Benthic assemblages in Cromer Shoal Chalk Beds MCZ

Comparisons among different types of terrain

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Executive summary

This Natural England commissioned report describes the distribution of seabed habitats in the Cromer Shoal Chalk Beds Marine Conservation Zone (CSCB MCZ) and their taxonomic composition. 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.

This report uses biological records collected since 2005 that are held and curated by Seasearch. Seasearch is a volunteer underwater survey project for recreational divers and snorkellers to record observations of marine habitats and the life they support. Conservation agencies monitor the marine environment and are responsible for conducting condition assessments of protected and priority features. Condition assessments designed to determine site objectives such as to maintain or restore protected features are challenging. Thus, there is a clear need to explore options for new and innovative ways to collect more data or make more efficient use of existing data, including those from citizen science projects.

The CSCB MCZ was designated under the Marine and Coastal Access Act (2009) and is valued for its features of conservation interest, including extensive areas of subtidal chalk. Outcrops of chalk within a larger area of sediment provide relatively stable surfaces on which many species depend. Because chalk is not very hard, it can erode into a wide variety of shapes and structures, thereby providing complex habitat for a diverse assemblage of benthic taxa, including those of economic value. The lack of hardness also means that it can be damaged.

The ecology of subtidal chalk habitat is neither well-researched nor well understood, although CSCB MCZ has received considerable survey effort by Seasearch volunteers. As yet, little exploration or interpretation of these records have been made. There remains a need to improve our understanding of the distribution and character of chalk features, and of any ecological associations between benthic organisms and these features so that implications of change or damage can be evaluated and managed.

This project uses Seasearch data and local knowledge for the spatial extent of CSCB MCZ to improve our understanding in three areas: spatial distributions of habitats and structural features; taxonomic diversity and presence of associations between species and structural features. This information does not yet exist elsewhere. Analytical methods used are well established from other applications of Seasearch data.

Local knowledge was used to create maps for distributions of different habitats (as six types of rocky substrata or with four different degrees of ruggedness). Following careful filtering and quality control, standard ecological analyses were applied to explore differences in biodiversity and composition of assemblages in different benthic habitats. The nature of unstructured citizen science data means that there are inherent limitations which preclude analyses of some aspects of the data. Anecdotal descriptions were

collated for observed associations between named topographical features and specific taxa.

Cromer Shoal Chalk Beds MCZ supports a diverse range of habitats and taxa, within a relatively small area of sampling. Different habitats and areas of different surface relief occur in different parts of the MCZ. For example, chalk seabed typically increases in surface relief with increasing distance from shore, and chalk has generally been replaced by sediment by 1.5 km from shore. Chalk substrata supported much greater diversity than did clay substrata and habitats with greater complexity (e.g. with gullies and cobbles) were more diverse than less complex habitats. Anecdotal observations collated from experienced divers provided additional illustration of what lives where. These featured taxa of different sizes and growth-forms including important predators, providers of structure, invasive species, those with very particular requirements, endemics and those of commercial value.

Knowledge about distributions of habitats patterns of diversity and associations with structural features has implications for understanding which areas are more vulnerable, sensitive or resistant to disturbance, which may influence how the area is managed. It also provides a 'baseline' against which any future change might be assessed and identifies directions for useful work in the future.

Contents

Introduction

Seasearch

Seasearch is a volunteer underwater survey project for recreational divers and snorkellers to record observations of marine habitats and the life they support. The information gathered is used to increase our knowledge of the marine environment and contribute towards its conservation. In its earliest incarnation, Seasearch coordination came under the remit of a Steering Group led by the Marine Conservation Society (MCS) and comprising representatives from the UK statutory nature conservation bodies (NRW, EHS(NI), JNCC, NE, NatureScot), the Environment Agency, The Wildlife Trusts, the Marine Biological Association, the diver training agencies (BSAC, PADI, SAA, SSAC), Nautical Archaeology Society and independent marine life experts. In recent years, the project has been delivered in partnership by local coordinators under contract to the MCS and, in some areas, employees of the local Wildlife Trust. Overall coordination and financial under-writing of the project has been the responsibility of the Marine Conservation Society. Ongoing financial support comes in part from NatureScot (funding Seasearch activities in Scotland), Natural Resources Wales (ditto in Wales) and Natural England (specific projects within England), as well as various other grants (restricted and unrestricted). Volunteers can participate in training courses and many dive surveys organized during the season. For more information visit the Seasearch website.

The objectives of the Seasearch programme are to:

- Gather information on seabed habitats and associated wildlife throughout Britain and Ireland, by the participation of recreational SCUBA divers and snorkellers;
- Provide standardized training to enable volunteer divers and snorkellers to participate in Seasearch surveys or undertake their own independent surveys and report back what they find;
- Ensure the quality of the data gathered;
- Make the data available through websites, reports, and publications;
- Raise awareness of the diversity of marine life in Britain and Ireland and its environment through participation of volunteer divers/snorkellers and dissemination of information.

The Seasearch programme has collected, maintains and uses almost 800,000 records of taxa or habitats. This exceeds the 593,313 records contributed by the Marine Nature Conservation Review (MNCR, jointly supplied by JNCC and English Nature (now Natural England). Seasearch records are broadly recognised as a robust and reliable source of data and information (e.g. Pikesley *et al.*, 2016), in part due to the careful and ongoing process of quality assurance (Bolton, 2018). Seasearch data have already been used effectively by statutory nature conservation bodies (SNCB) to support designation of marine protected areas (MPA), making use of information about distributions of features of conservation interest.

Marine Conservation Society

The Marine Conservation Society is the UK Charity dedicated to the protection of the marine environment and its wildlife. Since its formation in 1983, MCS has become a recognized authority on marine and coastal conservation and produces the Good Fish Guide (www.mcsuk.org/goodfishguide/) in addition to promoting public participation in volunteer projects and surveys such as Great British Beach Clean, Seasearch and Basking Shark Watch.

Background

This is a report to Natural England (NE) about the distribution of seabed habitats in the Cromer Shoal Chalk Beds Marine Conservation Zone (CSCB MCZ) and their taxonomic composition. It uses biological records collected since 2005, which are held and curated by Seasearch. As part of its vision for the marine environment (DEFRA, 2002), the UK Government made a commitment to achieve “clean, healthy, safe, productive and biologically diverse oceans and seas”. To do this, we clearly need to expand our understanding of the marine environment, and this need has been established as one of the six policies of the Governments 25 Year Environment Plan for sustainable farming and fisheries (DEFRA, 2018). The concept that “sound evidence and monitoring underpins effective marine management and policy development” is clearly embedded in the High-Level Marine Objectives of the UK Government (DEFRA, 2009). The UK has a large marine extent and a great variety of habitats supporting a wealth of biodiversity, for which comprehensive monitoring presents a considerable challenge.

The CSCB MCZ lies along the north coast of Norfolk and was designated as an MCZ in 2016 under the Marine and Coastal Access Act 2009. The MCZ contains, *inter alia*, areas of subtidal chalk and areas where clay is exposed, which are features of conservation interest designated under the Marine and Coastal Access Act 2009. The subtidal chalk within Cromer Shoal is the most extensive example within the UK’s portion of the North Sea (Net Gain, 2011). No particular species are listed as designated features, but the area is important for a variety of taxa. Outcrops of chalk provide relatively hard substrata within a larger area of sands and gravels. Rocky reefs and outcrops provide suitable stable surfaces on which many seaweeds and sessile fauna depend. Because chalk is not very hard, it can erode into a wide variety of shapes and structures, thereby providing complex habitat for a diverse assemblage of benthic taxa (Watson, 2012) and can be considered a biodiversity hotspot (DEFRA, 2016). A new species of purple *Hymedesmia* sponge was discovered in the MCZ in 2011, but which has yet to receive a scientific name. The chalk beds are home to lobster (*Homarus gammarus*) and brown crab (*Cancer pagurus*) which are the foundation of a long-standing, active small-scale fishery that influences greatly the character and economy of the area.

Conservation objectives for chalk habitat in the MCZ have been set as ‘maintain in favourable condition’ (DEFRA, 2016). Recent observations have indicated that some activities in the MCZ may be detrimental to some of these chalk features. The ecology of subtidal chalk habitat is neither well-researched nor well understood, although CSCB MCZ has been well-surveyed by Seasearch volunteers. As yet, little exploration or interpretation of these records have been made, although there is some evidence of anthropogenic damage to the seabed (Spray, 2021). Consequently, there is a pressing need to improve our understanding of the distribution and character of chalk features, and of any ecological associations between benthic organisms and these features.

Natural England (NE) are currently in the process of completing a condition assessment for CSCB MCZ. Specifically, this will include establishing status and changes in extent and distribution of designated habitats. Such data are not always available from organisations with responsibilities for conservation or management or through structured mechanisms of data collection. To provide appropriate guidance on protection and management of such features, current knowledge about their distribution and condition is crucial. To rise to the challenges presented when monitoring marine biodiversity in the present climate and circumstance, there is a need to identify new and innovative ways to collect more data or make more efficient use of existing data, including those from citizen science projects.

Chalk habitat

A band of infralittoral chalk extends east to west for most of the length of the MCZ and is mostly restricted to inshore waters <10m deep. Extending beyond this into deeper water is a band of circalittoral rock (Green *et al.*, 2015). Areas of rock within the site include chalk, in addition to areas of flint, clay and carstone.

Towards the south-east of the site, chalk seabed is replaced by sand and mixed sediments. Further offshore, beyond the chalk beds, the seabed is primarily sediment. This area of the southern North Sea is a dynamic environment, with large volumes of mobile sediment being moved around the site by tides, waves and currents, particularly during winter storms (HR Wallingford *et al.*, 2002), so apparent distributions of habitat are subject to change. Hydrodynamic conditions can also influence distributions of species. Suspended sediment can abrade organisms near the seabed. The consequences of this abrasion can be seen as a band of rock (~10 cm) scoured clean of fauna, just above the seabed where mobile sediment is present.

Very severe storms can cause almost complete removal of biota and surface layers from whole outcrops of chalk, resulting in very white, smooth rock with rounded features and tiny pockets of life on sheltered faces. Other disturbances, such as impacts or abrasion, can also remove biota from the surface leaving bare chalk, but these features are hard-edged and angular.

Within this study, habitat is considered in three different ways:

1) Using categories for surface relief defined during a Natural England workshop (Sam Parker pers.comm.).

    - Flat – no obvious surface relief
    - Low – depressions or elevations <0.5m in vertical dimension
    - Moderate – depressions or elevations >0.5m but less than 1m in vertical dimension
    - High – depressions or elevations >1m in vertical dimension

2) Using six major types of substratum (e.g. principal rock-types).

    - Chalk
    - Clay
    - Carstone
    - Sediment (sand / gravel)
    - Wood reef
    - Wreckage

3) Using structural features of the seabed referred to by Moffat *et al*. (2020), with detailed definitions developed here.

- **Chalk bedrock overlain with boulders and cobbles**:
  This habitat makes up most of the shallow reef, including some of the gully tops and bottoms. The mixed-size boulders and cobbles are a combination of flint and chalk, covering from 5 to 95% of the seabed. Exposed bedrock and boulder tops have dense mixed algae and the vertical sides of boulders have diverse animal turf with rich, mobile life in the gaps between. Chalk boulders support a different suite of species to those of flint. In some places, large flint cobbles/small boulders are interlocked and bonded together as a permanent pavement over chalk bedrock, mostly where tall gullies end, but sometimes as distinct areas between gullies. These pavements form a network of protected interstices, providing shelter for smaller organisms and may act as nursery areas.

- **Chalk outcrops with gullies**:
  Gullies in chalk bedrock mostly run perpendicular to the shore. These begin as grooves ~50cm deep in the bedrock and generally deepen to maximal depth close to their furthest extent, which ranges from 300 to 600m offshore. Gully walls are typically near-vertical and can be up to 3 m high, although are more usually up to 1.5 m. Intact gullies can vary from 1.5m to more than 5m wide. In some places remains of former gullies can be seen as single vertical walls or a row of tall outcrops where the rest of the feature has been removed. An exception to the general pattern is at Weybourne, where gullies within 50m of the beach are in soft chalk with walls up to 2m high, whereas those in deeper water further offshore generally have shorter walls and are in harder chalk.

- **Arches, overhangs, tunnels, caves, fissures and crevices**:
  Chalk is present as thick strata which often include horizontal faults. Where strata are of differing hardness, they wear and erode at different rates leading to a variety of structural or topographic features. Arches, overhangs, tunnels and caves are mostly (but not always) present towards the outer ends of walls and gullies. They can either be a result of geologically recent wear from tidal currents and wave-action, or historical freshwater drainage from when the chalk was above sea level. Where features are from historical processes, they are often lined with harder chalk than the surrounding reef and so are relatively stable compared to the more dynamic nature of features derived from contemporary water-movement. Arches occur in thin walls between adjacent gullies and contain species which appreciate faster currents. Faults in more substantial walls or outcrops can enlarge to form tunnels or caves. Large outcrops or connected gullies at 300-600m from shore may contain a network of connected tunnels and caves. These have more water movement and receive less light than surrounding open areas. These features shelter large shoals of fish and support mobile and encrusting species not seen elsewhere. Crevices and fissures form in the faults between the sheets of chalk. Crevices in this context are described as less than 8cm across and fissures are >8 cm across. Crevices or fissures can be any length or depth. The reason for differentiating by size is that different ranges of species make use of different-sized features, for instance, squat lobsters require the snug fit of a crevice, while *Oscarella* sp. sponge needs the current flow of a fissure to provide food.

- **Mobile sediments**:
  Cobbles and boulders tend to be very stable and are only moved by the very worst winter storms. Smaller, more mobile sediments are much more readily picked up and moved by currents. Sediments within the MCZ tend to be very well sorted. In the bottoms of gullies, these usually consist of fine sand and gravel (often composed of *Spirobranchus* sp. tubes). Where there are larger extents of sediment close to shore, these form ripples parallel to shore which switch to waves perpendicular to shore as the water-depth increases.
  Where water moves large amounts of sediment, large sand waves up to 2m high can form, which pass through a site within a few months, temporarily filling and obscuring rock features and smothering sessile species. The sand waves are very mobile, moving continuously roughly from West to East. Most taxa seem able to either wait out the inundation or move up to higher ground until the sediment has moved on.
  In the medium-term (~1 year) sand bars parallel to the coast (up to 3m high) can be deposited by storms. After a stormy winter, these may form a continuous band, up to 20 m wide, throughout the MCZ. The position of the bars varies from year to year, ranging from 50 to over 300 m offshore. Although these sand bars may dissipate gradually, they can be sufficiently robust to remain in place until the next major (usually winter) storm, particularly when stabilised by beds of *Lanice conchilega*.

Scope, remit and hypotheses

The Seasearch database includes almost 52000 biological records collected since 2005 from within the bounds of CSCB MCZ and the narrow strip between the MCZ and the shore. These records will be used in analyses of the diversity and taxonomic composition of assemblages of benthic taxa. It follows methods developed in previous studies that demonstrate that Seasearch records can be used effectively to test hypotheses about composition of assemblages (Jackson, 2022a, 2022c). The original intention for collecting data in Seasearch was not that set out in this project. Yet, with the proposed development of queries, reformatting, synthesis and analysis of Seasearch data, it is possible to extract information that will help support conservation and sustainable management in this MCZ. The methods and systems developed and the information derived, will facilitate subsequent hypothesis-driven research about the ecology of chalk reefs.

In addition to existing Seasearch records, this project takes advantage of the extensive local knowledge of experienced Seasearch divers which is used to summarise perceived associations between specific features of chalk reef and specific taxa. This information does not yet exist elsewhere.

Thus, the project will use Seasearch data and local knowledge to improve our understanding of the following three areas:

I. What taxa occur on the subtidal chalk beds? To include species list, measures of richness diversity, and any differences in composition of assemblages.
II. What different topographical features occur in the chalk beds and where are they?
III. Are these features associated with any specific assemblages or taxa? If yes, then which structures and which taxa?

The scope of the work includes the spatial extent of CSCB MCZ (Figure 1). Within the three areas set out above, the specific remit of this report includes:

1. Development of a protocol for formatting Seasearch data such that they can be used in analyses of chalk habitats now and in the future.
2. Analysis of diversity and compositions of assemblages in different benthic habitats of CSCB MCZ.
3. Creation of maps of the seabed that show distributions of the four different levels of surface relief and of the six major rock-types.
4. Anecdotal description of associations between named topographical features and specific taxa, with conjecture about possible reasons why.
5. Provision of information that can act as a ‘baseline’ against which to assess future change.

6. Focus and guidance for future sampling of chalk (or other) habitat.

Such analyses and maps will provide information about the distribution, diversity and composition of habitats in the MCZ and more specifically how assemblages of chalk habitats differ. The hypothesis being tested, with predictions and rationales are given in Table 1.

Table 1. Hypotheses being tested in this study, along with prior predictions and their rationales.

Hypothesis:	Taxonomic diversity and composition will differ between different types of seabed (because substrata differ in their hardness, structural complexity, chemical composition, etc.)		
Predicted differences in complexity between seabed types			
Factor	**Diversity**	**Composition**	**Rationale**
Rock-type	chalk > clay	chalk ≠ clay	Clay is much softer and erodes faster preventing may taxa from establishing.
Chalk seabed 1	cobbles >no cobbles	cobbles ≠ no cobbles	Cobbles provide greater structural complexity and therefore a wider range of niches that support more diverse assemblages.
Chalk seabed 2	gullies > no gullies	gullies ≠ no gullies	Gullies and associated features provide greater structural complexity and therefore a wider range of niches that support more diverse assemblages than does more structurally homogeneous chalk with no gullies
Gully surfaces	walls ≠ floors	walls ≠ floors	Vertical or horizontal surfaces will support different taxa, but there is no clear a priori expectation for differences in diversity.

Marine Recorder Terminology

Seasearch data are entered to and saved within an Access-based database called Marine Recorder (MR). To allow ready comprehension of the data and processes described in this report, some relevant terms are defined here.

Observer records – records from an 'observation form' collected by divers or snorkellers qualified to observer or surveyor level. All data are linked to a single sample.

Surveyor records – records from a 'survey form' collected by divers or snorkellers qualified to surveyor level. Data may be linked to one or more samples.

Survey – collection of dives for a stated location or area over a stated time period (often a year)

Survey-event – falls within a survey and is usually a single dive of a stated duration, but can include several combined forms created from a single site in the same time period.

Sample – data from a distinct habitat, within a single survey-event. Multiple samples (habitats) per survey-event may be recorded by Seasearch surveyors using a survey form.

Location – an area of seabed that can contain one or more survey-events.

Position – The latitude and longitude of a single survey event (and/or sample) using the WGS84 coordinate system.

Methods

This project will use records from the publicly available Seasearch database. Careful quality control and filtering will be applied to this unstructured, citizen-science data from the MCZ, ensuring that only the most robust information is used. For instance, only records from 'Seasearch surveyors' will be used as these might provide sufficient habitat-specific detail by which to analyse variation in assemblages from chalk habitats across the MCZ and to assess associations between assemblages and specific chalk bed topographies. A data processing protocol is presented (Table 2) which would be used for similar analyses of Seasearch records from chalk habitats in the future.

Distribution of habitats

Substratum and surface relief

It is not yet possible in CSCB MCZ to differentiate accurately between different types of rock or between different degrees of surface relief by using geophysical data. Polygons representing areas of a) six different substrata and b) four different categories of surface relief were prepared using knowledge and data obtained by experienced Seasearch volunteers who have surveyed the site extensively. Allocations of categories are made with a high degree of certainty, from only areas that have been surveyed (i.e. no inference, guess-work or extrapolation) and so there are many gaps where the character of the seabed is uncertain.

Structural features

This study needed to link taxon records unambiguously with different types of seabed or habitat. The immediately obvious method would be to match positions of samples with the categories of seabed defined as per the previous paragraph. Unfortunately, there are two reasons why this cannot be done.

1) Some features of interest (e.g. gully walls caves, arches, fissures, etc.) occur at spatial scales that are too fine to add to discrete polygons. Their extents are also smaller than the spatial uncertainty of sample positions meaning that even if they were plotted, any overlap (or lack of overlap) may well be erroneous.

2) Sample positions are often shown as a line representing the start and end (or start and turn-around point) of a dive. The position of the sample along that line was not recorded. Lines often pass across multiple types of substrata or habitat. Thus it was not clear to which category any individual sample might 'belong'. This issue is exacerbated in samples collected using the Seasearch Observer method, where a sample consists of records from potentially multiple different types of seabed or habitat, with no ability to distinguish between them.

Labels of seabed character were allocated to records using the presence of key terms with the Habitat and Description variables from records made by Seasearch Surveyors. The Habitat and Description variables are free-text fields into which anything can be entered (or not). Thus, they will never be an absolute and exclusive indicator of seabed character for that sample. Careful automated searches for keywords did allow, however, samples to be efficiently sorted into categories of interest that were mutually exclusive for any given comparison. Prior to allocation of categories, a protocol of data filters and treatments was developed to maximise the likelihood of reliable outputs (Table 2).

Table 2. Protocols for data filtering and treatment prior to analysis (applicable only to Seasearch records).

Procedure	Approach	Explanation
1.	Exclude survey events that are not in the time-frame of interest	By filtering on EventDate to exclude records prior to 2005
2.	Exclude survey events that are not in the spatial areas of interest	By importing positions (as Latitude & Longitude using coordinate reference system EPSG:4326, WGS84) and associated fields to the QGIS package (QGIS long-term release 3.16.16) and clipping these records to a polygon of Cromer Shoal Chalk Beds, then exporting attribute table to .csv.
3.	Exclude taxa that are recorded at greater than Family level	Whilst such records are much better than nothing and may be useful when determining biotopes, they can be too broad and vague for analysis of biodiversity. Their inclusion can artificially inflate taxon richness.
4.	Exclude taxa that do not have a SACFOR score	Analyses of diversity and composition require a measure of relative abundance for each.
5.	Exclude taxa where 'Uncertain = TRUE'	To minimise uncertainty about whether a taxon is actually present in a sample
6.	Exclude taxa where 'Dead = TRUE'	To minimise uncertainty about whether a taxon is actually present in a sample.

Procedure	Approach	Explanation
7.	Standardise taxon names	Substantial variation may exist in the taxonomic resolution at which records are made. Taxonomic consistency among samples was improved in two ways: a) When, within any Genus, there existed some records determined to species and some determined only to Genus, but the Genus is monospecific according to Marine Species for the British Isles and Adjacent Seas (MSBIAS), all entries were altered to the full species level. b) For Genera where the ability for a typical Seasearcher to identify reliably, a specimen in the field to species level is very unlikely, but a species determination has optimistically been made, all records were coarsened to the name of the Genus. The same principle was applied for Families where the ability to ascertain the correct Genus was unlikely. Any species determinations in the following Genera were coarsened to Genus level: *Cladophora*, *Codium*, *Porphyra*, *Ulva*, *Plocamium*, *Gelidium*, *Ceramium*, *Sertularella*, *Aglaophenia*, *Arenicola*. Records for *Scrupocellaria*, *Caberea* or *Cradoscrupocellaria* were coarsened to Candidae; *Ammodytes*, *Hyperoplus* or *Gymnammodytes* to Ammodytidae; *Bugula*, *Bugulina* or *Crisularia* to Bugulidae and *Salmacina* or *Filograna* to Serpulidae.
8.	Transform SACFOR data	Whilst the semi-quantitative SACFOR scale has many advantages (Hawkins & Jones, 1992; Hiscock, 1996; Strong & Johnson, 2020), the data on diversity or composition cannot easily be assessed directly with quantitative statistical methods. This is a consequence of ‘count’ and ‘cover’ scores having values over different ranges. Counts go from 0 to >1 $x10^6$ (on a log10 scale), whereas covers range from 0 to ~100 (on a log2 scale). A conversion process developed by Strong & Johnson (2020) merges observations onto a single, aligned scale from 0 – 8. This unified scale allows merging of scores for species of different size or growth form, allows a wide selection of quantitative statistics, and is already log-transformed (appropriate for observations spanning multiple orders of magnitude) ready for

Procedure	Approach	Explanation
		multivariate analysis, so that taxa of different sizes and growth forms can be compared in a fair way. The full process is described in detail in Strong & Johnson (2020).
9.	Exclude duplicate records	The taxonomic tidying from Procedure 7. can create duplicates (i.e. multiple occurrences of the same taxon within a single sample. For instance, if a sample originally included records of *Ulva* and *Ulva lactuca*, it would now contain two entries for *Ulva*, potentially with different scores for abundance. Errors in data entry can also cause duplicates. Such duplicates are not logical and cannot be handled correctly by diversity indices or multivariate analyses. Duplicate records within a sample were removed and the largest abundance value for the duplicates used for the remaining entry.
10.	Exclude samples that were not done by Seasearch surveyors	This ensures a more advanced level of training and greater experience. The recording of multiple samples per dive (where appropriate) also makes it much easier to attribute species to particular habitats.
11.	Exclude samples that have fewer than five taxa	Samples with very small numbers of taxa suggest incomplete records. They also add very large variance, obscuring patterns in multivariate data. This is an arbitrary threshold.
12.	Allocate habitats to records	Search for a set of key terms in the 'Habitat' and 'Description' fields in order to allocate records to specific habitats used in analyses. Records were first divided into those that mentioned specific types of rock (chalk, clay, chalk and clay, neither). Records that were from chalk-only samples were then subdivided into those that included cobbles or nor and those that included gullies or not. Finally, samples that included gullies were divided into those that referred only to gully walls, only to gully floors, or all other records (either both surfaces or not specified).

Taxonomic diversity and composition

Univariate analysis of assemblage diversity

Seasearch records are not collected against a restricted list of taxa. As a consequence, the lengths of taxa-lists per dive provides an indication of the number of taxa (taxon richness) for that habitat and site, allowing comparisons among areas or habitats (Szabo *et al.*, 2010; Jackson, 2022b). The best understanding about diversity is gained when multiple indices are used. Different indices provide different information. For example, the Simpson index is a dominance index because it gives more weight to common or dominant species. The presence of rare taxa with only a few representatives will have little effect on the index value. In contrast, values of the Shannon index are much more strongly affected by the presence of rare taxa. Diversity of assemblages was presented by univariate metrics (taxon richness, Shannon diversity, reciprocal Simpson diversity).

For hypotheses about differences in diversity, indices were calculated using the Diversity package for R. Variables were tested for normality of distribution using Shapiro-Wilk tests and for homogeneity of variances with Bartlett tests. Variables with a fixed range of values (e.g. Shannon or Simpson diversity) were not expected to be normal, so non-parametric tests were appropriate.

Comparisons of these metrics among different habitats or among areas with different topographies were made using appropriate difference tests (e.g. Mann Whitney [2 categories] or Kruskall-Wallis [3 categories]). Where significant differences were detected among groups by Kruskall-Wallis, *post-hoc* pairwise tests (Dunn's test) were used to identify where those differences occurred. Any lack of difference in diversity between units of comparison did not, however, mean that assemblage compositions were the same, so analyses of taxonomic composition were made irrespective of any patterns in diversity. All analyses of diversity were made in the R programming environment (version 4.0.3, R Core team, 2021).

Multivariate analysis of assemblage composition

Data were already as converted SACFOR scores (Strong and Johnson, 2020; Table 2). The conversions applied to the SACFOR scores for species' abundances have a similar effect to transforming data to down-weight the effects of very abundant taxa (Strong & Johnson, 2020) and computation of Bray-Curtis similarities acts to reduce contributions of rare taxa (Capone & Kushlan, 1991). No further transformation was applied to abundance measures.

To visualise any differences in assemblages among categories of seabed, Bray-Curtis similarities were ordinated using non-metrical multi-dimensional scaling (nMDS). Multivariate differences in benthic assemblages (among categories) were tested using the PERMANOVA routine (Anderson, 2001, 2017) with Bray-Curtis similarities. PERMANOVA tests whether distances differ between groups and is often more powerful than the

ANOSIM routine when detecting differences in assemblage structure (Anderson & Walsh, 2013).

Rare species occurring in small numbers receive little weight in biological measures such as Bray-Curtis (Clarke, 1993; Clarke & Warwick, 2001; Legendre & Legendre, 2012), so the presence of such species is not likely to have a large impact on patterns of multivariate difference. Thus, we would expect that analyses based on a subset of only more-frequently occurring taxa would reveal the same patterns as the full dataset. This was the case in previous analyses of Seasearch records, where analyses based on a 'full' set of taxa led to the same conclusions as the same analyses based on only the fifty most important taxa (Jackson, 2022a). Where there are many species, many of which occur seldomly, it is also harder to represent accurately the multivariate differences in a 2- (or 3-) dimensional ordination (i.e. the nMDS stress is larger). Stress values give an indication of how well the ordination plot fits the actual distances among the points in the data (Clarke, 1993; Legendre & Legendre, 2012). Large values of stress (>0.2) indicate a poor fit and the patterns in the plot give a poor representation. Large numbers of samples in an ordination plot can obscure visual representation of patterns and also increase stress. In such situations, plotting centroids of sets of samples (e.g. per year) reduces the number of points and reduces stress whilst maintaining an impression of underlying patterns in data. When making comparisons with large numbers of samples, centroids were plotted in preference. Statistical analyses were always done using the individual samples.

Arguably, unusual or rare species are more likely to be missed or not to be recorded (because they are not recognised) or recorded incorrectly or at least recorded at a coarse taxonomic resolution. Thus, inclusion of rare species may just be adding noise to the dataset. Where there are many rare species, this noise may obscure or create patterns of difference in the more common species.

Differences in assemblages among categories of seabed were tested using the 50 most important taxa in that dataset, where 'importance' is determined as those species that contribute more than a particular % abundance for every sample. The percentage threshold is manipulated until exactly 50 species are retained and thus, the value depends on the dataset in question. Where significant multivariate differences occurred between groups, the SIMPER routine (Clarke, 1993) was used to identify the taxa and their percent contributions to the overall dissimilarity. Multivariate analyses were performed using PRIMER7 v.7.0.17 and PERMANOVA+ v.1.0.1 software (PRIMER-e, Quest Research Ltd., New Zealand).

All these methods have been used previously in commissioned work for Natural England (Jackson, 2022a, 2022c). Categories of topography were based on previous work characterising chalk habitat (Moffat *et al.*, 2020).

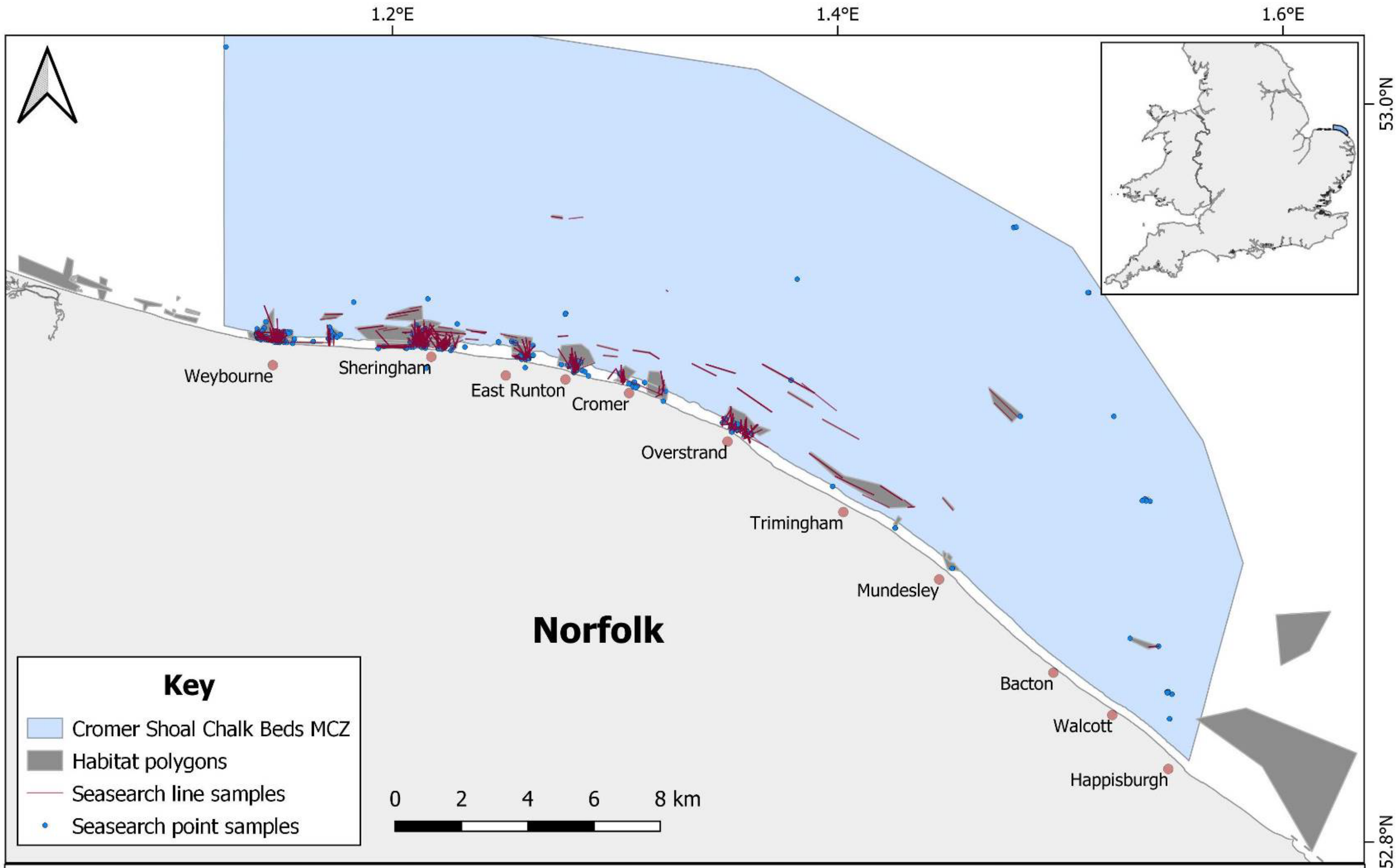
Species-feature associations

Experienced Seasearchers have acquired familiarity and knowledge over many years about the ecological function of the habitats that they survey. Detailed observations of organisms, their habitats and behaviours, can be of great value to inform about threats posed by human activities and how they may best be managed. Such observations are not always captured by standard data-collection processes (e.g. Seasearch data forms) and other more discursive mechanisms are needed to take advantage of these anecdotes. Anecdotal information about how divers in CSCB MCZ perceive ecological interactions between taxa and specific topographic features of the chalk was collated and illustrated with photographs. Experienced Seasearch volunteers were asked for their opinions and impressions of species found in the various parts of the MCZ. They were approached via email, social media messaging and via general posts in relevant Facebook groups. Responses were collated and curated by the Seasearch coordinator for East Anglia in order to identify observations which have become commonly recognised among divers. This anecdotal evidence was gathered under headings that broadly matched categories of habitat used elsewhere in the report.

Results

Distribution of seabed habitats

Seasearchers with over 20 years' experience of diving and surveying in the Cromer Shoal area used their knowledge combined with information on habitat from survey forms to create maps for distributions of different substrata (Figure 1). Prior to application of the data handling protocol, there were 1717 samples, which, after 'cleaning' and filtering were reduced to 1254 samples by Seasearch surveyors that were suitable for analysis. Samples were patchily distributed across the MCZ, determined mostly by availability of easy access to the shore for divers. The overlap of dive tracks with multiple types of seabed is clearly visible in a detailed plot for a small section of the MCZ (Figure 2). Areas outside of the marked polygons have had little or no survey effort and the character of the seabed is not yet known.



Map Projection is OSGB1936 / British National Grid.

Figure 1. Areas of habitat categorised in this study, with locations of line (purple line) or point (blue dot) samples collected by Seasearch since 2005.

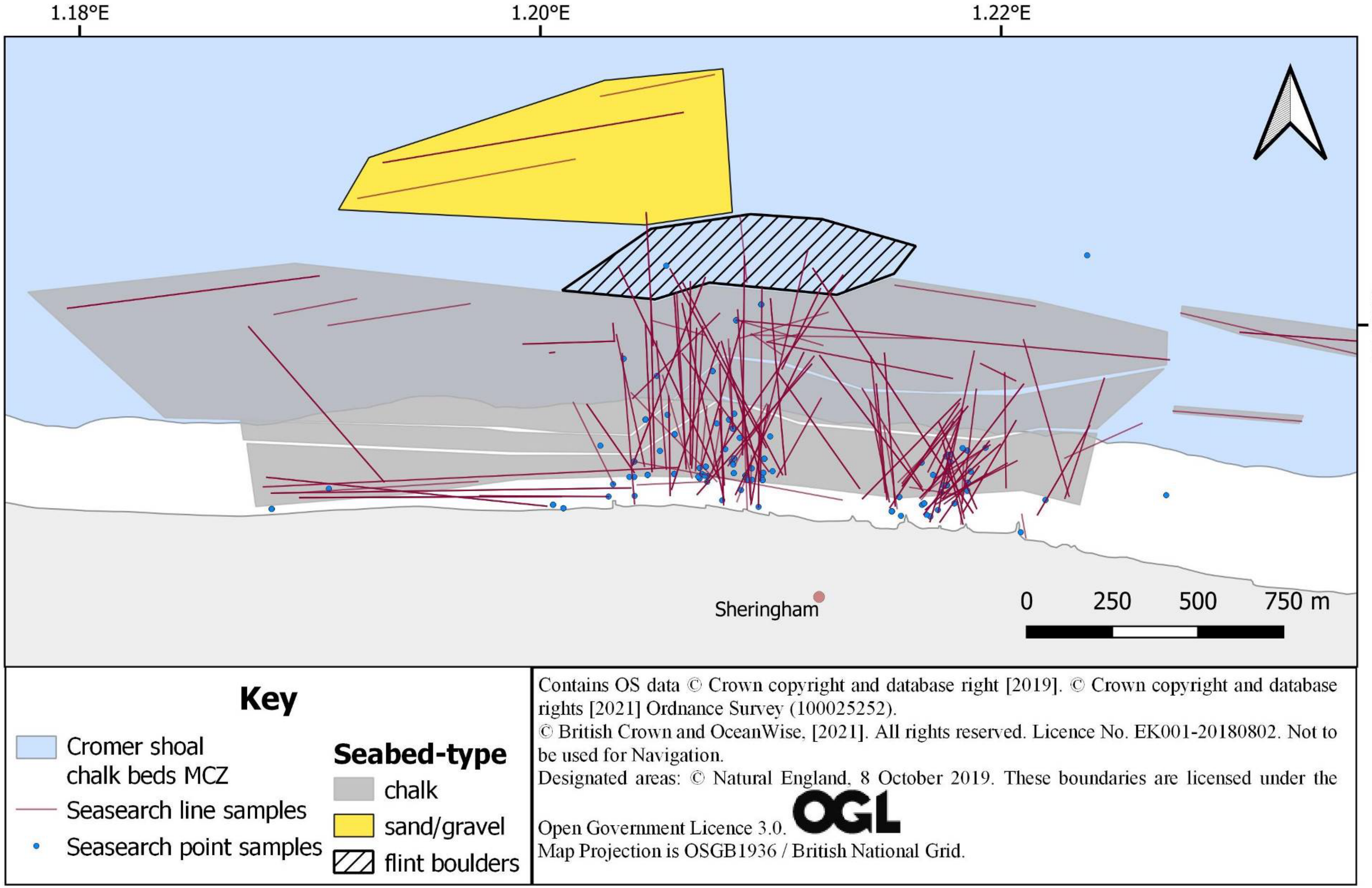


Figure 2. Survey detail illustrating large localised densities of survey effort and line surveys often crossing multiple habitats.

Substrata

Known distributions of six different types of seabed substrata are shown for the western (Figure 3) and eastern (Figure 4) areas of the MCZ. Inshore seabed (within about 1 km of shore) in the western section of the MCZ is predominantly chalk. Areas of sediment become more apparent towards the far western end. There are two areas of flint boulders (one off Sheringham and the other in a narrow strip bisecting an area of sediment off Weybourne). There is a patch of clay about 4km north of East Runton.

Surface relief of chalk seabed

The four different levels of surface relief are illustrated in (Figure 5). In order to show detail for areas of different surface relief, the MCZ was divided into three sections. Known distributions of flat, low, moderate or high levels of surface relief for chalk seabed are shown for far western (Figure 6), west central (Figure 7) and east central (Figure 8) areas of the MCZ. There is little evidence for chalk seabed in the south-eastern end of the MCZ. There are few areas of really flat chalk; examples include patches near Overstrand, >1 km offshore from Cromer and close inshore to Weybourne. Long thin polygons indicate information gained on long linear drift dives and are not likely to represent the actual distribution of that category of surface relief. Bands of chalk in the west and west-central sections tend to increase in surface relief with increasing distance from shore. Most known areas with high relief (>1m in vertical dimension) fall inside the shoreward boundary of the MCZ. Most of the known areas of low or moderate relief occur in the strip of seabed between the MCZ and the shore.

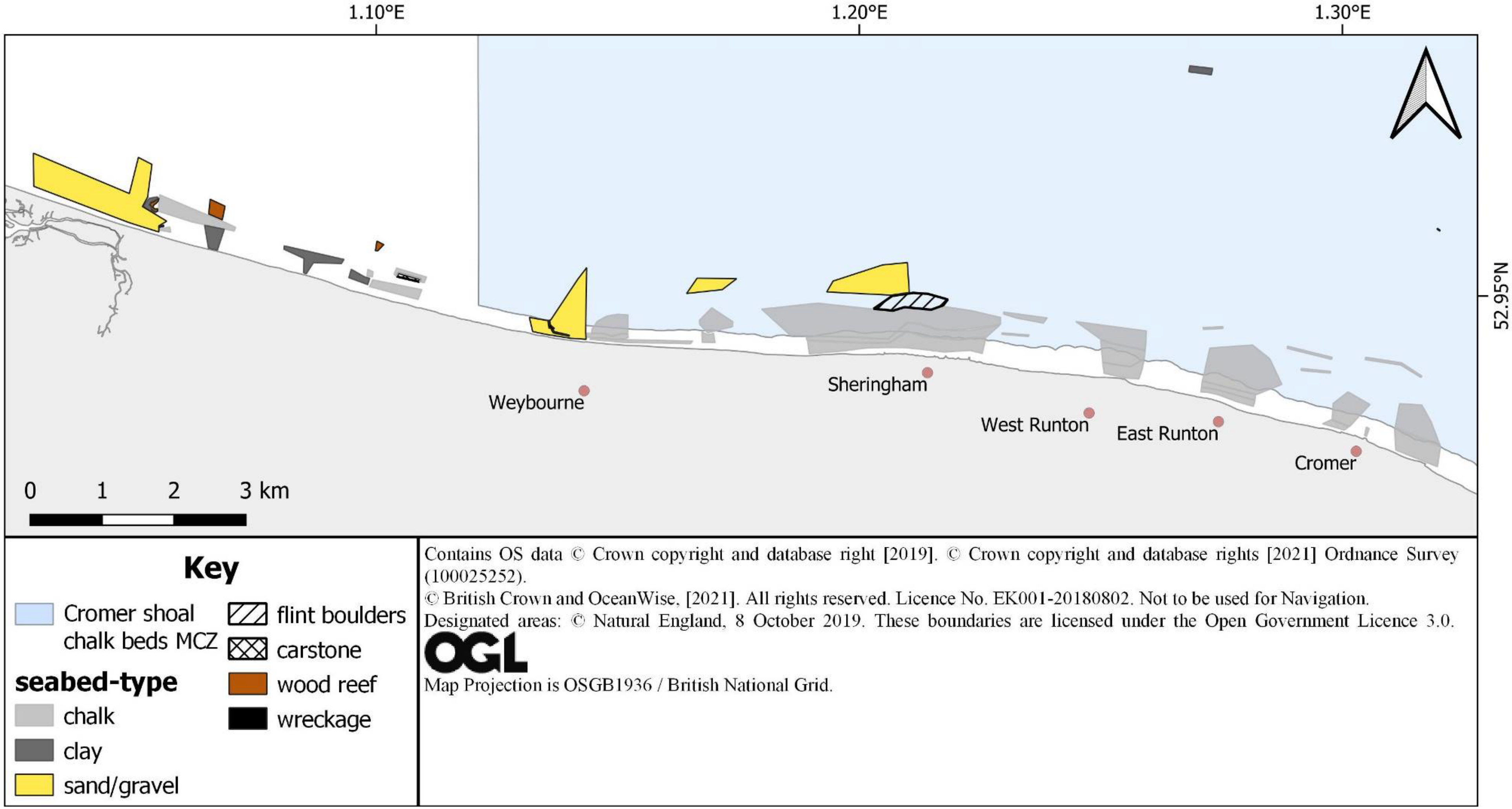


Figure 3. Known distributions of major seabed types in the western section of CSCB MCZ. Known distributions of major seabed types in the western section of CSCB MCZ.

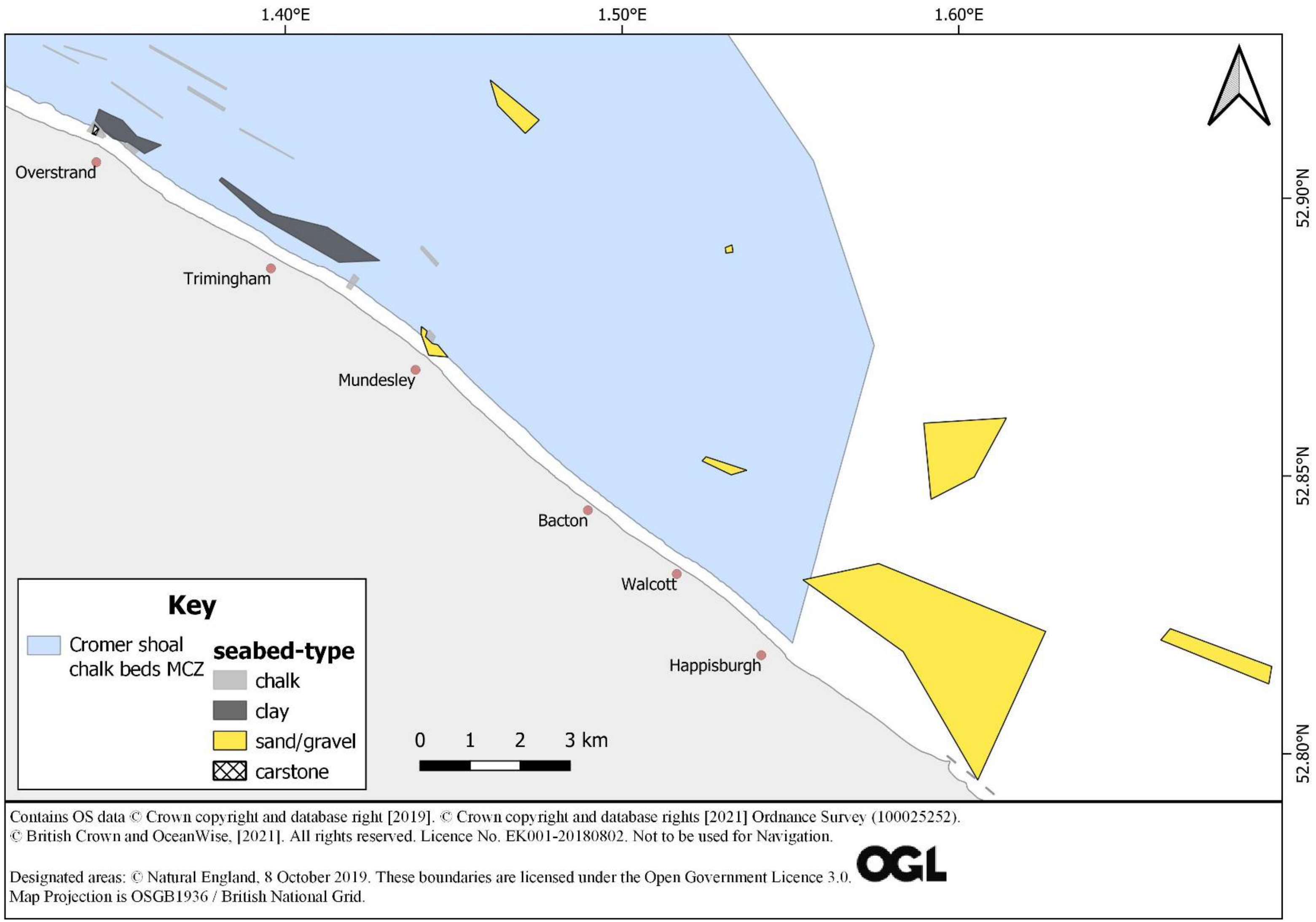


Figure 4. Known distributions of major seabed types in the eastern section of CSCB MCZ. Known distributions of major seabed types in the eastern section of CSCB MCZ.

Flat

Low

Moderate

High

Figure 5. Four levels of surface relief for chalk seabed in Cromer Shoal Chalk Beds MCZ. © Dawn Watson and Rob Spray

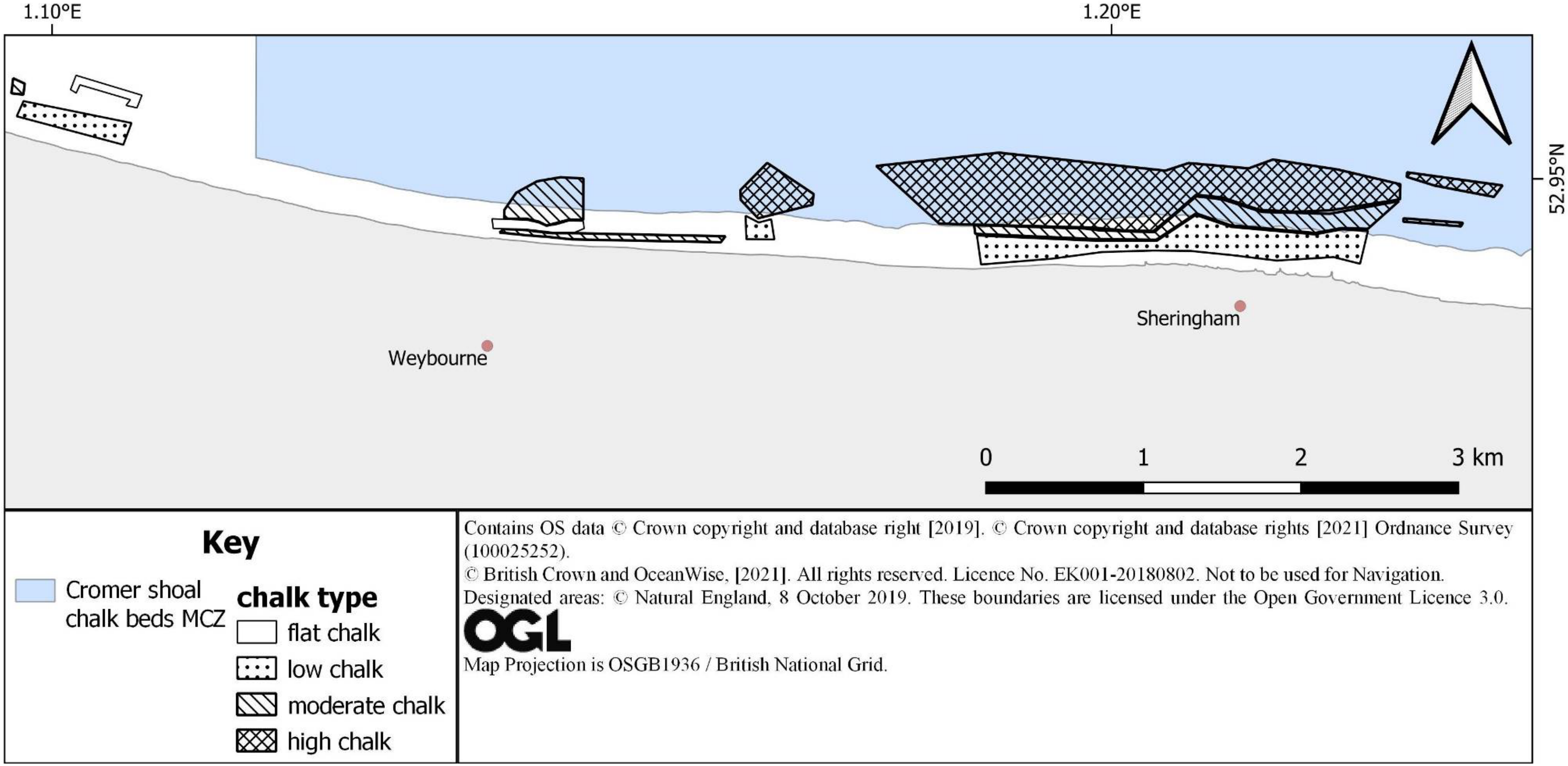


Figure 6. Known distributions for four categories of ruggedness for chalk seabed in the far western section of CSCB MCZ.

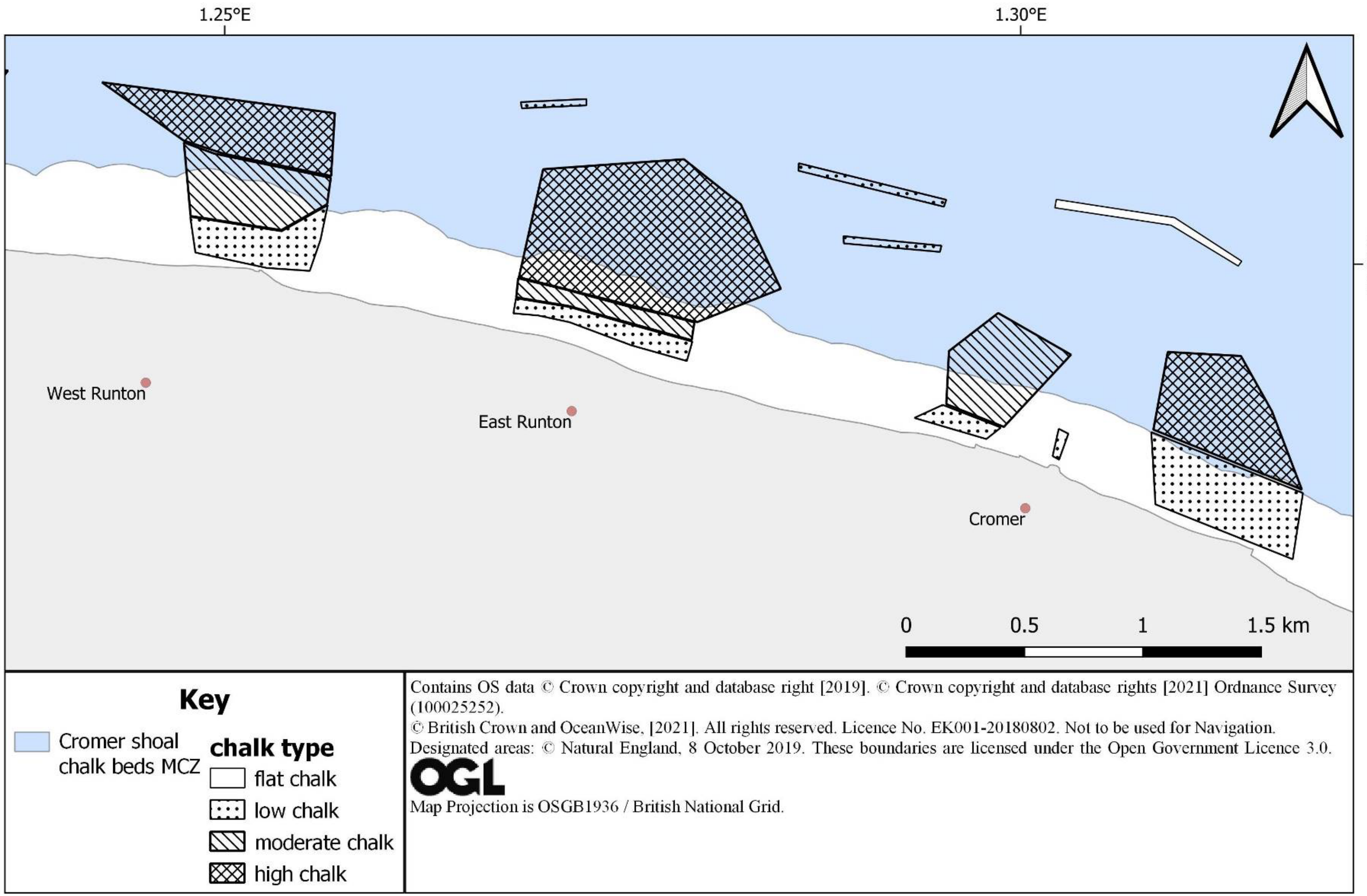


Figure 7. Known distributions for four categories of ruggedness for chalk seabed in the west central section of CSCB MCZ.

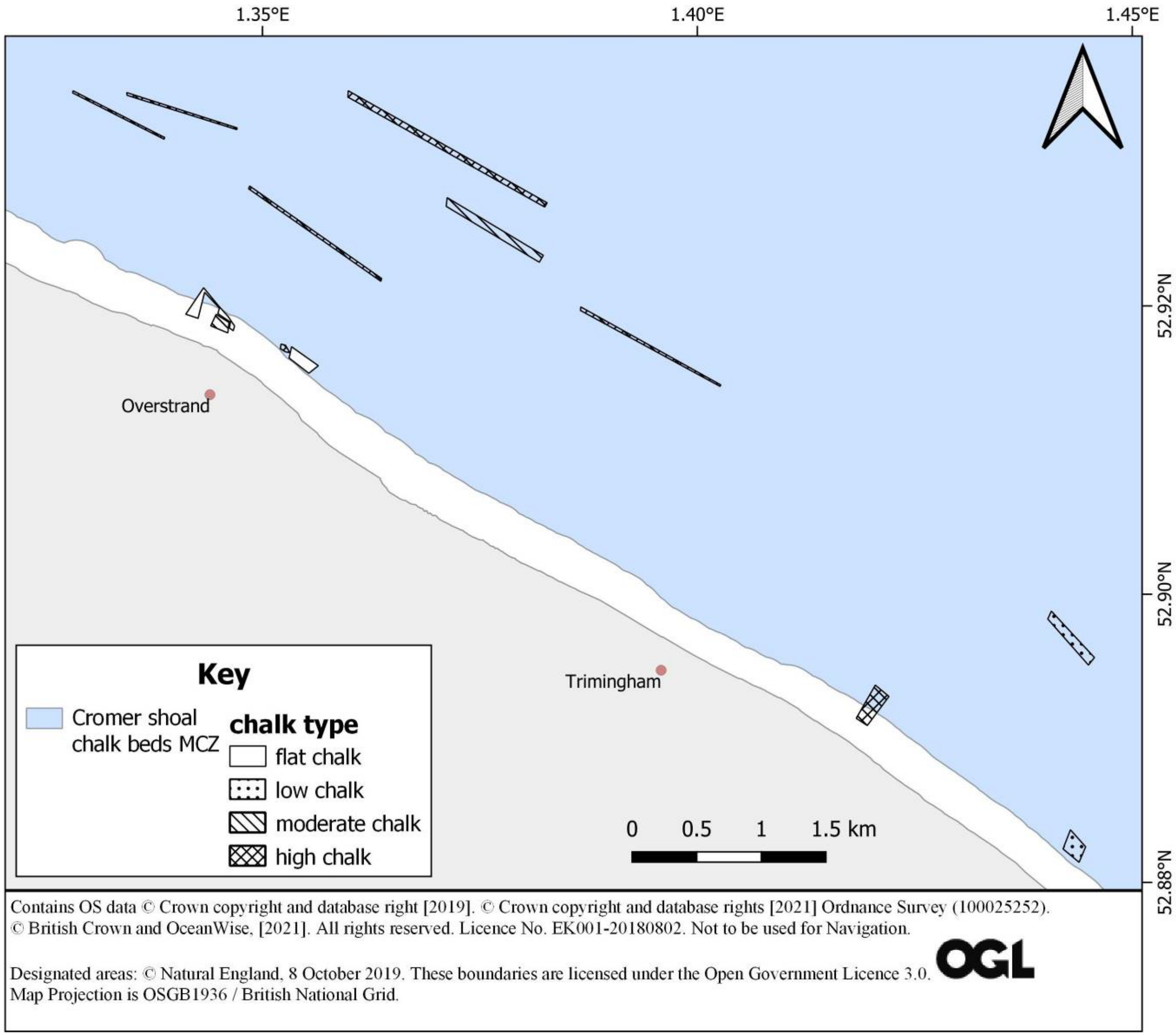


Figure 8. Known distributions for four categories of ruggedness for chalk seabed in the east central section of CSCB MCZ.

Taxonomic diversity and composition

Prior to any filtering of the dataset, there were 51,689 records for 674 different taxa in the site since 2005. The ten most frequently recorded taxa were *Cancer Pagurus, Urticina felina, Lanice conchilega, Asterias rubens, Homarus gammarus, Carcinus maenas, Cirripedia, Spirobranchus, Amphilectus fucorum* & *Cylista elegans*, each with over 750 records. One hundred and forty-two taxa were recorded only once. The full list of taxa and their frequencies are available in the Appendix.

The number of taxa recorded in the 1254 samples by Seasearch surveyors was 37,432 (compared with the 10114 recorded by Seasearch Observers). N.B., these numbers do not sum to the total above because some records were eliminated through the data handling protocol. Relatively few (36) taxa were recorded by Observers, but not Surveyors, about two-thirds of which were recorded only once.

Rock-type: Chalk or Clay

Data for rock-type were not normally distributed for richness, Shannon or Simpson (1/D) diversity indices (Shapiro-Wilk, $p < 0.001$) and variances were not homogeneous for taxon richness (Bartlett, $p < 0.05$). Each of the three diversity indices was significantly greater in samples from chalk than those from clay (Figure 9, Table 3). Compositions of assemblages of taxa differed significantly between the two types of rock (PERMANOVA MS = 16106, Pseudo-$F_{1,783} = 6.81$, $p < 0.001$; Figure 10).

The species that contributed most to dissimilarities in assemblages are shown in Table 4.

The taxa with the five largest contributions to dissimilarity between samples from chalk or clay were *Spirobranchus, Lanice conchilega, Polydora ciliata, Galathea squamifera* and *Carcinus maenas* (Table 4). Taxa such as *P. ciliata*, *Spirobranchus*, *Actinia equina*, *G. squamifera, Sycon ciliatum* and *Steromphala cineraria* were notably more abundant on chalk than on clay. A shade plot (Figure 11) shows patterns of mean abundance per year for the 50 most ‘important’ taxa in samples from the two rock-types. Averaged samples from clay typically had fewer taxa, but these often occurred in relatively large abundances (darker shading).

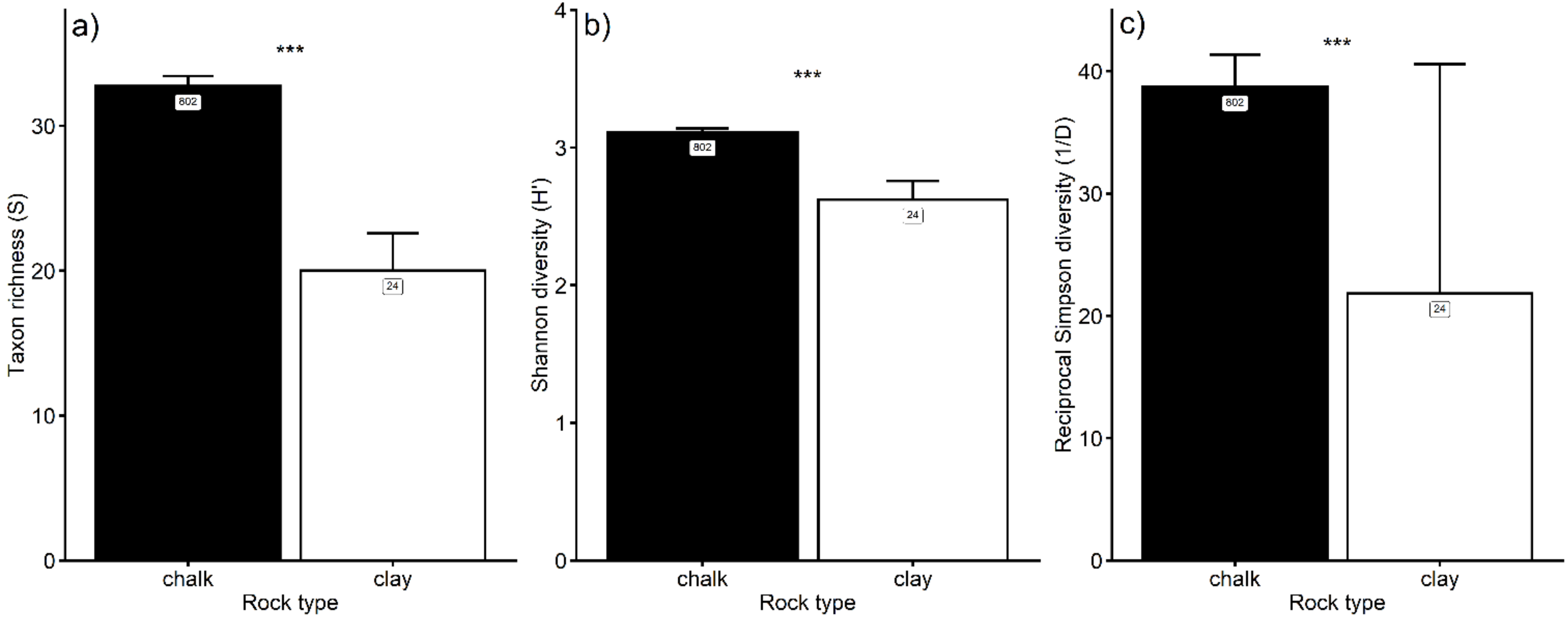


Figure 9. Mean (+s.e.) values for a) taxonomic richness (S), b) Shannon diversity (H') and c) reciprocal Simpson diversity (1/R) in samples from chalk (black bars) or clay (white bars) seabed in CSCB MCZ. White labels indicate the number of samples from each category. *: *p* < 0.001**

Table 3a. Comparisons of diversity indices between categories of rock-type, cobbles or gullies (Mann-Whitney) and among categories of gully surfaces (Kruskall-Wallis).

Factor	Diversity index	N	W	p
c) **Rock-type**	S	802, 24 (chalk, clay)	13388	< 0.01
	H'		13502	< 0.001
	1/D		13427	< 0.001
b) **Seabed cobbles**	S	235, 567 (cobbles, no cobbles)	97677	< 0.001
	H'		97527	< 0.001
	1/D		97018	< 0.001
c) **Seabed gullies**	S	266, 536 (gullies, no gullies)	96578	< 0.001
	H'		96595	< 0.001
	1/D		94212	< 0.001

Table 3b. Comparisons of diversity indices between categories gully surfaces (Kruskall-Wallis).

Factor	Diversity index	N	χ^2	*p*	Pairwise comparisons
a) **Gully surfaces**	S	100, 9, 157 (wall, floor, unspecified)	9.37	< 0.01	Unspecified = wall > floor
	H'		9.11	< 0.05	Unspecified = wall > floor
	1/D		9.09	< 0.05	Unable to resolve

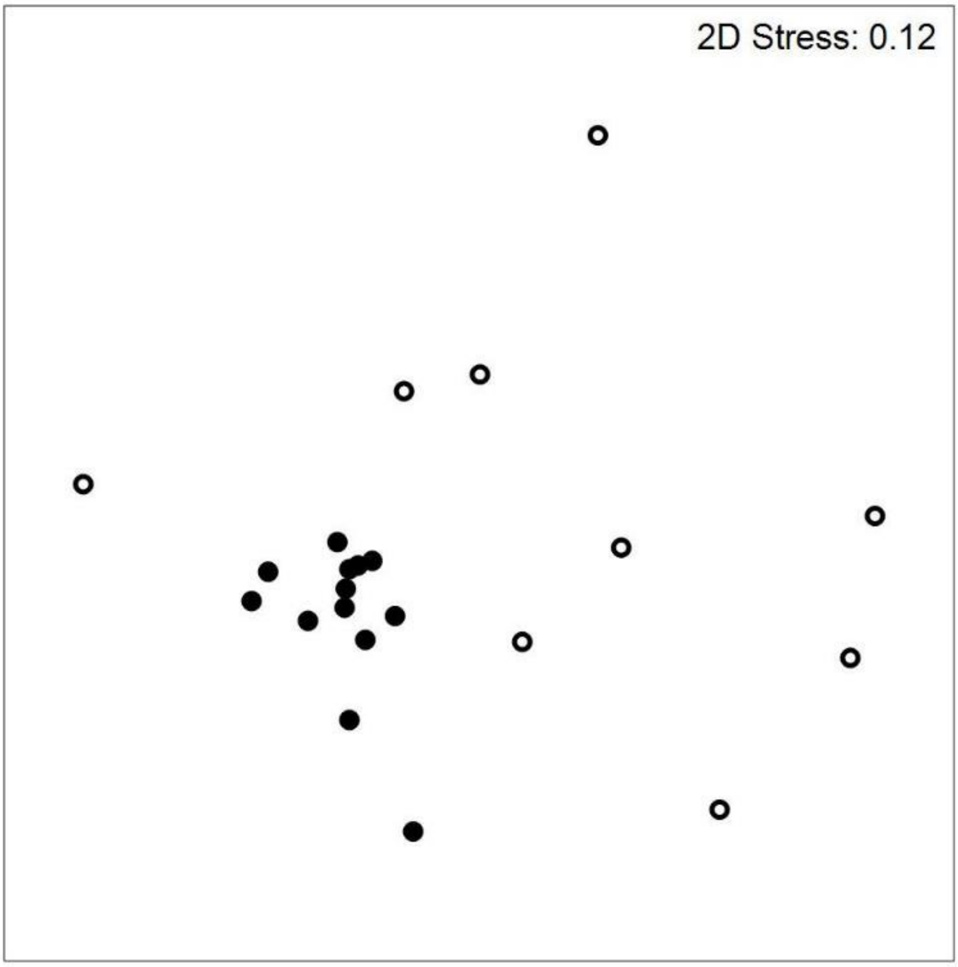


Figure 10. nMDS plot of samples from chalk (closed black dots) or clay (open white dots) seabed from CSCB MCZ, illustrating significant difference in composition of assemblages (PERMANOVA).

Table 4. Dissimilarity contributions of taxa between samples from Chalk or from Clay.

Taxon	Av.Abund Chalk	Av.Abund Clay	Av.Sim	Sim/SD	Contrib%	Cum.%
Spirobranchus	2.29	1.21	4.81	1.04	6.36	6.36
Lanice	1.68	1.96	4.08	1.09	5.39	11.75
Polydora ciliata	1.72	0.21	3.53	0.81	4.67	16.43
Galathea	1.64	0.50	3.35	1.06	4.43	20.85
Carcinus maenas	1.22	0.92	3.15	0.98	4.16	25.02
Urticina felina	1.36	1.29	3.01	1.05	3.99	29.01
Steromphala	1.26	0.46	2.81	0.79	3.72	32.73
Pagurus	0.84	0.92	2.75	0.97	3.64	36.37
Pomatoschistus	0.65	0.79	2.61	0.84	3.45	39.82
Arenicola	0.54	0.71	2.53	0.75	3.35	43.17
Sycon ciliatum	1.01	0.25	2.24	0.65	2.97	46.13
Cancer pagurus	1.18	0.71	2.20	1.08	2.91	49.04
Necora puber	0.83	0.67	2.15	0.97	2.85	51.89
Rissoa	1.16	0.00	2.15	0.47	2.84	54.73
Rissoa parva	0.55	0.67	1.98	0.48	2.62	57.36
Nucella lapillus	0.63	0.46	1.88	0.56	2.49	59.85
Asterias rubens	0.57	0.76	1.86	0.96	2.46	62.31
Macropodia	0.42	0.54	1.75	0.71	2.32	64.63
Diplosoma	0.77	0.33	1.67	0.95	2.21	66.85
Plocamium	0.68	0.25	1.56	0.87	2.07	68.92
Actinia equina	0.77	0.00	1.56	0.61	2.06	70.97

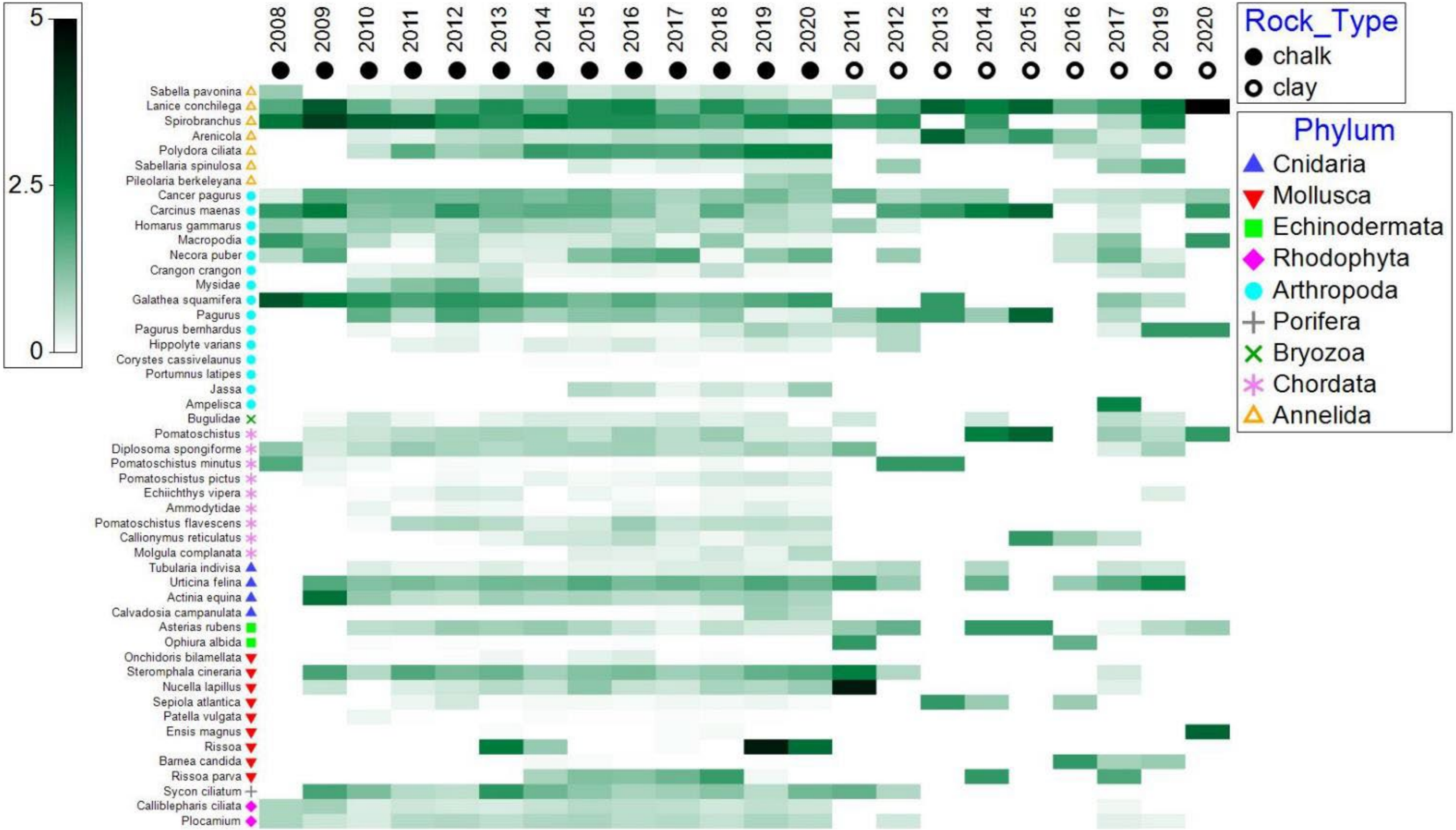


Figure 11. Shade plot showing the mean abundance of different taxa in samples collected from chalk and clay habitats in CSCB MCZ. Year (2008-2020) and rock type (chalk = closed black circle, clay = open white circle) are displayed along the x axis. Species names are displayed on the y axis with associated symbology to represent Phylum. These abundance data are presented in full in the Appendix.

Seabed-type: Cobbles

Habitat with chalk cobbles provided much greater structural complexity than did surfaces of bare chalk (e.g. Figure 5 low vs flat).

Data for seabed cobbles were not normally distributed for richness, Shannon or Simpson (1/D) diversity indices (Shapiro-Wilk, $p < 0.001$) and variances were homogeneous only for taxon richness (Bartlett, $p > 0.05$). Each of the three diversity indices was significantly greater in samples with cobbles than those without cobbles (Figure 12, Table 3).

There were also significant differences in the compositions of assemblages of taxa from chalk seabeds with or without cobbles (PERMANOVA MS = 72861, Pseudo-$F_{1,777}$ = 31.51, $p < 0.001$; Figure 13). The taxa with the five largest contributions to dissimilarity between samples with or without cobbles were *Spirobranchus, P. ciliata, Steromphala cineraria, G. squamifera* and *Rissoa* (Table 5). *Spirobranchus*, *Steromphala cinerea*, *G. squamifera* and *Actinia equina*, were notably more abundant in samples with than without cobbles. A shade plot (Figure 14) shows patterns of mean abundance per year for the 50 most 'important' taxa in samples from the categories. Averaged samples from cobbles had taxa in greater abundance (darker shading) that did those without cobbles.

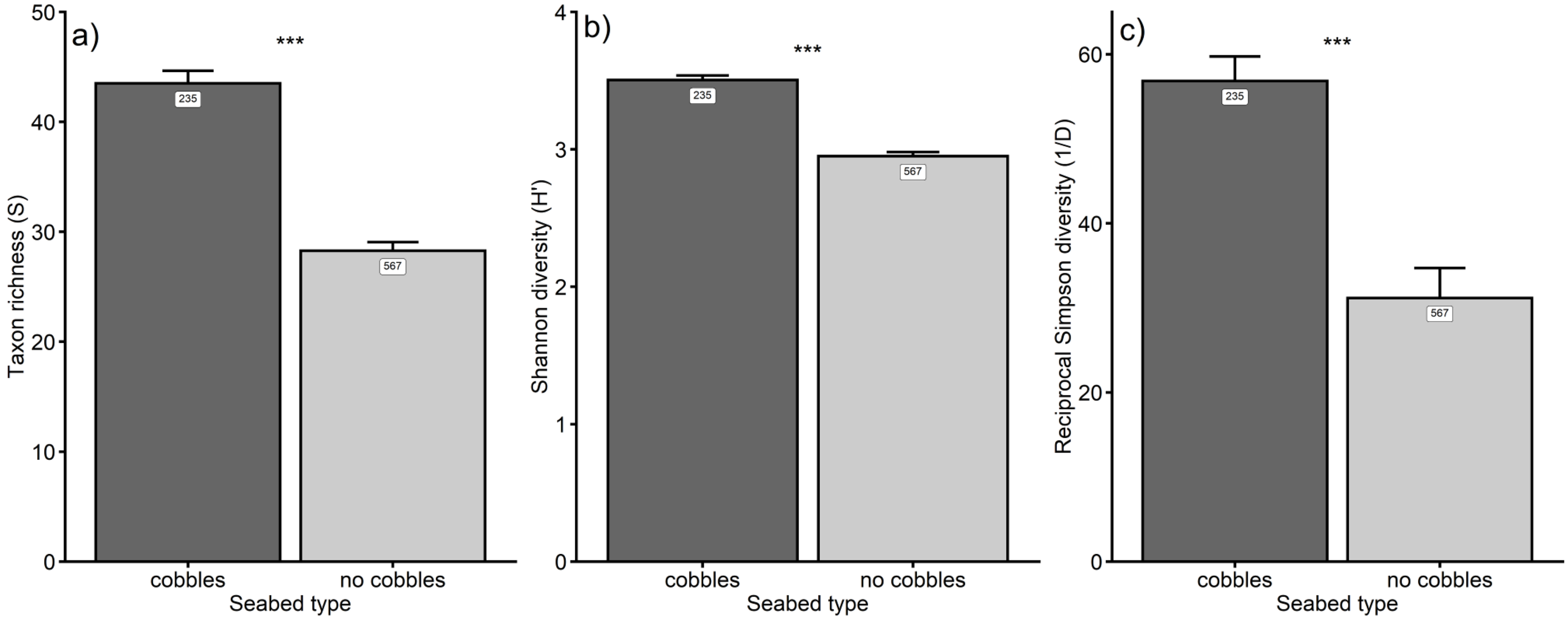


Figure 12. Mean (+s.e.) values for a) taxonomic richness (S), b) Shannon diversity (H') and c) reciprocal Simpson diversity (1/R) in samples from chalk with (dark grey bars) or without cobbles (light grey bars) in CSCB MCZ. White labels indicate the number of samples from each category. *: *p* < 0.001**

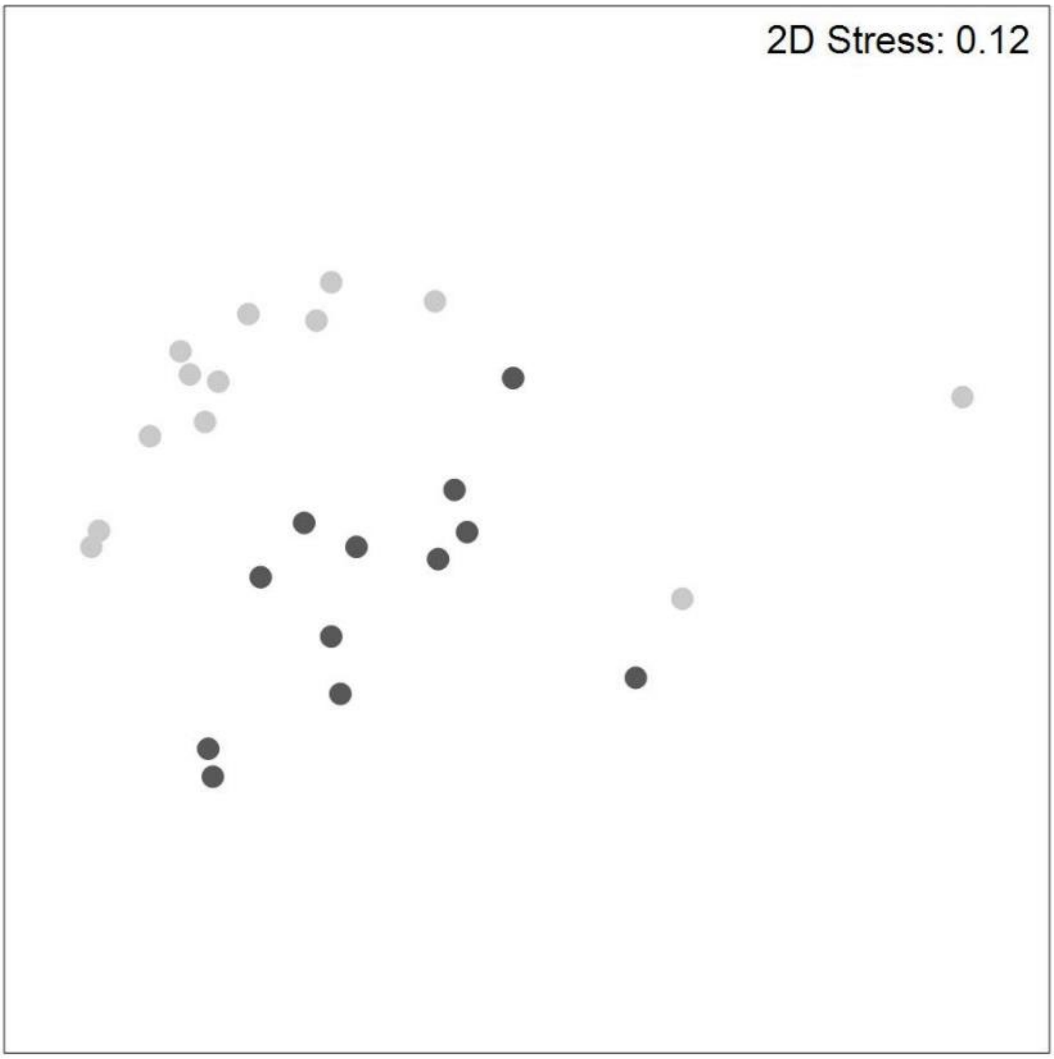


Figure 13. nMDS plot of samples from chalk seabed with cobbles (dark grey dots) or without cobbles (light grey dots) from CSCB MCZ, illustrating significant differences in composition of assemblages (PERMANOVA).

Table 5. Dissimilarity contributions of taxa between samples with or without cobbles.

Taxon	Av.Abund With cobbles	Av.Abund Without cobbles	Av.Sim	Sim/SD	Contrib%	Cum.%
Spirobranchus	3.46	1.80	4.35	1.09	6.49	6.49
Polydora ciliata	1.94	1.62	3.58	1.09	5.34	11.83
Steromphala	2.29	0.83	3.40	1.16	5.08	16.91
Galathea	2.47	1.29	3.29	1.21	4.91	21.82
Rissoa	1.60	0.97	3.18	0.71	4.75	26.57
Lanice	1.69	1.68	2.76	1.04	4.11	30.68
Sycon ciliatum	1.20	0.92	2.46	0.85	3.68	34.35
Carcinus maenas	1.30	1.19	2.36	1.06	3.52	37.87
Actinia equina	1.46	0.49	2.33	1.05	3.48	41.35
Urticina felina	1.62	1.25	2.06	1.01	3.07	44.42
Pagurus	0.81	0.86	1.97	0.88	2.94	47.36
Nucella lapillus	1.11	0.43	1.90	0.80	2.84	50.20
Necora puber	1.13	0.70	1.90	1.01	2.83	53.03
Rissoa parva	0.90	0.40	1.71	0.50	2.56	55.59
Pomatoschistus	0.50	0.71	1.69	0.73	2.51	58.10
Cancer pagurus	1.33	1.11	1.62	1.00	2.42	60.52
Pomatoschistus	0.74	0.54	1.54	0.76	2.30	62.82
Taonia atomaria	1.00	0.44	1.52	1.12	2.26	65.08
Plocamium	1.12	0.50	1.49	1.21	2.22	67.30
Diplosoma	0.99	0.68	1.45	1.07	2.16	69.46
Arenicola	0.20	0.68	1.41	0.61	2.10	71.57

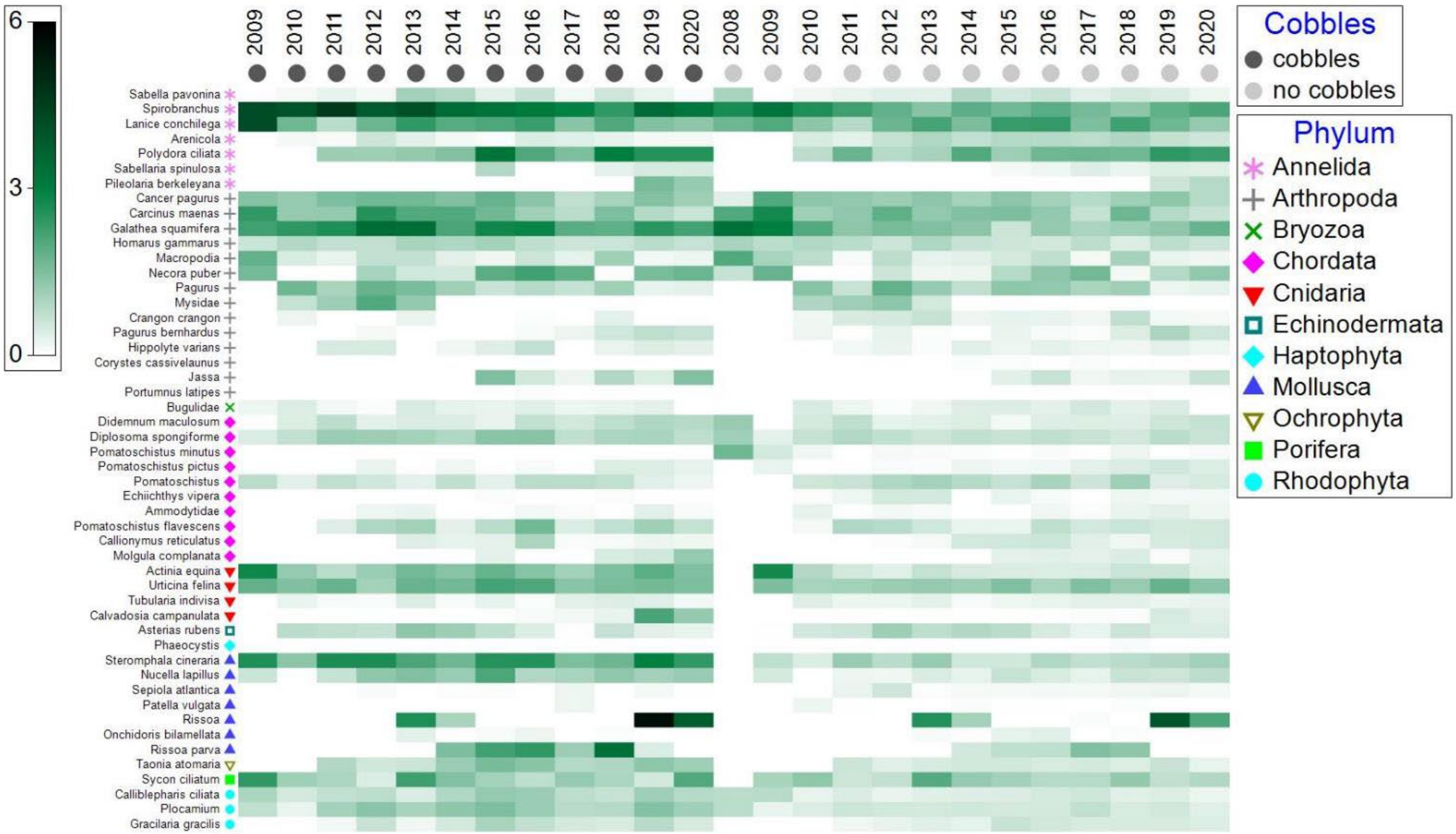


Figure 14. Shade plot showing the mean abundance of different taxa in samples from chalk with cobbles or without cobbles in CSCB MCZ. Year (2008-2020) and habitat type (Cobbles: cobbles = dark grey dots, no cobbles = light grey dots) are displayed along the x axis. Species names are displayed on the y axis with associated symbology to represent Phylum. These abundance data are presented in full in Appendix 1.

Seabed-type: Gullies

Gullies often provided clear examples of habitat with high surface relief (Figure 15).

Figure 15. Gullies provide large amounts of surface relief. © Dawn Watson and Rob Spray

Data for seabed gullies were not normally distributed for richness, Shannon or Simpson (1/D) diversity indices (Shapiro-Wilk, $p < 0.01$) and variances were not homogeneous for Shannon diversity (Bartlett, $p < 0.05$). Each of the three diversity indices was significantly greater in samples with gullies than those without gullies (Figure 16, Table 3).

There were also significant differences in the compositions of assemblages of taxa from chalk seabeds with or without gullies (PERMANOVA MS = 92462, Pseudo-$F_{1,777}$ = 40.43, $p < 0.001$; Figure 17).

The taxa with the five largest contributions to dissimilarity between samples with or without gullies were *P. ciliata, Spirobranchus, Rissoa, G. squamifera* and *L. conchilega* (Table 6). *Polydora ciliata* and *G. squamifera* were notably more abundant in samples with gullies than in those without. A shade plot (Figure 18) shows patterns of mean abundance per year for the 50 most ‘important’ taxa in samples from the categories.

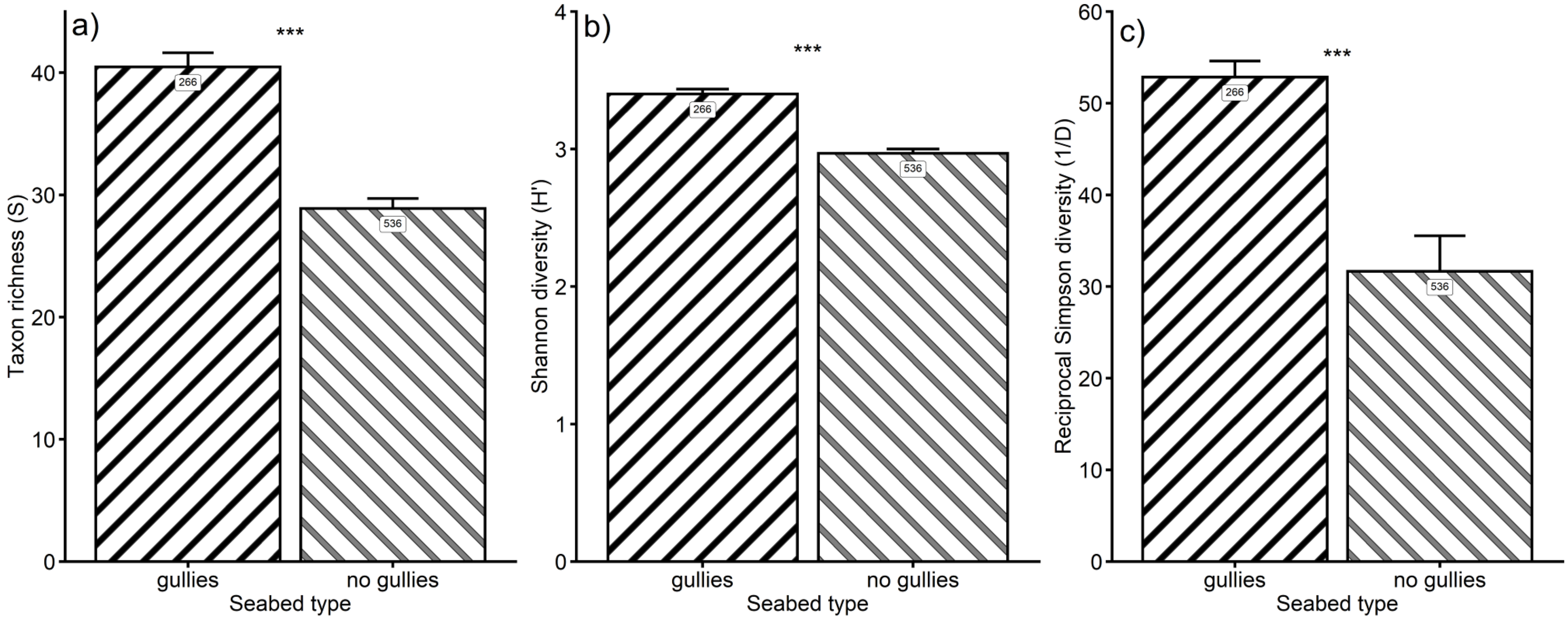


Figure 16. Mean (+s.e.) values for a) taxonomic richness (S), b) Shannon diversity (H') and c) reciprocal Simpson diversity (1/R) in samples from chalk with (black stripes) or without gullies (grey stripes) in CSCB MCZ. White labels indicate the number of samples from each category. *: *p* < 0.001**

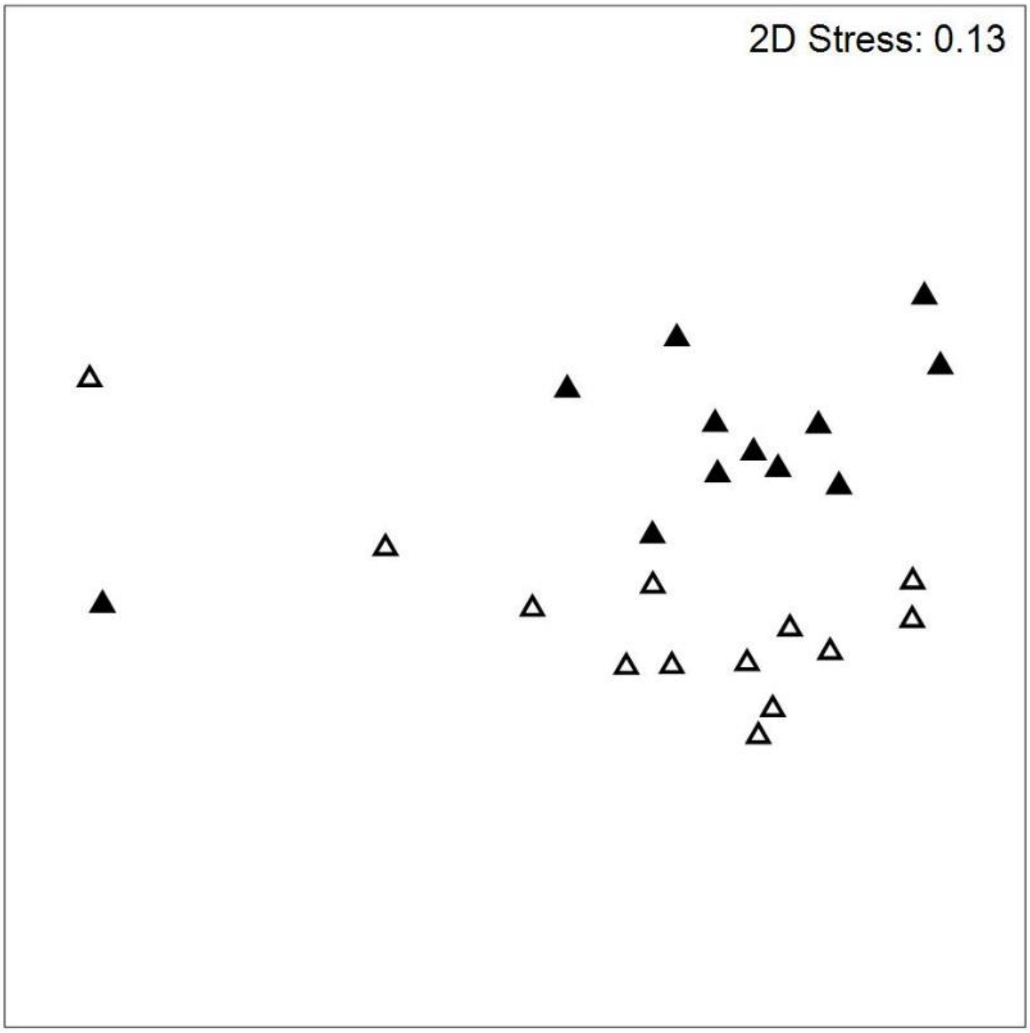


Figure 17. nMDS plot of samples from chalk seabed with gullies (closed black triangles) or without gullies (open white triangles) from CSCB MCZ, illustrating significant differences in composition of assemblages (PERMANOVA).

Table 6. Dissimilarity contributions of taxa between samples with or without gullies.

Taxon	Av.Abund With gullies	Av.Abund Without gullies	Av.Sim	Sim/SD	Contrib%	Cum.%
Polydora ciliata	3.05	1.06	4.82	1.16	7.02	7.02
Spirobranchus	2.77	2.05	4.00	1.04	5.83	12.85
Rissoa	1.67	0.90	3.30	0.70	4.81	17.66
Galathea	2.26	1.33	3.28	1.18	4.77	22.44
Lanice	1.18	1.92	2.94	1.01	4.29	26.72
Steromphala	1.63	1.07	2.86	0.98	4.16	30.88
Sycon ciliatum	1.19	0.91	2.52	0.85	3.67	34.56
Carcinus maenas	0.87	1.39	2.47	1.00	3.60	38.16
Urticina felina	1.56	1.26	2.18	0.95	3.18	41.34
Pagurus	0.69	0.92	1.99	0.87	2.90	44.24
Necora puber	1.09	0.70	1.94	0.98	2.82	47.06
Pomatoschistus	1.06	0.37	1.93	0.80	2.81	49.87
Cancer pagurus	1.46	1.03	1.80	1.02	2.62	52.50
Pomatoschistus	0.46	0.74	1.80	0.70	2.62	55.12
Actinia equina	0.68	0.82	1.77	0.82	2.58	57.69
Rissoa parva	0.82	0.41	1.65	0.49	2.40	60.09
Nucella lapillus	0.77	0.56	1.64	0.69	2.39	62.48
Arenicola	0.11	0.75	1.55	0.59	2.26	64.74
Diplosoma	1.05	0.63	1.55	1.07	2.26	67.00
Homarus	0.98	0.54	1.53	1.00	2.23	69.24
Taonia atomaria	0.75	0.53	1.37	0.94	2.00	71.24

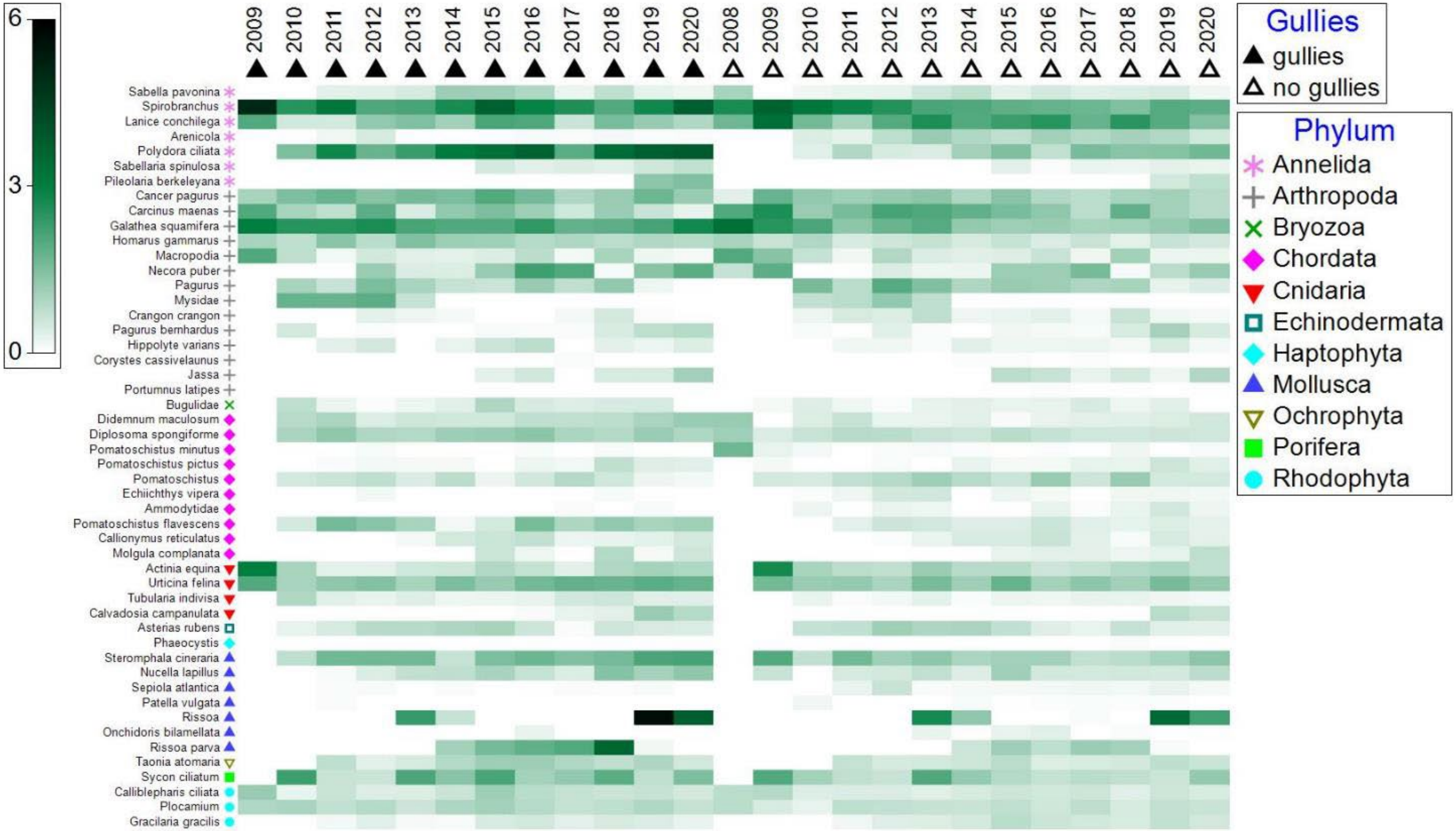


Figure 18. Shade plot showing the mean abundance of different taxa in samples from chalk with gullies or without gullies in CSCB MCZ. Year (2008-2020) and habitat type (Gullies: gullies = closed black triangles, no gullies = open white triangles) are displayed along the x axis. Species names are displayed on the y axis with associated symbology to represent Phylum. These abundance data are also presented in full in the Appendix.

Gully surface: wall or floor

Gully walls were strikingly different from gully floors (Figure 19).

Figure 18. Gully walls of steep chalk covered in floral and faunal turf, contrasting with sediment on the gully floor. © Dawn Watson and Rob Spray

Data for gully surfaces were not normally distributed for richness, Shannon or Simpson (1/D) diversity indices (Shapiro-Wilk, $p < 0.001$) and variances were homogeneous only for taxon richness (Bartlett, $p > 0.05$). Patterns were consistently that there was greater diversity on gully walls than on gully floors, but differences were significant only for richness and Shannon diversity. Diversity of samples from unspecified gully surfaces was typically similar to that from walls (and greater than that from floors). The exception to this was for Simpson diversity, where pairwise Dunn's tests were not able to resolve where differences occurred among the three groups (Figure 20, Table 3).

There were also significant differences in the compositions of assemblages of taxa from different surfaces of gullies (PERMANOVA MS = 15028, Pseudo-$F_{2,263} = 8.73$, $p < 0.001$; Figure 21). Pairwise tests indicated that there were significant differences between all three combinations of pairs ($p < 0.05$). The taxa with the five largest contributions to dissimilarity between samples with or without cobbles were *P. ciliata, Spirobranchus, G. squamifera, Calliostoma zizyphinum* and *Rissoa* (Table 7). *Polydora ciliata, Sycon* *ciliatum, Rissoa, Pomatoschistus flavescens* and *Cylista elegans* were markedly more abundant in samples from gully walls than from gully floors. A shade plot (Figure 22) shows patterns of mean abundance per year for the 50 most 'important' taxa in samples from the categories.

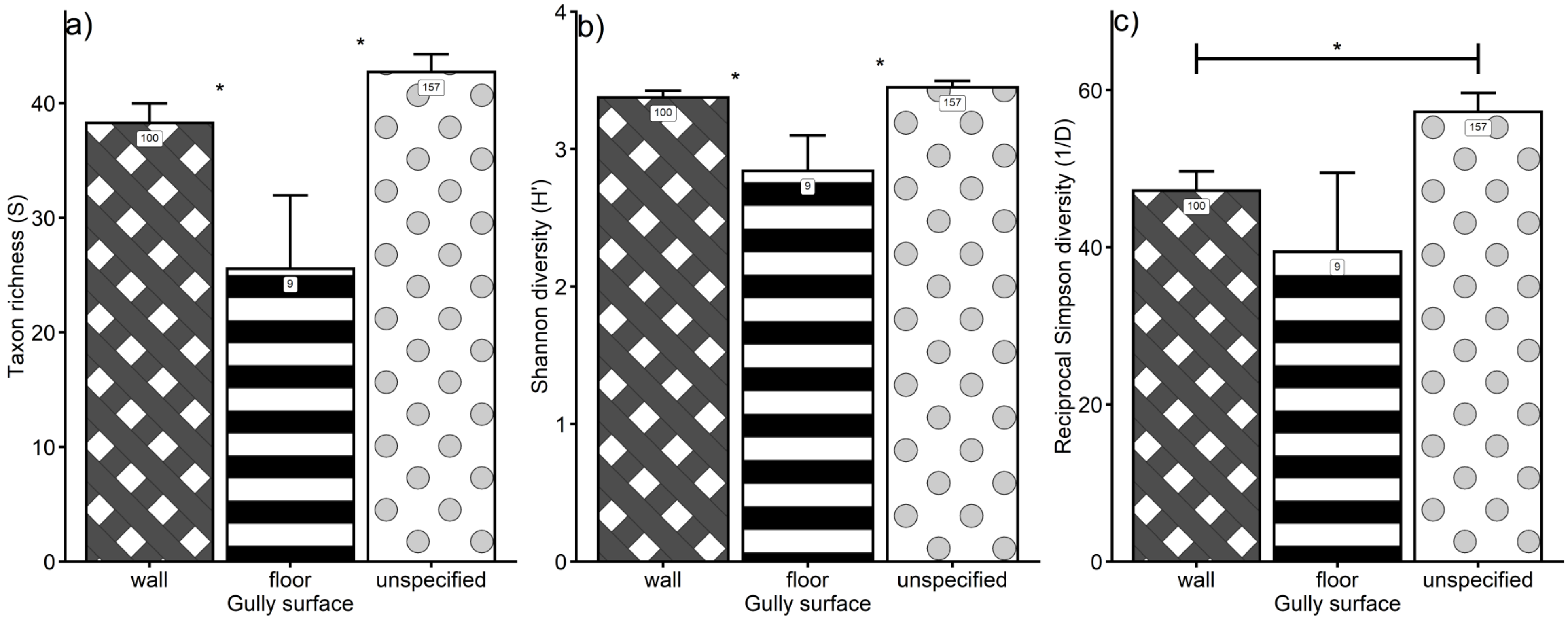


Figure 19. Mean (+s.e.) values for a) taxonomic richness (S), b) Shannon diversity (H') and c) reciprocal Simpson diversity (1/R) in samples from chalk gully walls (dark grey hatching), gully floors (horizontal black bars) or unspecified surfaces (light grey dots) in CSCB MCZ. White labels indicate the number of samples from each category. *: $p < 0.05$

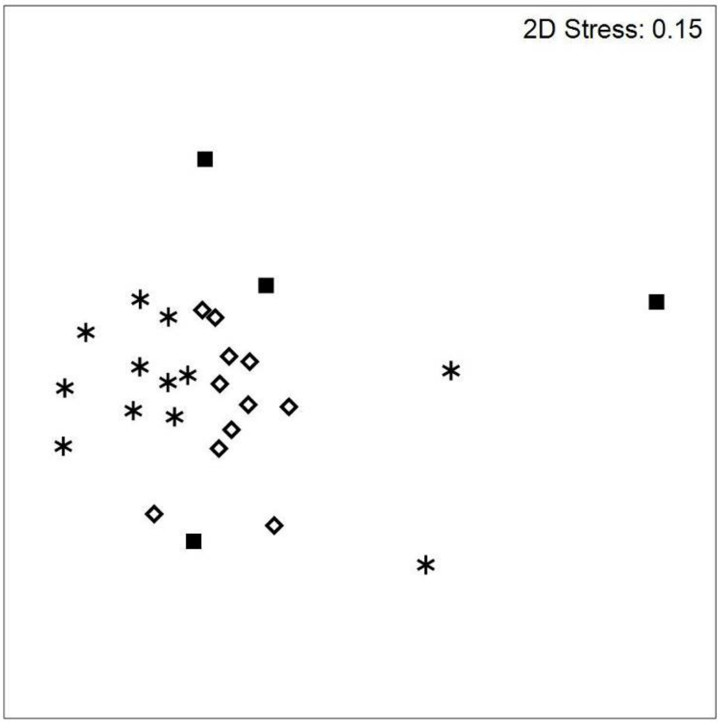


Figure 20. nMDS plot of samples from surfaces of chalk gulleys: floors (black squares), walls (stars) or not specified (white diamonds) from CSCB MCZ, illustrating significant differences in composition of assemblages (PERMANOVA).

Table 7. Dissimilarity contributions of taxa between samples from gulley walls or floors.

Taxon	Av.Abund Gully walls	Av.Abund Gully floors	Av.Sim	Sim/SD	Contrib%	Cum.%
Polydora ciliata	4.17	1.44	5.75	1.31	9.16	9.16
Spirobranchus	2.67	2.33	4.05	1.06	6.45	15.60
Galathea	2.28	2.00	2.86	1.00	4.55	20.16
Calliostoma	1.86	1.67	2.68	0.94	4.27	24.43
Rissoa	1.51	0.67	2.68	0.64	4.26	28.69
Amphilectus	2.45	1.67	2.60	0.95	4.14	32.83
Steromphala	1.56	1.00	2.56	0.95	4.07	36.91
Cylista elegans	1.40	0.56	2.13	1.14	3.39	40.30
Pomatoschistus	1.31	0.33	2.13	0.90	3.39	43.68
Sycon ciliatum	1.21	0.33	2.06	0.75	3.28	46.96
Symphodus	1.28	0.67	2.04	0.97	3.25	50.21
Urticina felina	1.38	2.00	2.02	0.95	3.21	53.42
Lanice	0.85	1.00	1.88	0.92	3.00	56.42
Cancer pagurus	1.69	1.22	1.70	1.03	2.71	59.13
Taonia atomaria	0.34	1.04	1.65	1.07	2.63	61.76
Palaemon	1.03	0.11	1.60	0.92	2.55	64.31
Taurulus bubalis	0.86	0.56	1.60	0.96	2.55	66.86
Homarus	1.29	0.90	1.51	1.03	2.40	69.26
Mysidae	0.54	0.44	1.34	0.51	2.13	71.39

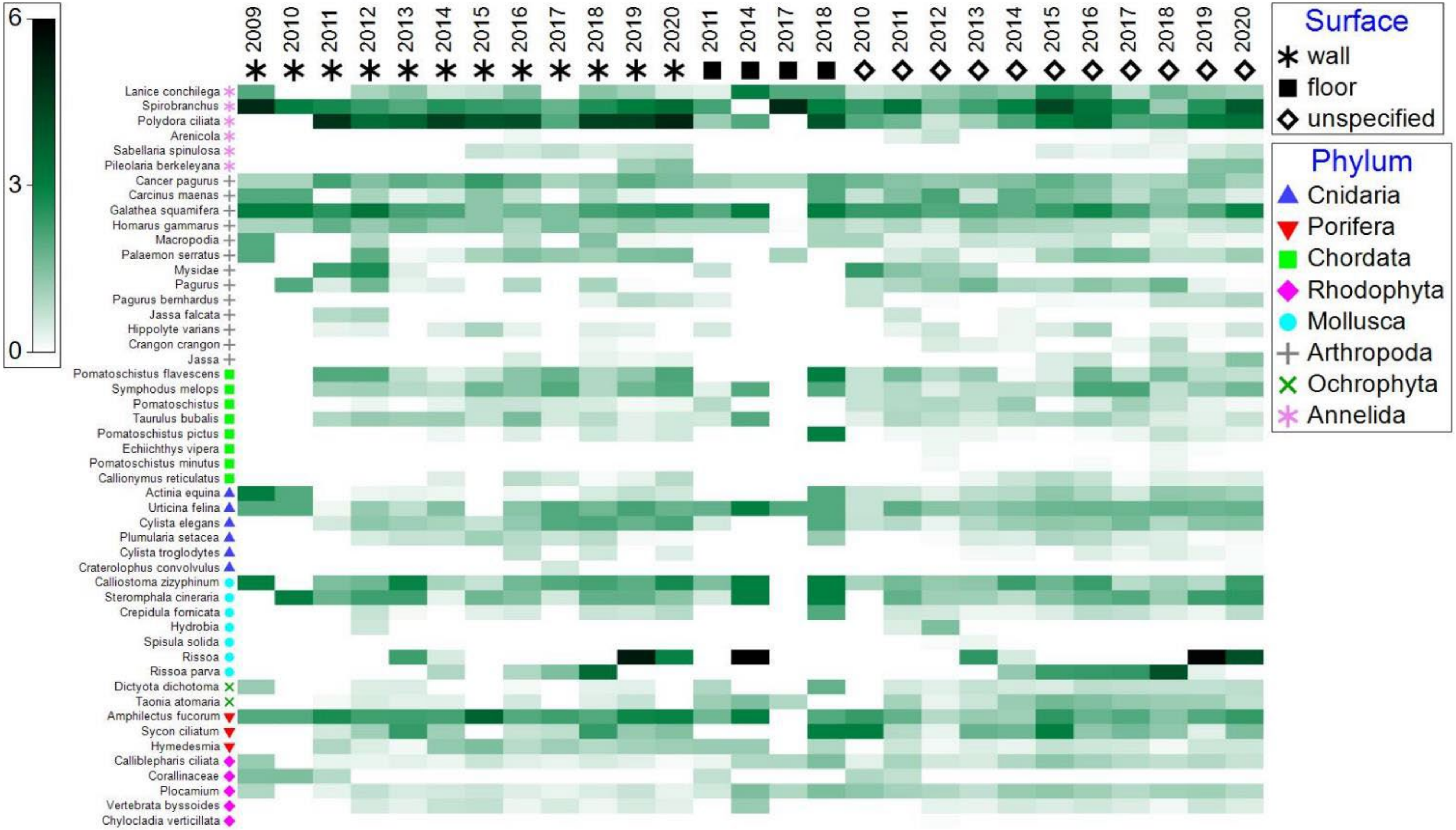


Figure 22. Shade plot showing the mean abundance of different taxa in samples from varying chalk surfaces in CSCB MCZ. Year (2008-2020) and surface type (Surface: wall = star, floor = square, unspecified = diamond) are displayed along the x axis. Species names are displayed on the y axis with associated symbology to represent Phylum. These abundance data are also presented in full in the Appendix.

Species-feature associations

Chalk

Chalk is the underlying substratum throughout the MCZ, and where exposed on the seabed, provides the most extensive type of static seabed. Due to its softness, it can develop complex topography, providing many sub-habitats. Chalk bedrock can feature mobile veneers of sediments or static veneers of cobbles, boulders and/or clay, which may themselves be swept by mobile veneers. The spatial extent of uncovered areas of chalk varies through time. The most rugged areas (those with the largest surface relief) are permanently uncovered, providing surfaces where biota can establish without risk of smothering. Such areas can act as source populations that allow re-colonisation of areas that are periodically exposed. Chalk seabed was divided into the following sub-habitats and features, each of which is associated with particular taxa.

Chalk plain topped with cobbles and small boulders

Horizontal chalk reef surfaces, often with a variable veneer of flint and chalk cobbles and boulders support very diverse red, green and brown algae. Notable species include *Taonia atomaria* (Figure 23) and *Gastroclonium reflexum*, previously thought to exist only as small populations off SW England, but now often recorded as Common within the MCZ. The invasive non-native *Grateloupia turuturu* is rapidly becoming Frequent across this habitat (Figure 24).

Figure 21. Meadow of *Taonia atomaria*. © Dawn Watson and Rob Spray

Figure 22. Invasive non-native *Grateloupia turuturu*. © Dawn Watson and Rob Spray

Small crustaceans, such as *Athanas nitescens, Pilumnus hirtellus* and *Pisidia longicornis* are found almost exclusively beneath cobbles and boulders on chalk (Figure 25). The cobbles and boulders also have encrusting species, such as the bryozoan *Conopeum reticulum* and *Disporella hispida*. These encrusting species have been completely replaced off East Runton by the invasive, non-native spirorbid worm *Pileolaria berkleyania* (Figure 26), which had also spread to Cromer and West Runton by 2021.

Figure 23. Small crustacea, including *Pisidia longicornis* (top), live under boulders and cobbles (bottom). © Dawn Watson and Rob Spray

Figure 24. Dense crusts of invasive *Pileolaria berkleyania*. © Dawn Watson and Rob Spray

Symphodus melops like to build their nests of seaweed clippings inside paramoudra - large vertebra-shaped flints found mainly on the more open chalk plain between Sheringham and Cromer.

The sponge *Cliona* sp. (Figure 27) is often found in upward facing chalk reef but is frequently overlooked because it grows in the boring rather than the massive form and is typically hidden under algae or animal turf.

The purple *Hymedesmia* sp. sponge unique to Norfolk grows more enthusiastically on flint than chalk (though it will grow on the very hard chalk around very old tunnels), but only if that flint is on chalk reef (Figure 28). It never grows on flint boulders on any other seabed type. We assume this is because of some chemical requirement, as it grows equally well on open plains and inside gullies.

Figure 25. The boring form of the sponge *Cliona celata* in a chalk boulder. © Dawn Watson and Rob Spray

Figure 26. The recently discovered purple *Hymedesmia* sponge, unique to Norfolk. © Dawn Watson and Rob Spray

Gully walls

The dense mixed algae of the chalk reef becomes dominated by *Heterosiphonia plumosa* and *Vertebrata byssoides* in the deeper water where gullies begin to form, before being replaced ca. 25m metres from shore by a dense turf of sponges and ascidians, including *Halisarca dujardinii, Oscarella* sp., *Dysidea pallescens, Didemnum maculosum, Clavelina lepadiformis* and *Pycnoclavella stolonialis,* most of which are absent or rare in other habitats (Figure 29).

Figure 27. *Dysidea pallescens*, a sponge characteristic of the outer ends of chalk gullies. © Dawn Watson and Rob Spray

Gully walls often present habitat with complex structure and 3-dimensional surfaces (Figure 30).

Figure 28. Chalk gully walls can provide complex habitat for many species. © Dawn Watson and Rob Spray

Thorogobius ephippiatus and *Parablennius gattorugine* inhabit small tunnels and holes towards the outer ends of gullies and very large *Cancer pagurus* and *Homarus gammarus* patrol the walls (Figure 31).

Figure 29. *Thorogobius ephippiatus* (top left) and *Parablennius gattorugine* (top right) make use of holes in the rock and large *Homarus gammarus* on a gully wall (bottom). © Dawn Watson and Rob Spray

Polydora ciliata is abundant on circalittoral chalk faces, often out-competing all other life on vertical or overhanging surfaces in areas with fast currents (Figure 32). The larger species *Pseudopolydora pulchra* is seen very occasionally. *Polydora* are occasionally seen on wreckage, hermit crab shells and stiff clay, but seem to require the soft but stable surface of chalk to thrive.

The sponge *Polymastia boletiformis* has been recorded only once during a drift dive between Overstrand and Trimingham, where it was found to be frequent and very healthy on rugged chalk gullies, with individuals 30cm across.

Figure 30. Crusts of *Polydora ciliata* worms completely covering an overhanging chalk wall. © Dawn Watson and Rob Spray

Gully floors

This habitat is very variable, ranging from stable boulders to mobile sand. The boulders support the same sponges and ascidians as do gully walls, while the sands and gravels are home to Ammodytidae, *Echiichthys vipera* and *Sepiola atlantica* (Figure 33), the latter hunting *Crangon crangon*. Shoals of *Aphia minuta* are frequently found in gullies, irrespective of the composition of the gully bottom, hovering perhaps 50cm above the seabed.

Figure 31. *Echiichthys vipera* (left) and *Sepiola atlantica* (right) are often found in or on the sediment of a gully floor. © Dawn Watson and Rob Spray

Caves and tunnels

Deep holes in the sides of chalk gullies form caves and tunnels which shelter shoals of territorial fish such as *Trisopterus luscus* and several species of wrasse (Figure 34). Large solitary *Gadus morhua* are also seen here. These features were formed when the chalk was under glacial pressure and acting as drainage for meltwater, so the walls are too hard to support the *Polydora ciliata.* They tend instead to be inhabited by Cnidaria such as *Cylista elegans* and *Tubularia indivisa*. Bryozoan crusts (*Schizomavella* spp.) and sponges (*Oscarella* sp.) line the entrances (Figure 35).

Figure 34. Caves provide shelter for shoals of territorial, predatory fish, like Trisopterus luscus.

Figure 35. Entrances to caves and tunnels are lined with bryozoans and sponges. © Dawn Watson and Rob Spray

Arches

Arches tend to stand either at the outer ends of gullies, or as individual outcrops. They are orphaned tunnels and caves separated from the main body of a gully wall during its destruction or truncation. These are likely the chalk features most vulnerable damage. Arches (Figure 36) attract shoals of large, predatory fish such as *Dicentrarchus labrax* and *Pollachius pollachius,* in the same manner as does upright wreckage. The fish endlessly circle through the arch and back over the top in what seems to be a resting pattern. The relatively soft rock enables *Polydora ciliata* and delicate hydroids such as *Halopteris catharina* and sheets of *Hydractinia echinata* to populate the surfaces inside the archway.

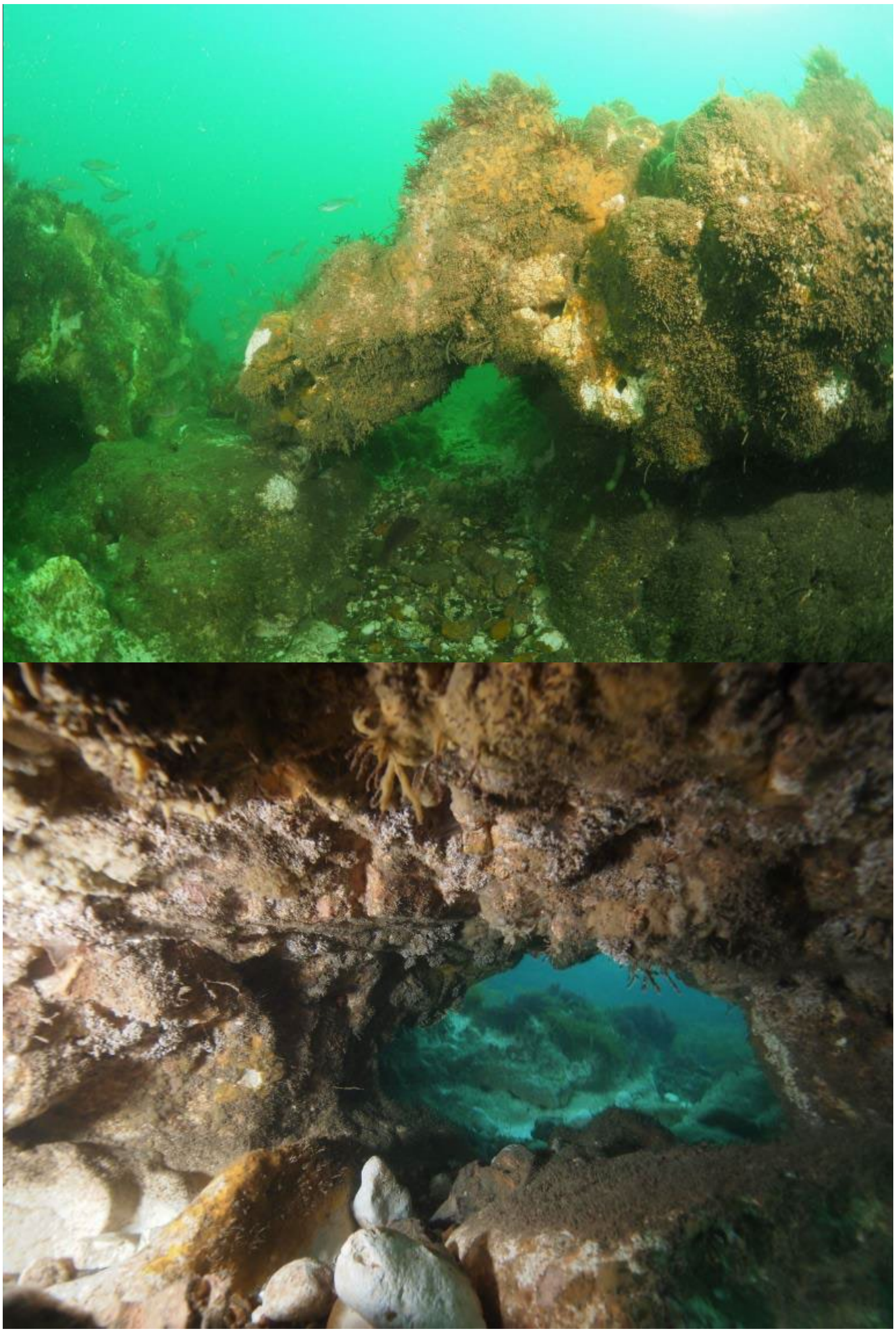


Figure 32. Chalk arches with shoals of fish (top) and dense faunal turf specific to overhanging surfaces (bottom). © Dawn Watson and Rob Spray

Crevices/fissures

These horizontal spaces between chalk layers tend to be filled with territorial mobile life, distributed according to body size and the space available. Crustacea such as *Pilumnus hirtellus, Palaemon* spp., *Eualus* spp. and *Galathea squamifera* are among the most frequent occupants. The only recorded spiny squat lobster (*Galathea strigosa*) inside the MCZ is known to have lived in a particular crevice (Figure 37) off West Runton for at least 12 months over 2011-12. Juvenile *Cancer pagurus* also make use of these spaces as they provide great protection from larger predators.

Figure 33. ***Galathea strigosa*** **(top) and** ***Cancer pagurus*** **(bottom) shelter in crevices or holes in the chalk. © Dawn Watson and Rob Spray**

Other substrata

Chalk is not the only substratum protected within the MCZ. Other substrata each have their own associated species and interactions.

Clay

This soft rock exists in several different forms within the MCZ and varies greatly in hardness and the amount of grit it contains (Figure 38). The piddock *Barnea candida* is almost common in horizontal, flat, sticky clay. Nothing burrows into the very hard, fragile clay to the east of Overstrand, although hydroids, such as *Nemertesia* and *Sertularia* colonise its surfaces. Large adult *Homarus gammarus* and *Cancer pagurus* burrow into the stiff steps of clay running parallel to shore off Weybourne when they are not covered by mobile sand.

Boulders and cobbles stabilised by clay

This habitat has been found only at Overstrand, where there is deeper water close inshore with faster currents than other parts of the MCZ. These conditions would normally be associated with a very mobile seabed, but the sticky clay keeps the mainly flint pebbles, cobbles and boulders firmly in place, allowing a unique collection of sponges and ascidians to thrive. The dominant species of ascidians are *Archidostoma aggregatum* and *Styela coriacea*, neither being seen in other habitats. The sponge *Polymastia penicillus* is seen frequently; a rare species elsewhere. The spaces between the rocks are often filled with the tubes of *Ampelisca* sp. (Figure 39), which were also unique to this site, but have recently begun to spread to other areas.

Figure 34. Clay seabed, showing much less life than chalk substratum, although *Barnea candida* (bottom) can be common. © Dawn Watson and Rob Spray

Figure 35. Tubes of *Ampelisca* sp. fill interstices between flint cobbles and boulders. © Dawn Watson and Rob Spray

Flint boulder pavement

This very stable habitat, a uniform layer of angular flint boulders cemented in place by thick encrusting calcareous algae, provides a home for *Galathea squamifera, Homarus gammarus* and *Cancer pagurus,* along with smaller prawns, such as *Pandalus montagui, Palaemon serratus* and *Eualus* sp*.* The stable surface is colonised by large sheets of sponges, such as the purple Norfolk *Hymedesmia* sp.*, Amphilectus fucorum* and *Dysidea fragilis*. This habitat has so far been recorded only between and beyond the ends of chalk gullies off Sheringham. Beyond the chalk gullies, *Flustra foliacea, Cylista elegans, Nemertesia* spp. and *Haliclona oculata* also appear, presumably encouraged by the greater availability of food where exposed to currents outside the gullies.

Flint boulder fields on sediment

This is a particularly hostile habitat. Flint boulders are generally found in depressions in mobile sand seabed and are subjected to intense scour and occasional smothering as the sand ebbs and flows. The only sessile species which grow on the flints are barnacles, which in turn attract abundant *Onchidoris bilamellata* and juvenile *Asterias rubens* whenever the flints are uncovered.

Carstone

This soft sandstone conglomerate is present as large rounded boulders at Overstrand and is inhabited by a very diverse animal turf. The carstone is of variable hardness and has a very pitted surface which allows many small species to find shelter from predators and allows larger hydroids and sponges such as *Nemertesia antenina* and *Haliclona oculata* to get a firm foothold. *Amathia pustulosa* is frequent on this rock, along with its predator *Palio nothus*.

Sediment veneers - Sand

Mobile sand contains very little visible infauna, but supports a selection of mobile species not seen in other habitats. The crabs *Corystes cassivellaunus* and *Portumnus latipes* hide themselves amongst the more common *Carcinus maenas* and *Cancer pagurus* buried in fine sand. Juvenile *Eutriglia gurnardus, Syngnathus rostellatus* and small shoals of *Mullus surmuletus* are often seen. *Alloteuthis subulata* lays its eggs on mobile sand, somehow injecting one part of the sac deep beneath the surface to keep it anchored.

In some years (e.g. 2018), vast beds of *Lanice conchilega* stabilise the sand into 1-2m high waves and attract large numbers of *Cancer pagurus* away from hard substrata (Figure 40). These beds tend to be seen between Weybourne and East Runton where the sand is relatively coarse. The sand at the South-east end of the MCZ tends to be very fine, which seems to limit the species which can make use of it. The fine sediments are easily suspended, increasing turbidity and restricting the opportunities for good diving.

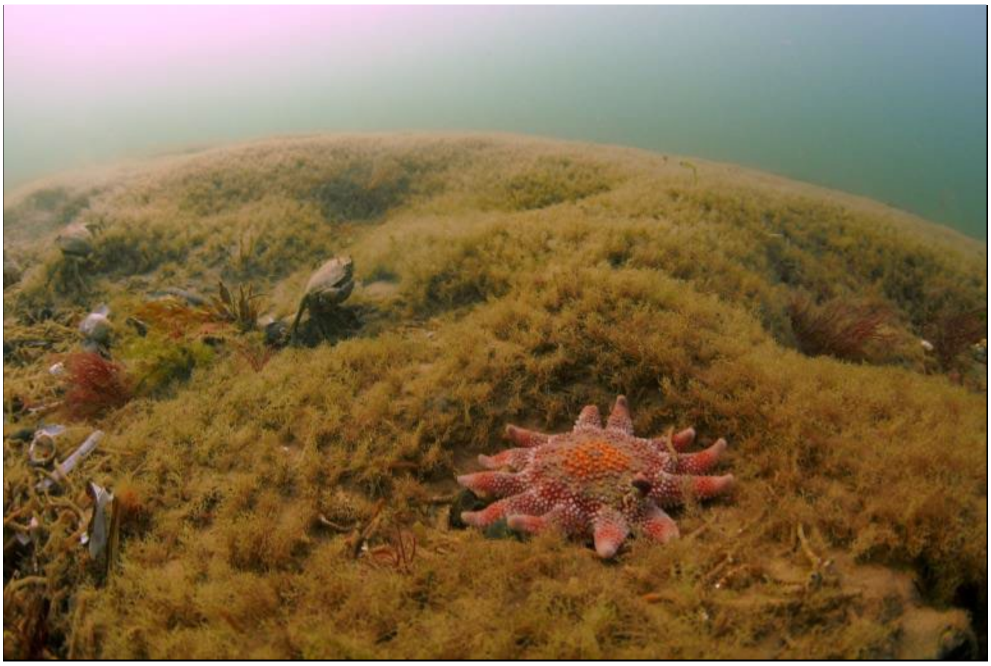


Figure 36. Dense forest of *Lanice conchilega*, stabilising sandy sediment and attracting predators like *Cancer pagurus* and *Crossaster papposus*. © Dawn Watson and Rob Spray

Where sand forms a thin veneer over flat chalk plain, meadows of *Gracilaria gracilis, Halidrys siliquosa* and *Polyides rotundus* form, attached to the underlying rock (Figure 41). These provide a home for the stalked jellyfish *Calvadosia campanulata*, which, although it can also be found on seaweed on chalk seabed, appears to thrive at the tips of algae around sand, despite the risk of abrasion (Figure 42).

Figure 37. ***Gracilaria gracilis*** **growing through a veneer of sand over chalk seabed. © Dawn Watson and Rob Spray**

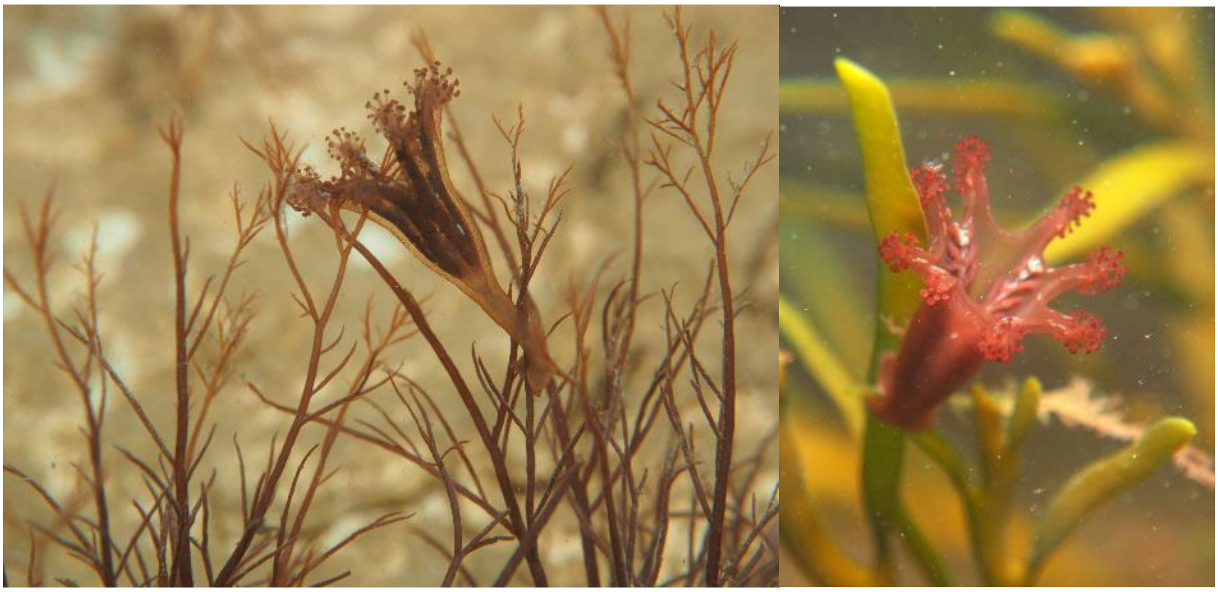


Figure 38. ***Calvadosia campanulata*** **on the tips of algae. © Dawn Watson and Rob Spray**

Large areas of flat sand collect piles of *Alcyonidium diaphanum* and its predator *Acanthodoris pilosa*, which can be locally abundant. The bryozoan does not need to be attached to substratum and can form a travelling 'reef' on the sand, often populated by *Sabella pavonina* and small ascidians (Figure 43). A similar mobile habitat is formed by 'tumbleweeds' of detached algae and the hydroid *Sertularia cupressina*, which seem to concentrate clouds of very small crustaceans, which in turn attract *Idotea linearis* and pipefish which travel inside the rolling masses. *Entelurus aequoreus*, which appeared and became unusually abundant in 2008, but vanished again in 2009, were mostly observed in this habitat.

Figure 39. Free-living fragments of *Alcyonidium diaphanum* can form travelling 'reefs', attracting other animals such as this *Idotea linearis*. © Dawn Watson and Rob Spray

Sediment veneers - Gravel

The two most commonly recorded forms of coarse sediment in the MCZ are light, fine gravel made from the crushed remains of *Spirobranchus* worm-tubes, and coarse stone gravel some distance from shore. The worm-tube gravel is an ideal habitat for juvenile stages of commercially valuable crustacea when they first settle from the plankton, and is otherwise inhabited by *Hyperoplus lanceolatus* and *Echiichthys vipera*. The coarse gravel is mainly seen by wreck divers and has rarely been fully surveyed. It is known to support meadows of *Flustra foliacea* and *Nemertesia antenina*, plus an infauna of bivalves.

Discussion

Data from Seasearch records and knowledge from experienced Seasearch recorders have been combined to create a series of maps of known distributions of different substrata and habitats within the CSCB MCZ. Records were also processed and analysed such that a range of comparisons of taxonomic diversity and composition were made for different categories of seabed.

Distribution of habitats

Cromer Shoal Chalk Beds MCZ supports a diverse range of habitats and taxa, within a relatively small area of sampling. Despite the patchy nature of the sampling (caused by limited easy access to the seabed), numerous polygons have been defined for six categories of seabed in and around the borders of the MCZ (Figure 1-2, 4-8).

Different habitats and areas of different surface relief occur in different parts of the MCZ. For example, chalk seabed typically increases in surface relief with increasing distance from shore, and chalk has generally been replaced by sediment by 1.5 km from shore. These patterns must be tempered with the recognition that sampling intensity beyond 1.5 km from the shore drops off sharply. Considerable areas of chalk with surface relief of at least 50 cm (moderate or high) occur within the strip of sea between land and the shoreward boundary of the MCZ. Knowing these distributions has implications for understanding which areas are more vulnerable, sensitive or resistant to physical disturbance, which may influence how the area is managed.

Allocation to habitats

It was not possible to allocate unambiguously samples to some of the seabed characteristics plotted in Figures 2-4, 6-8 and so no comparisons of taxonomic diversity or composition were made among the categories of surface relief. Small-scale features (arches, caves, fissures, etc.) were also not included in taxonomic comparisons because they were too small to be represented by individual polygons and the accepted spatial uncertainty (~70m) of sample positions meant that their placement would not be reliable relative to the size of the feature.

Uncertainty in allocation of habitats increases as categories become more restricted. This is because the categorisation process relies on presence of key words (spelled consistently) in free-text descriptive fields about the sample. For instance, failure to mention the word gully in a description of a sample from gullies would mean that an incorrect label was allocated. The large number of ‘unspecified’ surfaces from samples of gullies indicates that this is not an important or intended component of the data collection. The finer-scale the feature, the less likely it would be the only feature in a sample and the less likely it would be included in the description. Evidence for imperfect allocation of samples to habitats comes from the presence of unexpected taxa (e.g. *Lanice conchilega* in samples from gully walls). These issues highlight some of the limitations inherent in using data which were not collected with particular analyses in mind. Statistical purists might argue that deficiencies in data due to lack of structure during data collection and minimal experimental design preclude doing such analyses. Multiple reports on different topics have demonstrated, however, that Seasearch records, with consistent survey protocol, rigorous quality control and large sample size, can be used to answer a range of questions about taxonomic diversity and composition of benthic assemblages.

Taxonomic diversity and composition

The main focus of the present study was about chalk habitats, but there was also value in comparing chalk with other types of rock. Diversity and taxonomic composition of benthic assemblages varied significantly among the habitats considered. Chalk substrata clearly supported much greater diversity than did clay substrata (Figure 9). As per the prediction (Table 1), this was likely due to the softness and erodibility of clay substrata, where many sessile taxa were unable to establish (Connor *et al.*, 2004).

Since classic studies in the sixties and seventies (MacArthur & MacArthur, 1961; Levins, 1979), complexity of habitat has been recognised as having a positive influence on biodiversity that can be supported in that habitat, including in the marine environment (Jenkins *et al.*, 1997; Beck, 2000; Smith *et al.*, 2014). Within chalk habitats, those that feature cobbles or gullies supported more taxa than where these features were absent. This was again consistent with predictions (Table 1). The most obvious explanation was that presence of gullies and cobbles provided structural complexity to habitat that was not available in the absence of these features. Whilst there were significant differences in diversity and composition between gully walls and gully floors (Table 3; Figure 20-1), these were less clear-cut than for other comparisons.

Although it was not possible to test formally for taxonomic differences between the four levels of surface relief, the significantly greater diversity present in habitat with cobbles or gullies compared with habitats lacking these components leads to a clear prediction that diversity would increase with the greater complexity provided by greater surface relief. The degree of complexity available is considerable and varied, where relief is large (Figure 44).

Figure 40. Diverse and complex three-dimensional habitat provided by chalk features with large surface relief. © Dawn Watson and Rob Spray

There may also be interactions between components. For instance gullies with cobbles on the floor may have greater diversity than gullies with sandy floors. The process by which Seasearch data have been collected makes it unrealistic to separate out these components in order to make a formal test, but having such predictions helps with designing more targeted sampling for future surveys.

Species-feature associations

Anecdotal observations collated from experienced divers provide additional illustration of what lives where. These are different than, but complementary to more quantitative approaches and fill information gaps that cannot yet be plugged by formal analyses. Anecdotes regarding some of the larger-scale features often correspond with the outputs of statistical tests. For instance, divers recognise that the worms *Polydora ciliata* and *Spirobranchus* sp. are more typical of chalk than clay, and this is reflected in the percentage contributions to dissimilarity in the compositions of assemblages between these substrata (Table 4).

Anecdotes about smaller features had no comparable analysis, but did provide numerous interesting observations about associations between taxa and features of the seabed. Examples include: *Polymastia boletiformis* being found only in chalk gullies in a single location; squat lobsters being found predominantly in crevices; *Polydora ciliata* dominating on overhanging chalk; invasive *Pileolaria* displacing native taxa from encrusting biota of cobbles and use of gully walls and holes for foraging and shelter, respectively by species with commercial value (e.g. *Cancer pagurus* and *Homarus gammarus*).

Some features, e.g. arches and ends of gullies are recognised as being vulnerable to damage. Taxa associated with these features may be at risk if damage occurs.

Temporal variation

The patchy sampling and the mobile nature of sandy sediment in the area means that the boundaries of the polygons are not absolute. For instance, patches of a particular substratum may actually be much larger than shown (but this information is not available because the wider area has yet to be surveyed) and areas that are chalk one year may be completely hidden by sand the following year (or vice versa).

Shade plots show that temporal variation in abundances is apparent for some taxa. For example, *Rissoa* in some years were very abundant (e.g. 2019), but not in others (Figure 22). This may be due to some or all of several reasons including:

1) Actual variation in abundance
2) Locations with abundance being visited in some years but not others
3) Recorders able to identify the taxa diving in some years but not others
4) Temporal variation in extent of smothering of suitable habitat by mobile sediment

Sample size

In ad hoc survey programmes, sample sizes often differ between groups. Thus, any observed differences may be due to different sampling effort rather than any effect of the factor of interest. In the present study, sample sizes were often very large (>100) which greatly minimises the effect of differing sample effort. Two exceptions were for comparisons between samples from chalk or clay (802 vs 24) and between gully walls and floors (100 vs 9). Twenty-four samples from clay (although not an overly small amount of effort), clearly provide a weaker estimate of reality than do the 802 samples from chalk. Although the pattern was strongly as predicted (i.e. for diversity chalk > clay; Table 1) it is possible that the smaller diversity on clay is caused in part, by incomplete or chance non-representative sampling of this habitat.

Despite the noise inherent in such data, clear patterns emerge for diversity and composition (which are very unlikely to be created by the presence of noise alone). The larger sample-sizes and more robust allocation of samples to habitats suggests that patterns between chalk:clay, cobbles:no-cobbles and gullies:no-gullies should be treated with greater confidence that should patterns among gully surfaces.

This study provides information that facilitates greater knowledge about what lives where within the MCZ. Such knowledge could be used to influence management of anthropogenic activity within the MCZ and provides a 'baseline' against which any future change might be assessed.

Future work

Several areas of fruitful future work are facilitated or suggested by this study.

- Maps can be used to target areas for future sampling to fill gaps or to collect additional records from particular substrata or habitats.
- Of particular interest would be studies that assess how vulnerable or prone different features are to physical damage (putting at risk the taxa that depend on them)
- Collection of records from features of interest (e.g. from previous point) in a more targeted and structured way will allow more robust tests about taxonomic diversity, composition and changes within ecologically or economically valuable habitat.
- The anecdotal associations between species and features provide ready predictions for other survey work that focuses on either.
- The temporal variability in position of mobile sediment means that future visits to areas of a particular type of seabed may encounter seabed with different characters to those shown on the maps here. Greater understanding of the spatial and temporal extents of changes in the seabed (e.g. through redistribution of mobile sediment) and how this can impact biota dependent on rocky substrata would also be of value.

Conclusions

Our understanding of distribution of habitats and species within the CSCB MCZ has expanded considerably as a consequence of this report. Despite being spatially patchy, a large and valuable dataset exists of records from the MCZ. These data have been used so that we now know more about priority benthic habitats in the MCZ, specifically about:

1) the distributions of different substrata and types of chalk seabed with different degrees of surface relief. Expertise of Seasearch surveyors was used to delineate known areas of different benthic substrata and habitats within the CSCB MCZ.

2) what taxa occur and in which priority habitats within the MCZ. Uni- and multivariate analyses illustrated patterns of difference in taxonomic diversity and composition. For the habitats where comparisons were possible and justifiable, two main patterns were apparent, each of which was consistent with prior expectation, namely that diversity is significantly greater on chalk than on clay and also greater in topographically more complex habitat (with cobbles or gullies) than in structurally more simple habitat. This indicates very strongly that areas with large surface relief (i.e. with great complexity) will be of greater value for taxonomic diversity than areas with less rugged habitat. Species are often observed to exhibit associations with particular features of habitat.

3) which taxa are associated with specific structures or features of the seabed. Local knowledge of experienced Seasearch divers was used to describe consistent associations between specific features of chalk reef and taxa found there. Interesting associations were recognised for a wide variety of taxa, differing in taxonomic affiliation, abundance, commercial value and potential mechanism.

All of these constitute new information that does not exist elsewhere and formulation of which was possible only because of the large, long-term survey effort by Seasearch in CSCB MCZ. Outcomes from collation of human perception and formal analysis of records were often congruent, giving credence to each of these approaches. When filtered and formatted, with rigorous quality control, biological records collected by Seasearch can be used to assess taxonomic diversity and composition of priority features of the seabed. There are some limitations where sample sizes are small or where small size of features makes it challenging to attribute records to them. The study also provides several avenues for further, more targeted work.

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Appendix

Taxon list with occurrence tally in selected habitats for CSCB MCZ

Taxon Name	n	Chalk	Clay	Gull	NoGull	Cobb	NoCobb	Wall	Floor
Abietinaria abietina	21	7	NA	1	6	1	6	1	1
Acanthodoris pilosa	55	13	NA	1	12	2	11	NA	2
Acari	1	NA	NA	NA	NA	NA	NA	NA	NA
Actinia equina	401	270	NA	88	182	149	121	18	9
Actinia fragacea	3	3	NA	NA	3	3	NA	NA	NA
Actiniaria	1	NA	NA	NA	NA	NA	NA	NA	NA
Actinopterygii	1	NA	NA	NA	NA	NA	NA	NA	NA
Actinothoe sphyrodeta	1	NA	NA	NA	NA	NA	NA	NA	NA
Aeolidia	9	3	NA	1	2	1	2	1	NA
Aeolidia filomenae	6	2	NA	1	1	1	1	NA	NA
Aeolidia papillosa	23	7	NA	1	6	3	4	NA	1
Aeolidiella glauca	3	1	NA	NA	1	NA	1	NA	NA
Aequipecten opercularis	1	NA	NA	NA	NA	NA	NA	NA	NA
Aequorea	14	7	1	1	6	2	5	NA	NA
Aequorea forskalea	1	NA	NA	NA	NA	NA	NA	NA	NA
Aetea anguina	4	4	NA	2	2	2	2	NA	NA

Taxon Name	n	Chalk	Clay	Gull	NoGull	Cobb	NoCobb	Wall	Floor
Aglaozonia (asexual cutleria)	3	NA	NA	NA	NA	NA	NA	NA	NA
Agonus cataphractus	7	3	NA	NA	3	NA	3	NA	NA
Ahnfeltia plicata	58	53	NA	21	32	31	22	3	2
Alcyonidium	3	2	NA	1	1	1	1	NA	NA
Alcyonidium diaphanum	236	88	3	18	70	18	70	7	8
Alcyonidium gelatinosum	7	7	NA	2	5	5	2	NA	NA
Alcyonidium hirsutum	7	6	NA	3	3	4	2	NA	1
Alcyonium digitatum	331	51	1	12	39	14	37	1	3
Algae	243	NA	NA	NA	NA	NA	NA	NA	NA
Alloteuthis subulata	35	15	NA	8	7	2	13	3	1
Amathia	3	1	NA	NA	1	NA	1	NA	NA
Amathia citrina	132	52	NA	21	31	17	35	5	4
Amathia gracilis	4	3	NA	3	NA	NA	3	1	NA
Amathia imbricata	43	25	1	10	15	7	18	3	3
Amathia pustulosa	1	NA	NA	NA	NA	NA	NA	NA	NA
Amblyosyllis spectabilis	2	2	NA	1	1	1	1	1	NA
Ammodytes	42	NA	NA	NA	NA	NA	NA	NA	NA
Ammodytes tobianus	8	NA	NA	NA	NA	NA	NA	NA	NA

Taxon Name	n	Chalk	Clay	Gull	NoGull	Cobb	NoCobb	Wall	Floor
Ammodytidae	14	39	NA	2	37	8	31	1	2
Ampelisca	14	2	3	1	1	2	NA	NA	NA
Amphilectus	8	7	NA	6	1	3	4	3	NA
Amphilectus fucorum	763	457	3	209	248	180	277	91	12
Amphipholis	1	NA	NA	NA	NA	NA	NA	NA	NA
Amphipholis squamata	10	5	NA	1	4	3	2	NA	NA
Amphipoda	19	NA	NA	NA	NA	NA	NA	NA	NA
Amphisbetia operculata	3	1	NA	NA	1	NA	1	NA	NA
Amphitritides gracilis	12	10	NA	3	7	3	7	2	NA
Amphiura	2	2	NA	1	1	1	1	1	NA
Amphorina farrani	1	NA	NA	NA	NA	NA	NA	NA	NA
Amphorina pallida	5	2	NA	1	1	NA	2	1	NA
Anapagurus	4	3	NA	1	2	1	2	1	NA
Ancula gibbosa	2	1	NA	NA	1	1	NA	NA	NA
Anguilla anguilla	47	19	NA	6	13	8	11	1	NA
Anguinella palmata	4	3	NA	1	2	NA	3	NA	NA
Annelida	1	NA	NA	NA	NA	NA	NA	NA	NA
Antho (Antho) dichotoma	1	1	NA	1	NA	1	NA	NA	NA
Anthoathecata	27	NA	NA	NA	NA	NA	NA	NA	NA

Taxon Name	n	Chalk	Clay	Gull	NoGull	Cobb	NoCobb	Wall	Floor
Antiopella cristata	198	41	3	19	22	7	34	7	1
Antithamnionella	1	1	NA	NA	1	NA	1	NA	NA
Aphia minuta	36	29	NA	9	20	8	21	2	3
Aphrodita	2	NA	NA	NA	NA	NA	NA	NA	NA
Aphroditidae	1	NA	NA	NA	NA	NA	NA	NA	NA
Aplidium	24	11	NA	6	5	7	4	2	NA
Aplidium glabrum	48	11	NA	1	10	5	6	1	1
Aplidium nordmanni	1	1	NA	1	NA	NA	1	1	NA
Aplidium punctum	7	1	NA	NA	1	NA	1	NA	NA
Aplidium turbinatum	64	41	1	14	27	23	18	6	3
Aplysia punctata	18	12	NA	3	9	8	4	1	NA
Aplysilla rosea	2	NA	NA	NA	NA	NA	NA	NA	NA
Aplysilla sulfurea	17	NA	NA	NA	NA	NA	NA	NA	NA
Archidistoma aggregatum	61	19	3	9	10	5	14	6	NA
Arenicola	6	181	8	15	166	30	151	1	3
Arenicola defodiens	152	NA	NA	NA	NA	NA	NA	NA	NA
Arenicola marina	365	NA	NA	NA	NA	NA	NA	NA	NA
Ascidia	4	2	NA	NA	2	NA	2	NA	NA
Ascidia conchilega	1	1	NA	1	NA	NA	1	NA	NA

Taxon Name	n	Chalk	Clay	Gull	NoGull	Cobb	NoCobb	Wall	Floor
Ascidia mentula	2	NA	NA	NA	NA	NA	NA	NA	NA
Ascidiacea	15	NA	NA	NA	NA	NA	NA	NA	NA
Ascidiella	6	NA	1	NA	NA	NA	NA	NA	NA
Ascidiella aspersa	31	16	1	7	9	3	13	3	2
Ascidiella scabra	19	7	NA	4	3	1	6	2	1
Ascophyllum nodosum	1	NA	NA	NA	NA	NA	NA	NA	NA
Asterias rubens	1050	435	17	153	282	128	307	59	13
Asteroidea	1	NA	NA	NA	NA	NA	NA	NA	NA
Athanas nitescens	8	6	1	2	4	5	1	NA	NA
Atherina presbyter	9	3	NA	NA	3	1	2	NA	1
Aurelia aurita	26	9	NA	1	8	2	7	NA	NA
Austrominius modestus	6	2	NA	1	1	NA	2	NA	NA
Balanus	1	1	NA	NA	1	NA	1	NA	NA
Balanus balanus	1	1	NA	NA	1	1	NA	NA	NA
Balanus crenatus	2	2	NA	NA	2	1	1	NA	NA
Barnea candida	35	4	4	4	NA	1	3	NA	NA
Beroe	1	NA	NA	NA	NA	NA	NA	NA	NA
Beroe cucumis	2	NA	NA	NA	NA	NA	NA	NA	NA
Bicellariella ciliata	125	40	4	15	25	7	33	5	3
Bispira volutacornis	5	NA	NA	NA	NA	NA	NA	NA	NA

Taxon Name	n	Chalk	Clay	Gull	NoGull	Cobb	NoCobb	Wall	Floor
Bivalvia	2	NA	NA	NA	NA	NA	NA	NA	NA
Blenniidae	1	NA	NA	NA	NA	NA	NA	NA	NA
Boltenia echinata	1	NA	NA	NA	NA	NA	NA	NA	NA
Botrylloides	32	24	NA	13	11	7	17	5	2
Botrylloides leachii	132	100	1	46	54	45	55	22	4
Botrylloides violaceus	4	NA	NA	NA	NA	NA	NA	NA	NA
Botryllophilidae	1	1	NA	1	NA	NA	1	1	NA
Botryllus schlosseri	133	83	NA	36	47	35	48	14	2
Bryopsis	10	8	NA	2	6	1	7	1	1
Bryopsis hypnoides	71	58	NA	28	30	20	38	11	2
Bryopsis plumosa	308	187	2	90	97	86	101	23	4
Bryozoa	12	NA	NA	NA	NA	NA	NA	NA	NA
Bryozoa indet crusts	262	NA	NA	NA	NA	NA	NA	NA	NA
Buccinum undatum	43	15	1	4	11	8	7	2	NA
Buglossidium luteum	1	1	NA	NA	1	NA	1	NA	NA
Bugula	55	NA	NA	NA	NA	NA	NA	NA	NA
Bugulina flabellata	28	NA	NA	NA	NA	NA	NA	NA	NA
Bugulina turbinata	41	NA	NA	NA	NA	NA	NA	NA	NA
Caberea	5	1	NA	1	NA	NA	1	NA	NA
Caberea boryi	2	NA	NA	NA	NA	NA	NA	NA	NA

Taxon Name	n	Chalk	Clay	Gull	NoGull	Cobb	NoCobb	Wall	Floor
Cadlina laevis	2	NA	NA	NA	NA	NA	NA	NA	NA
Calliblepharis ciliata	573	355	1	140	215	169	186	30	6
Callionymus	50	16	4	6	10	4	12	3	1
Callionymus lyra	248	98	2	27	71	27	71	5	2
Callionymus reticulatus	253	129	4	49	80	29	100	18	3
Calliostoma zizyphinum	585	338	9	155	183	140	198	63	6
Calvadosia campanulata	70	61	NA	32	29	41	20	2	1
Cancer pagurus	1370	653	15	246	407	217	436	93	20
Capellinia doriae	3	3	NA	1	2	2	1	NA	NA
Caprella	154	49	2	22	27	10	39	11	4
Caprella linearis	4	2	NA	NA	2	NA	2	NA	NA
Carcinus maenas	957	438	10	111	327	142	296	26	16
Carradoriella elongata	25	19	NA	3	16	10	9	1	1
Catriona aurantia	5	NA	NA	NA	NA	NA	NA	NA	NA
Catriona gymnota	7	2	NA	NA	2	NA	2	NA	NA
Cellepora pumicosa	1	NA	NA	NA	NA	NA	NA	NA	NA
Celleporella hyalina	3	3	NA	1	2	1	2	1	NA
Celleporina	1	1	NA	1	NA	NA	1	NA	NA
Centrolabrus exoletus	3	1	NA	1	NA	NA	1	NA	NA

Taxon Name	n	Chalk	Clay	Gull	NoGull	Cobb	NoCobb	Wall	Floor
Ceramium	192	148	NA	53	95	73	75	9	3
Ceramium deslongchampsii	2	2	NA	2	NA	2	NA	NA	NA
Ceramium echionotum	39	35	NA	18	17	22	13	1	1
Ceramium virgatum	1	1	NA	NA	1	NA	1	NA	NA
Cerebratulus	1	1	NA	NA	1	NA	1	NA	NA
Cereus pedunculatus	3	NA	NA	NA	NA	NA	NA	NA	NA
Cerianthus lloydii	4	NA	NA	NA	NA	NA	NA	NA	NA
Chaetomorpha	3	2	NA	NA	2	2	NA	NA	NA
Chaetomorpha linum	73	58	NA	23	35	37	21	3	NA
Chaetomorpha melagonium	1	1	NA	NA	1	1	NA	NA	NA
Chelon labrosus	1	NA	NA	NA	NA	NA	NA	NA	NA
Chiton	7	NA	NA	NA	NA	NA	NA	NA	NA
Chlorophyceae	35	NA	NA	NA	NA	NA	NA	NA	NA
Chlorophyta	18	NA	NA	NA	NA	NA	NA	NA	NA
Chondracanthus acicularis	2	NA	NA	NA	NA	NA	NA	NA	NA
Chondria capillaris	2	NA	NA	NA	NA	NA	NA	NA	NA
Chondria dasyphylla	309	239	NA	96	143	119	120	20	7
Chondrus crispus	369	281	NA	101	180	160	121	17	4

Taxon Name	n	Chalk	Clay	Gull	NoGull	Cobb	NoCobb	Wall	Floor
Chorda filum	4	NA	NA	NA	NA	NA	NA	NA	NA
Chordaria flagelliformis	4	3	NA	NA	3	1	2	NA	NA
Chrysaora hysoscella	98	36	1	11	25	5	31	6	2
Chylocladia verticillata	4	4	NA	1	3	3	1	NA	NA
Ciliata mustela	10	5	NA	2	3	1	4	NA	NA
Ciocalypta penicillus	4	NA	NA	NA	NA	NA	NA	NA	NA
Ciona	4	4	NA	3	1	1	3	2	NA
Cirolanidae	1	NA	NA	NA	NA	NA	NA	NA	NA
Cirratulus cirratus	7	4	NA	2	2	NA	4	1	NA
Cirripedia	906	NA	NA	NA	NA	NA	NA	NA	NA
Cladophora	13	327	NA	115	212	163	164	20	7
Cladophora hutchinsiae	2	NA	NA	NA	NA	NA	NA	NA	NA
Cladophora rupestris	432	NA	NA	NA	NA	NA	NA	NA	NA
Cladostephus spongiosus	137	122	NA	49	73	77	45	7	NA
Clathrina coriacea	26	7	NA	3	4	NA	7	3	NA
Clavelina lepadiformis	506	233	NA	108	125	84	149	42	11
Cliona	58	51	NA	25	26	23	28	8	1
Cliona celata	307	194	6	105	89	76	118	48	6
Clupeidae	2	1	NA	1	NA	NA	1	NA	NA

Taxon Name	n	Chalk	Clay	Gull	NoGull	Cobb	NoCobb	Wall	Floor
Clytia hemisphaerica	107	74	3	37	37	27	47	11	1
Colpomenia peregrina	4	4	NA	2	2	3	1	NA	NA
Conger conger	2	NA	NA	NA	NA	NA	NA	NA	NA
Conopeum reticulum	200	139	2	53	86	57	82	18	2
Copepoda	4	NA	NA	NA	NA	NA	NA	NA	NA
Corallina officinalis	231	172	NA	57	115	128	44	6	2
Corallinaceae	86	68	NA	22	46	32	36	10	5
Corallinales	43	NA	NA	NA	NA	NA	NA	NA	NA
Corella eumyota	25	15	NA	5	10	5	10	2	1
Coryne eximia	106	64	1	24	40	32	32	4	2
Coryne pusilla	2	2	NA	NA	2	1	1	NA	NA
Corystes cassivelaunus	34	7	NA	1	6	NA	7	NA	1
Cradoscrupocellaria reptans	17	NA	NA	NA	NA	NA	NA	NA	NA
Crangon crangon	205	84	3	15	69	9	75	2	1
Craterolophus convolvulus	9	7	NA	2	5	6	1	1	1
Crepidula fornicata	343	191	5	84	107	97	94	30	9
Crisia	112	32	2	18	14	4	28	9	2
Crisia denticulata	6	2	NA	NA	2	NA	2	NA	NA

Taxon Name	n	Chalk	Clay	Gull	NoGull	Cobb	NoCobb	Wall	Floor
Crisia eburnea	38	9	NA	5	4	2	7	1	NA
Crisularia plumosa	412	25	NA	12	13	5	20	5	1
Crisularia purpurotincta	3	NA	NA	NA	NA	NA	NA	NA	NA
Crossaster papposus	174	24	9	7	17	4	20	2	1
Cryptopleura ramosa	196	170	1	93	77	82	88	29	2
Cryptosula pallasiana	9	9	NA	3	6	3	6	NA	NA
Ctenolabrus rupestris	18	10	NA	4	6	4	6	2	NA
Ctenophora	1	NA	NA	NA	NA	NA	NA	NA	NA
Cutleria	2	2	NA	1	1	1	1	NA	NA
Cutleria multifida	48	43	NA	29	14	30	13	11	NA
Cyanea	1	NA	NA	NA	NA	NA	NA	NA	NA
Cyanea capillata	15	6	NA	1	5	2	4	NA	NA
Cyanea lamarckii	9	4	1	2	2	1	3	1	NA
Cyclopterus lumpus	4	1	1	NA	1	1	NA	NA	NA
Cylista	2	NA	NA	NA	NA	NA	NA	NA	NA
Cylista elegans	761	340	8	164	176	132	208	66	8
Cylista troglodytes	288	79	5	20	59	14	65	8	4
Cystoclonium purpureum	22	16	NA	7	9	8	8	NA	NA
Decapoda	7	NA	NA	NA	NA	NA	NA	NA	NA

Taxon Name	n	Chalk	Clay	Gull	NoGull	Cobb	NoCobb	Wall	Floor
Delesseria sanguinea	9	8	NA	2	6	3	5	NA	NA
Dendrodoa grossularia	56	13	7	7	6	3	10	3	NA
Dendronotus frondosus	13	2	NA	1	1	1	1	1	NA
Derbesia	24	24	NA	16	8	7	17	8	NA
Derbesia marina	7	5	NA	1	4	2	3	1	NA
Derbesia tenuissima	4	3	NA	1	2	NA	3	NA	NA
Dercitus (Dercitus) bucklandi	1	NA	NA	NA	NA	NA	NA	NA	NA
Desmarestia	2	2	NA	2	NA	2	NA	NA	NA
Desmarestia ligulata	1	1	NA	NA	1	1	NA	NA	NA
Desmarestia viridis	2	NA	NA	NA	NA	NA	NA	NA	NA
Diadumene cincta	2	1	NA	1	NA	NA	1	1	NA
Diatoms film	31	NA	NA	NA	NA	NA	NA	NA	NA
Dicentrarchus labrax	105	6	NA	NA	6	2	4	NA	NA
Dictyopteris polypodioides	4	2	NA	1	1	1	1	NA	NA
Dictyota	2	1	NA	NA	1	1	NA	NA	NA
Dictyota dichotoma	315	256	1	90	166	137	119	14	4
Didemnidae	2	NA	NA	NA	NA	NA	NA	NA	NA
Didemnum	3	3	NA	2	1	2	1	NA	NA
Didemnum fulgens	8	6	1	3	3	NA	6	1	NA

Taxon Name	n	Chalk	Clay	Gull	NoGull	Cobb	NoCobb	Wall	Floor
Didemnum maculosum	432	283	6	145	138	109	174	62	7
Dilsea carnosa	1	NA	NA	NA	NA	NA	NA	NA	NA
Diplosoma	2	NA	NA	NA	NA	NA	NA	NA	NA
Diplosoma listerianum	56	41	NA	20	21	24	17	5	NA
Diplosoma spongiforme	683	427	6	192	235	166	261	82	10
Disporella hispida	81	69	1	42	27	30	39	18	NA
Distaplia rosea	217	114	2	45	69	40	74	24	5
Doridicola agilis	3	3	NA	NA	3	NA	3	NA	1
Doris pseudoargus	23	12	1	4	8	4	8	3	1
Doto	28	17	NA	5	12	3	14	2	NA
Doto coronata	3	1	NA	NA	1	1	NA	NA	1
Doto fragilis	1	1	NA	NA	1	NA	1	NA	NA
Doto millbayana	2	2	NA	1	1	NA	2	1	NA
Doto pinnatifida	25	11	NA	6	5	2	9	1	NA
Doto sarsiae	2	2	NA	NA	2	NA	2	NA	2
Drachiella heterocarpa	15	14	NA	8	6	7	7	4	NA
Drachiella spectabilis	7	6	NA	1	5	4	2	NA	1
Dynamena pumila	49	24	1	8	16	3	21	2	NA
Dyopedos	2	NA	NA	NA	NA	NA	NA	NA	NA

Taxon Name	n	Chalk	Clay	Gull	NoGull	Cobb	NoCobb	Wall	Floor
Dysidea fragilis	506	288	5	155	133	94	194	80	7
Dysidea pallescens	55	48	NA	32	16	11	37	20	NA
Ebalia	3	2	NA	NA	2	NA	2	NA	NA
Ebalia cranchii	1	NA	NA	NA	NA	NA	NA	NA	NA
Ebalia tuberosa	1	NA	NA	NA	NA	NA	NA	NA	NA
Ebalia tumefacta	19	8	1	5	3	5	3	1	NA
Echiichthys vipera	85	53	1	4	49	3	50	NA	2
Echinocardium cordatum	3	NA	NA	NA	NA	NA	NA	NA	NA
Echinus esculentus	10	NA	NA	NA	NA	NA	NA	NA	NA
Ectopleura larynx	59	19	4	4	15	7	12	1	1
Edmundsella pedata	253	57	1	24	33	15	42	9	1
Electra pilosa	375	260	4	86	174	121	139	19	4
Elysia viridis	3	NA	NA	NA	NA	NA	NA	NA	NA
encrusting algae indet.	709	NA	NA	NA	NA	NA	NA	NA	NA
Ensis	7	1	NA	NA	1	NA	1	NA	NA
Ensis magnus	29	3	1	NA	3	NA	3	NA	NA
Entelurus aequoreus	10	5	NA	NA	5	3	2	NA	NA
Entoprocta	10	NA	NA	NA	NA	NA	NA	NA	NA
Ergasilida	1	NA	NA	NA	NA	NA	NA	NA	NA

Taxon Name	n	Chalk	Clay	Gull	NoGull	Cobb	NoCobb	Wall	Floor
Erythroglossum laciniatum	2	2	NA	1	1	NA	2	1	NA
Escharella immersa	1	1	NA	NA	1	1	NA	NA	NA
Escharoides coccinea	2	2	NA	2	NA	1	1	NA	NA
Eualus	23	20	NA	10	10	9	11	4	NA
Eualus cranchii	2	2	NA	2	NA	NA	2	1	NA
Eualus pusiolus	1	NA	NA	NA	NA	NA	NA	NA	NA
Eubranchus	1	1	NA	1	NA	NA	1	1	NA
Eubranchus exiguus	1	1	NA	1	NA	NA	1	1	NA
Eubranchus tricolor	57	19	1	6	13	10	9	2	NA
Eucratea loricata	1	NA	NA	NA	NA	NA	NA	NA	NA
Eudendrium	115	59	1	20	39	16	43	13	2
Eudendrium annulatum	3	NA	NA	NA	NA	NA	NA	NA	NA
Eudendrium arbuscula	1	NA	NA	NA	NA	NA	NA	NA	NA
Eudendrium armstrongi	1	NA	NA	NA	NA	NA	NA	NA	NA
Eudendrium ramosum	5	3	NA	2	1	NA	3	NA	NA
Eulalia viridis	13	6	NA	3	3	1	5	2	1
Eupolymnia nebulosa	5	5	NA	1	4	2	3	NA	NA
Eutrigla gurnardus	23	6	NA	NA	6	NA	6	NA	NA
Facelina auriculata	18	3	NA	3	NA	NA	3	2	NA

Taxon Name	n	Chalk	Clay	Gull	NoGull	Cobb	NoCobb	Wall	Floor
Facelina bostoniensis	46	9	NA	4	5	4	5	2	1
Filograna implexa	28	NA	NA	NA	NA	NA	NA	NA	NA
Fjordia browni	8	NA	NA	NA	NA	NA	NA	NA	NA
Fjordia lineata	12	NA	NA	NA	NA	NA	NA	NA	NA
Flabellina	5	NA	NA	NA	NA	NA	NA	NA	NA
Flustra foliacea	484	164	8	57	107	47	117	23	8
Flustrellidra hispida	1	1	NA	1	NA	NA	1	NA	NA
Fucus	9	3	NA	1	2	1	2	1	NA
Fucus ceranoides	1	NA	NA	NA	NA	NA	NA	NA	NA
Fucus serratus	84	46	NA	11	35	30	16	NA	1
Fucus spiralis	27	5	NA	1	4	2	3	NA	NA
Fucus vesiculosus	44	12	NA	2	10	3	9	1	NA
Furcellaria lumbricalis	46	42	NA	10	32	21	21	2	NA
Gadus morhua	27	4	NA	3	1	NA	4	2	NA
Galathea	3	NA	NA	NA	NA	NA	NA	NA	NA
Galathea intermedia	24	15	NA	2	13	3	12	NA	1
Galathea squamifera	721	465	6	210	255	197	268	80	12
Galathea strigosa	6	3	NA	3	NA	NA	3	2	NA
Galatheidae	4	NA	NA	NA	NA	NA	NA	NA	NA
Gammarus	15	6	NA	NA	6	NA	6	NA	NA

Taxon Name	n	Chalk	Clay	Gull	NoGull	Cobb	NoCobb	Wall	Floor
Garveia nutans	11	2	NA	NA	2	NA	2	NA	NA
Gastroclonium reflexum	214	194	NA	90	104	117	77	21	3
Gelidium	1	NA	NA	NA	NA	NA	NA	NA	NA
Gobius	1	NA	NA	NA	NA	NA	NA	NA	NA
Gobius paganellus	13	13	NA	6	7	6	7	2	NA
Goniodoris nodosa	63	23	NA	9	14	12	11	2	1
Gracilaria gracilis	378	297	NA	74	223	109	188	10	5
Grantia compressa	138	74	3	33	41	31	43	3	NA
Grateloupia filicina	28	28	NA	19	9	21	7	3	NA
Grateloupia subpectinata	21	20	NA	10	10	15	5	NA	NA
Grateloupia turuturu	36	27	NA	11	16	22	5	NA	NA
Griffithsia corallinoides	5	5	NA	1	4	2	3	NA	NA
Gymnogongrus crenulatus	11	9	1	3	6	8	1	NA	NA
Halarachnion ligulatum	101	99	NA	64	35	61	38	12	NA
Halecium beanii	3	3	NA	2	1	NA	3	1	NA
Halecium halecinum	48	19	1	8	11	4	15	4	1
Halichoerus grypus	8	NA	NA	NA	NA	NA	NA	NA	NA
Halichondria	1	NA	NA	NA	NA	NA	NA	NA	NA

Taxon Name	n	Chalk	Clay	Gull	NoGull	Cobb	NoCobb	Wall	Floor
Halichondria (Halichondria) bowerbanki	118	77	NA	34	43	28	49	12	1
Halichondria (Halichondria) panicea	708	404	6	164	240	170	234	66	7
Haliclona	4	3	NA	1	2	NA	3	1	NA
Haliclona (Haliclona) oculata	269	81	NA	33	48	22	59	12	2
Haliclona (Reniera) cinerea	54	39	1	25	14	9	30	13	NA
Haliclona (Rhizoniera) viscosa	37	25	1	11	14	13	12	5	1
Halidrys siliquosa	33	30	NA	14	16	23	7	NA	NA
Halisarca	1	1	NA	1	NA	NA	1	1	NA
Halisarca dujardinii	177	154	1	82	72	60	94	32	1
Halopteris catharina	65	56	NA	37	19	18	38	19	2
Halurus equisetifolius	282	229	NA	95	134	117	112	11	2
Halurus flosculosus	14	10	NA	4	6	4	6	1	NA
Halyphysema tumanowiczii	67	37	3	20	17	7	30	12	NA
Haplopoma impressum	1	1	NA	1	NA	1	NA	NA	NA
Harmothoe	16	14	NA	5	9	6	8	NA	NA
Harmothoe impar	1	NA	NA	NA	NA	NA	NA	NA	NA

Taxon Name	n	Chalk	Clay	Gull	NoGull	Cobb	NoCobb	Wall	Floor
Hartlaubella gelatinosa	9	1	NA	NA	1	NA	1	NA	NA
Hediste diversicolor	2	1	NA	NA	1	1	NA	NA	NA
Hemimycale columella	1	1	NA	1	NA	NA	1	1	NA
Henricia	274	71	5	26	45	18	53	11	2
Henricia oculata	1	NA	NA	NA	NA	NA	NA	NA	NA
Hermaea bifida	1	1	NA	1	NA	NA	1	NA	NA
Heterosiphonia plumosa	244	165	1	96	69	77	88	30	3
Hippolyte varians	102	64	1	29	35	25	39	8	2
Homarus gammarus	968	501	7	211	290	170	331	85	14
Hyas araneus	211	95	2	24	71	36	59	9	2
Hydractinia echinata	9	3	NA	NA	3	1	2	NA	NA
Hydrallmania falcata	77	38	2	9	29	4	34	3	2
Hydrobia	26	9	NA	6	3	5	4	1	NA
Hydroides norvegica	1	NA	NA	NA	NA	NA	NA	NA	NA
Hydrozoa	55	NA	NA	NA	NA	NA	NA	NA	NA
Hymedesmia	274	218	3	130	88	81	137	67	2
Hymedesmia (Stylopus) coriacea	1	NA	NA	NA	NA	NA	NA	NA	NA
Hyperoplus lanceolatus	8	NA	NA	NA	NA	NA	NA	NA	NA

Taxon Name	n	Chalk	Clay	Gull	NoGull	Cobb	NoCobb	Wall	Floor
Hypoglossum hypoglossoides	122	101	1	48	53	39	62	16	1
Idotea	29	20	NA	2	18	10	10	1	NA
Idotea chelipes	1	NA	NA	NA	NA	NA	NA	NA	NA
Idotea granulosa	2	1	NA	NA	1	1	NA	NA	NA
Idotea linearis	23	8	NA	1	7	1	7	NA	1
Idotea neglecta	3	3	NA	NA	3	1	2	NA	NA
Inachus	474	280	6	132	148	104	176	53	5
Inachus phalangium	1	NA	NA	NA	NA	NA	NA	NA	NA
Iphimedia obesa	2	1	NA	1	NA	NA	1	NA	NA
Isopoda	4	NA	NA	NA	NA	NA	NA	NA	NA
Janira maculosa	1	1	NA	NA	1	1	NA	NA	NA
Jassa	107	69	NA	24	45	34	35	4	1
Jassa falcata	61	18	1	7	11	5	13	4	1
Kirchenpaueria	8	3	NA	2	1	1	2	1	NA
Kirchenpaueria pinnata	55	51	NA	28	23	12	39	16	NA
Labridae	2	NA	NA	NA	NA	NA	NA	NA	NA
Labrus bergylta	256	71	NA	49	22	12	59	25	3
Lacuna parva	2	2	NA	NA	2	2	NA	NA	NA
Lacuna vincta	2	1	NA	NA	1	NA	1	NA	NA

Taxon Name	n	Chalk	Clay	Gull	NoGull	Cobb	NoCobb	Wall	Floor
Lamellaria	1	1	NA	NA	1	1	NA	NA	NA
Lamellaria perspicua	2	2	NA	1	1	2	NA	1	NA
Lanice conchilega	1084	533	17	139	394	161	372	39	13
Laomedea flexuosa	2	2	NA	2	NA	NA	2	NA	NA
Laurencia obtusa	2	NA	NA	NA	NA	NA	NA	NA	NA
Lekanesphaera rugicauda	1	1	NA	1	NA	1	NA	NA	NA
Lepidochitona cinerea	3	2	NA	NA	2	2	NA	NA	NA
Lepidonotus squamatus	1	NA	NA	NA	NA	NA	NA	NA	NA
Leptoplana tremellaris	1	1	NA	NA	1	1	NA	NA	NA
Leucosolenia	146	81	NA	29	52	32	49	10	4
Leucosolenia botryoides	3	1	NA	1	NA	1	NA	NA	NA
Leucosolenida	1	NA	NA	NA	NA	NA	NA	NA	NA
Limacia clavigera	1	NA	NA	NA	NA	NA	NA	NA	NA
Limanda limanda	88	34	2	3	31	6	28	NA	2
Liocarcinus corrugatus	3	NA	NA	NA	NA	NA	NA	NA	NA
Liocarcinus depurator	128	33	6	3	30	6	27	1	2
Liocarcinus holsatus	32	10	NA	3	7	3	7	2	NA
Liparis	17	10	NA	2	8	6	4	1	NA

Taxon Name	n	Chalk	Clay	Gull	NoGull	Cobb	NoCobb	Wall	Floor
Liparis montagui	6	5	NA	NA	5	1	4	NA	NA
Lipophrys pholis	69	51	NA	22	29	16	35	10	1
Lissoclinum perforatum	67	47	1	22	25	20	27	8	NA
Littorina	2	NA	NA	NA	NA	NA	NA	NA	NA
Littorina littorea	5	2	NA	NA	2	NA	2	NA	NA
Littorina obtusata	3	2	NA	NA	2	NA	2	NA	NA
Littorina saxatilis	24	6	NA	2	4	2	4	1	NA
Loligo	10	3	NA	1	2	1	2	NA	NA
Loligo forbesii	1	NA	NA	NA	NA	NA	NA	NA	NA
Loligo vulgaris	1	NA	NA	NA	NA	NA	NA	NA	NA
Lomanotus marmoratus	5	1	NA	1	NA	1	NA	NA	NA
Lomentaria clavellosa	1	NA	NA	NA	NA	NA	NA	NA	NA
Lumbrineris latreilli	1	NA	NA	NA	NA	NA	NA	NA	NA
Lychaete pellucida	10	NA	NA	NA	NA	NA	NA	NA	NA
Macropodia	371	177	8	54	123	55	122	19	2
Macropodia rostrata	1	NA	NA	NA	NA	NA	NA	NA	NA
Macropodia tenuirostris	2	NA	NA	NA	NA	NA	NA	NA	NA
Maja brachydactyla	3	NA	NA	NA	NA	NA	NA	NA	NA
Mastocarpus stellatus	4	3	NA	1	2	1	2	NA	NA

Taxon Name	n	Chalk	Clay	Gull	NoGull	Cobb	NoCobb	Wall	Floor
Membranipora membranacea	1	1	NA	NA	1	1	NA	NA	NA
Membraniporidae	4	NA	NA	NA	NA	NA	NA	NA	NA
Metridium dianthus	93	26	NA	14	12	6	20	9	2
Metridium senile	422	108	3	40	68	23	85	16	4
Micrenophrys lilljeborgii	4	4	NA	4	NA	1	3	4	NA
Microstomus kitt	8	3	NA	1	2	NA	3	1	NA
Modiolus modiolus	5	NA	NA	NA	NA	NA	NA	NA	NA
Molgula	170	62	4	20	42	14	48	10	NA
Molgula complanata	90	59	NA	19	40	28	31	3	NA
Mollusca	1	NA	NA	NA	NA	NA	NA	NA	NA
Molva molva	2	NA	NA	NA	NA	NA	NA	NA	NA
Morchellium argus	443	292	NA	131	161	129	163	55	6
Mullus surmuletus	43	5	3	4	1	2	3	2	NA
Mycale	3	3	NA	1	2	1	2	1	NA
Mycale (Carmia) macilenta	3	2	NA	1	1	1	1	1	NA
Myoxocephalus scorpius	83	25	1	7	18	10	15	3	1
Myrianida pinnigera	6	NA	NA	NA	NA	NA	NA	NA	NA
Myrianida prolifera	2	2	NA	1	1	NA	2	NA	NA

Taxon Name	n	Chalk	Clay	Gull	NoGull	Cobb	NoCobb	Wall	Floor
Mysida	225	NA	NA	NA	NA	NA	NA	NA	NA
Mysidae	93	63	NA	29	34	21	42	14	3
Mytilus edulis	23	3	NA	NA	3	NA	3	NA	NA
Myxilla (Myxilla) incrustans	27	17	NA	10	7	6	11	6	NA
Myxilla (Myxilla) rosacea	1	1	NA	1	NA	NA	1	1	NA
Naccaria wiggii	14	14	NA	12	2	5	9	2	NA
Nassarius	1	NA	NA	NA	NA	NA	NA	NA	NA
Necora puber	706	332	10	142	190	132	200	52	6
Nemertesia antennina	272	78	2	27	51	18	60	7	3
Nemertesia ramosa	13	6	NA	1	5	1	5	1	NA
Neoamphitrite figulus	1	NA	NA	NA	NA	NA	NA	NA	NA
Neocopepoda	1	NA	NA	NA	NA	NA	NA	NA	NA
Nephtyidae	1	1	NA	NA	1	NA	1	NA	NA
Nolella stipata	8	7	NA	6	1	1	6	4	NA
Nucella lapillus	237	174	3	70	104	91	83	28	1
Nudibranchia	35	NA	NA	NA	NA	NA	NA	NA	NA
Nymphon	1	1	NA	NA	1	NA	1	NA	NA
Obelia	2	NA	NA	NA	NA	NA	NA	NA	NA
Obelia dichotoma	25	16	NA	6	10	4	12	NA	NA

Taxon Name	n	Chalk	Clay	Gull	NoGull	Cobb	NoCobb	Wall	Floor
Obelia longissima	1	1	NA	NA	1	NA	1	NA	NA
Ocenebra	1	1	NA	1	NA	NA	1	NA	NA
Ocenebra erinaceus	5	5	NA	3	2	4	1	NA	NA
Ocinebrina aciculata	1	NA	1	NA	NA	NA	NA	NA	NA
Oerstedia dorsalis	7	6	NA	1	5	2	4	NA	NA
Oligocladus sanguinolentus	1	1	NA	NA	1	NA	1	NA	NA
Onchidoris bilamellata	43	20	NA	4	16	4	16	2	NA
Onchidoris muricata	1	NA	NA	NA	NA	NA	NA	NA	NA
Ophiopholis aculeata	1	1	NA	1	NA	NA	1	1	NA
Ophiothrix	1	NA	NA	NA	NA	NA	NA	NA	NA
Ophiothrix fragilis	10	4	NA	3	1	NA	4	2	NA
Ophiura	4	3	NA	1	2	1	2	NA	NA
Ophiura albida	27	9	2	2	7	4	5	1	1
Ophiura ophiura	3	1	NA	NA	1	NA	1	NA	NA
Ophiuroidea	1	NA	NA	NA	NA	NA	NA	NA	NA
Oscarella	159	123	NA	85	38	39	84	48	1
Oscarella lobularis	6	6	NA	3	3	1	5	1	1
Osmundea	160	147	NA	67	80	90	57	15	NA
Osmundea hybrida	3	2	NA	NA	2	1	1	NA	NA

Taxon Name	n	Chalk	Clay	Gull	NoGull	Cobb	NoCobb	Wall	Floor
Osmundea oederi	19	17	NA	7	10	13	4	1	NA
Osmundea osmunda	1	1	NA	1	NA	NA	1	NA	NA
Ostracoda	2	NA	NA	NA	NA	NA	NA	NA	NA
Ostrea edulis	1	1	NA	NA	1	NA	1	NA	NA
Pachymatisma johnstonia	1	NA	NA	NA	NA	NA	NA	NA	NA
Paguridae	32	7	NA	NA	7	4	3	NA	1
Pagurus	659	298	11	83	215	83	215	22	6
Pagurus bernhardus	250	120	7	42	78	35	85	13	3
Pagurus cuanensis	11	9	NA	5	4	1	8	2	NA
Palaemon	1	NA	NA	NA	NA	NA	NA	NA	NA
Palaemon elegans	15	8	NA	3	5	1	7	1	NA
Palaemon serratus	484	277	3	118	159	96	181	52	3
Palio dubia	1	1	NA	NA	1	NA	1	NA	NA
Palio nothus	32	16	NA	8	8	4	12	1	NA
Palmaria palmata	51	33	NA	11	22	12	21	4	3
Pandalus montagui	112	51	2	21	30	19	32	10	1
Parablennius gattorugine	22	13	NA	9	4	2	11	5	2
Paramphiascella vararensis	1	1	NA	NA	1	1	NA	NA	NA

Taxon Name	n	Chalk	Clay	Gull	NoGull	Cobb	NoCobb	Wall	Floor
Parasabella langerhansi	1	1	NA	1	NA	NA	1	NA	NA
Parasmittina trispinosa	3	3	NA	1	2	1	2	1	NA
Patella	1	NA	NA	NA	NA	NA	NA	NA	NA
Patella pellucida	1	1	NA	1	NA	1	NA	NA	NA
Patella vulgata	40	11	NA	1	10	2	9	NA	NA
Patinella verrucaria	1	1	NA	NA	1	1	NA	NA	NA
Pectinaria belgica	7	2	NA	NA	2	1	1	NA	NA
Pelvetia canaliculata	2	2	NA	NA	2	1	1	NA	NA
Perophora	18	11	NA	8	3	2	9	6	1
Perophora japonica	73	46	NA	22	24	22	24	9	NA
Perophora listeri	191	132	5	72	60	43	89	36	NA
Petalonia fascia	15	15	NA	11	4	10	5	2	NA
Phaeocystis	2	2	NA	NA	2	NA	2	NA	NA
Phaeophyceae	25	NA	NA	NA	NA	NA	NA	NA	NA
Phalacrocorax carbo	1	NA	NA	NA	NA	NA	NA	NA	NA
Phoca vitulina	1	NA	NA	NA	NA	NA	NA	NA	NA
Pholadidae	1	NA	NA	NA	NA	NA	NA	NA	NA
Pholas dactylus	36	18	1	10	8	6	12	4	1
Pholis gunnellus	167	98	2	42	56	43	55	17	3

Taxon Name	n	Chalk	Clay	Gull	NoGull	Cobb	NoCobb	Wall	Floor
Pholoe minuta	1	1	NA	NA	1	1	NA	NA	NA
Phoronida	1	NA	NA	NA	NA	NA	NA	NA	NA
Phoronis hippocrepia	7	2	1	2	NA	NA	2	1	1
Phyllodoce	1	NA	NA	NA	NA	NA	NA	NA	NA
Phyllodoce maculata	1	1	NA	NA	1	NA	1	NA	NA
Phyllophora pseudoceranoï¿½des	17	NA	NA	NA	NA	NA	NA	NA	NA
Pileolaria berkeleyana	39	37	NA	20	17	18	19	7	NA
Pilumnus hirtellus	28	23	NA	8	15	18	5	3	NA
Pisa armata	2	2	NA	NA	2	2	NA	NA	NA
Pisces	12	NA	NA	NA	NA	NA	NA	NA	NA
Pisidia longicornis	45	35	NA	20	15	17	18	8	NA
Plagioecia patina	49	34	1	15	19	17	17	10	NA
Platichthys flesus	65	31	NA	8	23	11	20	1	NA
Pleonosporium flexuosum	1	NA	NA	NA	NA	NA	NA	NA	NA
Pleurobrachia pileus	2	1	NA	NA	1	NA	1	NA	NA
Pleuronectes	4	NA	NA	NA	NA	NA	NA	NA	NA
Pleuronectes platessa	76	31	1	3	28	4	27	NA	NA
Pleuronectiformes	4	NA	NA	NA	NA	NA	NA	NA	NA
Plocamium	255	415	6	162	253	189	226	43	4

Taxon Name	n	Chalk	Clay	Gull	NoGull	Cobb	NoCobb	Wall	Floor
Plocamium cartilagineum	359	NA	NA	NA	NA	NA	NA	NA	NA
Plocamium maggsiae	1	NA	NA	NA	NA	NA	NA	NA	NA
Plumaria plumosa	19	15	NA	5	10	8	7	1	NA
Plumularia setacea	337	177	3	75	102	48	129	34	3
Pollachius pollachius	68	16	1	11	5	1	15	6	NA
Pollachius virens	1	NA	NA	NA	NA	NA	NA	NA	NA
Polycarpa pomaria	3	NA	NA	NA	NA	NA	NA	NA	NA
Polycarpa scuba	12	5	NA	2	3	1	4	1	NA
Polycera faeroensis	5	2	NA	1	1	1	1	NA	NA
Polycera quadrilineata	12	8	NA	1	7	4	4	1	NA
Polychaeta	5	NA	NA	NA	NA	NA	NA	NA	NA
Polyclinum aurantium	58	28	NA	13	15	11	17	5	NA
Polydora ciliata	421	356	3	198	158	138	218	86	5
Polyides rotunda	276	252	NA	61	191	114	138	11	6
Polymastia	1	NA	NA	NA	NA	NA	NA	NA	NA
Polymastia boletiformis	2	2	NA	2	NA	NA	2	1	NA
Polymastia mamillaris	1	NA	NA	NA	NA	NA	NA	NA	NA
Polymastia penicillus	100	21	5	9	12	6	15	3	NA
Polynoidae	11	6	NA	2	4	2	4	2	NA

Taxon Name	n	Chalk	Clay	Gull	NoGull	Cobb	NoCobb	Wall	Floor
Polyplacophora	32	NA	NA	NA	NA	NA	NA	NA	NA
Polysiphonia	132	106	NA	35	71	60	46	4	4
Polysiphonia devoniensis	3	2	NA	1	1	1	1	NA	NA
Polysiphonia stricta	19	17	NA	10	7	8	9	2	NA
Polysyncraton bilobatum	105	91	NA	46	45	38	53	23	1
Pomatoschistus	552	220	10	54	166	59	161	12	5
Pomatoschistus flavescens	277	198	NA	110	88	74	124	51	2
Pomatoschistus microps	1	1	NA	NA	1	NA	1	NA	NA
Pomatoschistus minutus	49	18	4	3	15	NA	18	NA	NA
Pomatoschistus pictus	121	78	NA	30	48	23	55	12	2
Porifera	48	NA	NA	NA	NA	NA	NA	NA	NA
Porifera indet crusts	228	NA	NA	NA	NA	NA	NA	NA	NA
Porphyra	42	18	NA	3	15	5	13	1	NA
Portumnus latipes	10	5	NA	NA	5	1	4	NA	NA
Processa	3	3	NA	NA	3	1	2	NA	NA
Processa canaliculata	1	1	NA	1	NA	1	NA	NA	NA
Protosuberites epiphytum	2	2	NA	2	NA	NA	2	1	NA

Taxon Name	n	Chalk	Clay	Gull	NoGull	Cobb	NoCobb	Wall	Floor
Protula tubularia	1	1	NA	1	NA	1	NA	NA	NA
Psammechinus miliaris	1	1	NA	NA	1	NA	1	NA	NA
Pseudopolydora pulchra	2	2	NA	1	1	NA	2	NA	NA
Pterothamnion plumula	2	2	NA	NA	2	1	1	NA	NA
Pycnoclavella	10	6	NA	6	NA	1	5	4	NA
Pycnoclavella aurilucens	1	NA	NA	NA	NA	NA	NA	NA	NA
Pycnoclavella stolonialis	36	9	NA	5	4	3	6	1	1
Pycnogonida	74	NA	NA	NA	NA	NA	NA	NA	NA
Pycnogonidae	9	1	NA	NA	1	NA	1	NA	NA
Pyura	3	NA	NA	NA	NA	NA	NA	NA	NA
Radicilingua thysanorhizans	2	2	NA	1	1	2	NA	NA	NA
Raja	1	NA	NA	NA	NA	NA	NA	NA	NA
Raja clavata	3	1	1	1	NA	NA	1	NA	NA
Raniceps raninus	3	NA	NA	NA	NA	NA	NA	NA	NA
Raspailia (Raspailia) ramosa	50	26	1	17	9	10	16	7	NA
Rhizoclonium	1	NA	NA	NA	NA	NA	NA	NA	NA
Rhodomela confervoides	2	2	NA	NA	2	2	NA	NA	NA

Taxon Name	n	Chalk	Clay	Gull	NoGull	Cobb	NoCobb	Wall	Floor
Rhodomela lycopodioides	1	1	NA	NA	1	1	NA	NA	NA
Rhodophycota indet. (non-calc. crusts)	36	NA	NA	NA	NA	NA	NA	NA	NA
Rhodophyllis divaricata	4	2	NA	NA	2	1	1	NA	NA
Rhodophyta	343	NA	NA	NA	NA	NA	NA	NA	NA
Rhodothamniella floridula	12	10	NA	3	7	3	7	1	NA
Rhodymenia	1	NA	NA	NA	NA	NA	NA	NA	NA
Rhodymenia ardissonei	93	71	1	41	30	23	48	19	NA
Rhodymenia holmesii	353	253	1	132	121	96	157	51	3
Rissoa	223	160	NA	74	86	64	96	25	4
Rissoa parva	139	83	3	40	43	39	44	12	NA
Rubramoena amoena	1	1	NA	NA	1	NA	1	NA	1
Sabella pavonina	642	248	3	114	134	72	176	45	3
Sabellaria spinulosa	93	50	5	26	24	20	30	11	NA
Salmacina dysteri	332	NA	NA	NA	NA	NA	NA	NA	NA
Scalibregma celticum	1	1	NA	NA	1	NA	1	NA	NA
Schizomavella (Schizomavella) linearis	227	165	3	78	87	56	109	36	3
Schottera nicaeensis	13	9	NA	2	7	4	5	2	NA

Taxon Name	n	Chalk	Clay	Gull	NoGull	Cobb	NoCobb	Wall	Floor
Scinaia	23	20	NA	6	14	8	12	NA	NA
Scinaia furcellata	126	114	NA	61	53	67	47	7	2
Scophthalmus rhombus	5	4	NA	1	3	NA	4	NA	NA
Scorpaenidae	2	NA	NA	NA	NA	NA	NA	NA	NA
Scrupocellaria	18	NA	NA	NA	NA	NA	NA	NA	NA
Scrupocellaria scrupea	3	NA	NA	NA	NA	NA	NA	NA	NA
Scrupocellaria scruposa	24	NA	NA	NA	NA	NA	NA	NA	NA
Scyliorhinus canicula	17	8	NA	3	5	5	3	2	NA
Scytosiphon	1	1	NA	NA	1	NA	1	NA	NA
Scytosiphon lomentaria	2	2	NA	1	1	1	1	1	NA
Semibalanus balanoides	4	1	NA	NA	1	NA	1	NA	NA
Sepia officinalis	2	NA	NA	NA	NA	NA	NA	NA	NA
Sepiola atlantica	153	77	4	10	67	9	68	2	NA
Serpulidae	1	196	3	91	105	66	130	54	6
Sertularella mediterranea	1	1	NA	1	NA	NA	1	NA	NA
Sertularella rugosa	71	34	2	14	20	6	28	4	1
Sertularia	2	NA	NA	NA	NA	NA	NA	NA	NA
Sertularia cupressina	108	35	3	9	26	8	27	3	NA

Taxon Name	n	Chalk	Clay	Gull	NoGull	Cobb	NoCobb	Wall	Floor
Solea solea	9	7	NA	NA	7	NA	7	NA	NA
Spermothamnion repens	6	5	NA	1	4	5	NA	NA	NA
Spermothamnion strictum	2	NA	NA	NA	NA	NA	NA	NA	NA
Spirobranchus	824	484	9	195	289	208	276	75	10
Spirorbinae	1	1	NA	NA	1	1	NA	NA	NA
Spirorbis	30	26	NA	9	17	18	8	2	NA
Spisula solida	4	2	1	2	NA	1	1	NA	NA
Spongomorpha	1	NA	NA	NA	NA	NA	NA	NA	NA
Sprattus sprattus	3	NA	NA	NA	NA	NA	NA	NA	NA
Stauromedusae	11	NA	NA	NA	NA	NA	NA	NA	NA
Stelligera montagui	24	18	NA	10	8	4	14	5	NA
Steromphala cineraria	427	315	3	136	179	163	152	51	9
Stolonica socialis	1	NA	NA	NA	NA	NA	NA	NA	NA
Stylostomum ellipse	1	NA	NA	NA	NA	NA	NA	NA	NA
Suberites	3	3	NA	2	1	1	2	1	NA
Suberites carnosus	1	1	NA	NA	1	NA	1	NA	NA
Suberites ficus	6	4	NA	1	3	3	1	NA	1
Suberites massa	91	79	1	38	41	31	48	15	4
Suberitidae	1	1	NA	1	NA	NA	1	1	NA

Taxon Name	n	Chalk	Clay	Gull	NoGull	Cobb	NoCobb	Wall	Floor
Sycon ciliatum	460	244	2	101	143	87	157	39	8
Syllidia	1	NA	NA	NA	NA	NA	NA	NA	NA
Symphodus melops	470	277	NA	141	136	105	172	51	4
Syngnathus	41	6	1	NA	6	1	5	NA	NA
Syngnathus acus	92	44	NA	8	36	17	27	1	2
Syngnathus rostellatus	19	9	NA	1	8	NA	9	1	NA
Synoicum pulmonaria	4	2	NA	1	1	1	1	1	NA
Talitrus	1	NA	NA	NA	NA	NA	NA	NA	NA
Taonia atomaria	449	323	1	131	192	154	169	24	6
Taurulus bubalis	633	317	3	122	195	124	193	51	8
Tectura virginea	44	37	1	19	18	19	18	9	2
Tellinidae	2	1	1	NA	1	NA	1	NA	NA
Terebellida	7	NA	NA	NA	NA	NA	NA	NA	NA
Terpios gelatinosus	1	NA	NA	NA	NA	NA	NA	NA	NA
Thorogobius ephippiatus	6	5	NA	4	1	1	4	4	NA
Tima bairdii	4	4	NA	1	3	NA	4	NA	NA
Tisbe furcata furcata	1	NA	NA	NA	NA	NA	NA	NA	NA
Trachinus draco	3	2	NA	NA	2	NA	2	NA	NA
Trachurus trachurus	1	NA	1	NA	NA	NA	NA	NA	NA

Taxon Name	n	Chalk	Clay	Gull	NoGull	Cobb	NoCobb	Wall	Floor
Trididemnum cereum	85	62	NA	38	24	20	42	19	2
Trisopterus luscus	381	107	2	64	43	27	80	29	3
Trisopterus minutus	9	2	NA	1	1	NA	2	NA	NA
Tritia reticulata	3	NA	NA	NA	NA	NA	NA	NA	NA
Tritonia hombergii	7	NA	NA	NA	NA	NA	NA	NA	NA
Tubificoides insularis	1	1	NA	1	NA	NA	1	1	NA
Tubulanus annulatus	24	12	NA	8	4	6	6	1	NA
Tubularia indivisa	410	186	11	97	89	56	130	46	4
Tunicata	18	NA	NA	NA	NA	NA	NA	NA	NA
Ulva	138	176	NA	56	120	91	85	9	2
Ulva intestinalis	7	NA	NA	NA	NA	NA	NA	NA	NA
Ulva lactuca	152	NA	NA	NA	NA	NA	NA	NA	NA
Ulva linza	69	NA	NA	NA	NA	NA	NA	NA	NA
Ulva rigida	1	NA	NA	NA	NA	NA	NA	NA	NA
Ulvales	1	NA	NA	NA	NA	NA	NA	NA	NA
Urosalpinx cinerea	2	NA	1	NA	NA	NA	NA	NA	NA
Urticina	7	NA	NA	NA	NA	NA	NA	NA	NA
Urticina eques	26	15	NA	5	10	4	11	2	NA
Urticina felina	1142	527	14	196	331	186	341	66	16
Verruca stroemia	4	4	NA	3	1	2	2	2	NA

Taxon Name	n	Chalk	Clay	Gull	NoGull	Cobb	NoCobb	Wall	Floor
Vertebrata	2	NA	NA	NA	NA	NA	NA	NA	NA
Vertebrata byssoides	211	163	NA	92	71	61	102	34	4
Vertebrata fucoides	4	4	NA	1	3	1	3	NA	NA
Vertebrata lanosa	1	1	NA	NA	1	1	NA	NA	NA
Vertebrata nigra	17	14	NA	8	6	5	9	1	NA
Vesicularia spinosa	17	9	NA	3	6	5	4	1	1
Zoarces viviparus	1	NA	NA	NA	NA	NA	NA	NA	NA

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