* = 39%) respectively; whereas in the sample from DVDL2 *Nucula nitidosa* was not present and *Abra alba* only accounted for 5% of the relative abundance. This variability was supported by SIMPROF analysis that showed the three samples could be split into two communities, one characterised primarily *by Abra alba* (DVDL1, DVDL4), and one by *Spisula sp.* (DVDL2) (Table 7, Figure 6). Infaunal quality within this BSH was classified as ‘Good’ for all samples according to their IQI scores (Table 5).

Subtidal Mud (SS.SSA.IMuSa.SsubNhom)
***Spisula subtruncata* and *Nephtys hombergii* in shallow muddy sand.**

Subtidal Mud (SS.SSA.CMuSa.AalbNuc)
***Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediments.**

Figure 12. Example images from the 2016 Dover to Deal MCZ survey of faunal samples in 0.1m2 Day grabs (left) and on the 1mm sieve (right) associated with the 'A5.3 Subtidal mud' Broadscale Habitat (© Environment Agency and Natural England 2016).

3.1.4 Subtidal mixed sediments

A total of 15 benthic infaunal samples from the 2016 Dover to Deal MCZ survey were assigned to the 'A5.4 Subtidal mixed sediments' BSH, of which nine were from within the MCZ boundary and six were from outside the MCZ boundary. The mean percentage mud, sand and gravel content of samples in this BSH were 13%, 32% and 55% respectively. Example images of the 2016 infaunal samples assigned to the Subtidal Mixed Sediments BSH can be found in Figure 12.

Samples from the 'A5.4 Subtidal mixed sediments' BSH had the greatest overall abundance (21,822) of all the BSHs sampled. Mean similarity between benthic communities assigned to this BSH was the greatest of all BSHs sampled at 49.48%. Mean total biomass was 7.26 $\pm$ 1.88g wet weight. Mean species diversity in this BSH was between 46-52% less diverse than the 'A5.1 Subtidal coarse sediment' BSH, but significantly more diverse than 'A5.3 Subtidal mud' (one-way ANOVA using square-root-transformed abundance data, $p < 0.05$).

Subtidal mixed sediment (SS.SMU.ISaMu.AmpPlon)
Ampelisca spp., Photis longicaudata **and other tube building amphipods and polychaetes in infralittoral sandy mud.**

Subtidal mixed sediment (SS.SBR.PoR.SspiMx)
Sabellaria spinulosa **on stable circalittoral mixed sediment.**

Figure 13. Example images from the 2016 Dover to Deal MCZ survey of faunal samples in 0.1m2 Day grabs (top, left) and on the 1mm sieve (right) associated with the 'A5.4 Subtidal mixed sediments' Broadscale Habitat (© Environment Agency and Natural England 2016).

Species diversity among samples assigned to the 'A5.4 Subtidal mixed sediments' BSH was 17% greater outside of the MCZ boundary than inside the MCZ boundary. SIMPER analysis showed that the mixed sediment benthic communities inside the MCZ boundary had slightly greater similarity (52%) than the mixed sediment benthic communities outside the MCZ boundary (48%). The benthic communities inside and outside the MCZ boundary were characterised by diverse species assemblages and ANOSIM results confirmed there were small, but significant differences between the communities inside and outside of the MCZ (Global $R = 0.23$, $p<0.05$). Infaunal quality within this BSH was classified as 'High' for all samples according to their IQI scores (Table 5) with no significant differences between samples inside and outside the MCZ boundary (one-way ANOVA using square-root-transformed data, $p > 0.05$).

The relatively high abundance in the 'A5.4 Subtidal mixed sediments' BSH was largely driven by the reef-forming polychaete *Sabellaria spinulosa. S. spinulosa* dominated the overall mean relative abundance with equal contribution both inside (18%) and outside (18%) the MCZ boundary and accounting for > 25% of the relative abundance at 11 of the 15 stations sampled (range 1 – 69 %). The amphipod *Ampelisca diadema* dominated the assemblage at station DVDL 18 (inside the MCZ boundary) where it accounted for 91% of the relative abundance. At station DVDL 24 (outside the MCZ boundary), the assemblage was dominated by two species; the barnacle *Balanus crenatus* (54% relative abundance) and the amphipod *A. diadema* (39% relative abundance). At all other stations *S*. *spinulosa* was the most abundant species often in association with the tunicate *Dendrodoa grossularia*. SIMPROF analysis showed that there were six different communities (two of which were single samples) that occurred within the 'A5.4 Subtidal mixed sediments' BSH (Figure 6, Table 7). The relative abundances of *S. spinulosa, D. grossularia* and *A. diadema* primarily defined the different communities.

Temporal comparisons of the 2012 and 2016 data

There was a significant difference in community structure (at the genus level) between the 'A5.4 Subtidal mixed sediments' samples collected inside the MCZ in 2016 using a Day grab (n = 9) and those collected in the 2012 verification survey using a Hamon grab (n = 8) (Global R = 0.758, $p < 0.001$) (Figure 17). Four stations sampled in 2016 were also sampled in 2012. Taxa richness (analysed at Genus level) was significantly higher in the 2016 samples than the 2012 samples (2012 mean = 57.00 ± 4.75; 2016 mean = 79.56 ± 5.42 genera sample^{-1}, T = -3.13, p = 0.007)

SIMPER analysis showed that differing abundance of *Sabellaria* and the amphipod *Ampelisca* were responsible for the greatest dissimilarity between the 2012 and 2016 samples (28.4 % and 19.7% of the total between-year dissimilarity respectively). The mean abundance of *Sabellaria* in 'A5.4 Subtidal mixed sediments; inside the MCZ in 2012 and 2016 was 220.9 ± 83.0 and 375.8 ± 81.2 individuals sample^{-1} respectively; the mean abundance of *Ampelisca* in 2012 and 2016 was 5.8 ± 2.5 and 782.4 ± 702.8 individuals sample^{-1} respectively.

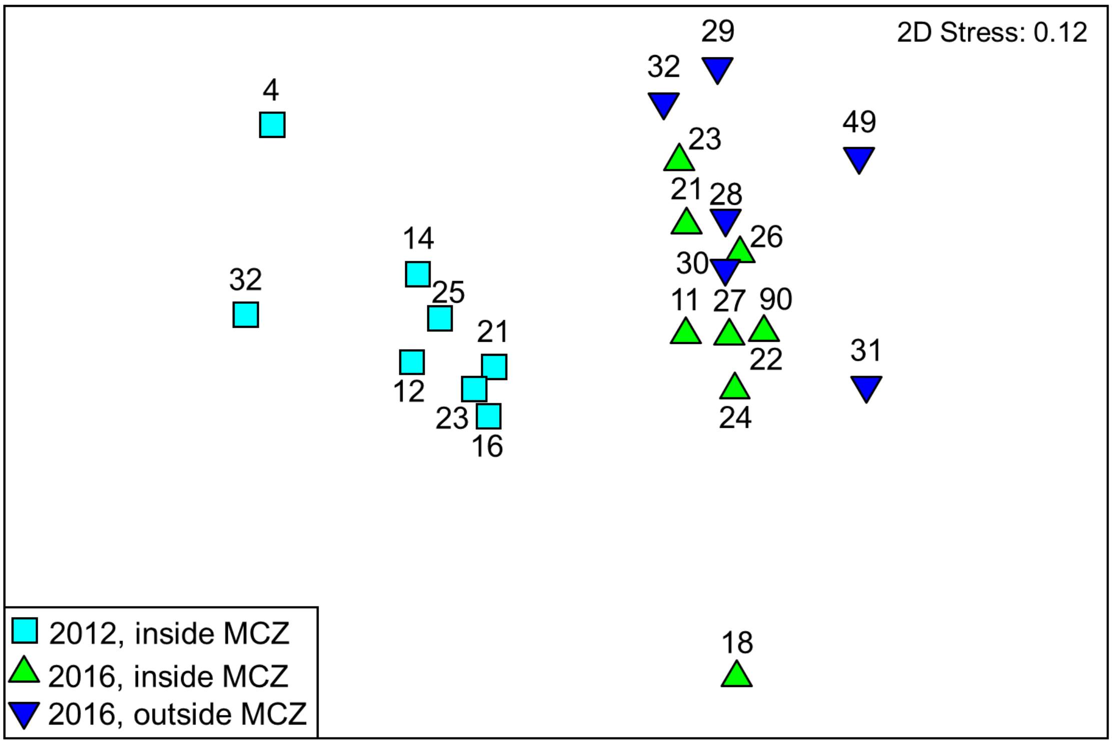

Figure 14. Multidimensional scaling plot of infauna community composition (based on square root transformation of taxa abundance (© Natural England and Environment Agency 2022). Samples were compared using a Bray-Curtis similarity index) of samples collected during the 2016 Dover to Deal MCZ baseline survey inside and outside the MCZ using a Day grab, and the 2012 Dover to Deal verification survey, collected inside the MCZ with a Hamon grab.

3.2 Features of Conservation Importance (FOCI)

No habitat or species FOCI designated in the Dover to Deal designation order were found in the 2016 Dover to Deal MCZ survey. However, the survey reported here was not designed to specifically monitor (or identify the presence of) species or habitat FOCI. As such, this should not be interpreted as an absence of these species or habitat FOCI from the site.

3.2.1 Ross Worm (*Sabellaria spinulosa*) Reefs

The Dover to Deal MCZ was designated for 'Ross Worm (*Sabellaria spinulosa*) Reefs' in May 2019, after the survey had taken place in 2016. Many of the infaunal samples from the 'A5.1 Subtidal coarse sediment' (n=2) and 'A5.4 Subtidal mixed sediments' (n=14), both inside and outside the MCZ boundary, were assigned to a *S. spinulosa* reef biotope (SS.SBR.PoR.SspiMx, *Sabellaria spinulosa* on stable circalittoral mixed sediment). The average *S. spinulosa* abundance per grab assigned to reef biotopes was 406 compared to 12 in non-reef biotopes.

S. spinulosa reefs are spatially extensive structures, distinctly raised above the surrounding seabed, which can persist for a number of years (Gubbay, 2007; Jenkins *et al*., 2015). *S. spinulosa* is widespread around the UK, often forming spatially localised and temporary crusts or aggregations which are not considered true reefs (Gubbay, 2007; Jenkins *et al*., 2015). Where present around the Dover to Deal MCZ, *S. spinulosa* were mostly present as crusts or small aggregations, but at two stations, to the north of the MCZ off Deal (DVDL30 and DVDL31), the grab samples provided evidence of more extensive *S. spinulosa* structures which may be indicative of extensive *S. spinulosa* reefs in this area of the coast (Figure 19).

3.2.2 Other Habitat FOCI

The Dover to Deal MCZ was designated for 'Blue Mussel Beds' in May 2019, after the survey had taken place in 2016. 'Blue Mussel Beds' were not observed inside the MCZ during the 2016 survey. The blue mussel, *Mytilus edulis*, was only recorded at two stations (DVDL 91 and 92) inside the MCZ. Three juvenile mussels were recorded at DVDL 91, and four juvenile mussels at DVDL 92. Outside of the site, adult mussels were recorded at three stations (DVDL 29, 31 and 49), but not at densities high enough to be recorded as a mussel bed biotope.

Figure 15: *Sabellaria spinulosa* structures at station DVDL31, observed in a 0.1 m^2 Day grab sample during the 2016 Dover to Deal MCZ survey (© Environment Agency and Natural England 2016).

3.3 Non-indigenous species (NIS)

All taxa identified in grab samples collected in 2016 were cross referenced with the list of non-native target species compiled in Eno *et al*. (1997), and the 49 non-indigenous target species which have been selected for assessment of Good Environmental Status (GES) in UK waters under MSFD D2 (Stebbing *et al.,* 2014; Annex 4). Two non-indigenous species were identified from the benthic infaunal sample (Figure 15).

A total of 11 individuals of Darwin's barnacle, *Austrominius modestus*, were present at three stations outside the MCZ boundary (eight individuals at DVDL 29, one individual at DVDL 32 and two individuals at DVDL 49). The Slipper Limpet, *Crepidula fornicata*, known to be well-established on the southern coast of England, was present at two stations (DVDL 31 and DVDL 91), albeit only as single individuals. An additional potential non- indigenous species was also identified; colonial tunicates from the family *Didemnidae* were found at nine stations inside and six stations outside the MCZ, but could not be reliably identified to species level without genetic analyses (Stefaniak *et al*., 2009) .

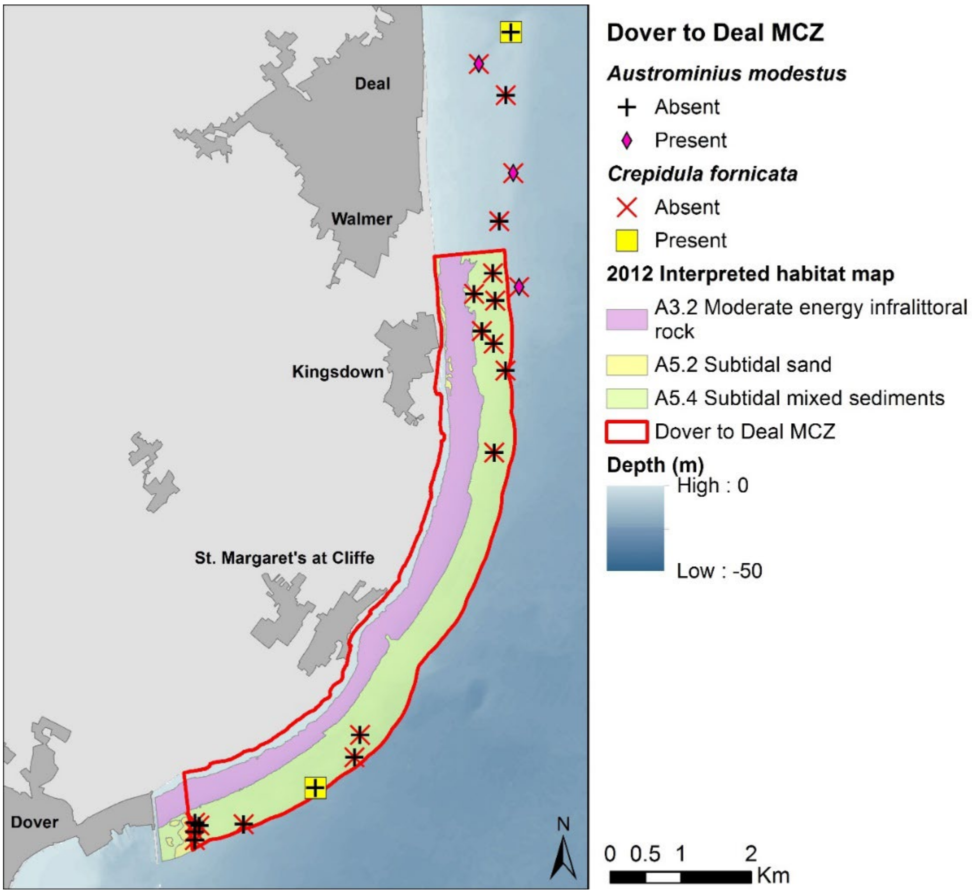

Figure 16. Presence and distribution of non-indigenous species sampled in the 0.1 m^2 Day grab from the 2016 Dover to Deal MCZ survey (© Natural England and Environment Agency 2022).

3.4 Supporting processes

3.4.1 Water quality parameters

Near seabed water column salinity was recorded at the stations where contaminants were sampled. It ranged from 34.95 to 35.04.

3.4.2 Sediment quality parameters

Surface sediment scrapes were taken at four grab stations (Figure 2) within the MCZ boundary providing a record of the most recent heavy metal (Figure 16) and organic contaminants (Figure 17) levels deposited in the surficial sediments.

All samples had at least one heavy metal concentration above background concentrations (above the OSPAR BAC thresholds). Stations DVDL 1 and DVDL 2 had lead concentrations elevated above background concentrations and in excess of the OSPAR ERL threshold, above which concentrations are deemed to have chronic adverse impacts on biota (Figure 16). Lead concentrations at DVDL 2 (143.9 mg kg^{-1} dry weight normalised to 5% aluminium) exceeded the ERL threshold (47 mg kg^{-1} dry weight) by 206 %.

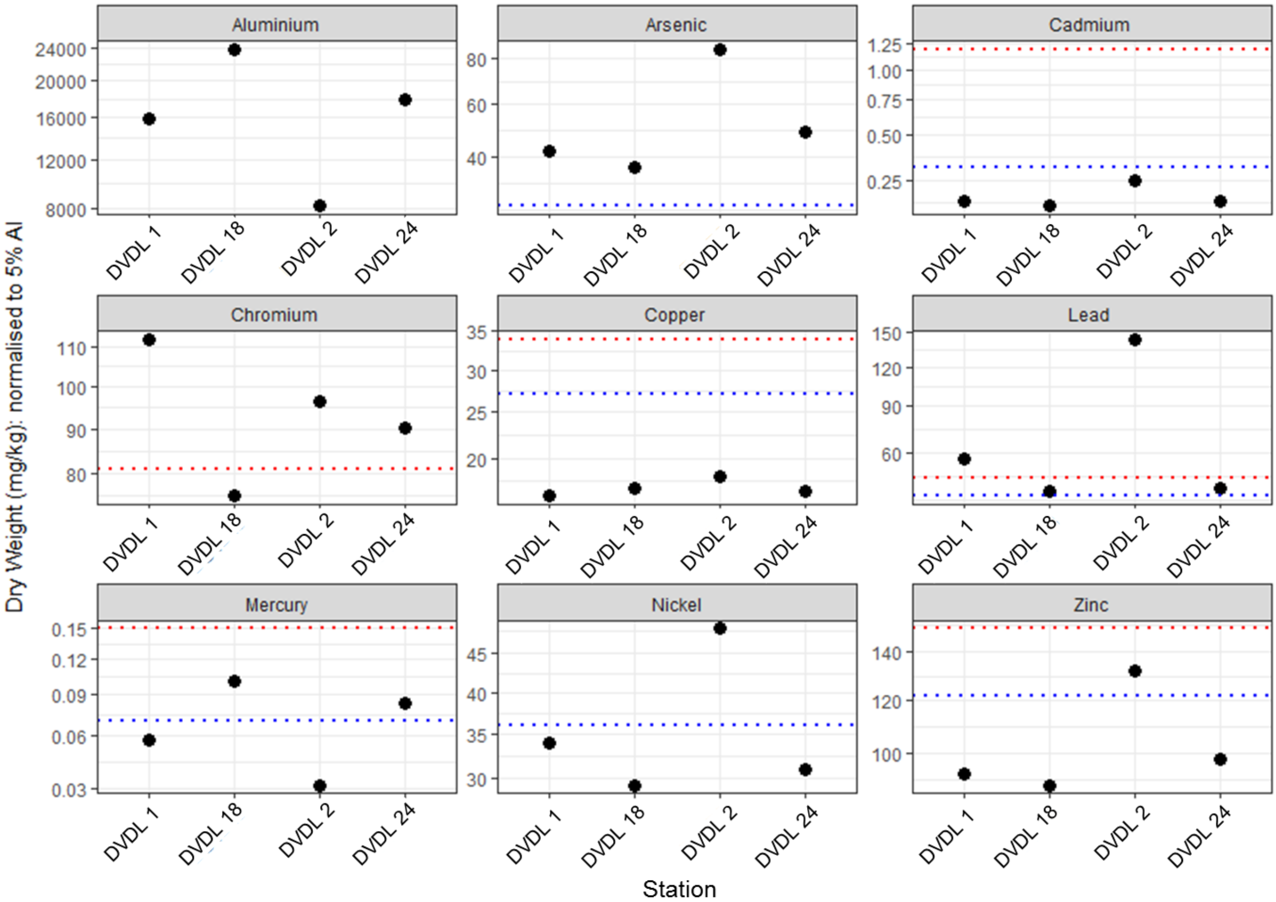

Figure 17. Results of heavy metal contaminants analyses of sediment samples collected in the 2016 Dover to Deal MCZ survey from within the MCZ boundary (© Natural England and Environment Agency 2022). The blue reference lines indicate the OSPAR Background Assessment Concentrations (BAC) thresholds and the red reference lines indicate the OSPAR Effects Range Low (ERL) thresholds.

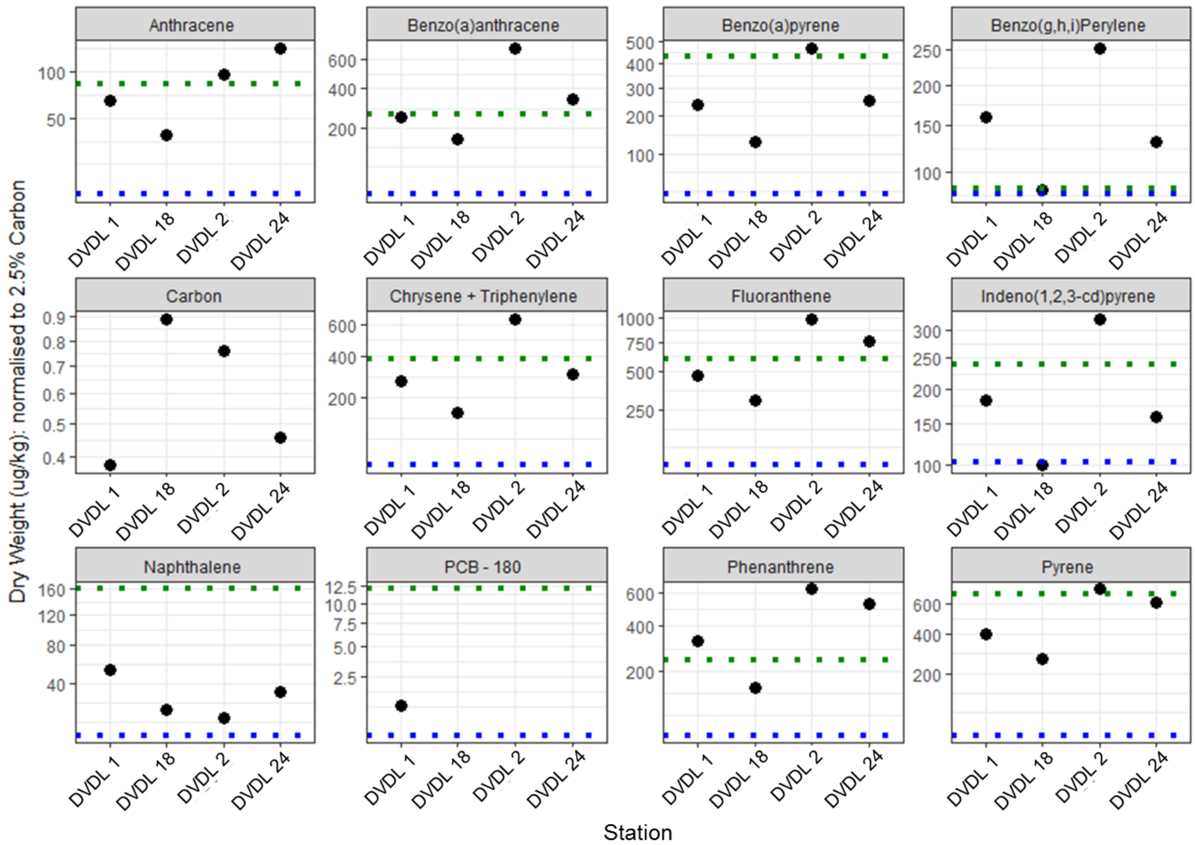

Figure 18. Results of organic contaminants analyses of sediment samples collected in the 2016 Dover to Deal MCZ survey from within the MCZ boundary (© Natural England and Environment Agency 2022). The blue reference lines indicate the OSPAR Background Assessment Concentrations (BAC) thresholds and the green reference lines indicate the OSPAR Environmental Assessment Criteria (EAC) thresholds. With the exception of Carbon and PCB 180 all these contaminants belong to the Polycyclic aromatic hydrocarbons (PAHs) chemical group.

All stations sampled had PAHs above background concentrations (the OSPAR BAC threshold), Multiple PAHs exceeded the OSPAR EAC threshold (levels above which they would cause chronic adverse impacts on marine biota) at DVDL 2 (Figure 17). Two PAHs (anthracene and phenanthrene) were also above the EAC threshold at DVDL 24. A single PCB congener, PCB-180, was the only PCB recorded at a single station, DVDL 1. This was at below background concentrations (OSPAR BAC threshold). Tabulated contaminants results can be found in Annex 5.

3.4.3 Marine litter

All marine litter found during the 2016 Dover to Deal MCZ survey falls within the 'A: Plastic' category of marine litter under OSPAR/IECS/IBTS guidance (Annex 3). This plastic litter was present at five stations (four stations inside the MCZ boundary and one station outside the MCZ boundary) sampled but no more than one fragment was found at any station (Figure 23). All plastic fragments were subcategorised as 'A14. Other' except at DVDL2 where 'A13. Sanitary towels/tampons' was found.

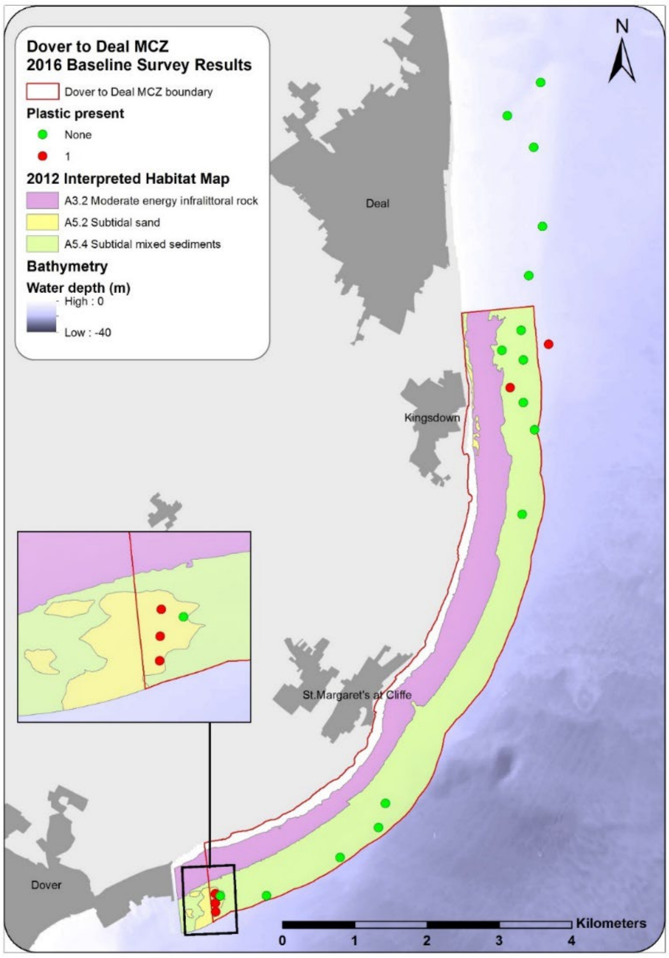

Figure 19. Distribution of plastic presence in Day grab samples from the 2016 Dover to Deal MCZ survey (© Natural England and Environment Agency 2022).

4 Discussion

This monitoring report provides the initial characterisation of designated subtidal sedimentary features within the Dover to Deal MCZ. This section discusses the evidence provided in this report used to address report objectives 1, 2 and 3, and makes recommendations for future assessment and monitoring of the designated features of the Dover to Deal MCZ (report objective 4). This evidence is discussed in relation to the sub-set of feature attributes outlined in Table 2.

Any statements or interim conclusions on feature condition or ecological status provided in this report are underpinned by the evidence collected, analysed and presented herein. Formal assessment of the condition status of designated features is carried out for this MCZ by Natural England using all available data, including the information presented in this report.

4.1 Subtidal sedimentary Broadscale Habitats (BSHs)

The infaunal communities of the designated sediment BSHs sampled in the Dover to Deal MCZ survey are considered to be representative of transitional sediment communities located along the eastern English Channel. The structural composition of the biological communities characterising the sedimentary features in the Dover to Deal MCZ suggests their current condition is of a healthy status. Owing to a lack of available evidence to draw temporal or spatial inferences from the existing surveys additional surveys are required to understand whether the condition of the site is deteriorating or improving.

4.1.1 Extent and distribution

The 2016 Dover to Deal MCZ survey observed one of the two designated subtidal sediments BSHs. No 'A5.2 Subtidal sand' habitats were observed in 2016 with the four PSA samples targeting this habitat having particle size distributions attributed to the non-designated BSHs 'A5.3 Subtidal mud' (n=3) and 'A5.1 Subtidal coarse sediment' (n=1).

In 2012 the presence of the designated BSH 'A5.2 Subtidal sand' was confirmed by a single PSA sample; when this station (DVDL 4) was resampled in 2016 the particle size distribution was attributable to the BSH 'A5.3 Subtidal mud'. Because of the small number of samples targeting the 'A5.2 Subtidal Sand' BSH (one in 2012 and four in 2016) it is not possible to confidently discern whether the PSA results from these stations reflect: the locally heterogeneous nature of the seabed; a short-lived or seasonal particle size distribution; or an actual change in BSH. It should be noted that the 2012 'A5.2 Subtidal Sand' PSA sample (2012 station code DOVD 01), had a percentage gravel, sand and silt content of 1.93 %, 80.65 % and 17.42 % respectively, which is a Folk classification of 'Muddy sand' (Colenutt *et al*. 2015), and with 2.6 % more silt would be classified as 'A5.3 Subtidal Mud'.

In 2012 the presence of the designated BSH ‘A5.4 Subtidal mixed sediments’ was confirmed from eight samples inside the MCZ boundary; five of these stations were resampled in 2016 where the PSA results reconfirmed the presence of this BSH. The 2016 survey also sampled an additional 11 stations targeting the ‘A5.4 Subtidal mixed Sediments’ BSH inside the MCZ boundary; seven had particle size distributions which confirmed the presence of this BSH and four were assigned to the non-designated BSH ‘A5.1 Subtidal coarse sediment’. Nine stations were sampled outside the MCZ boundary, of which, seven had particle size distributions attributed to the ‘A5.4 Subtidal Mixed Sediments’ BSH and three to the ‘A5.1 Subtidal coarse sediments’ BSH. Based on these results, the ‘A5.4 Subtidal mixed Sediments’ BSH still has a wide distribution across the site, and the BSH extends beyond the MCZ boundary (notably to the north), and no evidence of deterioration in the extent of this BSH inside the MCZ boundary was found. To date, only the 2016 survey observed the non-designated BSH ‘A5.1 Subtidal coarse sediment’ albeit none of the sites in which this habitat was observed had previously been sampled. It is therefore not possible to discern whether these data reflect a habitat change with enclaves of ‘A5.1 Subtidal coarse sediment’ becoming established within the ‘A5.4 Subtidal mixed Sediments’ BSH or whether the ‘A5.1 Subtidal coarse sediment’ BSH was always present at these previously unsampled locations. It should also be noted that the small number of samples assigned to the ‘A5.1 Subtidal coarse sediment’ preclude an accurate characterisation of this BSH.

4.1.2 Structure and function: Biological communities

This section discusses evidence related to several inter-related feature attributes; species presence and spatial distribution of biological communities, presence and abundance of key structural and influential species, and species composition of component communities.

Six biotopes were observed during the 2016 Dover to Deal MCZ survey (Table 8). Inside the MCZ boundary, the biotope SS.SBR.PoR.SspiMx (*Sabellaria spinulosa* on stable circalittoral mixed sediment) was the most prevalent biotope being observed across the whole extent of the BSH ‘A5.4 Subtidal mixed sediments’ and reflects the dominance of *Sabellaria spinulosa* among stations assigned to this BSH. This biotope also characterised three of the four samples assigned to the BSH ‘A5.1 Subtidal coarse sediment’. These mismatches between assigned BSH and biotope reflectthe mismatches in how the biotopes and BSHs are defined where the biotope definition is applicable across the boundary between ‘A5.1 Subtidal coarse sediment’ and ‘A5.4 Subtidal mixed sediments’ where the mud:sand ratio is 9:1. The four samples taken within the predicted habitat ‘A5.2 Subtidal sand’ BSH were equally split among two biotopes; *Spisula subtruncata* and *Nephtys hombergii* in shallow muddy sand (SS.SSA.IMuSa.SsubNhom) and *Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment (SS.SSA.CMuSa.AalbNuc).

Table 8. Summary of EUNIS level 5 biotopes assigned to samples taken in each Broadscale Habitat during the 2016 Dover to Deal MCZ survey (© Natural England and Environment Agency 2022).

Broadscale Habitat	Biotope code (EUNIS level 5)	Description	Count
A5.1 Subtidal Coarse Sediment	SS.SSA.IMuSa.SsubNhom	Spisula subtruncata and Nephtys hombergii in shallow muddy sand	1
	SS.SBR.PoR.SspiMx	Sabellaria spinulosa on stable circalittoral mixed sediment	2
A5.3 Subtidal Mud	SS.SSA.CMuSa.AalbNuc	Abra alba and Nucula nitidosa in circalittoral muddy sand or slightly mixed sediment	2
	SS.SSA.IMuSa.SsubNhom	Spisula subtruncata and Nephtys hombergii in shallow muddy sand	1
A5.4 Subtidal Mixed Sediment	SS.SBR.PoR.SspiMx	Sabellaria spinulosa on stable circalittoral mixed sediment	12
	SS.SBR.PoR.SspiMx/ SS.SCS.ICS.Slan	Sabellaria spinulosa on stable circalittoral mixed sediment/ Dense Lanice conchilega and other polychaetes in tide-swept infralittoral sand and mixed gravelly sand	1
	SS.SBR.PoR.SspiMx/ SS.SCS.CCS.PomB	Sabellaria spinulosa on stable circalittoral mixed sediment/ Pomatoceros triqueter with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles	1
	SS.SMU.ISaMu.AmpPlon	Ampelisca spp., Photis longicaudata and other tubebuilding amphipods and polychaetes in infralittoral sandy mud	1

Several taxa present in the Dover to Deal MCZ may be considered as key structural and/or influential species based on their abundance, biomass and ecology:

- The amphipod *Ampelisca diadema* is the overall most abundant species accounting for 29% of the total species abundance for all taxa observed in the 2016 Dover to Deal survey and being present at 71% of infaunal sampling stations. However, 90% (6385 individuals) of *Ampelisca diadema* abundance is derived from one station (DVDL 18) and other than at DVDL 24, where 546 individuals were recorded, all other stations had <30 individuals present. Figure 13 shows an example of an *Ampelisca diadema*-dominated biotope (SS.SMU.ISaMu.AmpPlon, *Ampelisca* spp., *Photis longicaudata* and other tube-building amphipods and polychaetes in infralittoral sandy mud) where the flattened, flexible mud-covered tubes created by *Ampelisca diadema* and associated tubebuilding amphipods are clearly visible. These structures have the potential to alter the sedimentary and biogeochemical properties of the surficial seabed through water column exchange processes and the deposition of faecal pellets excreted by these amphipods (Woodin *et al.,* 2010; Rigolet *et al.,* 2014).

- The Ross Worm (*Sabellaria spinulosa)* is the second most abundant species accounting for 26% of the total species abundance and 26% of total biomass for all taxa observed in the 2016 Dover to Deal survey and was present at 86% of infaunal sampling stations. *Sabellaria spinulosa* was also the characterising species for all but one of the biotopes within both the 'A5.4 Subtidal Mixed Sediments' and 'A5.1 Subtidal coarse sediment' BSHs. *Sabellaria spinulosa* can act to stabilise sedimentary habitats, providing a biogenic habitat that facilitates the establishment of many other associated species (JNCC,2008).
- The bivalve Abra alba was present in 77% of the samples, predominately in mixed sediments, and is a rapid-recruiting species that can quickly colonise after disturbances.

The structural composition of the biological communities characterising the A5.4 Subtidal Mixed Sediment features in Dover to Deal MCZ and their current status/condition suggests the sediment features overall are in a favourable condition. The IQI score for the samples closer to Dover Harbour were lower than those sampled in the east of the site. This indicates some impact to the communities, which could be as a consequence of the increased pressures from shipping and associated activities closer to Dover Harbour (MMO, 2014). Future surveys could undertake further sampling to investigate if there is a correlation between harbour distance and the IQI.

There were changes in the subtidal mixed sediment communities and an increase in taxa richness inside the MCZ since the verification survey in 2012 (Colenutt *et al*. 2015). Whilst some of these differences could be due to the differing sampling gear used between surveys (Hamon grab was used in 2012 compared to Day grab in 2016), it is possible that the increase in *Sabellaria spinulosa* and *Ampelisca diadema* abundance from 2012 to 2016 lead to increased habitat complexity and biogenic habitat formation, resulting in a change in community structure (Figure 14).

4.2 Non-indigenous species (NIS)

Two confirmed non-indigenous species, the barnacle *Austrominius modestus* and the Slipper Limpet, *Crepidula fornicata* were observed in the 2016 Dover to Deal MCZ survey. Both species were not observed in grab samples collected in the 2012 verification survey (Colenutt *et al.* 2015). However, fewer grab samples were collected in 2012, and *C. fornicata* shells were observed in the 2012 video survey, so their appearance in the 2016 survey is not unexpected. *Austrominius modestus* are not among the taxa selected for assessment of good environmental status (GES) in British waters under MSFD Descriptor 2 (Stebbing *et al*., 2014; Annex 5) but is listed on the JNCC list of non-indigenous marine species in British waters (Eno *et al.,* 1997) where it has been known to be present for over 70 years. *Austrominius modestus* is known to outcompete the native barnacles *Amphibalanus improvisus* and *Semibalanus balanoides* (Noël, 2011), but neither were observed in the 2016 Dover to Deal MCZ survey. At present, the low abundance of *A. modestus* (11 individuals observed) suggests a low threat from this non-indigenous species. *C. fornicata* are among the taxa selected for assessment of GES under MSFD descriptor 2 (Stebbing *et al*., 2014; Annex 5), however, the current impact of this species cannot be confidently assessed based on the two individuals identified. Whilst there was no evidence that *Crepidula fornicata* was acting as a habitat structure by forming extensive beds, the small physical area of the seabed covered by grab means this cannot be ruled out.

Colonial tunicates from the family Didemnidae were found at eight stations inside the MCZ boundary, but could not be identified to species level. The Didemnidae family includes the non-indigenous species *Didemnum vexillum* therefore future surveys should consider further investigation (genetic analyses) to confirm whether this species is present or not.

4.3 Supporting processes

4.3.1 Sediment contaminants

At three of the four stations sampled for sediment contaminant analyses, several heavy metal and organic contaminants were present at concentrations above thresholds at which they cause an adverse impact on marine biota. Stations DVDL 1 and DVDL 2 both within ‘A5.3 Subtidal mud’ BSHs, and located close to Dover harbour (Figure 2), had the highest exceedances of OSPAR thresholds (Figures 16 and 17).The proximity of these samples to Dover harbour may suggest that increased pressure from shipping and industrial activity explain the elevated contaminants in this area. Both stations (along with other samples in the area) had associated infaunal samples that were at good environmental status (IQI score between 0.64 and 0.75), all other stations sampled away from the harbour were at high environmental status (IQI score > 0.75). This indicates that despite elevated contaminant levels due to pressures on the infaunal communities closer to Dover, the ecological status of infaunal communities is not detrimentally affected at present.

It is not possible to attribute the excess contaminant concentrations at DVDL 24, north of Kingsdown, to any known source(s) nor is it clear whether this is an isolated contaminated area within the MCZ or whether contaminants are exceeding acceptable thresholds in other areas of the MCZ. Sampling for sediment contaminants (n=4) was proportionally under-represented among all samples (n=29) collected in the Dover to Deal 2016 MCZ survey therefore future surveys are required to investigate contaminant levels throughout the MCZ as well as continued monitoring of contaminants at DVDL 18 to identify temporal trends. The proximal area around DVDL 18, and areas close to Dover harbour, should be examined more closely in future monitoring surveys, with repeated infaunal and contaminant analyses spaced at regular intervals, in order to identify the extent of any impact and the potential source of the elevated concentrations.

5 Recommendations for future monitoring

5.1 Operational and survey strategy recommendations

- Surveys to date have only partially covered the full extent of the Dover to Deal MCZ, resulting in imbalanced survey designs and preventing robust spatial and temporal comparisons. Therefore, future surveys should employ an appropriate survey design which samples all protected BSH features, with stations resampled over multiple surveys, in order to improve our understanding of the observed spatial and temporal variability, or:
- Future surveys should target the ‘A5.4 Subtidal mixed sediments’ for use as a sentinel BSH within the MCZ, sampling this BSH outside the MCZ for BACI assessments to put temporal changes in context and assess the efficacy of the general management approach.
- Seabed sediment samples were collected using a Day grab in this study. This was to allow the data to be used for additional assessments, such as Water Framework Directive classifications. However, there were a large number of ‘no samples’ with this sampling method due to (a) samples were being collected areas of chalk that were originally considered to be sediment or (b) coarse sediment jamming the jaws of the grab, resulting in a loss of material and the sample was discarded. A Hamon grab could be used for future surveys to ensure the collection of coarser sediment samples without the loss of material from the grab.
- Sample from as many sites as is necessary (accounting for discards and sediment movement or local-scale heterogeneity) to collect a minimum of 20 PSA and infauna samples, separated by at least 758 m horizontal distance, from ‘A5.4 Subtidal mixed sediments’ inside and outside the MCZ (Annex 2).
- Contaminant samples should be resampled at the same stations in future monitoring surveys to identify trends in densities / concentrations, and potentially the source of the input. This could be complimented with finer-scale sampling at targeted areas (e.g. around stations DVDL 1, DVDL 2 and DVDL 18) to better understand the scale of the contamination and potentially narrow down source location. Consideration should also be given to whether the contaminants are being taken up by the associated biota; therefore, further sampling could be undertaken on appropriate biota (following EQSD monitoring protocols, European Union (2010).
- Several differences were noted between the 2012 habitat map derived from acoustic methods and the 2016 BSHs assigned based on the ground truthed PSA results. An additional acoustic survey, to allow the production of an updated, spatially resolute habitat map of the site would aid the interpretation of whether these differences reflect local-scale heterogeneous habitat changes or a wider-scale change within the MCZ – but would be expensive.

- To better assess the current impact, if any, of *Crepidula* a video survey encompassing areas of the seabed where *Crepidula* were present in grab samples should be undertaken.
- A combination of sidescan and subtidal video surveys should be undertaken to assess the extensiveness of *Sabellaria spinulosa* reefs, especially as this was an additional feature designated in May 2019.
- An alternative, less expensive, approach for mapping the BSH extents of the site could be to model between existing data points using geostatistical interpolation techniques. This would require additional PSA samples taken at sufficient spatial density (ideally <750 m separation distance) to ensure significant autocorrelation for modelling purposes (Annex 2).
- High turbidity meant that the drop-down video survey did not provide viable results. The site was successfully surveyed with a drop-down video in 2012, so such surveys are possible, although such alignment of weather and tide to provide clear conditions could be rare. A drop-down video survey using a freshwater lens could be considered as an alternative method to collect video data in turbid conditions.

5.2 Analysis and interpretation recommendations

- The non- indigenous ascidian *Didemnum vexillum* was not identified within the site, but individuals of its parent family Didemidae were confirmed at eight stations. *D. vexillum* has a range of morphotypes but it is not possible to positively identify this species using routine Day grab samples fixed in 6% formaldehyde. Previous studies have used mitochondrial DNA analysis (Graham *et al.,* 2015) to confirm *D. vexillum* presence, so future grab surveys should collect samples for suspected *D. vexillum* presence separately from routine samples collected for infaunal analysis, in order to confirm identification using molecular approaches.
- Multivariate analysis methods may be more reliable for detecting spatial differences and temporal changes and should be used alongside statistical analysis of univariate summary statistics.
- Where univariate methods are used, emphasis should be on Hill's diversity indices when examining differences between groups.

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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 should be checked and truncated to ensure that each row represents a legitimate taxon and that they are consistently recorded within the dataset. An artificially inflated taxon list (i.e., one that has not had spurious entries removed) risks distorting the interpretation of pattern contained within the sampled assemblage.

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

Taxa are often assigned as 'juveniles' during the identification stage with little evidence for their actual reproductive natural history (with the exception of some well-studied molluscs and commercial species). Many truncation methods involve the removal of all 'juveniles'. However, a decision must be made on whether removal of all juveniles from the dataset is appropriate or whether they should be combined with the adults of the same species where present. For the infaunal data collected at The Dover to Deal MCZ: where a species level identification was labelled 'juvenile', the record was combined with the associated species, genus or family level identification, when present or the 'juvenile' label removed where no adults of the same species had been recorded.

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

1) Entries of certain taxa groups are initially removed:

    a. Any species marked with an 'eggs' or 'epitoke' qualifier

    b. Insects (e.g. springtails, Collembola, etc.)

    c. Macroalgae (coded ZM___, ZR____, etc.)

    d. Litter (coded ZZ____)

    e. Demersal/pelagic fish (coded ZG___, but keep the lancelet *Branchiostoma lanceolatum*)

2) Juveniles and adults of the same named species are merged together to provide a single entry per named species, e.g.:

1	P0494	Nephtys assimilis	Juvenile	2	**Merge**
2	P0495	Nephtys assimilis		4	

3) If there are taxa identified to genus or family level only:

    a. If there is a single entry (juveniles or adults) for that genus or family, and no child taxa, then that entry is retained, e.g.:

1	P0494	Nephtys	Juvenile	1	**Keep**

    b. If there is a single entry of a genus with a 'juvenile' qualifier and a single entry of a child species (juvenile or adult), the parent genus entry is removed:

1	P0494	Nephtys	Juvenile	2	**Remove**
2	P0495	Nephtys assimilis		4	**Keep**

    c. If there is a single entry of a genus (adult) and a single child species (adult), then the entries are merged to single genus row:

1	P0494	Nephtys		2	**Merge**
2	P0495	Nephtys assimilis		4	

    d. If there is an entry of genus (juvenile and/or adult), multiple entries of child species underneath, then the parent genus entry is removed:

1	P0494	Nephtys		2	**Delete**
2	P0494	Nephtys	Juvenile	1	**Delete**
3	P0495	Nephtys assimilis		4	**Keep**
4	P0499	Nephtys hombergii		1	**Keep**

4) All colonial species (bryozoans, coded Y____ and some cnidarians and ascidians) recorded as 'P' (present) are converted to '1'.

5) All entries recorded as 'fragments' (recorded as 'F' , 'fragment' or 'Frag') are converted to '0'.

Annex 2. Assessment of sampling sufficiency

The ability to detect change depends on what the type of change being examined (the question being asked), the magnitude of the change, the magnitude and scale of temporal and spatial variability in the environment, the rate of Type I errors deemed permissible and sampling effort (Noble-James *et al.,* 2017), as well as the statistical method of data analysis (non-parametric procedures are often considered to be less powerful than parametric procedures). Thus, the ability of future surveys to detect change (power analysis) can be considered from this baseline study, assuming future studies resample stations sampled here or use a similar process for site selection.

In the power analysis presented here, the level of 'adequate' statistical power (1-β - the ability of a test to detect an effect if the effect actually exists) is defined as 0.80 (80%), whilst statistical significance (α; the probability of not detecting an effect when in fact it exists) is conventionally set at 0.05 (5%). This results in a ratio of α to 1-β which equates to a 5:20 error probability (i.e. the likelihood of detecting an effect when it exists (Type II error) is four times greater than the likelihood of falsely detecting an effect that does not exist (Type I error) – as per convention. In practice, but beyond the scope of this report, the ratio of α and 1-β should be defined on a case-by-case basis according to perceived costs of committing Type I and Type II errors to both stakeholders and the environment, taking into account the trade-off between the resources required and the need to provide robust evidence i.e. the costs of making incorrect decisions (Noble-Jones *et al.,* 2017). Post-hoc power analysis of the 2016 Dover to Deal MCZ survey data is presented in Table A2.1..

Table A2.1. Predicted number of samples needed to obtain a statistical power of 80% to detect a given level of change in each of the univariate metrics of community structure of 'A5.4 Subtidal mixed sediments' in the Dover to Deal MCZ (© Natural England and Environment Agency 2022). The number of samples required to detect change in the base statistics (abundance and species richness) is given as a percent change in the mean. Change is given in absolute values for the derived statistics. Power analysis based on two-sample independent t-test, using untransformed data and a significance level of 5%.

Metric	Mean	StDev	Number of samples needed to detect		
			10% change	20% change	50% change
Abundance	1455	1597	1906	478	77
Species Richness	14.3	0.72	6	4	2
			Number of samples needed to detect given magnitude of change		
Shannon H' ($\log_e$)	2.5	0.19	16 (d 0.2)	5 (d 0.4)	3 (d 1.0)
Simpson's D (1-λ')	0.73	0.05	17(d 0.05)	6 (d 0.1)	3 (d 0.2)
Hill's N1(exp[H'])	15.24	2.54	45 (d 1.52)	12 (d 3.05)	4 (d 7.62)
IQI	0.85	0.01	3 (d 0.05)	2 (d 0.1)	2 (d 0.2)

Although the statistical analysis used in this report used ANOVA, and any future analysis is likely to use the same to account for the BACI survey design, power analysis was carried out using the independent two sample t-test option. It therefore does not consider the potential increased power gained from repeated sampling over time, nor does it consider any issues arising from heteroscedasticity in the data. Estimates of standard deviation came from the untransformed sample data collected from 'A5.4 Subtidal mixed sediments' inside the site.

The results of the power analysis agree with the outcome of the analyses carried out in section 2. Differences between habitat types were identified using species richness and the IQI, but the derived diversity indices were generally non-suggestive of these differences. It is worth noting here that the Shannon and Simpson indices are nonlinear so differences in absolute values of these metrics are not relative, therefore in practical terms Hill's indices provide more intuitive information on species diversity between groups where the absolute values can be considered as the effective number of species (c.f. Jost, 2006). It should also be noted that multivariate analysis of community composition is likely to be more powerful than analysis of univariate metrics.

Additional insights about effective monitoring strategies can also be obtained through spatial autocorrelation analysis. Spatial autocorrelation is a natural phenomenon in which observations from nearby locations are likely to have values more similar than would be expected due to chance alone (Fortin *et al* 2002). Positive autocorrelation occurs when taxa are distributed in clumps or patches, or form aggregations. For example, *Sabellaria spinulosa* reefs are colonised by gregarious settlement, with existing aggregations of *Sabellaria spinulosa* encouraging settlement of larvae (Wilson 1970), therefore two sampling units taken in close proximity are likely to be highly spatially autocorrelated. The randomised sampling design employed in this study was chosen to minimise the influence of positive spatial autocorrelation i.e. sampling locations ensure spatial independence among the communities sampled.

The degree of spatial dissimilarity is evaluated for the 2016 Dover to Deal MCZ survey data by quantifying the significance of spatial autocorrelation in the benthic communities sampled at each station assigned to the 'A5.4. Subtidal mixed sediments' BSH. This analysis is performed by computing the Mantel's correlogram. Mantel's correlorgam (Sokal, 1986; Oden and Sokal 1986) is a special case of a simple Mantel test (Mantel, 1967) - a measure used to evaluate the resemblance between two matrices (e.g. ecological and geographic distance) – where the analysis is partitioned into a series of discreet distance classes (analogous to the lag bins of a semivariogram). That is, a first distance matrix is evaluated by computing a standardised Mantel statistic (r_M) for all pairs of points within the first distance class; then a second matrix is scored for all pairs of points within the second distance interval, and so on. The result is analogous to an autocorrelation function or semivariogram but performed on a multivariate distance matrix (c.f. Legendre and

Legendre, 1998, pp. 736-738) where no spatial correlation is $r_M = 0$ and a perfect positive autocorrelation is $r_M = 1$.

Before the correlogram was computed a Hellinger transformation was performed on the species data in order to reduce the influence (give lower weighting) to taxa with low counts or many zeros. The mantel correlogram for the Dover to Deal 2016 MCZ data was computed in the *Vegan R* package (Oksanen *et al.,* 2017). Here a multiple testing approach is employed to produce the correlorgam where the Mantel test is performed for each distance class over multiple permutations (n=999) to compute the significance (*p* value) of spatial autocorrelation. There is an inherent increased risk of Type I error in the multiple testing approach so the Holm (1979) approach was used to correct *p* after permutation testing. Distance classes were assigned following Sturges' rule (Sturges, 1926): number of classes = 1 + (3.3219 x $\log_{10}n$) where *n* is the number of pairwise distances.

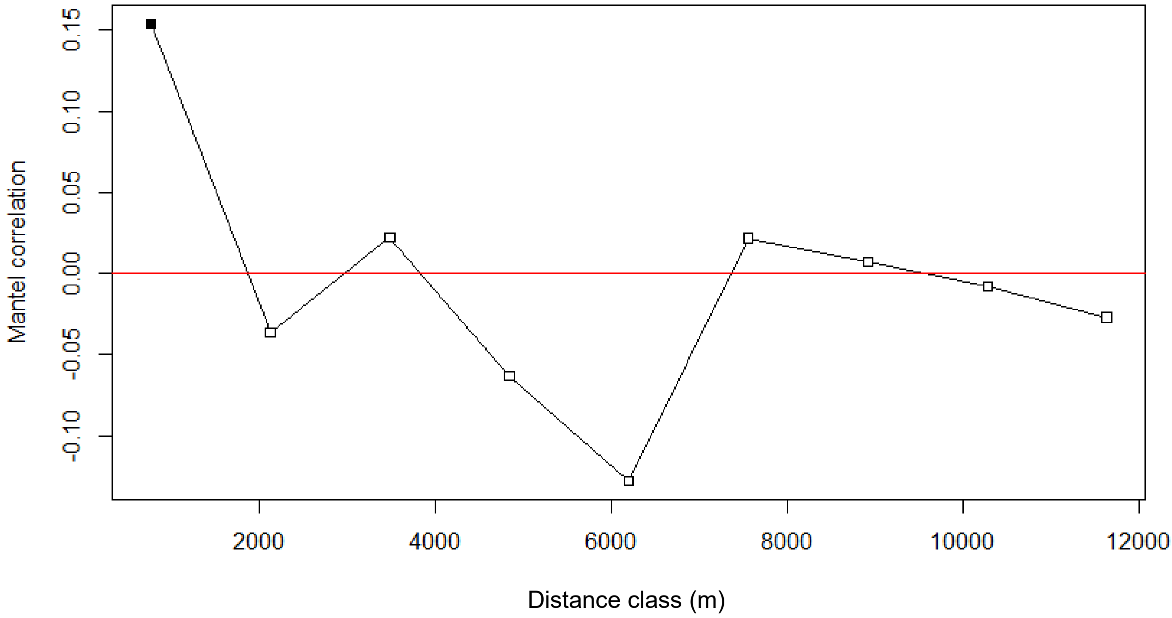

Figure A2.1 Mantel correlogram of the Hellinger transformed Dover to Deal 'A5.4 Subtidal mixed sediments' faunal data (© Natural England and Environment Agency 2022). Filled black squares indicate significant multivariate spatial autocorrelation after Holm correction for multiple testing (n=999 permutations).

The correlogram for Dover to Deal 'A5.4. Subtidal mixed sediments' infaunal community data has a single significant distance class indicating significant (*p* = 0.05) positive correlation (r_M = 0.15) at distance class 1 (0 – 758 m). Beyond this separation distance (>758 m) no significant autocorrelation is identified. This means that for practical purposes (i.e. future monitoring) measurements (samples) taken more than 758 m apart can be considered as spatially independent with respect to infaunal community composition.

Species accumulation curves were also undertaken for 'A5.4 Subtidal mixed sediments' stations sampled inside the MCZ to assess the sampling sufficiency (Figure A2.2). The Michaelis-Menton curve identified a S_{max} (the predicted maximum number of taxa present in that feature) of 295.23. The number of taxa identified (using the Michaelis-Menton model) from the 9 samples of ‘A5.4 Subtidal mixed sediments’ collected was 239.60, 81.2 % of the S_{max}.

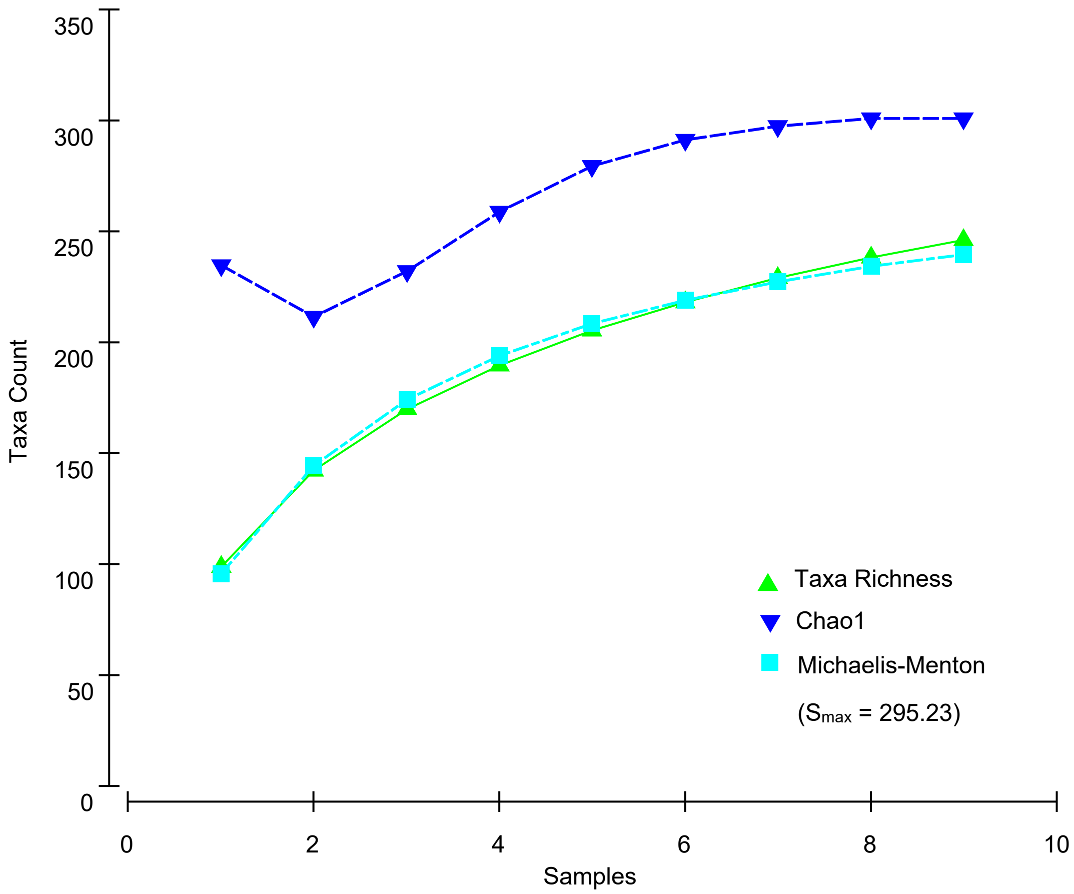

Figure A2.2. Species accumulation curves using taxa richness and two models for ‘A5.4 Subtidal mixed sediments’ stations sampled inside the Dover to Deal MCZ. The S_{max} for the Michaelis-Menton curve was predicted to be 295.23 taxa (© Natural England and Environment Agency 2022).

Annex 3. Marine litter

Table A3.1. Standardised categories and sub-categories for sea-floor litter as defined by the OSPAR/ICES/IBTS for North East Atlantic and Baltic. Guidance on Monitoring of Marine Litter in European Seas, a guidance document within the Common Implementation Strategy for the Marine Strategy Framework Directive, MSFD Technical Subgroup on Marine Litter, 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

Annex 4. Non-indigenous species (NIS).

Table A4.1. 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		

Table A4.2. 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 Descriptor 2.

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	
Potamopyrgus antipodarum	
Tiostrea lutaria	*Tiostrea chilensis*

Species name (1997)	Updated name (2017)
Mercenaria mercenaria	
Petricola pholadiformis	
Mya arenaria	

Annex 5. Sediment contaminants

Table A5.1. Sediment contaminant results for the four stations sampled for contaminants analysis in the Dover to Deal 2016 survey (© Natural England and Environment Agency 2022). Heavy metal contaminants are normalised to 5% aluminium and organic contaminants are normalised to 2.5 % carbon. BAC = Background Assessment Concentrations, EAC = Environmental Assessment Criteria and ERL = Effects Range Low OSPAR thresholds. < MRV indicates below minimum readable value of the measuring instrument.

						Station (DVDL__)			
	Material (dry weight at 30ºC)	**Unit**	**BAC**	**EAC**	**ERL**	**1**	**2**	**18**	**24**
Heavy metals	Mercury	mg/kg	**0.07**		**0.15**	0.06	0.03	0.10	0.08
	Aluminium, HF Digest	mg/kg				0.05	0.05	0.05	0.05
	Iron, HF Digest	mg/kg				61949.69	92073.17	42016.80	51955.31
	Arsenic, HF Digest	mg/kg	**25**			41.82	84.76	36.34	48.88
	Cadmium, HF Digest	mg/kg	**0.31**		**1.2**	0.16	0.24	0.14	0.16
	Chromium, HF Digest	mg/kg	**81**		**81**	111.95	96.34	75.21	90.22
	Copper, HF Digest	mg/kg	**27**		**34**	16.35	18.23	17.04	16.79
	Lead, HF Digest	mg/kg	**38**		**47**	56.92	143.90	40.13	41.90
	Lithium, HF Digest	mg/kg				50.94	57.20	51.68	47.21
	Manganese, HF Digest	mg/kg				562.89	896.34	651.26	731.84
	Nickel, HF Digest	mg/kg	**36**			33.96	48.41	29.20	31.01
	Zinc : HF Digest	mg/kg	**122**		**150**	92.77	131.71	88.87	98.04
Chloro-carbons	Hexachlorobenzene	µg/kg				< MRV	< MRV	< MRV	< MRV
	Hexachlorobutadiene	µg/kg				< MRV	< MRV	< MRV	< MRV

Table 5.1: Continued…

						Station (DVDL__)			
	Material (dry weight at 30ºC)	**Unit**	**BAC**	**EAC**	**ERL**	**1**	**2**	**18**	**24**
Polyaromatic hydrocarbons (PAHs)	Anthracene	µg/kg	**5**	**85**		66.49	97.17	36.15	132.68
	Benzo(a)anthracene	µg/kg	**16**	**261**		244.68	685.11	153.59	339.36
	Benzo(a)pyrene	µg/kg	**30**	**430**		236.70	471.01	129.76	253.29
	Benzo(ghi)perylene	µg/kg	**80**	**85**		159.57	253.62	84.08	131.58
	Chrysene + Triphenylene	µg/kg	**20**	**384**		267.29	639.00	141.82	305.37
	Fluoranthene	µg/kg	**39**	**600**		468.09	988.14	305.49	762.06
	Indeno(1,2,3-c,d)pyrene	µg/kg	**103**	**240**		183.51	322.46	100.34	159.54
	Naphthalene	µg/kg	**8**	**160**		52.79	16.47	21.02	33.83
	Phenanthrene	µg/kg	**32**	**240**		326.46	619.24	143.22	527.96
	Pyrene	µg/kg	**24**	**665**		401.60	708.17	266.26	608.55
Polybrominated diphenyl ethers	2,2,4,4,5,5-Hexabromodiphenyl ether :- {PBDE 153}	µg/kg				< MRV	< MRV	< MRV	< MRV
	2,2,4,4,5,6-Hexabromodiphenyl ether :- {PBDE 154}	µg/kg				< MRV	< MRV	< MRV	< MRV
	2,2,4,4,5-Pentabromodiphenyl ether :- {PBDE 99}	µg/kg				0.27	< MRV	< MRV	< MRV
	2,2,4,4,6-Pentabromodiphenyl ether :- {PBDE 100}	µg/kg				< MRV	< MRV	< MRV	< MRV
	2,2,4,4-Tetrabromodiphenyl ether :- {PBDE 47}	µg/kg				< MRV	< MRV	< MRV	< MRV
	2,4,4-Tribromodiphenyl ether :- {PBDE 28}	µg/kg				< MRV	< MRV	< MRV	< MRV

Table 5.1: Continued…

	Material (dry weight at 30ºC)	Unit	BAC	EAC	ERL	Station (DVDL__) 1	2	18	24
Polychlorinated biphenyls (PCBs)	PCB - 028	µg/kg	**0.22**	**1.7**		< MRV	< MRV	< MRV	< MRV
	PCB - 052	µg/kg	**0.12**	**2.7**		< MRV	< MRV	< MRV	< MRV
	PCB - 101	µg/kg	**0.14**	**3**		< MRV	< MRV	< MRV	< MRV
	PCB - 118	µg/kg	**0.17**	**0.6**		< MRV	< MRV	< MRV	< MRV
	PCB - 138	µg/kg	**0.15**	**7.9**		< MRV	< MRV	< MRV	< MRV
	PCB - 153	µg/kg	**0.19**	**40**		< MRV	< MRV	< MRV	< MRV
	PCB - 180	µg/kg	**0.1**	**12**		0.137	< MRV	< MRV	< MRV
	Tributyl Tin as Cation	µg/kg				3.32	1.32	0.18	2.19
	Carbon, Organic as C	%				0.89	0.76	0.46	0.38

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