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EMODnet Seabed Habitats

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EMODnet Phase III extension

A combined, harmonized data product showing the best evidence for the extent of biogenic substrate in Europe

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1 Introduction

The 2019 version of the EUNIS marine habitat classification system includes 'biogenic habitat' at level 2 of the classification hierarchy, putting it on the same footing as other, grain-size-based substrate types such as 'mud' and 'sand'.

Until now, the EUSeaMap seabed substrate data product[1] has been primarily composed of grain-size based classes, plus rock and *Posidonia oceanica* meadows. The process was:

1. The EMODnet Geology consortium compiled a data product showing the extent of grain-size based sediment classes, plus rock.
2. The EMODnet Seabed Habitats consortium made some additional ad hoc changes, including:
    a. Addition of data that did not make it into the EMODnet Geology product for various reasons,
    b. Addition of *Posidonia oceanica* meadows polygons in the Mediterranean. This is the only biogenic substrate type that has been included in EUSeaMap to date.

    The ad hoc changes previously made to the EMODnet Geology substrate layer by EMODnet Seabed Habitats are described in the EUSeaMap 2019 and EUSeaMap 2016 technical reports (Vasquez et al, 2020; Populus et al, 2017).

Therefore, in 2017, the EMODnet Seabed Habitats consortium agreed that they should create a new data product for 'biogenic substrate', which may be combined with the grain-size-based substrate data from EMODnet Geology to provide a more complete representation of all substrate types relevant to biological communities.

It is important to note that:

- biogenic substrates have not been mapped comprehensively in any region of Europe and therefore the final product is not representative of the full distribution.
- The purpose of this compilation is not to compile data on habitats of conservation interest, although several biogenic substrate types are also habitats of conservation interest.

[1] Metadata record for 'EUSeaMap (2019) Broad-Scale Predictive Habitat Map - Substrate type (a habitat descriptor)' can be found in the EMODnet Seabed Habitats metadata catalogue: http://gis.ices.dk/geonetwork/srv/eng/catalog.search#/metadata/f7d5a168-0097-4437-944e-cc63111d15c6

1.1 Defining biogenic substrate

For the purposes of this data product, the EMODnet Seabed Habitats consortium agreed on the following rules and criteria:

- Although the EUNIS classification refers to "biogenic *habitat*", we have chosen to refer to "biogenic *substrate*" to highlight that this is specifically about substrate-modifying features.

- "Biogenic substrate" strictly refers to beds or reefs of a species that meet similar criteria to Mediterranean *Posidonia oceanica* meadows in that they:
    - Cover and replace the underlying substrate as a structuring factor, so that the underlying substrate cannot always be detected
    - Can occur on different substrate types, so that the underlying substrate is difficult to infer
    - Are detectable using acoustic survey techniques, so that they are typically mapped in the same way as other substrate types

1.2 Objectives

The production of this compilation can be divided into several objectives:

1. Identify a list of biogenic substrate types that will:
    a. Allow us to identify EUNIS 2019 types beyond level 3 of the EUNIS classification hierarchy, once combined with biogeographic region and biological zone. For example, using 'Desmophyllum pertusum (Lophelia pertusa) reefs' as a biogenic substrate type in the Atlantic would allow us to reach level 5 of EUNIS (e.g. "MC2231 Atlantic circalittoral Lophelia pertusa reefs"), whereas if we only knew that it was 'biogenic substrate', then we could only reach level 3 (e.g. "MC2 Atlantic circalittoral biogenic habitat").

    b. Allow us to extract as much information as possible from other, existing data products. For example, the biogenic substrate type 'Desmophyllum pertusum (Lophelia pertusa) reefs' can be extracted from the OSPAR Threatened and/or Declining habitats data product for the Atlantic and Arctic regions, so this would be a sensible type to use.
2. Identify and access the most complete source of data on the extent of each biogenic substrate type in each biogeographic region. Note that:
    a. For some types it will be quite straightforward; i.e. there will be a single data source providing the data within a particular region; see example for 1b, above.

    b. For other types, we will have to pick out the equivalent EUNIS habitat types and extract them from the individual habitat maps from surveys, collated by EMODnet Seabed Habitats.
3. Compile all data into a single data product, removing overlaps according to some standard criteria.

2 Method

2.1 Identify biogenic substrate types for each biogeographic region

As a reminder, the first objective was to identify biogenic substrate types that:

a) Allow us to identify EUNIS 2019 types beyond level 3 of the EUNIS classification hierarchy, once combined with biogeographic region and biological zone, and

b) Allow us to extract as much information as possible from other, existing data products.

To achieve the first requirement, we interrogated the EUNIS 2019 habitat classification system to find which types of biogenic substrate are explicitly mentioned.

The marine section (level 1) of the EUNIS 2019 hierarchy begins by dividing the sea floor into (level 2) classes based on a combination of biological zone (littoral, infralittoral, (shallow) circalittoral, deep circalittoral, upper bathyal, lower bathyal and abyssal) and substrate type (rock, biogenic, coarse sediment, mixed sediment, sand and mud) (Table 1). The next level (level 3) divides these classes into regions (Arctic, Atlantic, Baltic Sea, Black Sea and Mediterranean). Within these regional sections, different biotopes and communities (levels 4, 5 and 6) are described depending on what has been observed in each region.

Table 1: criteria for defining seafloor habitats at level 2 of EUNIS 2019 (from official EUNIS 2019 read me). The classes included in this data product are shaded dark grey.

			Substrate					
			Hard/firm		Soft			
			Rock	Biogenic habitat	Coarse	Mixed	Sand	Mud
Biological zone	Phytal gradient / hydrodynamic gradient	Littoral	MA1	MA2	MA3	MA4	MA5	MA6
		Infralittoral	MB1	*MB2*	MB3	MB4	MB5	MB6
		Circalittoral	MC1	*MC2*	MC3	MC4	MC5	MC6
	Aphytal/ hydodynamic gradient	Offshore circalittoral	MD1	*MD2*	MD3	MD4	MD5	MD6
		Upper bathyal	ME1	*ME2*	ME3	ME4	ME5	ME6
		Lower bathyal	MF1	*MF2*	MF3	MF4	MF5	MF6
		Abyssal	MG1	*MG2*	MG3	MG4	MG5	MG6

We began by downloading EUNIS marine habitat classification 2019 in spreadsheet format from https://www.eea.europa.eu/data-and-maps/data/eunis-habitat-classification on 28/01/2021. Then we:

1. Filtered to exclude those classes from the littoral zone – that is any class in which the second value in the alphanumeric habitat code is "A" (see Table 1). This is because EUSeaMap is only concerned with sublittoral and deep-sea zones.
2. Filtered to show only those classes where 'biogenic habitat' is the given substrate type in the level 2 parent class. That is any class in which the third value in the alphanumeric habitat code is "2" (see Table 1).

We were left with only the level 2 habitats shown in the shaded cells in Table 1 and their child habitats. Then, for each region in turn, we reviewed the level 4, 5 and 6 biotopes and bioceonoses, and for each one picked out the component of its name that described the type of biogenic substrate. For example, in "MB221 - Worm reefs in the Atlantic infralittoral zone", the relevant biogenic substrate type was called "worm reefs".

After the first iteration, we found that the same biogenic substrate type was described differently in the EUNIS biotope names in different regions. To allow some comparison between regions, we carried out a second iteration in which the names of biogenic substrate types were standardised when we deemed that they described the same thing, for example the biogenic substrate type 'Sabellaria alveolata reefs' was used for biotope 'MB2211 Atlantic infralittoral Sabellaria alveolata reefs' in the Atlantic and biotope 'MB2541 Mediterranean Sabellaria alveolata worm reefs' in the Mediterranean.

The final iteration was to use our knowledge of other classification systems and priority habitat lists in which the majority of existing data sources would be classified into to ensure that the biogenic substrate types could be easily extracted from existing data sources. The main classification systems and priority habitat lists we considered were:

1. EUNIS version 2007-11 (all regions)
2. Habitats Directive Annex I habitat types (all regions)
3. HELCOM Underwater Biotopes (HUB) classification (Baltic only)
4. OSPAR threatened and/or declining habitats list (Atlantic and Arctic only)
5. Barcelona Convention classification of marine benthic habitat types (Mediterranean only)

Finally, the list was shared with project partners with regional expertise to review. Changes were made and the final list was agreed by all.

2.2 Extract the relevant data from the identified sources

Using the team's knowledge of the data landscape around seabed habitat maps in Europe we were able to identify the key data sources for potential polygons of biogenic substrate (Table 2). Nearly all of the data sources could be accessed via EMODnet Seabed Habitats.

Table 2: Summary of data sources uses to extract existing data on biogenic substrate types in Europe.

Name and version, with link to metadata	Classification system	Type of data source	Date accessed	Access
Individual habitat maps from surveys – EUNIS classification system	EUNIS version 2007-11	Individual habitat maps	2021-07-19	View: EMODnet Seabed Habitats interactive map Download: EMODnet Seabed Habitats download page
Individual habitat maps from surveys – Habitats Directive Annex I	Habitats Directive Annex I	Individual habitat maps	2021-08-02	View: EMODnet Seabed Habitats interactive map Download: EMODnet Seabed Habitats download page
Individual habitat maps from surveys – Other classification systems	HELCOM Underwater Biotopes (HUB)	Individual habitat maps	2021-07-21	View: EMODnet Seabed Habitats interactive map Download: EMODnet Seabed Habitats download page
Essential Ocean Variables in Europe (draft): seagrass cover (polygons, 2019)	Essential Ocean Variables	Composite data product - international	2021-07-21	View: EMODnet Seabed Habitats interactive map Download: EMODnet Seabed Habitats download page
OSPAR habitats – official 2020 public reference dataset	OSPAR threatened and/or declining	Composite data product -	2021-07-19	View: EMODnet Seabed Habitats interactive map

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Name and version, with link to metadata	Classification system	Type of data source	Date accessed	Access
	habitats	international		Download: EMODnet Seabed Habitats download page
EMODnet Geology seabed substrate (draft) July 2021	Free text description of surface features	Composite data product - international	2021-07-01	
Natural England Marine Evidence Base June 2021	MCZ Habitat Features of Conservation Importance	Composite data product - national	2021-06-24	View: Defra Magic Map (Go to 'Marine' > 'Marine Protected Area Features' > 'Marine Conservation Zone Designated Features (England)'
Environment (Wales) Act Section 7 and OSPAR: Marine Habitats July 2020	Environment (Wales) Act Section 7 Marine Habitats	Composite data product - national	2021-07-21	View and download: Lle Geoportal for Wales
Geodatabase of Marine features adjacent to Scotland (GeMS) V9 (i25)	Priority Marine Features (PMFs)	Composite data product - national	2021-07-19	View: Marine Scotland National Marine Plan Interactive portal (Go to 'View Layers to Add/Remove', then 'Healthy and Biologically Diverse' > [habitat group] > [individual PMF]) Download: NatureScot Natural Spaces

2.3 Compile into a single data product

2.3.1 Standardise attributes

Different data sources have different columns in their attribute tables, so in order to be able to combine them, we designed a new, simplified standard table structure (Table 3) and translated them all into this standard format.

Table 3: attribute table format. Short field names have 10 characters or fewer for compatibility with ESRI Shapefiles. Long field names are used as aliases in the File Geodatabase format.

Long field name (short field name)	Data type	Description
Biogenic most detailed level (BIO_DETAIL)	Text	Most detailed level of information on biogenic substrate type. For more information on the different levels of biogenic substrate type see Table 5: biogenic substrate types in Europe. 'x' means that the type is thought to be present in that region..
Source data product name (SRC_NAME)	Text	Name and version of the source data product. All source data products are listed in Table 2.

2.3.2 Apply rules that extract the desired information for our output

The requirement is to show the best available understanding of the current extent of biogenic substrate in European seas, including the type of biogenic substrate (the 'sub-type'). This means that overlaps must be removed according to some standard criteria.

Where overlaps occurred, a series of rules were established to determine which data attributes should be retained. These overlaps were addressed once the data had been intersected, meaning that the following rules were applied on a polygon-by-polygon basis (

Figure 1), not on the dataset scale. No polygons were removed during this process, only the attributes were edited.

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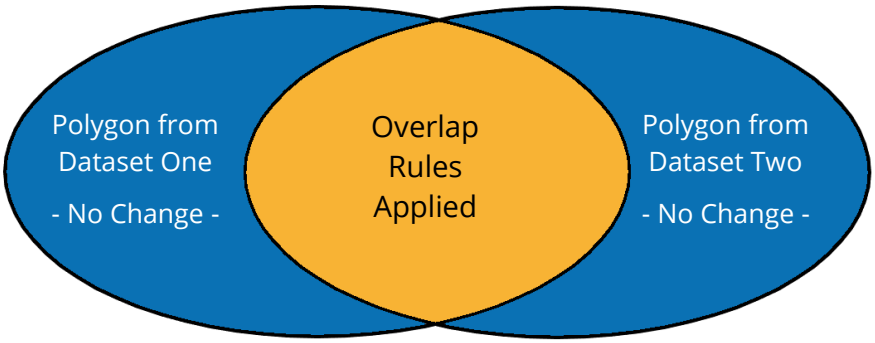

Figure 1: How overlap rules were applied to overlapping polygons to determine the new data attributes

1. Order of priority – where polygons from different data sources overlapped, habitat maps with higher priority were used in favour of those of a lower priority, regardless of whether the attribute data agreed or differed (Table 4).
2. Where overlaps occurred between maps of equal priority, or polygons within the same map overlapped, several different rules were implemented:
    a. If the overlap was between two official composite products – this required expert judgement to determine which data source and subtype should be used. If expert judgement was unavailable, other habitat maps were assessed to see which dataset was in agreement
    b. If the overlap was between two products of equal priority or a self-intersection - The map with the highest confidence, or, if the confidence is equal or unavailable, the map with most recent date, wins.

Table 4: Priority of different habitat maps for addressing overlaps between layers in descending order with 1 being the highest priority.

Priority	Products included at each priority level			
1	OSPAR Threatened and Declining Habitats (in Northeast Atlantic)	Essential Ocean Variables in Europe: seagrass cover (in Mediterranean)	Natural England Marine Evidence Base (in England)	Geodatabase of Marine features adjacent to Scotland (in Scotland)
2	Individual habitat maps from surveys – Habitats Directive Annex I classification system			
3	Individual habitat maps from surveys – EUNIS classification system			
4	EMODnet Geology seabed substrate surface features			

3 Results

3.1 Identify biogenic substrate types for each biogeographic region

Biogenic substrate types are described at different levels of detail depending on the data source. To make it clear to users, we have created a four-level hierarchy of biogenic substrate types. Level 1 is 'biogenic substrate'; the other levels are shown in **Error! Reference source not found.**.

Table 5: biogenic substrate types in Europe. 'x' means that the type is thought to be present in that region. * species has been observed in the region but it does not form a reef.

level 2	level 3	level 4	Atlantic/ Arctic	Baltic Sea	Black Sea	Mediterranean
bivalve reefs	mussel beds	*Modiolus modiolus* beds	x	x	-	-
	mussel beds	*Mytilus edulis* beds	x	x	-	-
	mussel beds	dominated by zebra mussel	-	x	-	-
	dominated by valve snails	-	-	x	-	-
	Ostrea edulis beds	-	x	-	x	x
	Hiatella arctica beds	-	x	-	-	-
	Limaria hians beds	-	x	-	-	x
shell gravel	-	-	x	x	-	-
worm reefs	*Sabellaria alveolata* reefs	-	x	-	-	x
	Sabellaria spinulosa reefs	-	x	-	-	x
	Serpula vermicularis reefs	-	x	-	-	-*
peat bottoms	-	-	-	x	-	-
seagrass beds	*Posidonia oceanica* meadows	live *Posidonia oceanica* meadows	-	-	-	x

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level 2	level 3	level 4	Atlantic/ Arctic	Baltic Sea	Black Sea	Mediterranean
	Posidonia oceanica meadows	dead mattes of *Posidonia oceanica*	-	-	-	x
	Posidonia oceanica meadows	*Posidonia oceanica* "Barrier-reef"	-	-	-	x
coralligenous platforms	-	-	-	-	-	x
Facies with *Vermetus* of the infralittoral algae biocenosis	-	-	-	-	-	x
Facies with *Ficopomatus enigmaticus* of the euryhaline and/or eurythermal lagoon biocenosis	-	-	-	-	-	x
cold water coral reefs	*Desmophyllum pertusum (Lophelia pertusa)* reefs	-	x	-	-	x
	Solenosmilia variabilis reefs	-	x	-	-	-
	Madrepora oculata reefs	-	x	-	-	x
biogenic detritic bottoms	-	-	-	-	x	-

For each of these, Appendix 1 contains a table showing the habitat types that correlate with the identified biogenic substrate types. Using these crosswalks we were able to extract polygons from existing habitat maps that have previously been classified according to these classification systems.

3.2 Extract the relevant data from the identified sources

The tables that follow (Table 6 to Table 9) show the best potential data source for each biogenic substrate type and the query used to extract the relevant polygons. Some queries returned zero results but are included here so that the method may be repeated in future when more data becomes available.

Table 6: Most detailed biogenic substrate type and potential data sources for the Atlantic and Arctic regions

Biogenic substrate type	Potential data source – name, version and classification system of data product	Potential data source – query string	Polygons returned as a result of query?
biogenic substrate	Individual habitat maps from surveys – EUNIS classification system (version 2007-11)	HAB_TYPE = 'A5.6' (Sublittoral biogenic reefs) OR HAB_TYPE = 'A6.6' (Deep sea bioherms)	y
Ostrea edulis beds	OSPAR habitats – official 2020 public reference dataset	HabType = 'Ostrea edulis beds'	y
Hiatella arctica beds	Individual habitat maps from surveys – EUNIS classification system (version 2007-11)	HAB_TYPE = 'A5.626' (Hiatella arctica beds on silty clay with small pebbles and shells)	n
Limaria hians beds	Within the UK EEZ: Geodatabase of Marine features adjacent to Scotland (GeMS) V9 (i25) - Scottish Priority Marine Features (PMFs)	PMF = 'Flame shell beds'	y
	Outside of the UK EEZ: Individual habitat maps from surveys – EUNIS classification system (version 2007-11)	HAB_TYPE = 'A5.434' (Limaria hians beds in tide-swept sublittoral muddy mixed sediment)	n
mussel beds	Individual habitat maps from surveys – EUNIS classification system (version 2007-11)	HAB_TYPE = 'A5.62' (Sublittoral mussel beds on sediment)	y
Modiolus modiolus beds	OSPAR habitats – official 2020 public reference dataset	HabType = 'Modiolous modiolus Horse mussel beds'	y

Biogenic substrate type	Potential data source – name, version and classification system of data product	Potential data source – query string	Polygons returned as a result of query?
Mytilus edulis beds	Within Scottish part of UK EEZ: Geodatabase of Marine features adjacent to Scotland (GeMS) V9 (i25) - Scottish Priority Marine Features (PMFs)	PMF = 'Blue mussel beds'	y
	Within English part of UK EEZ: Natural England Marine Evidence Base – MCZ Habitat Features of Conservation Importance June 2021	FOCI_name = 'Blue Mussel beds' OR FOCI_name = 'Blue Mussel Beds' OR FOCI_name = 'Blue Mussel (Mytilus edulis) beds'	y
	Within Welsh part of UK EEZ: Environment (Wales) Act Section 7 and OSPAR: Marine Habitats July 2020	"layer_id" = 'CCW_Blue_Mussel_Beds_01' AND "zone" <> 'Intertidal'	n
	Outside of the Scottish, English and Welsh parts of UK EEZ: Individual habitat maps from surveys – EUNIS classification system (version 2007-11)	HAB_TYPE = 'A5.625' (Mytilus edulis beds on sublittoral sediment)	y
worm reefs	Individual habitat maps from surveys – EUNIS classification system (version 2007-11)	HAB_TYPE = 'A5.61' (Sublittoral polychaete worm reefs on sediment)	y
Sabellaria alveolata reefs	Within English part of UK EEZ: Natural England Marine Evidence Base – MCZ Habitat Features of Conservation Importance June 2021	"FOCI_name" 'Honeycomb worm (Sabellaria alveolata) reefs' OR "FOCI_name" = 'Sabellaria alveolata reefs'	y
	Within Welsh part of UK EEZ: Environment (Wales) Act Section 7 and OSPAR: Marine Habitats July 2020	"Habitat_na" = 'Honeycomb worm (Sabellaria alveolata) reefs' AND "zone" <> 'Intertidal'	n

Biogenic substrate type	**Potential data source – name, version and classification system of data product**	**Potential data source – query string**	**Polygons returned as a result of query?**
	Outside of the English and Welsh parts of UK EEZ: Individual habitat maps from surveys – EUNIS classification system (version 2007-11)	HAB_TYPE = 'A5.612' (Sabellaria alveolata on variable salinity sublittoral mixed sediment)	n
Sabellaria spinulosa reefs	OSPAR habitats – official 2020 public reference dataset	HabType = 'Sabellaria spinulosa reefs'	y
Serpula vermicularis reefs	Within the UK EEZ: Geodatabase of Marine features adjacent to Scotland (GeMS) V9 (i25) - Scottish Priority Marine Features (PMFs)	PMF = 'Serpulid aggregations'	y
	Outside of the UK EEZ: Individual habitat maps from surveys – EUNIS classification system (version 2007-11)	HAB_TYPE = 'A5.613' (Serpula vermicularis reefs on very sheltered circalittoral muddy sand)	n
cold water coral reefs	Individual habitat maps from surveys – EUNIS classification system (version 2007-11)	HAB_TYPE = 'A5.63' (Circalittoral coral reefs)	n
Desmophyllum pertusum (Lophelia pertusa) reefs	OSPAR habitats – official 2020 public reference dataset	HabType = 'Lophelia pertusa reefs'	y
Madrepora oculata reefs	Not applicable – there are currently no known sources of polygon data on these reefs as EUNIS version 2007-11 does not include any *Madrepora oculata* reef biotopes.	-	n
Solenosmilia variabilis reef	Not applicable – there are currently no known sources of polygon data on these reefs as EUNIS version 2007-11 does not include any *Solenosmilia variabilis* reef biotopes. However, EUNIS 2019 does, so eventually there may be some data on it.	-	n

Table 7: Most detailed biogenic substrate type and potential data sources for the Mediterranean Sea

Biogenic substrate type	Potential data source - name of data product	Potential data source – query string	Polygons returned as a result of query?
biogenic substrate	Individual habitat maps from surveys – EUNIS classification system (version 2007-11)	HAB_TYPE = 'A5.6' (Sublittoral biogenic reefs) OR HAB_TYPE = 'A6.6' (Deep sea bioherms)	n
Posidonia oceanica meadows	Individual habitat maps from surveys – Habitats Directive Annex I	Annex I feature = '1120'	y
	Individual habitat maps from surveys – EUNIS classification system (version 2007-11)	HAB_TYPE = 'A5.535'	y
	Essential Ocean Variables in Europe - seagrass cover (polygons, v2019)	eunis_code = 'A5.535'	y
	EMODnet Geology seabed substrate (draft) July 2021	Surface_feature = 'Posidonia meadow' OR Surface_feature = 'Posidonia meadow ; Bio-lithoclastic sediment (50%<CaCO3<75%)' OR (Surface_feature = 'Seagrass meadow' AND 'comments' contains 'posidonia oceanica')	y
live *Posidonia oceanica* meadows	Essential Ocean Variables in Europe - seagrass cover (polygons, v2019)	"eunis_code" = 'A5.5351' OR "eunis_code" = 'A5.5354'	n
	Individual habitat maps from surveys – EUNIS classification system (version 2007-11)	HAB_TYPE = 'A5.5351' OR HAB_TYPE = 'A5.5354'	n
dead mattes of *Posidonia oceanica*	Individual habitat maps from surveys – EUNIS classification system (version 2007-11)	HAB_TYPE = 'A5.5353'	y
	Essential Ocean Variables in Europe - seagrass cover (polygons, v2019)	"eunis_code" = 'A5.5353'	y
	EMODnet Geology seabed substrate (draft) July 2021	Surface_feature = 'Seagrass matte (degraded)'	y
Posidonia oceanica "Barrier-reef"	Individual habitat maps from surveys – EUNIS classification system (version 2007-11)	HAB_TYPE = 'A5.5352'	n

Biogenic substrate type	**Potential data source - name of data product**	**Potential data source – query string**	**Polygons returned as a result of query?**
	Essential Ocean Variables in Europe - seagrass cover (polygons, v2019)	Habitat subtype = 'Posidonia oceanica "Barrier-reef"'	n
Sabellaria alveolata reefs	Individual habitat maps from surveys – EUNIS classification system (version 2007-11)	HAB_TYPE = 'A5.612' (Sabellaria alveolata on variable salinity sublittoral mixed sediment)	A polygon was returned but on further inspection, it appears to have been miscoded.
coralligenous platforms	Individual habitat maps from surveys – EUNIS classification system (version 2007-11)	HAB_TYPE = 'A4.26D'	y
Madrepora oculata reefs	Not applicable – there are currently no known sources of polygon data on these reefs as EUNIS version 2007-11 does not include any *Madrepora oculata* reef biotopes.	-	n
Facies with *Vermetus* of the infralittoral algae biocenosis	Not applicable – in the Med Sea this habitat has very limited extension, so it can be represented only by using points or lines	-	-
Facies with *Ficopomatus enigmaticus* of the euryhaline and/or eurythermal lagoon biocenosis	Individual habitat maps from surveys – EUNIS classification system (version 2007-11)	HAB_TYPE = 'A5.529' (Facies with Ficopomatus enigmaticus)	y

Table 8: Most detailed biogenic substrate type and potential data sources for the Baltic Sea

Biogenic substrate type	Potential data source - name of data product	Potential data source – query string	Polygons returned as a result of query?
biogenic substrate	Individual habitat maps from surveys – Habitats Directive Annex I	Annex I = '1170' (Reefs) AND subtype = 'Biogenic concretions'	y
bivalve reefs	Individual habitat maps from surveys – Other classification systems (i.e., HELCOM HUB)	ORIG_HAB is one of 'A[A or B].[A, B, E, H, I, J or M]1E' (Baltic [photic or aphotic] [various substrates] dominated by bivalves), e.g. AA.A1E, AB.E1E, etc.	n
mussel beds	Individual habitat maps from surveys – Other classification systems (i.e., HELCOM HUB)	ORIG_HAB is one of 'A[A or B].[A, B, E, H, I, J or M]1E1' (Baltic [photic or aphotic] [various substrates] dominated by Mytilidae), e.g. AA.A1E1, AB.E1E1, etc.	n
dominated by zebra mussel	Individual habitat maps from surveys – Other classification systems (i.e., HELCOM HUB)	ORIG_HAB = 'AA.A1E2' (Baltic photic rock and boulders characterized by zebra mussels) OR ORIG_HAB = 'AA.H1E2' (Baltic photic muddy sediment characterized by zebra mussels) OR ORIG_HAB = 'AA.M1E2' (Baltic photic mixed substrate characterized by zebra mussels)	n
dominated by valve snails	Individual habitat maps from surveys – Other classification systems (i.e., HELCOM HUB)	ORIG_HAB = 'AA.H1E3' (Baltic photic muddy sediment dominated by valve snails (Valvata spp.))	n
shell gravel	Individual habitat maps from surveys – Other classification systems (i.e., HELCOM HUB)	ORIG_HAB contains 'AA.E*' (Baltic photic shell gravel), except AA.E1E and AA.E1E1 OR ORIG_HAB contains 'AB.E*' (Baltic aphotic shell gravel), AB.E1E and AB.E1E1	n
worm reefs	Individual habitat maps from surveys – Other classification systems (i.e., HELCOM HUB)	ORIG_HAB = 'AA.H1K' (Baltic photic muddy sediment characterized by epibenthic polychaetes) OR ORIG_HAB = 'AB.H1K' (Baltic aphotic muddy sediment characterized by epibenthic polychaetes)	n
peat bottoms	Not applicable – no known sources of polygons for this habitat.	-	n

Table 9: Most detailed biogenic substrate type and potential data sources for the Black Sea

Biogenic substrate type	Potential data source - name of data product	Potential data source – query string	Polygons returned as a result of query?
biogenic substrate	Individual habitat maps from surveys – EUNIS classification system (version 2007-11)	HAB_TYPE = 'A5.6' (Sublittoral biogenic reefs) OR HAB_TYPE = 'A6.6' (Deep sea bioherms)	n
Ostrea edulis beds	Individual habitat maps from surveys – EUNIS classification system (version 2007-11)	HAB_TYPE = 'A5.64' (Pontic *Ostrea edulis* biogenic reefs on mobile seabottom)	n
mussel beds	Individual habitat maps from surveys – EUNIS classification system (version 2007-11)	HAB_TYPE = 'A5.62' (Sublittoral mussel beds on sediment)	n
worm reefs	Individual habitat maps from surveys – EUNIS classification system (version 2007-11)	HAB_TYPE = 'A5.61' (Sublittoral polychaete worm reefs on sediment)	n

3.3 Compile into a single data product

Once all overlaps had been addressed according to priority, confidence or date, a single data product was created with the attribute table from Table 3. This product was then dissolved into single-part polygons according to the biogenic substrate type and the data source (Figure 2). This product is now available on the EMODnet Seabed Habitats portal to view and download. Metadata can be found on the EMODnet Seabed Habitats metadata catalogue. It is also available by web map service and web feature service.

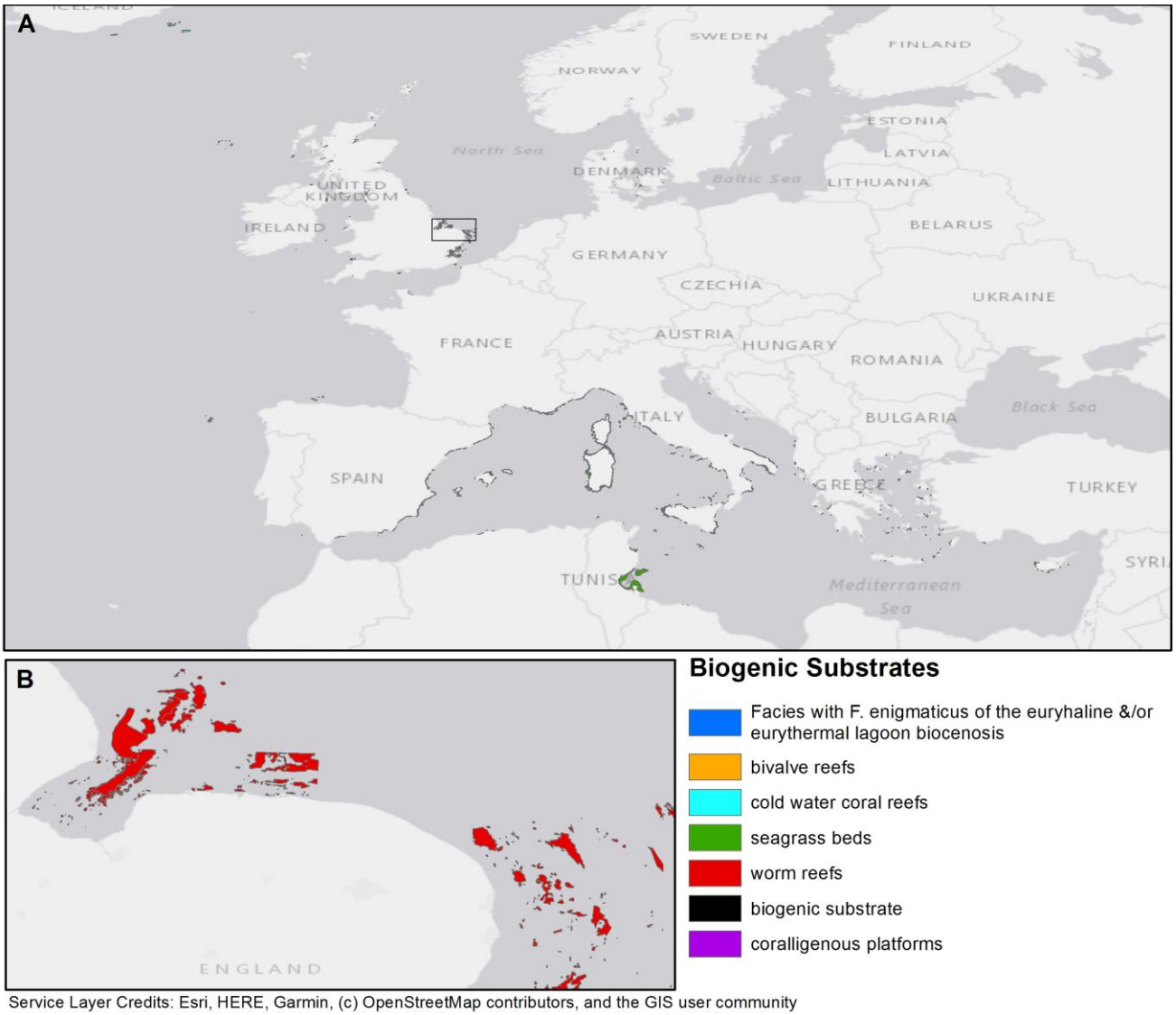

Figure 2 - Biogenic substrate in Europe (draft). Figure 1B shows an extract of the map in more detail, with the bounding box shown in Figure 1A.

The European Marine Observation and Data Network (EMODnet) is financed by the European Union under Regulation (EU) No 508/2014 of the European Parliament and of the Council of 15 May 2014 on the European Maritime and Fisheries Fund.

3.4 Combine with the grain-size-based substrate data

For use in EUSeaMap 2021, this composite product was combined with EMODnet Geology substrate data to create one over-arching substrate layer (Figure 3). Where a substrate already existed in the EMODnet Geology layer, the biogenic substrate took priority, replacing the existing substrate classification.

This combined product is also available on the EMODnet Seabed Habitats portal to view and download. Metadata can be found on the EMODnet Seabed Habitats metadata catalogue. This is also available by web map service and web feature service.

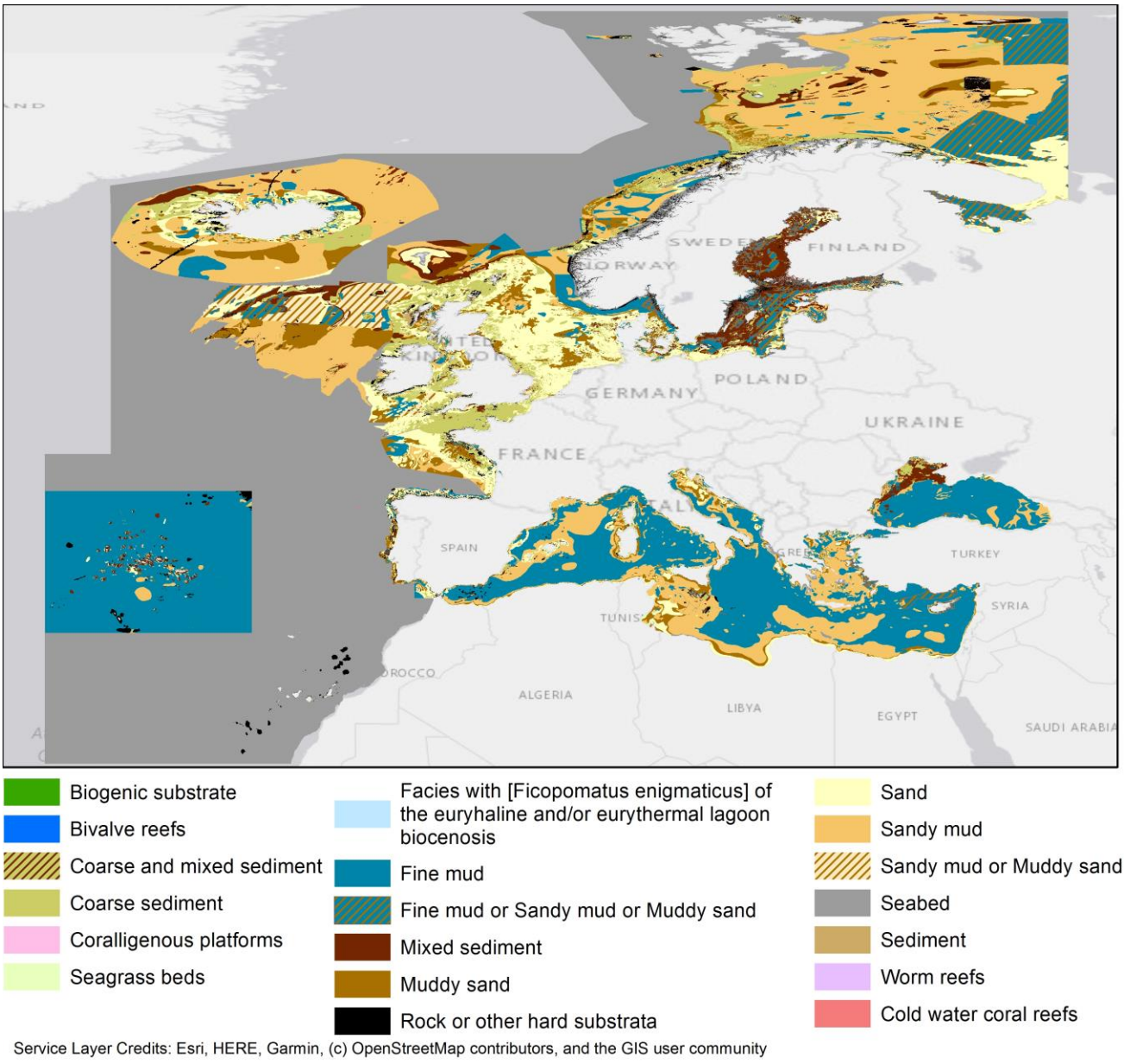

Figure 3: Combined substrate layer used for EUSeaMap 2021 containing EMODnet Geology substrate data and additional biogenic substrate polygons.

4 Discussion

4.1 Use of this product in EUSeaMap

In the process of creating this composite data product a variety of data sources were used. Some of these were habitat maps already translated into the EUNIS classification system. Due to the nature of the data collation process with this product, these habitat maps would have been re-classified as one of the specified biogenic substrate types in **Error! Reference source not found.**. Then, on input into EUSeaMap these same polygons will have been classified into a specific biotope under several different classification systems, one of which being the EUNIS classification system. Therefore, these converted polygons could have a final EUNIS biotope that differs from that of the source polygons.

Furthermore, some of this data is on a finer resolution than the majority of the substrate polygons in EUSeaMap, which will add to the complexity of the final map. As more data gets added to this product it may become necessary to simplify the data before using it as an input in EUSeaMap, in order to prevent the final product becoming too large.

4.2 Data gaps

Although this data product has been incorporated into the inputs of EUSeaMap 2021, it is important to note that this data product is incomplete and can be added to as more data becomes available. For example, there was very little data in the Baltic or Black Seas. This can hopefully be addressed with future partnerships with other organisations and increasing availability of data.

4.3 Future improvements to methods

4.3.1 Identify data or habitat types that may be used as a proxy for the absence of a biogenic substrate type

With the final data product only showing polygons of biogenic substrate, the rest of the sea area is therefore ambiguous – has there been some other substrate type observed, or is it unknown? There are no existing polygons labelled as 'not biogenic substrate'; therefore, it would be useful to find polygons that could act as a proxy for the absence of biogenic substrate.

A broad-brush approach would be to select all habitat types that are not the habitat types correlated with biogenic substrate types, from each data source. However, this approach assumes that the map maker was looking for biogenic substrate types. This is not always the case, for example they may have intended only to produce a map at a coarse level of thematic detail, which may not have explicitly identified every biogenic substrate type. Alternatively, the map may be at a coarse spatial scale, which is not fine enough to pick out the biogenic substrate types.

Therefore, we suggest for future iterations to reduce the scope. For individual habitat maps in which one or more biogenic substrate types have been identified, all other polygons in those maps could be labelled as 'probably not biogenic substrate'. Note that this is still based on an assumption, which is that any map that identified one or more biogenic substrate types would have identified any other biogenic substrate type too.

For composite data products it is not possible to identify any proxies for 'not biogenic substrate', seeing as though they are already composite products.

4.3.2 Develop a standard approach to recording surface features in EMODnet Geology seabed substrate data product

The EMODnet Geology seabed substrate data product provided an additional source of data for Posidonia meadows in the Mediterranean. This is a data product compiled by geologists with the primary purpose of the classifying the seabed into grain-size based classes, such as sand, mud and gravel. However, incidental observations of surface features are often recorded in a free text field as well. It was this field in which observations of Posidonia were made.

On further inspection, we found references to various biogenic substrate types, including *Sabellaria alveolata* reefs and coralligenous platforms; however, the terminology varies. EMODnet Geology are now working on adding value to the surface features information contained within this field, with assistance from EMODnet Seabed Habitats. Therefore, future iterations of the biogenic substrates data product may be able to make better use of the additional information provided.

4.1.3 Improve the priority rule for the selection of biogenic features

The definition of the selection rules is a crucial aspect to produce a composite layer. There were several occasions where EUNIS habitat maps and official composite products overlapped. In these instances, even before combining them into one data-product, the official composite product was used in preference (see Table 4).

In some cases, it was noticed that EUNIS habitat maps had more polygons than the official composite product. These additional polygons have not been included in this phase, choosing to follow the official composite products designations.

For the future it would be important to test other rules in order to consider dataset with high resolution / confidence / age with a higher priority. This is especially important for those biogenic habitats that have a fragmented and non-extensive distribution. Furthermore, it would be beneficial to contact the official data product providers to evaluate why some datasets are not in their official composite maps, and whether they should be incorporated into the next phase's version of the official product or omitted.

When it has been determined that a map should be excluded from the process, a log should be kept of these exclusions, included the reason for each map's exclusion.

5 Conclusion

The EMODnet Seabed Habitats consortium has produced the first Europe-wide map of biogenic substrates. This was made possible by the efforts of the consortium to collate, standardise and publish nearly 1,000 individual habitat maps from surveys via the EMODnet Seabed Habitats portal.

The product should be viewed as a first draft because there are many more areas that are not represented due to a lack of data. Adding a layer of survey sample points may go some way to demonstrating the additional areas of biogenic substrate where habitat maps have not been sourced.

6 References

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7 Appendix 1: Biogenic substrate crosswalks

This section contains a series of tables that show the relationship between several habitat classification systems and the types of sublittoral biogenic substrate we have identified for this data product:

1. EUNIS 2007-11 in the Atlantic/Arctic, Mediterranean, Baltic and Black Sea
2. Habitats Directive Annex I in the Atlantic/Arctic, Mediterranean, Baltic and Black Sea
3. HELCOM HUB in the Baltic
4. OSPAR threatened and/or declining habitats in the Atlantic/Arctic

Using these crosswalks we were able to extract polygons from existing habitat maps that have previously been classified according to these classification systems.

7.1 EUNIS 2007-11

Table 10: Atlantic and Arctic sublittoral biogenic substrate types that can be determined from EUNIS 2007-11 habitat types.

EUNIS 2007-11 habitat types			Most detailed biogenic substrate type
Code	**Level**	**Habitat name**	
A4.22	4	*Sabellaria reefs* on circalittoral rock	*Sabellaria spinulosa* reefs
A4.221	5	*Sabellaria spinulosa* encrusted circalittoral rock	*Sabellaria spinulosa* reefs
A4.2211	6	*Sabellaria spinulosa* with a bryozoan turf and barnacles on silty turbid circalittoral rock	*Sabellaria spinulosa* reefs
A5.434	5	*Limaria hians* beds in tide-swept sublittoral muddy mixed sediment	*Limaria hians* beds
A5.435	5	Oyster beds on shallow sublittoral muddy mixed sediment	*Ostrea edulis* beds
A5.6	3	Sublittoral biogenic reefs	biogenic substrate
A5.61	4	Sublittoral polychaete worm reefs on sediment	worm reefs
A5.611	5	*Sabellaria spinulosa* on stable circalittoral mixed sediment	*Sabellaria spinulosa* reefs
A5.612	5	*Sabellaria alveolata* on variable salinity sublittoral mixed sediment	*Sabellaria alveolata* reefs
A5.613	5	*Serpula vermicularis* reefs on very sheltered circalittoral muddy sand	*Serpula vermicularis* reefs
A5.62	4	Sublittoral mussel beds on sediment	mussel beds
A5.621	5	*Modiolus modiolus* beds with hydroids and red seaweeds on tide-swept circalittoral mixed substrata	*Modiolus modiolus* beds
A5.622	5	*Modiolus modiolus beds on open coast circalittoral mixed sediment*	*Modiolus modiolus* beds
A5.623	5	*Modiolus modiolus* beds with fine hydroids and large solitary ascidians on very sheltered circalittoral mixed substrata	*Modiolus modiolus* beds
A5.624	5	*Modiolus modiolus* beds with Chlamys varia, sponges, hydroids and bryozoans on slightly	*Modiolus modiolus* beds

		tide-swept very sheltered circalittoral mixed substrata	
A5.625	5	*Mytilus edulis* beds on sublittoral sediment	*Mytilus edulis* beds
A5.626	5	*Hiatella arctica* beds on silty clay with small pebbles and shells	*Hiatella arctica* beds
A5.63	4	Circalittoral coral reefs	cold water coral reefs
A5.631	5	Circalittoral *Lophelia pertusa* reefs	*Desmophyllum pertusum (Lophelia pertusa) reefs*
A6.6	3	Deep-sea bioherms	cold water coral reefs
A6.611	5	Deep-sea *Lophelia pertusa* reefs	*Desmophyllum pertusum (Lophelia pertusa) reefs*

Table 11: Baltic Sea sublittoral biogenic substrate types that can be determined from EUNIS 2007-11 habitat types.

EUNIS 2007-11 habitat types			**Most detailed biogenic substrate type**
Code	**Level**	**Habitat name**	
A5.113	5	Baltic shell gravel bottoms in the infralittoral photic zone	shell gravel
A5.115	5	Baltic shell gravel bottoms of the aphotic zone	shell gravel
A5.6	3	Sublittoral biogenic reefs	biogenic substrate
A5.62	4	Sublittoral mussel beds on sediment	mussel beds
A5.627	5	Baltic mussel beds in the infralittoral photic zone	mussel beds
A5.6271	6	Baltic mussel beds in the infralittoral photic zone with little or no macrophyte vegetation	mussel beds
A5.6272	6	Baltic mussel beds of the infralittoral photic zone dominated by macrophyte vegetation	mussel beds

Table 12: Black Sea sublittoral biogenic substrate types that can be determined from EUNIS 2007-11 habitat types.

EUNIS 2007-11 habitat types			**Most detailed biogenic substrate type**
Code	**Level**	**Habitat name**	
A5.6	3	Sublittoral biogenic reefs	biogenic substrate
A5.61	4	Sublittoral polychaete worm reefs on sediment	worm reefs
A5.62	4	Sublittoral mussel beds on sediment	mussel beds
A5.64	4	Pontic *Ostrea edulis* biogenic reefs on mobile seabottom	*Ostrea edulis* beds
A6.6	3	Deep-sea bioherms	biogenic substrate

Table 13: Mediterranean sublittoral biogenic substrate types that can be determined from EUNIS 2007-11 habitat types.

EUNIS 2007-11 habitat types	**Most detailed biogenic**

Code	Level	Habitat name	substrate type
A3.133	5	Facies with *Vermetus* spp.	Facies with *Vermetus* of the infralittoral algae biocenosis
A5.535	5	Posidonia beds	*Posidonia oceanica* meadows
A5.5351	6	Ecomorphosis of striped *Posidonia oceanica* meadows	*Live Posidonia oceanica* meadows
A5.5352	6	Ecomorphosis of "barrier-reef" *Posidonia oceanica* meadows	*Posidonia oceanica* "Barrier-reef"
A5.5353	6	Facies of dead "mattes" of *Posidonia oceanica* without much epiflora	Dead mattes of *Posidonia oceanica*
A5.5354	6	Association with *Caulerpa prolifera* on *Posidonia* beds	*Live Posidonia oceanica* meadows
A5.529	5	Facies with *Ficopomatus enigmaticus*	Facies with *Ficopomatus enigmaticus* of the euryhaline and/or eurythermal lagoon biocenosis
A5.612	5	*Sabellaria alveolata* on variable salinity sublittoral mixed sediment	*Sabellaria alveolata* reefs
A4.26D	5	Coralligenous platforms	coralligenous platforms
A5.6	3	Sublittoral biogenic reefs	biogenic substrate
A6.6	3	Deep-sea bioherms	biogenic substrate

7.2 Habitats Directive Annex I

Table 14: sublittoral biogenic substrate types that can be determined from Habitats Directive Annex I habitat types in all regions of Europe. * Note that the 'biogenic' subtype of Reef is not always made explicit in Annex I habitat maps, so it is not always possible to extract this information.

Habitats Directive Annex I habitat	Most detailed biogenic substrate type	Region
1120 *Posidonia* beds	*Posidonia oceanica* meadows	Mediterranean
1170 Reefs – biogenic subtype only*	biogenic substrate	All

7.3 HELCOM Underwater Biotopes

Table 15: Baltic Sea sublittoral biogenic substrate types that can be determined from HELCOM Underwater Biotopes (HUB) habitat types. (* AA.E/AB.E also include all child habitats except AA.E1E/AB.E1E (which have been matched to 'bivalve reefs – unspecific') and AA.E1E1/AB.E1E1 (which have been matched to 'mussel beds – unspecific').

HELCOM Underwater Biotopes (HUB) habitat types			Most detailed biogenic substrate type
Code	**Level**	**Habitat name**	
AA.A1E	5	Baltic photic rock and boulders characterized by epibenthic bivalves	bivalve reefs
AA.A1E1	6	Baltic photic rock and boulders dominated by *Mytilidae*	mussel beds
AA.A1E2	6	Baltic photic rock and boulders characterized by zebra mussels	dominated by zebra mussel
AA.B1E	5	Baltic photic hard clay characterized by epibenthic bivalves	bivalve reefs
AA.B1E1	6	Baltic photic hard clay dominated by *Mytilidae*	mussel beds
AA.E*	3	Baltic photic shell gravel	shell gravel
AA.E1E	5	Baltic photic shell gravel characterized by epibenthic bivalves	bivalve reefs
AA.E1E1	6	Baltic photic shell gravel dominated by *Mytilidae*	mussel beds
AA.G	3	Baltic photic peat bottoms	peat bottoms
AA.H1E	5	Baltic photic muddy sediment characterized by epibenthic bivalves	bivalve reefs
AA.H1E1	6	Baltic photic muddy sediment dominated by *Mytilidae*	mussel beds
AA.H1E2	6	Baltic photic muddy sediment characterized by zebra mussels	dominated by zebra mussel
AA.H1E3	6	Baltic photic muddy sediment dominated by valve snails (Valvata spp.)	dominated by valve snails
AA.H1K	5	Baltic photic muddy sediment characterized by epibenthic polychaetes	worm reefs
AA.I1E	5	Baltic photic coarse sediment characterized by epibenthic bivalves	bivalve reefs
AA.I1E1	6	Baltic photic coarse sediment dominated by *Mytilidae*	mussel beds
AA.J1E	5	Baltic photic sand characterized by epibenthic bivalves	bivalve reefs
AA.J1E1	6	Baltic photic sand dominated by *Mytilidae*	mussel beds
AA.M1E	5	Baltic photic mixed substrate characterized by epibenthic bivalves	bivalve reefs
AA.M1E1	6	Baltic photic mixed substrate dominated by *Mytilidae*	mussel beds
AA.M1E2	6	Baltic photic mixed substrate characterized by zebra mussels	dominated by zebra mussel
AB.A1E	5	Baltic aphotic rock and boulders characterized by epibenthic bivalves	bivalve reefs
AB.A1E1	6	Baltic aphotic rock and boulders dominated by *Mytilidae*	mussel beds
AB.B1E	5	Baltic aphotic hard clay characterized by epibenthic bivalves	bivalve reefs
AB.B1E1	6	Baltic aphotic hard clay dominated by *Mytilidae*	mussel beds
AB.E*	3	Baltic aphotic shell gravel	shell gravel

AB.E1E	5	Baltic aphotic shell gravel characterized by epibenthic bivalves	bivalve reefs
AB.E1E1	6	Baltic aphotic shell gravel dominated by *Mytilidae*	mussel beds
AB.G	3	Baltic aphotic peat bottoms	peat bottoms
AB.H1E	5	Baltic aphotic muddy sediment characterized by epibenthic bivalves	bivalve reefs
AB.H1E1	6	Baltic aphotic muddy sediment dominated by *Mytilidae*	mussel beds
AB.I1E	5	Baltic aphotic coarse sediment characterized by epibenthic bivalves	bivalve reefs
AB.I1E1	6	Baltic aphotic coarse sediment dominated by *Mytilidae*	mussel beds
AB.J1E	5	Baltic aphotic sand characterized by epibenthic bivalves	bivalve reefs
AB.J1E1	6	Baltic aphotic sand dominated by Mytilidae	mussel beds
AB.M1E	5	Baltic aphotic mixed substrate characterized by epibenthic bivalves	bivalve reefs
AB.M1E1	6	Baltic aphotic mixed substrate dominated by *Mytilidae*	mussel beds
AB.H1K	5	Baltic aphotic muddy sediment characterized by epibenthic polychaetes	worm reefs

7.4 OSPAR threatened and/or declining habitats

Table 16: sublittoral biogenic substrate types that can be determined from OSPAR threatened and/or declining habitat types in the Atlantic and Arctic.

OSPAR threatened and/or declining habitat	Most detailed biogenic substrate type
***Ostrea edulis* beds**	*Ostrea edulis* beds
***Modiolus modiolus* Horse mussel beds**	*Modiolus modiolus* beds
***Sabellaria spinulosa* beds**	*Sabellaria spinulosa* beds
***Lophelia pertusa* reefs**	*Desmophyllum pertusum (Lophelia pertusa) reefs*

8 Appendix 2: EUNIS 2019 habitat types that can be determined from the biogenic substrate types

8.1 Arctic

The Arctic section of EUNIS 2019 does not include any biotopes within the biogenic habitat section. Therefore, it is only possible to classify to level 3 of EUNIS 2019 in the Arctic for biogenic substrates.

Table 17 - EUNIS 2019 Habitat types that can be determined from the biogenic substrate types in the Arctic

biological zone	Most detailed biogenic substrate type	EUNIS 2019			EUNIS 2007-11		
		Level	Code	Habitat name	Level	Code	Habitat name
infralittoral	biogenic substrate	3	MB21	Arctic infralittoral biogenic habitat	3	A5.6	Sublittoral biogenic reefs
infralittoral	worm reefs	3	MB21	Arctic infralittoral biogenic habitat	4	A5.61	Sublittoral polychaete worm reefs on sediment
infralittoral	*Sabellaria alveolata* reefs	3	MB21	Arctic infralittoral biogenic habitat	5	A5.612	*Sabellaria alveolata* on variable salinity sublittoral mixed sediment
infralittoral	*Serpula vermicularis* reefs	3	MB21	Arctic infralittoral biogenic habitat	5	A5.613	[*Serpula vermicularis*] reefs on very sheltered circalittoral muddy sand
infralittoral	bivalve reefs	3	MB21	Arctic infralittoral biogenic habitat	3	A5.6	Sublittoral biogenic reefs
infralittoral	*Limaria hians* beds	3	MB21	Arctic infralittoral biogenic habitat	5	A5.434	[*Limaria hians*] beds in tide-swept sublittoral muddy mixed sediment
infralittoral	*Ostrea edulis* beds	3	MB21	Arctic infralittoral biogenic habitat	5	A5.435	Oyster beds on shallow sublittoral muddy mixed sediment

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biological zone	Most detailed biogenic substrate type	EUNIS 2019			EUNIS 2007-11		
		Level	Code	Habitat name	Level	Code	Habitat name
infralittoral	mussel beds	3	MB21	Arctic infralittoral biogenic habitat	4	A5.62	Sublittoral mussel beds on sediment
infralittoral	*Mytilus edulis* beds	3	MB21	Arctic infralittoral biogenic habitat	5	A5.625	[*Mytilus edulis*] beds on sublittoral sediment
shallow circalittoral	biogenic substrate	3	MC21	Arctic circalittoral biogenic habitat	3	A5.6	Sublittoral biogenic reefs
shallow circalittoral	worm reefs	3	MC21	Arctic circalittoral biogenic habitat	4	A5.61	Sublittoral polychaete worm reefs on sediment
shallow circalittoral	*Sabellaria spinulosa* reefs	3	MC21	Arctic circalittoral biogenic habitat	5	A5.611	[*Sabellaria spinulosa*] on stable circalittoral mixed sediment
shallow circalittoral	*Serpula vermicularis* reefs	3	MC21	Arctic circalittoral biogenic habitat	5	A5.613	[*Serpula vermicularis*] reefs on very sheltered circalittoral muddy sand
shallow circalittoral	cold water coral reefs	3	MC21	Arctic circalittoral biogenic habitat	4	A5.63	Circalittoral coral reefs
shallow circalittoral	*Desmophyllum pertusum (Lophelia pertusa) reefs*	3	MC21	Arctic circalittoral biogenic habitat	5	A5.631	Circalittoral *Lophelia pertusa* reefs
shallow circalittoral	bivalve reefs	3	MC21	Arctic circalittoral biogenic habitat	4	A4.24	Mussel beds on circalittoral rock
shallow circalittoral	mussel beds	3	MC21	Arctic circalittoral biogenic habitat	4	A4.24	Mussel beds on circalittoral rock
shallow circalittoral	*Modiolus modiolus* beds	3	MC21	Arctic circalittoral biogenic habitat	4	A4.24	Mussel beds on circalittoral rock
shallow circalittoral	*Mytilus edulis* beds	3	MC21	Arctic circalittoral biogenic habitat	5	A5.625	[*Mytilus edulis*] beds on sublittoral sediment
shallow circalittoral	*Hiatella arctica* beds	3	MC21	Arctic circalittoral biogenic habitat	5	A5.626	[*Hiatella arctica]* beds on silty clay with small pebbles and shells

biological zone	Most detailed biogenic substrate type	EUNIS 2019			EUNIS 2007-11		
		Level	Code	Habitat name	Level	Code	Habitat name
offshore circalittoral	biogenic substrate	3	MD21	Arctic offshore circalittoral biogenic habitat	3	A5.6	Sublittoral biogenic reefs
offshore circalittoral	cold water coral reefs	3	MD21	Arctic offshore circalittoral biogenic habitat	4	A5.63	Circalittoral coral reefs
offshore circalittoral	*Desmophyllum pertusum (Lophelia pertusa) reefs*	3	MD21	Arctic offshore circalittoral biogenic habitat	5	A5.631	Circalittoral *Lophelia pertusa* reefs
upper bathyal	cold water coral reefs	3	ME21	Arctic upper bathyal biogenic habitat	4	A6.61	Communities of deep-sea corals
upper bathyal	*Desmophyllum pertusum (Lophelia pertusa) reefs*	3	ME21	Arctic upper bathyal biogenic habitat	5	A6.611	Deep-sea *Lophelia pertusa* reefs
lower bathyal	cold water coral reefs	3	MF21	Arctic lower bathyal biogenic habitat	4	A6.61	Communities of deep-sea corals
lower bathyal	*Solenosmilia variabilis* reefs	3	MF21	Arctic lower bathyal biogenic habitat	4	A6.61	Communities of deep-sea corals
abyssal	cold water coral reefs	3	MG21	Arctic abyssal biogenic habitat	4	A6.61	Communities of deep-sea corals
abyssal	*Solenosmilia variabilis* reefs	3	MG21	Arctic abyssal biogenic habitat	4	A6.61	Communities of deep-sea corals

8.2 Atlantic

Note that we found some errors in the official EUNIS 2019 habitat classification publication. We are raising these with the European Environment Agency and in the meantime, have made corrections for the purpose of this data product. Corrections are described in the table.

Table 18- EUNIS 2019 Habitat types that can be determined from the biogenic substrate types in the Atlantic

biological zone	Most detailed biogenic substrate type	EUNIS 2019 (with unofficial corrections)				EUNIS 2007-11		
		Level	Code	Habitat name	Description of corrections	Level	Code	Habitat name
infralittoral	biogenic substrate	3	MB22	Atlantic infralittoral biogenic habitat		3	A5.6	Sublittoral biogenic reefs
infralittoral	worm reefs	4	MB221	Worm reefs in the Atlantic infralittoral zone		4	A5.61	Sublittoral polychaete worm reefs on sediment
infralittoral	*Sabellaria alveolata* reefs	5	MB2211	Atlantic infralittoral *Sabellaria alveolata* reefs	name change: habitat incorrectly called 'Atlantic littoral *Sabellaria alveolata* reefs' in EUNIS 2019	5	A5.612	*Sabellaria alveolata* on variable salinity sublittoral mixed sediment
infralittoral	*Serpula vermicularis* reefs	5	MB2212	Atlantic infralittoral *Serpula vermicularis* reefs	name change: habitat incorrectly called 'Atlantic littoral *Serpula vermicularis* reefs' in EUNIS 2019	5	A5.613	[*Serpula vermicularis*] reefs on very sheltered circalittoral muddy sand
infralittoral	bivalve reefs	4	MB222	Bivalve reefs in the Atlantic infralittoral zone		3	A5.6	Sublittoral biogenic reefs
infralittoral	*Limaria hians* beds	5	MB2221	*Limaria hians* beds in tide-swept Atlantic infralittoral muddy mixed sediment		5	A5.434	[*Limaria hians*] beds in tide-swept sublittoral muddy mixed sediment

biological zone	Most detailed biogenic substrate type	EUNIS 2019 (with unofficial corrections)				EUNIS 2007-11		
		Level	Code	Habitat name	Description of corrections	Level	Code	Habitat name
infralittoral	*Ostrea edulis* beds	5	MB2222	*Ostrea edulis* beds on Atlantic infralittoral muddy mixed sediment		5	A5.435	Oyster beds on shallow sublittoral muddy mixed sediment
infralittoral	mussel beds	4	MB222	Bivalve reefs in the Atlantic infralittoral zone		4	A5.62	Sublittoral mussel beds on sediment
infralittoral	*Mytilus edulis* beds	5	MB2224	*Mytilus edulis* beds on Atlantic infralittoral sediment	addition: habitat missing from EUNIS 2019	5	A5.625	[*Mytilus edulis*] beds on sublittoral sediment
shallow circalittoral	biogenic substrate	3	MC22	Atlantic circalittoral biogenic habitat		3	A5.6	Sublittoral biogenic reefs
shallow circalittoral	worm reefs	4	MC221	Worm reefs in the Atlantic circalittoral zone		4	A5.61	Sublittoral polychaete worm reefs on sediment
shallow circalittoral	*Sabellaria spinulosa* reefs	5	MC2211	*Sabellaria spinulosa* on stable Atlantic circalittoral mixed sediment		5	A5.611	[*Sabellaria spinulosa*] on stable circalittoral mixed sediment
shallow circalittoral	*Serpula vermicularis* reefs	5	MC2212	*Serpula vermicularis* reefs on very sheltered Atlantic circalittoral muddy sand		5	A5.613	[*Serpula vermicularis*] reefs on very sheltered circalittoral muddy sand
shallow circalittoral	cold water coral reefs	4	MC222	Cold water coral reefs in the Atlantic circalittoral zone		4	A5.63	Circalittoral coral reefs
shallow circalittoral	*Desmophyllum pertusum (Lophelia pertusa) reefs*	5	MC2221	Atlantic circalittoral *Lophelia pertusa* reefs		5	A5.631	Circalittoral *Lophelia pertusa* reefs

biological zone	Most detailed biogenic substrate type	EUNIS 2019 (with unofficial corrections)				EUNIS 2007-11		
		Level	Code	Habitat name	Description of corrections	Level	Code	Habitat name
shallow circalittoral	bivalve reefs	4	MC223	Bivalve reefs in the Atlantic circalittoral zone	addition: habitat missing from EUNIS 2019	3	A5.6	Sublittoral biogenic reefs
shallow circalittoral	mussel beds	4	MC223	Bivalve reefs in the Atlantic circalittoral zone	addition: habitat missing from EUNIS 2019	4	A5.62	Sublittoral mussel beds on sediment
shallow circalittoral	*Modiolus modiolus* beds	5	MC223	Bivalve reefs in the Atlantic circalittoral zone	addition: habitat missing from EUNIS 2019	4	A5.62	Sublittoral mussel beds on sediment
shallow circalittoral	*Mytilus edulis* beds	5	MC2237	*Mytilus edulis* beds on Atlantic circalittoral sediment	code change: habitat incorrectly assigned to code MC2217 in EUNIS 2019	5	A5.625	[*Mytilus edulis*] beds on sublittoral sediment
shallow circalittoral	*Hiatella arctica* beds	5	MC2238	*Hiatella arctica* beds on Atlantic circalittoral silty clay with small pebbles and shells	code change: habitat incorrectly assigned to code MC2218 in EUNIS 2019	5	A5.626	[*Hiatella arctica*] beds on silty clay with small pebbles and shells
offshore circalittoral	biogenic substrate	3	MD22	Atlantic offshore circalittoral biogenic habitat	name change: 'biogenic habitats' changed to 'biogenic habitat' for consistency	3	A5.6	Sublittoral biogenic reefs
offshore circalittoral	cold water coral reefs	4	MD221	Cold water coral reefs in the Atlantic offshore circalittoral zone		4	A5.63	Circalittoral coral reefs
offshore circalittoral	*Desmophyllum pertusum (Lophelia pertusa) reefs*	5	MD2211	Atlantic offshore circalittoral Lophelia pertusa reefs		5	A5.631	Circalittoral *Lophelia pertusa* reefs

biological zone	Most detailed biogenic substrate type	EUNIS 2019 (with unofficial corrections)				EUNIS 2007-11		
		Level	Code	Habitat name	Description of corrections	Level	Code	Habitat name
upper bathyal	cold water coral reefs	4	ME221	Atlantic upper bathyal cold water coral reef		4	A6.61	Communities of deep-sea corals
upper bathyal	*Desmophyllum pertusum (Lophelia pertusa) reefs*	4	ME221	Atlantic upper bathyal cold water coral reef		5	A6.611	Deep-sea *Lophelia pertusa* reefs
lower bathyal	cold water coral reefs	4	MF221	Atlantic lower bathyal cold water coral reef		4	A6.61	Communities of deep-sea corals
lower bathyal	*Solenosmilia variabilis* reefs	4	MF221	Atlantic lower bathyal cold water coral reef		4	A6.61	Communities of deep-sea corals
abyssal	cold water coral reefs	3	MG22	Atlantic abyssal biogenic habitat		4	A6.61	Communities of deep-sea corals
abyssal	*Solenosmilia variabilis* reefs	3	MG22	Atlantic abyssal biogenic habitat		4	A6.61	Communities of deep-sea corals

8.3 Baltic Sea

Table 19 - EUNIS 2019 Habitat types that can be determined from the biogenic substrate types in the Baltic Sea

biological zone	Most detailed biogenic substrate type	EUNIS 2019			EUNIS 2007-11		
		Level	Code	Habitat name	Level	Code	Habitat name
infralittoral	biogenic substrate	3	MB23	Baltic infralittoral biogenic habitat	3	A5.6	Sublittoral biogenic reefs
infralittoral	bivalve reefs	4	MB231	Baltic infralittoral bottoms dominated by epibentic bivalves	3	A5.6	Sublittoral biogenic reefs
infralittoral	mussel beds	5	MB2311	Baltic infralittoral bottoms habitat dominated by *Mytilidae*	5	A5.627	Baltic mussel beds in the infralittoral photic zone
infralittoral	dominated by zebra mussel	5	MB2312	Baltic infralittoral bottoms dominated by *Dreissena polymorpha*	5	A5.627	Baltic mussel beds in the infralittoral photic zone
infralittoral	dominated by valve snails	5	MB2313	Baltic infralittoral bottoms habitat dominated by valve snails	3	A5.6	Sublittoral biogenic reefs
infralittoral	shell gravel	4	MB232	Baltic infralittoral bottoms characterized by shell gravel	5	A5.113	Baltic shell gravel bottoms in the infralittoral photic zone
infralittoral	peat bottoms	4	MB233	Baltic infralittoral biogenic peat bottoms	3	A5.6	Sublittoral biogenic reefs
shallow circalittoral	biogenic substrate	3	MC23	Baltic circalittoral biogenic habitat	3	A5.6	Sublittoral biogenic reefs
shallow circalittoral	bivalve reefs	4	MC231	Baltic circalittoral bottoms dominated by epibentic bivalves	3	A5.6	Sublittoral biogenic reefs
shallow circalittoral	mussel beds	5	MC2311	Baltic circalittoral bottoms dominated by *Mytilidae*	4	A5.62	Sublittoral mussel beds on sediment
shallow circalittoral	worm reefs	4	MC232	Baltic circalittoral bottoms dominated by epibenthic polychaetes	4	A5.61	Sublittoral polychaete worm reefs on sediment

biological zone	Most detailed biogenic substrate type	EUNIS 2019			EUNIS 2007-11		
		Level	Code	Habitat name	Level	Code	Habitat name
shallow circalittoral	shell gravel	4	MC233	Baltic circalittoral shell gravel bottoms	5	A5.115	Baltic shell gravel bottoms of the aphotic zone
shallow circalittoral	peat bottoms	4	MC234	Baltic circalittoral peat bottoms	3	A5.6	Sublittoral biogenic reefs
deep circalittoral	biogenic substrate	3	MD23	Baltic offshore circalittoral biogenic habitats	3	A5.6	Sublittoral biogenic reefs
deep circalittoral	bivalve reefs	4	MD231	Baltic offshore circalittoral biogenic bottoms characterized by epibenthic bivalves	3	A5.6	Sublittoral biogenic reefs
deep circalittoral	mussel beds	5	MD2312	Baltic offshore circalittoral biogenic habitats dominated by Mytilidae	4	A5.62	Sublittoral mussel beds on sediment
deep circalittoral	shell gravel	4	MD23	Baltic offshore circalittoral biogenic habitats	3	A5.6	Sublittoral biogenic reefs

8.4 Black Sea

Table 20 - EUNIS 2019 Habitat types that can be determined from the biogenic substrate types in the Black Sea

biological zone	Most detailed biogenic substrate type	EUNIS 2019			EUNIS 2007-11		
		Level	Code	Habitat name	Level	Code	Habitat name
infralittoral	biogenic substrate	3	MB24	Black Sea infralittoral biogenic habitat	3	A5.6	Sublittoral biogenic reefs
infralittoral	worm reefs	4	MB241	Polychaete worm reefs in the Black sea infralittoral zone	4	A5.61	Sublittoral polychaete worm reefs on sediment

biological zone	Most detailed biogenic substrate type	EUNIS 2019			EUNIS 2007-11		
		Level	Code	Habitat name	Level	Code	Habitat name
infralittoral	mussel beds	4	MB242	Mussel beds in the Black sea infralittoral zone	4	A5.62	Sublittoral mussel beds on sediment
infralittoral	*Ostrea edulis* beds	4	MB243	Oyster reefs on Black sea lower infralittoral rock	4	A5.64	Pontic *Ostrea edulis* biogenic reefs on mobile seabottom
shallow circalittoral	biogenic substrate	3	MC24	Black Sea circalittoral biogenic habitats	3	A5.6	Sublittoral biogenic reefs
shallow circalittoral	mussel beds	4	MC241	Mussel beds on Black sea circalittoral terrigenous muds	4	A5.62	Sublittoral mussel beds on sediment
shallow circalittoral	biogenic detritic bottoms	4	MC242 or MC243	Black sea circalittoral biogenic detritic bottoms dead or alive mussel beds with encrusting corallines and attached foliose sciaphilic macroalgae OR Black sea circalittoral biogenic detritic bottoms with unattached *Phyllophora crispa*	3	A5.6	Sublittoral biogenic reefs
shallow circalittoral	worm reefs	4	MC244	Marmara circalittoral worm reefs	4	A5.61	Sublittoral polychaete worm reefs on sediment
offshore circalittoral	biogenic substrate	3	MD24	Black Sea offshore circalittoral biogenic habitats	3	A5.6	Sublittoral biogenic reefs
upper bathyal	biogenic substrate	3	ME24	Black Sea upper bathyal biogenic habitat	3	A6.6	Deep-sea bioherms
lower bathyal	biogenic substrate	3	MF24	Black Sea lower bathyal biogenic habitat	3	A6.6	Deep-sea bioherms
abyssal	biogenic substrate	3	MG24	Black Sea abyssal biogenic habitat	3	A6.6	Deep-sea bioherms

8.5 Mediterranean

Table 21 - EUNIS 2019 Habitat types that can be determined from the biogenic substrate types in the Mediterranean

biological zone	Most detailed biogenic substrate type	EUNIS 2019			EUNIS 2007-11		
		Level	Code	Habitat name	Level	Code	Habitat name
infralittoral	biogenic substrate	4	MB25	Mediterranean infralittoral biogenic habitat	3	A5.6	Sublittoral biogenic reefs
infralittoral	Facies with *Vermetus* of the infralittoral algae biocenosis	6	MB2511	Facies with *Vermetus* spp.	5	A3.133	Facies with *Vermetus* spp.
infralittoral	*Posidonia oceanica* meadows	5	MB252	Biocenosis of *Posidonia oceanica*	5	A5.535	*Posidonia* beds
infralittoral	*Posidonia oceanica* meadows	6	MB2521	Ecomorphosis of striped *Posidonia oceanica* meadows	6	A5.5351	Ecomorphosis of striped *Posidonia oceanica* meadows
infralittoral	*Posidonia oceanica* "Barrier-reef"	6	MB2522	Ecomorphosis of "barrier-reef" *Posidonia oceanica* meadows	6	A5.5352	Ecomorphosis of "barrier-reef" *Posidonia oceanica* meadows
infralittoral	Dead mattes of *Posidonia oceanica*	6	MB2523	Facies of dead "mattes" of *Posidonia oceanica* without much epiflora	6	A5.5353	Facies of dead "mattes" of *Posidonia oceanica* without much epiflora
infralittoral	*Posidonia oceanica* meadows	6	MB2524	Association with *Caulerpa prolifera* on Posidonia beds	6	A5.5354	Association with *Caulerpa prolifera* on Posidonia beds
infralittoral	Facies with *Ficopomatus enigmaticus* of the euryhaline and/or eurythermal lagoon biocenosis	6	MB2531	Facies with *Ficopomatus enigmaticus*	5	A5.529	Facies with *Ficopomatus enigmaticus*
infralittoral	*Sabellaria alveolata* reefs	6	MB2541	Mediterranean *Sabellaria alveolata* worm reefs	5	A5.612	*Sabellaria alveolata* on variable salinity sublittoral mixed sediment

biological zone	Most detailed biogenic substrate type	EUNIS 2019			EUNIS 2007-11		
		Level	Code	Habitat name	Level	Code	Habitat name
circalittoral	coralligenous platforms	5	MC251	Coralligenous platforms	5	A4.26D	Coralligenous platforms
offshore circalittoral	biogenic substrate	4	MD25	Mediterranean offshore circalittoral biogenic habitats	3	A5.6	Sublittoral biogenic reefs
upper bathyal	biogenic substrate	4	ME25	Mediterranean Upper bathyal biogenic habitat	3	A6.6	Deep-sea bioherms
lower bathyal	biogenic substrate	4	MF25	Mediterranean lower bathyal biogenic habitat	3	A6.6	Deep-sea bioherms
abyssal	biogenic substrate	4	MG25	Mediterranean abyssal biogenic habitat	3	A6.6	Deep-sea bioherms