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Updated crosswalks between European marine habitat typologies - A contribution to the MAES marine assessment

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1 Background

Both the MAES (Mapping and Assessment of Ecosystems and their Services) analytical framework, which is EU-level guidance on Target 2/Action 5 of the EU 2020 Biodiversity Strategy, and the MAES marine pilot, which scoped and tested this guidance to support Member States' implementation efforts, acknowledge the need for crosswalks between existing European marine habitat type classifications. The role of these crosswalks is to support harmonisation of ecosystem definitions and mapping in a MAES context (Maes et al, 2013, 2014).

The 2018 edition of this report updates the original 2014 report to take into account developments with EUNIS, MSFD and EUSeaMap marine habitat classifications. The original EUNIS marine component dating from 2004 was revised in order, *inter alia*, to integrate increasing knowledge on the marine environment over 2013-2018, including a revision of the Level 2 (the European level) agreed in 2016. The MSFD predominant habitat types were revised and renamed as MSFD broad habitat types in 2017. EUSeaMap is the existing European scheme for consistent broad scale seabed habitat mapping. A new version of these broad scale modelled seabed habitats was published in 2016, which also delivered a spatial layer portraying the new MSFD benthic broad habitat types through a process of aggregation of the depth zones and the modelled habitat features.

These developments mean that the crosswalks in the previous version of this report (2014) needed updating focusing on the benthic aspect. The classifications that need to be crosswalked are:

1. the marine component of EUNIS (European Nature Information System),
2. the broad habitat types of the EU Marine Strategy Framework Directive (MSFD),
3. the habitat types used by EUSeaMap, and
4. the coastal and marine habitat types listed in Annex I of the EU Habitats Directive

These crosswalks are necessary in order to link existing European, national or regional marine assessments and maps, based on marine EUNIS and/or mapped using EUSeaMap, to the marine ecosystem typology put forward in the MAES analytical framework, i.e. Maes et al (2013). Thus, the MAES marine ecosystem typology includes the MSFD pelagic predominant habitat types and is an aggregation of the MSFD benthic predominant habitat types to a large extent[1]. These now need to be crosswalked to the new MSFD broad habitat types as well as other existing or revised habitat classifications.

The links with Annex I habitat types are needed to fully benefit from information included in assessments of Annex I marine and coastal habitats under Article 17 of the Habitats Directive in a MAES context. Thus, Article 17 assessment information could be used, in particular, to assess some of the marine ecosystem services supplied by the habitats included in the MAES marine ecosystem typology.

[1] Cf. Table 3 in Maes et al (2013)

2 Introduction

The EUNIS habitats classification classifies all habitat types in Europe, covering terrestrial, freshwater and marine habitats. It was developed by the European Topic Centre on Biological Diversity (ETC/BD) for the European Environment Agency (EEA) and has been used as the basis for habitat type and ecosystem typologies for a variety of European issues. Examples are the implementation of the MSFD, the coding of modelled broad scale seabed habitats, and the mapping of marine ecosystems and their services, such as in the context of MAES.

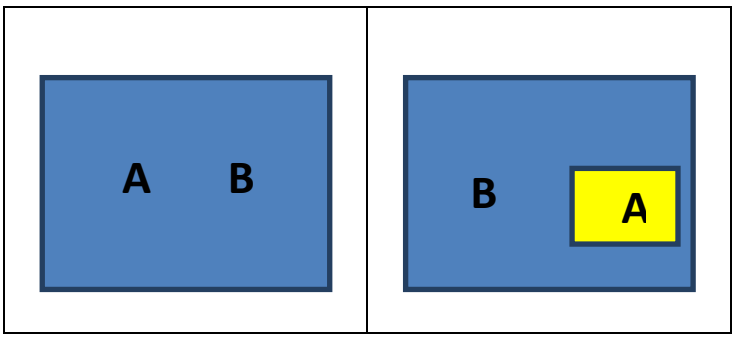
After a general introduction to crosswalks, this report briefly describes the EUNIS habitats classification, highlighting some known difficulties to get common criteria due to the specificities of the differences between some regional seas (no significant tide in Mediterranean Sea, relative low depth in the Baltic Sea, etc.). It then describes: (1) the MSFD predominant and broad habitat types, (2) Annex I of the Habitats Directive, and (3) the relationship between the MSFD benthic broad habitat types and the original modelled EUSeaMap broad scale seabed habitats, in each case showing how they also relate to the EUNIS classification. Finally, the MSFD broad habitat types and Annex I marine habitat types are linked to the typology for marine ecosystem mapping and assessment in the context of MAES. The following crosswalks are included as appendices:

- Crosswalks between MFSD predominant habitat types 2010, broad habitat types 2017, and marine benthic habitats in EUNIS Level 2 v.2016 (Appendix 1)
- Crosswalk between MSFD benthic broad habitat types and Habitats Directive Annex I marine habitat types (Appendix 2)
- Crosswalk between EUSeaMap broad scale modelled seabed habitats and MSFD benthic broad habitat types (Appendix 3)
- Crosswalks between MSFD broad habitat types, Habitats Directive Annex I marine habitats and MAES European marine ecosystem typology – crosswalks for MAES (Appendix 4)

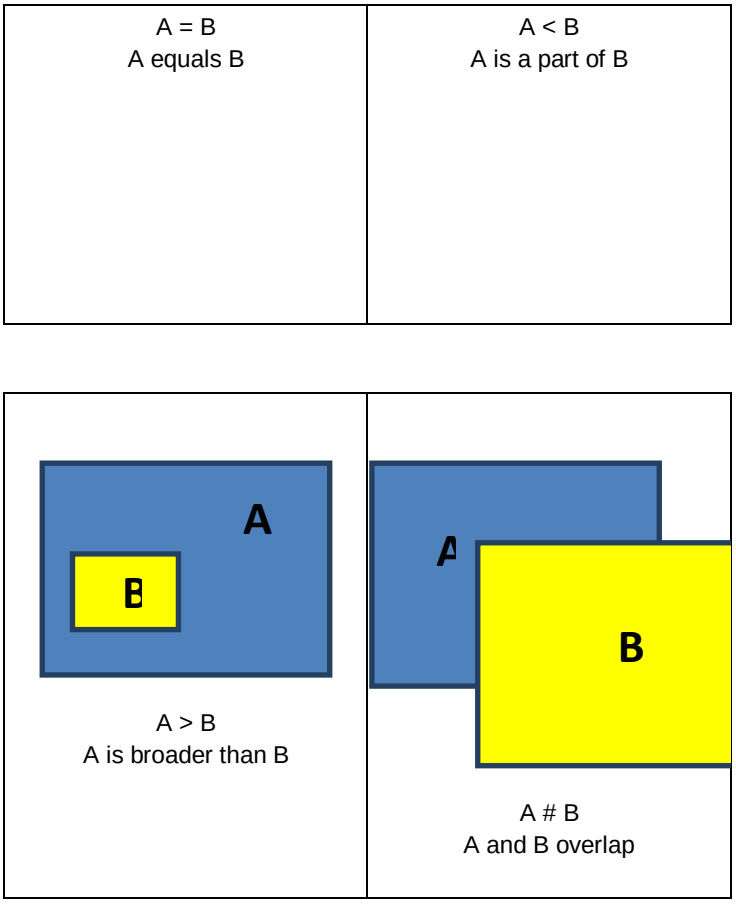
3 Crosswalks

Although there are many habitat classification systems, it is usually possible to derive links between them, often presented as tables and known as crosswalks. Unfortunately, often the links are from 'many to many' rather than 'one to one'. These relationships can be described and the EUNIS website[2] uses a series of symbols to do so as described in Figure 3.1.

Figure 3.1: Possible relationships between different habitat classifications and the symbols used by EUNIS.



([2]) http://eunis.eea.europa.eu/habitats.jsp



Crosswalks aid the translation between different habitat classifications but often need to be used with care. In many cases, it is possible to give more definitive relationships if a crosswalk is for a region or country rather than for the whole of Europe.

4 The EUNIS habitat classification

In the 1980s, when the CORINE Biotopes project started, there was no suitable classification of habitats or biotopes covering all Europe for sea, freshwater and land; although there were several national or regional classifications such as Pérès & Picard (1964) for the marine benthic habitats of the Mediterranean Sea. The EUNIS habitat classification was developed for the EEA by the ETC/BD and its predecessors, and can be considered to be a development from the earlier CORINE biotopes and Palaearctic habitat classifications (Evans, 2012). EUNIS was based on similar principles but aimed to give better coverage of marine habitats and to have agreed criteria to define the habitat classes. Development started in the mid-1990s with the last major revision being published in 2004. EUNIS is a hierarchical classification with 10 Level 1 classes (plus habitat complexes), Class 'A' is 'marine'. The divisions at Level 2 and 3 for the marine habitats are based on physical variables, including those related to depth such as light penetration, wave disturbance and temperature (collectively they define the 'biological zones'), substrate type and energy. Biology (species composition) begins to appear in the habitat descriptions at Level 4.

The EUNIS habitats classification was produced for Levels 1 to 3 (terrestrial) and Levels 1-4 (marine). In order to give finer divisions, units from other classifications have been added to give lower levels. For the marine part, these mostly came from the British marine classification or from the Helsinki Convention (1998) and the Barcelona Convention (2002) (Connor et al, 2004). Thus, they may not

cover the entire variation within the parent class and there may be overlap between types from different sources.

The current version of the EUNIS habitats classification dates from 2004 (Davies et al., 2004), with an extension into the Black Sea (Pontic habitats) in 2007. With increasing knowledge of the marine environment and from experience in using the EUNIS classification for seabed mapping, it had become evident that a revision was required. For example, Howell (2010) proposed that 'A6 Deep-sea bed' should be divided into several zones. A meeting organised by the MESH Atlantic project[3] in 2012 brought together researchers, who had been using the classification for seabed mapping in various parts of Europe, and made recommendations for future revisions (Galparsoro et al., 2012). These recommendations were the basis for a revision of the marine component of EUNIS by the EEA and its ETC/BD. An expert workshop held in November 2013 agreed the principles for such a revision leading to a revised classification, which was the subject of an EIONET based consultation with interested parties in summer 2015. The classification was further revised to take into account comments received during the consultation but, for several issues, there had been conflicting comments, which needed resolving before the revision could be completed. To address these issues, ETC/BD organised an expert workshop on 12 and 13 May 2016. An overview of the proposed upper levels was agreed at and is outlined in the report from this workshop (Evans et al., 2016); where the revised Level 2 for benthic habitat types is presented as Table 4.1 here. The final version of the revised EUNIS for all marine habitats and of all levels of the classification is due to be published at the end 2018.

Table 4.1: Level 2 units of the marine benthic component of the revised (v.2016) EUNIS habitats classification, including Level 2 codes

			Hard/firm		Soft			
			Rock*	Biogenic habitat**	Coarse	Mixed	Sand	Mud
Depth Zones	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

* Includes soft rock, marls, clays, artificial hard substrata

** Biogenic habitat formed by plants or animals

([3]) http://www.meshatlantic.eu/

The EUNIS habitats classification was conceived as a tool to aid the harmonisation of information on habitats at a European scale and not to replace the many existing national or regional classifications. Several crosswalks have been produced to help EUNIS function as a common language, such as the crosswalks to plant communities (Schaminée et al., 2012) and all habitat types listed on Annex I of the EU Habitats Directive can be allocated to one or more EUNIS classes. EUNIS is an approved code list under the EU INSPIRE Directive and is recommended as the typology for the proposed European Red List of habitats (Rodwell et al., 2013).

5 Marine Strategy Framework Directive predominant habitat types and broad habitat types

The Marine Strategy Framework Directive (MSFD) adopted in July 2008 aims at achieving or maintaining a 'good environmental status' (GES) in the EU's marine environment by 2020 at the latest. GES is defined as **"The environmental status of marine waters where these provide ecologically diverse and dynamic oceans and seas which are clean, healthy and productive". E**leven qualitative descriptors describing what the environment will look like when GES has been achieved are given in Annex I of the MSFD. Each Descriptor has several associated criteria and indicators for its further characterisation and operationalization as included in the EC Decision defining the GES criteria and methodological standards (Decision 2010/477/EU, referred to as EC, 2010).

Habitat types are relevant to two of these descriptors: Descriptor 1: "*Biodiversity is maintained. The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climate conditions*" and Descriptor 6: "*Sea-floor integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected*".

Based on Cochrane et al (2010), the Commission Staff Working Paper on the 'Relationship between the initial assessment of marine waters and the criteria for good environmental status' (EC, 2011) listed 24 **predominant seabed and water column habitat types** (18 benthic/seabed, 5 pelagic/water column and 1 ice associated, see Appendix I). The benthic and ice-associated habitat types were defined by reference to the EUNIS habitats classification v2007-11, except that in the MSFD: 1) the sublittoral zone was divided into "shallow" & "shelf", and 2) the deep-sea zone was divided into "upper bathyal", "lower bathyal" and "abyssal" zones following proposals from Howell (2010).

In 2012, Member States reported on the environmental status of their marine waters and notified to the Commission their determination of GES and their environmental targets defined following EC (2010). To ensure that the second cycle of implementation of the marine strategies of the Member States further contributes to the achievement of the objectives of the MSFD and yields more consistent determinations of GES, the Commission's report on the first phase of MSFD implementation recommended that Decision 2010/477/EU should be revised. This revision aimed at providing a clearer, simpler, more concise, more coherent and comparable set of criteria and methodological standards defining GES.

As a result, EC (2010) was revised into Commission Decision (EU) 2017/848 of 17 May 2017, which revised the definition of the GES Descriptors. For Descriptor 1, this included providing a new list of 'Pelagic and benthic broad habitat types' to replace those predominant water column and seabed

habitat types listed in the 2011 Commission Staff Working Paper. The new benthic[4] broad habitat types followed the Level 2 of the revised marine EUNIS classification as shown in Table 4.1, and this was done one-to-one to allow full compatibility between classifications.

One of the consequences of this alignment, and which is also one of the aspects most worthy of notice in the new Decision, is that the original MSFD benthic broad habitat categories referring to the sublittoral zone are now split into three finer levels of benthic zone detail, namely the infralittoral, the circalittoral and the offshore circalittoral. In addition, the abyssal predominant categories, which were formerly listed in terms of their gross substrate nature (i.e. sediment and hard bottoms), are now joined into one broad habitat, which encompasses the entire abyssal zone. The introduced differentiation of the sublittoral zone in the new broad habitat categories eliminates the previous divergent definition of the shallow / shelf sublittoral boundary. Thus, this was interpreted by some Member States, in the 2012 MSFD reporting, as referring to the past EUNIS shallow circalittoral / deep circalittoral boundary; in contrast to other Member States interpretations referring to the past EUNIS infralittoral /circalittoral boundary. In the North East Atlantic region, for instance, the wave base (depth) was considered by some to be the determining variable for the split between the shallow and shelf sublittoral, but this was not considered appropriate for the Mediterranean region, where the boundary generated by light reaching the seabed was considered to be the determining variable for this boundary.

Because of the one-to-one correspondence between the new marine EUNIS benthic Level 2 and the MSFD benthic broad habitat types:

- The absolute limit of the photic zone (the phytal/aphytal boundary in Table 4.1) can now be discriminated across the MSFD circalittoral and offshore circalittoral habitat types for all marine regions. This would correspond to the limit of the oligophotic zone, which is biologically marked by the limit for crustose coralline (red) algal growth. The limit of the euphotic zone would fall between the MSFD infralittoral and circalittoral habitat types for all regions, and is biologically marked by the limit for angiosperms and photophilic (e.g. green and some brown) macroalgal growth.

- The MSFD littoral benthic broad habitat types can occur beyond the Highest Astronomical Tide (HAT), or equivalent in non-(significantly) tidal seas, matching the littoral zone definition in EUNIS. Thus, it is now acknowledged that these habitats can make up the benthos of certain physiographic features in the land-sea interface[5] that can fully occur in the supralittoral zone, namely coastal wetlands (e.g. saltmarshes) and coastal lagoons. It is also acknowledged that littoral habitats can occur in specific supralittoral enclaves that are under strong marine influence through, e.g., spray, splash and/or sporadic inundation above the HAT (or equivalent in non-(significantly) tidal seas), such as the splash zone (including the lower part of seacliffs); semi- or exposed rocks; rockpools; and seacliff caves. These enclaves could happen within physiographic features or as part of nearshore, open coastal waters[6]. This situation is different from the MSFD predominant habitat types, where the definition of the littoral excluded the supralittoral zone. However, dry beaches, dunes and other supralittoral elements are still classed as terrestrial habitats (under EUNIS).

[4] The pelagic aspect cannot be developed here due to some characteristics of the EUNIS classification and the fact that EUSeaMap is dedicated to seabed habitats.

[5] Physiographic features in the land-sea interface include coastal wetlands (saltmarshes, salines and intertidal flats); coastal lagoons; estuaries and other transitional waters; fjords and sea lochs as well as embayments; see description of the 'Marine inlets and transitional waters' ecosystem type on Table 8.1.

[6] These would be 'coastal waters' according to the definition of the EU Water Framework Directive (extending up to 1nm from the territorial baseline)

Appendix 1 shows how the MSFD broad habitat types (2017) are related to the predominant habitat types (2010) as well as to the Level 2 of the revised EUNIS marine benthic habitat classification (v.2016).

6 Annex I of the Habitats Directive

Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora [7], more commonly known as the Habitats Directive, aims to protect the EU's "natural habitats and of wild fauna and flora". The Directive requires the designation and appropriate management of sites known as Special Areas of Conservation (SACs) for habitat types and species of Community Interest listed on Annexes I & II of the Directive. Annex I currently lists 231 habitat types, the initial list (as included in the 1992 Directive) was a selection of habitat types mostly from the CORINE Biotopes classification (Devillers et al., 1991). Habitat types added later due to EU enlargements in 1995, 2003 and 2007 were mostly based on the Palaearctic classification (Devillers and Devillers-Terschuren, 1996). Descriptions of the habitat types, often with links to other national or regional classifications, are given in a manual (EC, 2013) formally adopted by the Habitats Committee (a body established under the Directive to help its implementation).

The number of marine habitats is limited, probably as it was not clear at first if the Directive covered more than inshore waters. The habitat types differ widely in their inherent variability, with some of the marine habitat types (e.g. 1170 Reefs) covering more variation that any of the terrestrial habitat types. It is clear that there is often a difference between Member States in the interpretation of the habitat types (Evans, 2006, 2010). This is probably less of a problem for marine habitat types although the interpretation of '1110 Sandbanks which are slightly covered by sea water all the time' has been problematic.

For the EU 2010 Biodiversity Baseline (EEA, 2010), 6 Annex I habitat types were considered 'marine' while 10 are considered 'marine' for reporting under Article 17 of the Directive, see Table 6.1. For Article 17, marine habitats were defined by being part of, or connected to, the open seas (Evans and Arvela, 2011). There are further Annex I types which occur at the boundary with terrestrial systems (e.g. certain saltmarsh habitats); where these are regularly covered by seawater they can also be considered as part of the marine environment.

([7]) http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31992L0043:EN:NOT

Table 6.1 Habitats Directive Annex I habitats considered as 'marine'

Natura code	Annex I habitat name	Marine for Article 17 reporting	Marine for 2010 Biodiversity baseline
1110	Sandbanks which are slightly covered by sea water all the time	**X**	**X**
1120	*Posidonia* beds (*Posidonion oceanicae*)	**X**	**X**
1130	Estuaries	**X**	
1140	Mudflats and sandflats not covered by seawater at low tide	**X**	
1150	Coastal lagoons	**X**	
1160	Large shallow inlets and bays	**X**	**X**
1170	Reefs	**X**	**X**
1180	Submarine structures made by leaking gasses	**X**	**X**
1650	Boreal Baltic narrow inlets	**X**	
8330	Submerged or partially submerged sea caves	**X**	**X**

Based on the Interpretation manual of EU28 Habitats (EC, 2013) and the revised EUNIS marine habitats classification, Appendix 2 shows how the MSFD benthic broad habitat types (2017) are related to the marine habitats of Annex I. Most of the latter habitats are within the infralittoral zone due to their physical or geographic characteristics. In most cases, an MSFD habitat type cannot be associated to an Annex I habitat type without additional information. This is partly a result of some Annex I habitat types being 'landscape' units which can contain several other habitats, e.g. both '1130 Estuaries' and '1160 Large shallow inlets and bays' can contain '1110 Sandbanks which are slightly covered by sea water all the time' and '1140 Mudflats & sandflats not covered at low tide' – see Figure 6.1.. In contrast, MSFD benthic broad habitat types referring to more than one benthic zone can host those Annex I habitats the distribution of which spans across a wide depth range (i.e. '1170 Reefs' and '8330 Submerged or partially submerged caves').

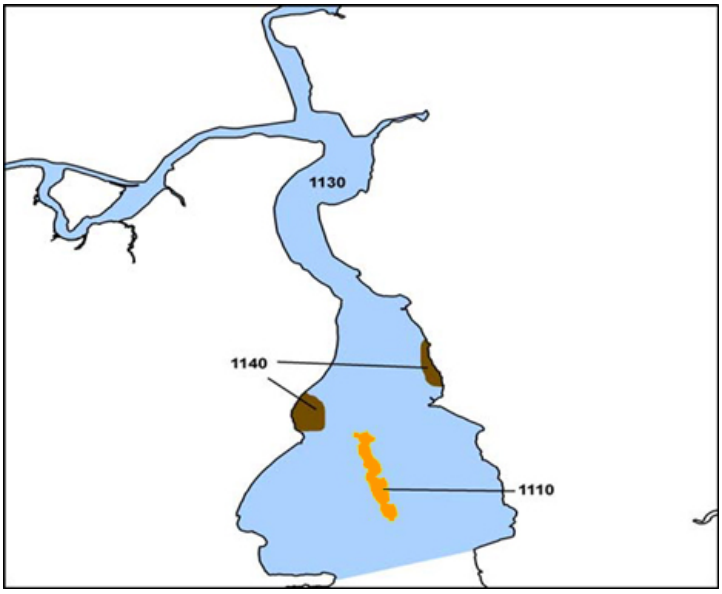


Figure 6.1 Overlapping of the Habitats Directive Annex I habitats. '1130 Estuaries' (blue, light grey) may also include areas of '1110 Sandbanks which are slightly covered by sea water all the time' (orange, medium grey) and '1140 Mudflats and sandflats not covered by seawater at low tide' (brown, dark grey) (from Evans and Arvela 2011).

7 EUSeaMap

The need for maps of the seabed has become increasingly urgent in recent years, for a wide range of reasons and uses, including reporting on the state of the marine environment to implement EU policies such as the MSFD, the Integrated Maritime Policy[8] and the EU 2020 Biodiversity strategy[9] as described by Marine Knowledge 2020[10]. Building on earlier regional projects, such as BALANCE[11] for the Baltic Sea and MESH[12] for the seas around north-west Europe, the EMODnet Seabed Habitats[13] initiative has produced maps for all EU and European marine regions, where input data allowed (see Figure 7.1) – the resultant maps are known collectively as 'EUSeaMap'. In the first phase (2009–12), over two million square kilometres of Europe's seabed was mapped, across four regions/sub-regions: the Baltic Sea, Greater North Sea, Celtic Seas and Western Mediterranean Sea (EUSeaMap 2012; Cameron et al., 2011). In the second phase (2013–16), the existing EUSeaMap was improved and its coverage extended to encompass all remaining EU and European regions from the Barents Sea to Macaronesia, the whole of the Mediterranean Sea, and the Black Sea (EUSeaMap 2016). These are broad-scale seabed habitat maps, using rule-based predictive modelling with rules for classification based on biological data. The maps assume that biological assemblages within a given region are largely determined by the combination of physical and chemical factors, e.g. salinity, light (related to depth), kinetic energy, substrate type, oxygen concentration etc. Details of how the EUSeaMap model was produced, and how the latest version differs from previous versions, can be found in the technical report (Populus et al., 2017).

([8]) http://ec.europa.eu/maritimeaffairs/policy
([9]) http://ec.europa.eu/environment/nature/biodiversity/comm2006/2020.htm
([10]) http://ec.europa.eu/maritimeaffairs/policy/marine_knowledge_2020
([11]) http://www.balance-eu.org
([12]) MESH project: www.emodnet-seabedhabitats.eu/mesh
([13]) EMODnet Seabed Habitats: www.emodnet-seabedhabitats.eu

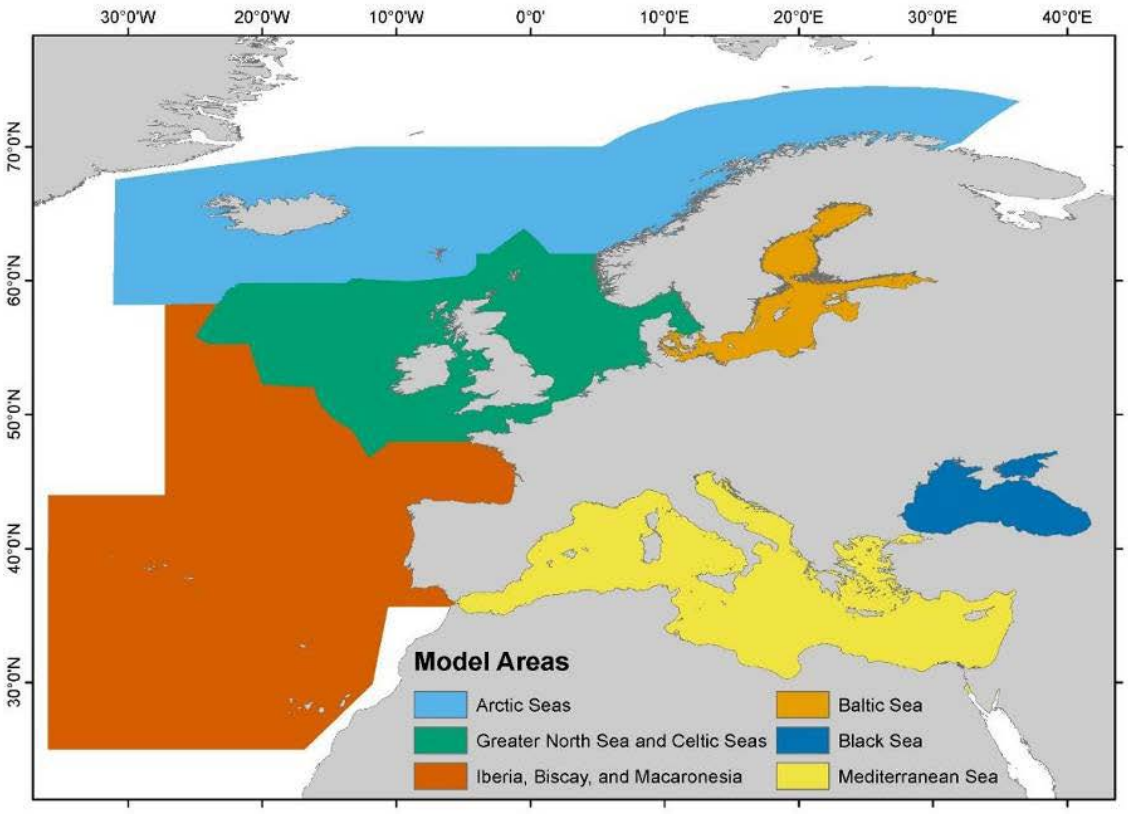


Figure 7.1 Geographic extent of EUSeaMap in the respective MSFD regions (Populus et al. 2017).

EUSeaMap 2016 provides maps in three classification systems:

- Modelled broad scale seabed habitat map using the EUNIS version 2007-11;
- EUNIS version 2007-11 plus additional classes where additional information is available that provides further discrimination, may be referred to as the 'full detail classification';
- MSFD benthic broad habitat types.

The 2016 draft MSFD benthic broad habitat types were used for consistent mapping units in an aggregate map combining the different regions across the whole mapped area (see Figure 7.2). The rules used for aggregating the modelled habitats, based on their environmental characteristics, into the MSFD benthic broad habitat layer, are provided along with the EUSeaMap technical report (Manca et al., 2017)

Each region in the full detail classification used slightly different habitat units. Crosswalk between the full detail classification including the EUNIS habitat codes, and the MSFD benthic broad habitat types is provided in Appendix 3 as used for EUseaMap 2016.

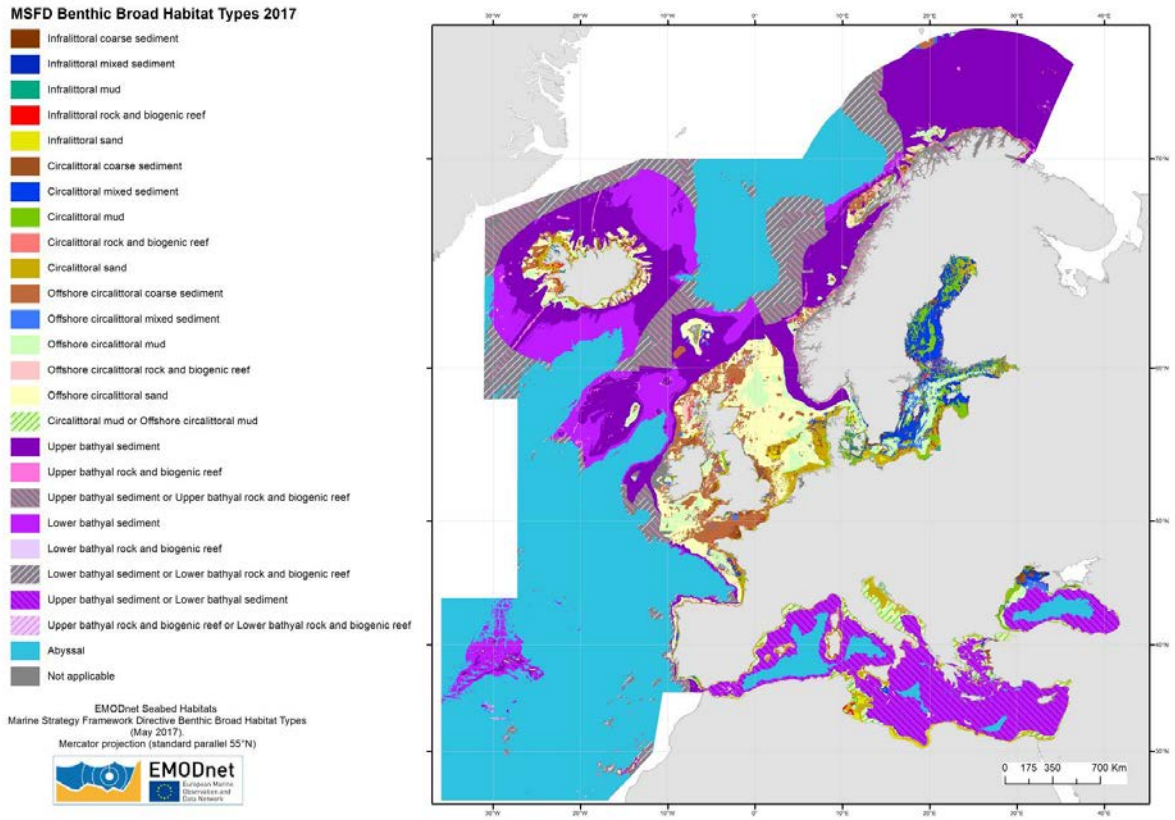


Figure 7.2 EUSeaMap MSFD benthic broad habitat map (Populus et al. 2017).

Nevertheless, there are:

- 5 pelagic MSFD broad habitat types that are not mapped by EUSeaMap, although some of these could be linked to EUSeaMap classes (e.g. shelf water). However, the current treatment of pelagic habitats by EUNIS is not considered to be useful.

- 2 littoral MSFD benthic broad habitat types that are not mapped by EUSeaMap ('Littoral rock & biogenic reef', 'Littoral sediment') due to the typically narrow spatial extent of the littoral zone in relation to the resolution of the EUSeaMap modelling (the zone is often narrower than the grid size of the model). CORINE Land Cover may cover these habitats (3.3.2. Bare rock, 3.3.1. Beaches, dunes, and sand plains) although this would need to be tested. It may also be possible to assume that the littoral is the same as the adjacent shallow habitat (e.g. the coastal limit of an area mapped as 'Infralittoral rock & biogenic reef' may be assumed to be 'Littoral rock & biogenic reef').

- MSFD 'ice associated habitats' within the broad habitat types and these are not mapped by EUSeaMap (and not covered by any Habitats Directive Annex I habitat type either)

Appendix 2 shows how MSFD benthic broad habitat types correspond to the Habitats Directive Annex I habitat types. As the EUSeaMap classes from the aggregate map are the same as the MSFD benthic broad habitat types, except for the cases listed above, Appendix 2 can also be used to correlate EUSeaMap with Annex I habitats; although this brings additional variations or exceptions as follows:

- The Habitats Directive Annex I habitat types include several habitats which are physiographic ('landscape') features (e.g. estuaries, large shallow bays) and which could be mapped as

several EUSeaMap classes, or which are particular forms of an EUSeaMap class (e.g. not all areas mapped as shallow sand will be the Annex I habitat '1110 Sandbanks slightly covered all the time'). However, two Annex I habitats can be identified – '1170 Reefs' which includes all rocky classes regardless of depth (although littoral reefs which are also part of this habitat are not mapped) and '1120 *Posidonia* beds (*Posidonion oceanicae*)'.

- The EUSeaMap classes also provide information on the distribution of *Cymodocea* beds. Discussions at the Marine Natura 2000 seminar held in Brindisi, Italy in 2011 revealed that in some Mediterranean EU countries, ***Cymodocea*** **and Zostera beds have been regarded as equivalent to the Annex I habitat '**1110 Sandbanks slightly covered all the time' although they do not conform to the definition given in the EU Interpretation Manual (EC 2013), which is based on sandbanks from northern Europe. However discussions at the Marine Natura 2000 seminar, and results on Member State Art.17 reporting for habitat 1110 also revealed that some Mediterranean Member States have pushed the habitat 1110 sandbank interpretation to encompass a wide variety of infralittoral soft bottom assemblages, which have no connection to the original concept (conservation importance) for which the habitat sandbank was first introduced into the Habitats Directive. This implies that all the EUSeaMap Mediterranean soft bottom infralittoral habitats could potentially predict Annex I habitat "1110 Sandbanks which are slightly covered by sea water all the time" although this assumption is likely to introduce a large overestimation bias.

- Three Habitats Directive Annex I habitat types are not mapped by EUSeaMap ('1140 Mudflats and sandflats not covered by seawater at low tide', '1150 Coastal lagoons' & '1650 Boreal Baltic narrow inlets'). However, CORINE Land Cover has classes corresponding to the first 2 (4.2.3. Intertidal flats, 5.2.1. Coastal lagoons) so information will be available; while the third is only found in the Baltic and are usually relatively small features.

8 Mapping and Assessment of Ecosystems and their Services (MAES)

Any exercise in mapping and assessing ecosystems needs to be prepared with an agreed and shared ecosystem typology. This is, especially, if several projects aim at the same goal, such as supporting the maintenance of ecosystems in good health or to restore them. In 2013, the MAES initiative defined an ecosystem typology with basic units for an assessment at European scale and the goal to allow consistent assessments from local to that highest scale. Any detailed classification developed to support more detailed analyses should be compatible with and be susceptible of being aggregated within the MAES ecosystem typology.

The 2013 MAES typology of marine ecosystems reduces the 3-dimensional structure of the ocean to the 2 dimensions of the seabed (benthic) habitats, attributing the 3rd dimension, i.e. the water column (pelagic habitats), to depth zones. Brackish water and marine ecosystems in the land-sea interface are grouped together in a single type. But the important role of the photic zone is ignored (MAES et al, 2013). This photic limit is now part of the MSFD broad habitat types following from the revised (benthic) Level 2 of the marine component of EUNIS (v.2016).

Table 8.1 below provides a description of the MAES marine ecosystem categories and links them to the 2010 MSFD predominant habitat types. Thus, these categories are an aggregation of the MSFD benthic predominant habitat types to a large extent, and include the MSFD pelagic predominant habitat types. This table also contains comments relating to Table 8.2, which links the MAES marine ecosystem categories and the benthic habitats in Level 2 of the revised EUNIS marine classification, and which help to understand how such a crosswalk can be established between them. This is equivalent to aligning the former to the 2017 MSFD benthic broad habitat types as explained in Section 5 of this paper (also note that Appendix 1 lists the links between MSFD predominant habitat types and MSFD broad habitat types and the benthic habitats in the Level 2 of the revised EUNIS marine classification).

Appendix 4 lists the four MAES marine ecosystem categories and their link with the MSFD broad habitat types as well as the Habitats Directive Annex I marine habitat types of the Habitats Directive.

Table 8.1 Description of the four MAES marine ecosystem categories and the associated MSFD predominant habitat types (EC, 2010 as listed in Table 3 of MAES et al., 2013) and comments on how they link to the benthic habitat types in the revised EUNIS Level 2 marine classification (and the same with the MSFD benthic broad habitat types in EC, 2017)

MAES ecosystem category	2013 MAES Description	Representation of habitats based on the MSFD *predominant* habitat types (as provided by MAES 2013)	Comments related to Table 8.2 on the link to the revised EUNIS Level 2 marine habitats (and the new MSFD *broad* habitat types)
Marine inlets & transitional waters	*Brackish water and marine ecosystems in the land-sea interface are grouped together in a single type. Marine inlets and transitional waters are ecosystems on the land-water interface under the influence of tides and with salinity higher than 0.5 ‰. They include coastal*	**Benthic habitats:** • Littoral rock and biogenic reef • Littoral sediment • Shallow sublittoral rock and biogenic reef • Shallow sublittoral sediment	• Distinction between this and the next category ('Coastal') is not clear as the MAES benthic marine habitats here are duplicated across both categories • Similarly with the MAES pelagic marine habitat 'coastal waters' (called 'Marine salinity water (of other inlets)' here), which is also duplicated

	wetlands (saltmarshes, salines and intertidal flats), lagoons, estuaries and other transitional waters, fjords and sea lochs as well as embayments. *Pelagic habitats in this type include the photic zone, benthic habitats can include it or not*	**Pelagic habitats:** • Low/reduced salinity water (of lagoons) • Variable salinity water (of coastal wetlands, estuaries and other transitional waters) • Marine salinity water (of other inlets)	across both categories • The MAES marine benthic habitats in this category are defined according to the Corine Land Cover definitions, so – despite the similarities in their names – their correspondence to the EUNIS habitats is not always clear • Nevertheless, all EUNIS benthic habitat types identified as 'Marine inlets and transitional waters' by the IUCN Red List project have been listed together within coastal wetlands.
Coastal	*The coastal areas refer to coastal, shallow, marine systems that experience significant land-based influences. These systems undergo diurnal fluctuations in temperature, salinity and turbidity, and are subject to wave disturbance. Depth is between 50 and 70 m.* *Pelagic habitats in this type include the photic zone, benthic habitats can include it or not*	**Benthic habitats**: • Littoral rock and biogenic reef • Littoral sediment • Shallow sublittoral rock and biogenic reef • Shallow sublittoral sediment **Pelagic habitats:** • Coastal waters	• This category includes the revised EUNIS (and the new MSFD) littoral, infralittoral and circalittoral benthic habitat types. This means that its lower limit is the absolute limit of the photic zone, and that all these benthic habitats are now photic
Shelf	*The shelf refers to marine systems away from coastal influence, down to the shelf break. They experience more stable temperature and salinity regimes than coastal systems, and their seabed is below wave disturbance. They are usually about 200 m deep.* *Pelagic habitats in this type include the photic zone, benthic habitats are beyond the photic limit (aphotic)*	**Benthic habitats:** • Shelf sublittoral rock and biogenic reef • Shelf sublittoral sediment **Pelagic habitats:** • Shelf waters	• All benthic habitat types identified by the revised EUNIS (and the new MSFD) classification as offshore circalittoral are included in this category. • However, the MAES shelf sub littoral habitats here could have been defined as including the past EUNIS shallow circalittoral and deep circalittoral habitat types, where the former would now be the revised EUNIS (and the new MSFD) circalittoral habitat types and belong in the previous category ('Coastal')'
Open ocean	*The open ocean refers to marine systems beyond the shelf break with very stable temperature and salinity regimes, in particular in the deep seabed. Depth is beyond 200 m.* *Pelagic habitats in this type are, in proportion, mostly aphotic, benthic habitats are aphotic*	**Benthic habitats:** • Bathyal (upper, lower) rock and biogenic reef • Bathyal (upper, lower) sediment • Abyssal rock and biogenic reef • Abyssal sediment **Pelagic habitats:** • Ocean waters	• All benthic habitat types identified by the revised EUNIS (and the new MSFD) classification as upper/lower bathyal and abyssal are included in this category altogether

Table 8.2: Level 2 benthic units (and codes) of the marine component of the revised (v.2016) EUNIS habitat classification and of MAES 2013

	EUNIS marine benthic habitats Level 2 v.2016						
MAES 2013 marine ecosystem types	***Zone***	**Rock(*)**	**Biogenic habitat(**)**	**Coarse**	**Mixed**	**Sand**	**Mud**
Marine inlets & transitional waters	Littoral	MA1	MA2	MA3	MA4	MA5	MA6
Coastal							
Marine inlets & transitional waters	Infralittoral	MB1	MB2	MB3	MB4	MB5	MB6
Coastal							
Marine inlets & transitional waters	Circalittoral	MC1	MC2	MC3	MC4	MC5	MC6
Coastal							
Shelf	Offshore circalittoral	MD1	MD2	MD3	MD4	MD5	MD6
Open ocean	Upper bathyal	ME1	ME2	ME3	ME4	ME5	ME6
Open ocean	Lower bathyal	MF1	MF2	MF3	MF4	MF5	MF6
Open ocean	Abyssal	MG1	MG2	MG3	MG4	MG5	MG6

(*) Includes soft rock, marls, clays, artificial hard substrata

(**) Biogenic habitat formed by plants or animals

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Appendix 1 – Crosswalks between MFSD predominant habitat types 2010, broad habitat types 2017 and marine benthic habitats in EUNIS level2 v.2016

Realm	MSFD predominant habitat types (2011 Commission Staff Working Paper)	MSFD broad habitat types (Commission Decision (EU) 2017/848)	EUNIS (v.2016) marine benthic habitats
Benthic/ seabed	Littoral rock and biogenic reef	Littoral rock and biogenic reef	MA1, MA2
	Littoral sediment	Littoral sediment	MA3, MA4, MA5, MA6
	Shallow sublittoral rock and biogenic reef	Infralittoral rock and biogenic reef	MB1, MB2
		Circalittoral rock and biogenic reef	MC1, MC2
	Shallow sublittoral coarse sediment	Infralittoral coarse sediment	MB3
		Circalittoral coarse sediment	MC3
	Shallow sublittoral mixed sediment	Infralittoral mixed sediment	MB4
		Circalittoral mixed sediment	MC4
	Shallow sublittoral sand	Infralittoral sand	MB5
		Circalittoral sand	MC5
	Shallow sublittoral mud	Infralittoral mud	MB6
		Circalittoral mud	MC6
	Shelf sublittoral rock and biogenic reef	Offshore circalittoral rock and biogenic reef	MD1, MD2
	Shelf sublittoral coarse sediment	Offshore circalittoral coarse sediment	MD3
	Shelf sublittoral mixed sediment	Offshore circalittoral mixed sediment	MD4
	Shelf sublittoral sand	Offshore circalittoral sand	MD5
	Shelf sublittoral mud	Offshore circalittoral mud	MD6
	Upper bathyal rock and biogenic reef	Upper bathyal rock and biogenic reef	ME1, ME2
	Upper bathyal sediment	Upper bathyal sediment	ME3, ME4, ME5, ME6
	Lower bathyal rock and biogenic reef	Lower bathyal rock and biogenic reef	MF1, MF2
	Lower bathyal sediment	Lower bathyal sediment	MF3, MF4, MF5, MF6
	Abyssal rock and biogenic reef	Abyssal	MG1, MG2
	Abyssal sediment		MG3, MG4, MG5, MG6
Pelagic/ water column	Reduced salinity water	Variable salinity water	N/A
	Variable salinity water		
	Coastal water	Coastal water	
	Shelf water	Shelf water	
	Oceanic water	Oceanic/beyond shelf water	
Ice-associated	Ice-associated habitats	Ice-associated habitats	

Appendix 2 - Crosswalk between MSFD benthic broad habitat types and Habitats Directive Annex I marine habitat types

Adapted from 'Links between the Marine Strategy Framework Directive (MSFD 2008/56/EC) and the Nature Directives (Birds Directive 2009/147/EEC (BD) and Habitats Directive 92/43/EEC (HD)) - Interactions, overlaps and potential areas for closer coordination', 27 July 2012 http://ec.europa.eu/environment/nature/natura2000/marine/docs/FAQ%20final%202012-07-27.pdf, and checked with the Interpretation manual of EU28 Habitats (2013) and the revised EUNIS marine habitats classification and definitions (early 2018 draft)

MSFD benthic broad habitat types (Commission Decision (EU) 2017/848)	**Habitat types listed in Annex 1 of the Habitats Directive and considered 'marine' for Article 17 reporting**									
	1110 Sandbanks slightly covered all the time	1120 *Posidonia* beds (*)	1130 Estuaries	1140 Mudflats & sandflats not covered at low tide	1150 Coastal lagoons	1160 Large shallow inlets and bays	1170 Reefs	1180 Submarine structures made by leaking gas	1650 Boreal Baltic narrow inlets	8330 Submerged or partially submerged sea caves
Littoral rock & biogenic reef								These structures may occur in a range of broad habitat types		
Littoral sediment										
Infralittoral rock & biogenic reef										
Infralittoral coarse sediment										
Infralittoral mixed sediment										
Infralittoral sand										
Infralittoral mud										
Circalittoral rock & biogenic reef										
Circalittoral coarse sediment										
Circalittoral mixed sediment										
Circalittoral sand										

MSFD benthic broad habitat types (Commission Decision (EU) 2017/848)	Habitat types listed in Annex 1 of the Habitats Directive and considered 'marine' for Article 17 reporting									
	1110 Sandbanks slightly covered all the time	1120 *Posidonia* beds (*)	1130 Estuaries	1140 Mudflats & sandflats not covered at low tide	1150 Coastal lagoons	1160 Large shallow inlets and bays	1170 Reefs	1180 Submarine structures made by leaking gas	1650 Boreal Baltic narrow inlets	8330 Submerged or partially submerged sea caves
Circalittoral mud										

(*) The shading in the cell linking Annex 1 "1120 Posidonia beds" to the MSFD benthic broad habitat type "Infralittoral rock & biogenic reef" is included to indicate that Posidonia meadows are considered to be a biogenic forming habitat by EUSeaMap, which then links them to that MSFD habitat type through their biogenic aspect (see Mediterranean Sea table in Appendix 3)

MSFD benthic broad habitat types (Commission Decision (EU) 2017/848)	Habitat types listed in Annex 1 of the Habitats Directive and considered 'marine' for Article 17 reporting									
	1110 Sandbanks slightly covered all the time	1120 *Posidonia* beds	1130 Estuaries	1140 Mudflats & sandflats not covered at low tide	1150 Coastal lagoons	1160 Large shallow inlets and bays	1170 Reefs	1180 Submarine structures made by leaking gas	1650 Boreal Baltic narrow inlets	8330 Submerged or partially submerged sea caves
Offshore circalittoral rock & biogenic reef								These structures may occur in a range of broad habitat types		
Offshore circalittoral coarse sediment										
Offshore circalittoral mixed sediment										
Offshore circalittoral sand										
Offshore circalittoral mud										
Upper bathyal rock & biogenic reef										?
Upper bathyal sediment										

MSFD benthic broad habitat types (Commission Decision (EU) 2017/848)	Habitat types listed in Annex 1 of the Habitats Directive and considered 'marine' for Article 17 reporting									
	1110 Sandbanks slightly covered all the time	1120 *Posidonia* beds	1130 Estuaries	1140 Mudflats & sandflats not covered at low tide	1150 Coastal lagoons	1160 Large shallow inlets and bays	1170 Reefs	1180 Submarine structures made by leaking gas	1650 Boreal Baltic narrow inlets	8330 Submerged or partially submerged sea caves
Lower bathyal rock & biogenic reef										?
Lower bathyal sediment										
Abyssal										?

Appendix 3 - Crosswalks between EUSeaMap modelled habitat types (EUNIS and non) and MSFD benthic broad habitat types

An ecosystem assessment exercise may need to rely on the finest available habitat spatial resolution in order to take into account specific ecosystem services provided by the single modelled habitat as well as on the more generic and wider MSFD broad habitat category. EUSeaMap delivers an MSFD benthic broad habitat type layer, which must be crosswalked with each single modelled habitat in order to facilitate the development of marine ecosystem assessments.

The EUSeaMap modelled habitat layers are provided in the EUNIS v2007-11 classification codes. The only exception to this is in the Black Sea, where modelled habitats are provided with titles that do not refer to EUNIS codes. This is due to the fact that the EUNIS benthic habitat description in the Black sea is not complete. Therefore, the process by which EUSeaMap habitats were **modelled is based on the intersection of an array of environmental variables that are relevant for** the distribution of biological assemblages observed at a regional level (i.e. substrate combinations, depth zone, temperature and anoxic conditions).

The EUSeaMap modelled habitats and the respective MSFD benthic broad habitat types into which they were converged by Manca et al. 2017 (in order to produce the MSFD benthic broad habitat type layer that is available on the EMODnet habitat portal) are listed in the tables below according to each European marine region (note these include the Arctic, which is not included in the MSFD's North East Atlantic region). The crosswalking relationship between each EUSeaMap modelled habitat and the respective MSFD benthic broad habitat type is indicated using the symbols reported in Figure 3.1 of this report and described in the EUNIS website for crosswalking habitats.

The rules applied for defining the qualifying symbology are the following:

"=" indicates situations where a modelled EUSeaMap habitat matches completely with a given MSFD benthic broad habitat type

"<" indicates situations where a modelled EUSeaMap habitat is contained, together with other habitats, within a unique MSFD benthic broad habitat type

">" indicates situations where a modelled EUSeaMap habitat matches into more than one MSFD benthic broad habitat type occurring within a biological depth zone. This situation usually occurs when a EUSeaMap habitat is modelled by merging more than one substrate category. The ">" qualifier is not used for situations in which a modelled habitat carries a EUNIS code that is so wide to allow it to be matched across more than one biological depth zone or subzone (upper, lower, medium bathyal or abyssal zones) or geographic province as inferred from the EUSeaMap attribute information listed in column "Biozone". This occurs for EUNIS habitats qualifying the deep-sea, which comprehends both the bathyal and abyssal zones, their respective subzones and the geographical realms identified by EUSeaMap (i.e. Artic, Atlantic, Atlantic-Mediterraneans). In these cases, the modelled habitat name used is always the same but in reality refers to distinct habitats occurring in discreet depth zones and geographic areas.

The results of the crosswalking exercise below indicate that in the Baltic and Atlantic-Arctic regions, there are fewer EUSeaMap modelled habitats that match directly into a distinct MSFD benthic broad habitat types, while there are more situations in which more than one modeled habitats is contained within a unique MSFD benthic broad habitat type. In the Mediterranean and Black Seas, apart from the pattern observed in the Baltic and Atlantic-Arctic seas, there are some noticeable cases where a single modeled habitat type may be represented in more than one MSFD benthic broad habitat type.

The reason for these observed regional differences is that the Mediterranean broad scale habitats were modelled in both EUSeaMap 1 and EUSeaMap 2 by first identifying the benthic assemblages (or groups of assemblages) the extension of which is such that they can be portrayed at a broad scale level, and then identifying the qualifying environmental factors that can be used to model each assemblage /groups of assemblages distribution (i.e. substrate classes, depth zones, estimated light reaching the sea bottom). The same approach was applied for the Black Sea in EUSeaMap2.

The approach above deviates marginally from that used in the Atlantic Ocean, where the EUNIS 2007-2011 Folk 5 substrate classes each allowed to model distinctly different broad scale habitats. In the Mediterranean and Black Sea, merging of more than one substrate class was often necessary in order to model a given broad scale habitat type. This is particularly evident in the Mediterranean circalittoral soft bottoms where, in the absence of spatial layers qualifying for bioclastic / biogenic features that would allow to model the detritic bottoms (derived for example from shelly debris), the coarse and mixed habitat class was sometimes considered together with other soft bottom classes to model specific habitat types. The same problem was found in the Black Sea, where coarse and mixed sediment were added to the substrate considerations necessary to model some circalittoral assemblages known to occur on sand and mud. The addition of coarse and mixed sediments as an additional determining modelling variable is justified on the basis that these assemblages occur on sand and muddy bottoms characterized by a high proportion of shelly debris. Since no additional layers were provided by EMODnet Geology regarding the presence of bioclastic/biogenic material, the only way to model the above-mentioned habitat types was to add the category “coarse and mixed” to the substrate type of these habitats.

In both the Mediterranean and Black seas, it was not possible to incorporate energy into the model due to coarse resolution of the energy data. Therefore, habitats were modelled according to substrate, depth zone and light values (in the Mediterranean) and substrate, depth zone, temperature and oxic conditions on the seabottom (in the Black Sea).

Baltic Sea

Biozone (for reference)	Substrate type (for reference)	Habitat type in EUNIS v2007-11 classification	Qua.	Habitat type in MSFD benthic broad habitats (2017) classification
Infralittoral	Coarse sediment	A5.13: Infralittoral coarse sediment	=	Infralittoral coarse sediment
Infralittoral	Mixed sediment	A5.43: Infralittoral mixed sediment	=	Infralittoral mixed sediment
Infralittoral	Mud	A5.33 or A5.34: Infralittoral sandy mud or infralittoral fine mud	<	Infralittoral mud

Biozone (for reference)	Substrate type (for reference)	Habitat type in EUNIS v2007-11 classification	Qua.	Habitat type in MSFD benthic broad habitats (2017) classification
Infralittoral	Mud	A5.33: Infralittoral sandy mud	<	
Infralittoral	Mud	A5.34: Infralittoral fine mud	<	
Infralittoral	Rock or other hard substrata	A3.4: Baltic exposed infralittoral rock	<	Infralittoral rock and biogenic reef
Infralittoral	Rock or other hard substrata	A3.5: Baltic moderately exposed infralittoral rock	<	
Infralittoral	Rock or other hard substrata	A3.6: Baltic sheltered infralittoral rock	<	
Infralittoral	Sand	A5.23 or A5.24: Infralittoral sand or infralittoral muddy sand	=	Infralittoral sand
Circalittoral	Coarse sediment	A5.14: Circalittoral coarse sediment	=	Circalittoral coarse sediment
Circalittoral	Mixed	A5.44: Circalittoral mixed sediment	=	Circalittoral mixed sediment
Circalittoral	Mud	A5.35 or A5.36: Circalittoral sandy mud or circalittoral fine mud	<	Circalittoral mud
Circalittoral	Mud	A5.35: Circalittoral sandy mud	<	
Circalittoral	Mud	A5.36: Circalittoral fine mud	<	
Circalittoral	Rock or other hard substrata	A4.4: Baltic exposed circalittoral rock or A4.5: Baltic moderately exposed circalittoral rock or A4.6: Baltic sheltered circalittoral rock	=	Circalittoral rock and biogenic reef
Circalittoral	Sand	A5.25 or A5.26: Circalittoral fine sand or circalittoral muddy sand	=	Circalittoral sand
Deep circalittoral	Coarse sediment	A5.15: Deep circalittoral coarse sediment	=	Offshore circalittoral coarse sediment
Deep circalittoral	Mixed sediment	A5.45: Deep circalittoral mixed sediment	=	Offshore circalittoral mixed sediment
Deep circalittoral	Mud	A5.37: Deep circalittoral mud	=	Offshore circalittoral mud
Deep circalittoral	Sand	A5.27: Deep circalittoral sand	=	Offshore circalittoral sand

Atlantic – Arctic

Biozone (for reference)	Substrate type (for reference)	Habitat type in EUNIS v2007-11 classification (for reference)	Qua.	Habitat type in MSFD benthic broad habitats (2017) classification
Infralittoral	Coarse sediment	A5.13: Infralittoral coarse sediment	=	Infralittoral coarse sediment
Infralittoral	Mixed sediment	A5.43: Infralittoral mixed sediments	=	Infralittoral mixed sediment
Infralittoral	Mud	A5.33 : Infralittoral sandy mud	<	
Infralittoral	Mud	A5.33 or A5.34: Infralittoral sandy mud or infralittoral fine mud	<	
Infralittoral	Mud	A5.34: Infralittoral fine mud	<	
Infralittoral	Rock or other hard substrata	A3.1: Atlantic and mediterranean high energy infralittoral rock	<	Infralittoral rock and biogenic reef
Infralittoral	Rock or other hard substrata	A3.2: Atlantic and mediterranean moderate energy infralittoral rock	<	
Infralittoral	Rock or other hard substrata	A3.3: Atlantic and mediterranean low energy infralittoral rock	<	
Infralittoral	Rock or other hard substrata	A3: Infralittoral rock and other hard substrata	<	
Infralittoral	Cymodocea beds	A5.531: Cymodocea beds	<	Infralittoral sand
Infralittoral	Sand	A5.23 or A5.24: Infralittoral fine sand or infralittoral muddy sand	<	
Circalittoral	Coarse sediment	A5.14: Circalittoral coarse sediment	=	Circalittoral coarse sediment
Circalittoral	Mixed sediment	A5.44: Circalittoral mixed sediments	=	Circalittoral mixed sediment
Circalittoral	Mud	A5.35 : Circalittoral sandy mud	<	Circalittoral mud
Circalittoral	Mud	A5.35 or A5.36: Circalittoral sandy mud or circalittoral fine mud	<	
Circalittoral	Mud	A5.36: Circalittoral fine mud	<	
Circalittoral	Rock or other hard substrata	A4.1: Atlantic and mediterranean high energy circalittoral rock	<	Circalittoral rock and biogenic reef

Biozone (for reference)	Substrate type (for reference)	Habitat type in EUNIS v2007-11 classification (for reference)	Qua.	Habitat type in MSFD benthic broad habitats (2017) classification
Circalittoral	Rock or other hard substrata	A4.2: Atlantic and mediterranean moderate energy circalittoral rock	<	
Circalittoral	Rock or other hard substrata	A4.3: Atlantic and mediterranean low energy circalittoral rock	<	
Circalittoral	Rock or other hard substrata	A4: Circalittoral rock and other hard substrata	<	
Circalittoral	Sand	A5.25 or A5.26: Circalittoral fine sand or circalittoral muddy sand	=	Circalittoral sand
Deep circalittoral	Coarse sediment	A5.15: Deep circalittoral coarse sediment	=	Offshore circalittoral coarse sediment
Deep circalittoral	Mixed sediment	A5.45: Deep circalittoral mixed sediments	=	Offshore circalittoral mixed sediment
Deep circalittoral	Mud	A5.37: Deep circalittoral mud	=	Offshore circalittoral mud
Deep circalittoral	Rock or other hard substrata	A4.12 or A4.27 or A4.33: Sponge communities on deep circalittoral rock or faunal communities on deep moderate energy circalittoral rock or faunal communities on deep low energy circalittoral rock	<	Offshore circalittoral rock and biogenic reef
Deep circalittoral	Rock or other hard substrata	A4.12: Sponge communities on deep circalittoral rock	<	
Deep circalittoral	Rock or other hard substrata	A4.27: Faunal communities on deep moderate energy circalittoral rock	<	
Deep circalittoral	Rock or other hard substrata	A4.33: Faunal communities on deep low energy circalittoral rock	<	
Deep circalittoral	Sand	A5.27: Deep circalittoral sand	=	Offshore circalittoral sand
Atlanto-Arctic upper bathyal	Rock or other hard substrata	A6.11: Deep-sea rock	<	Upper bathyal rock and biogenic reef
Atlantic upper bathyal	Rock or other hard substrata	A6.11: Deep-sea rock	<	
Arctic mid bathyal	Rock or other hard substrata	A6.11: Deep-sea rock	<	

Biozone (for reference)	Substrate type (for reference)	Habitat type in EUNIS v2007-11 classification (for reference)	Qua.	Habitat type in MSFD benthic broad habitats (2017) classification
Atlantic mid bathyal	Rock or other hard substrata	A6.11: Deep-sea rock	<	
Atlanto-Mediterranean mid bathyal	Rock or other hard substrata	A6.11: Deep-sea rock	<	
Atlanto-Arctic upper bathyal	Coarse sediment	A6: Deep-sea bed	<	Upper bathyal sediment
Atlanto-Arctic upper bathyal	Mixed sediment	A6.2: Deep-sea mixed substrata	<	
Atlanto-Arctic upper bathyal	Mud	A6.5: Deep-sea mud	<	
Atlanto-Arctic upper bathyal	Mud	A6.4 or A6.5: Deep-sea muddy sand or Deep-sea mud	<	
Atlanto-Arctic upper bathyal	Sand	A6.3: Deep-sea sand	<	
Atlanto-Arctic upper bathyal	Mud	A6.4: Deep-sea muddy sand	<	
Atlantic upper bathyal	Coarse sediment	A6: Deep-sea bed	<	
Atlantic upper bathyal	Mixed sediment	A6.2: Deep-sea mixed substrata	<	
Atlantic upper bathyal	Mud	A6.5: Deep-sea mud	<	
Atlantic upper bathyal	Mud	A6.4 or A6.5: Deep-sea muddy sand or Deep-sea mud	<	
Atlantic upper bathyal	Sand	A6.3: Deep-sea sand	<	
Atlantic upper bathyal	Mud	A6.4: Deep-sea muddy sand	<	
Arctic mid bathyal	Coarse sediment	A6: Deep-sea bed	<	
Arctic mid bathyal	Mixed sediment	A6.2: Deep-sea mixed substrata	<	

Biozone (for reference)	Substrate type (for reference)	Habitat type in EUNIS v2007-11 classification (for reference)	Qua.	Habitat type in MSFD benthic broad habitats (2017) classification
Arctic mid bathyal	Mud	A6.5: Deep-sea mud	<	
Arctic mid bathyal	Sand	A6.3: Deep-sea sand	<	
Arctic mid bathyal	Mud	A6.4: Deep-sea muddy sand	<	
Atlantic mid bathyal	Coarse sediment	A6: Deep-sea bed	<	
Atlantic mid bathyal	Mixed sediment	A6.2: Deep-sea mixed substrata	<	
Atlantic mid bathyal	Mud	A6.5: Deep-sea mud	<	
Atlantic mid bathyal	Mud	A6.4 or A6.5: Deep-sea muddy sand or Deep-sea mud	<	
Atlantic mid bathyal	Sand	A6.3: Deep-sea sand	<	
Atlantic mid bathyal	Mud	A6.4: Deep-sea muddy sand	<	
Atlanto-Mediterranean mid bathyal	Coarse sediment	A6: Deep-sea bed	<	
Atlanto-Mediterranean mid bathyal	Mixed sediment	A6.2: Deep-sea mixed substrata	<	
Atlanto-Mediterranean mid bathyal	Mud	A6.5: Deep-sea mud	<	
Atlanto-Mediterranean mid bathyal	Mud	A6.4 or A6.5: Deep-sea muddy sand or Deep-sea mud	<	
Atlanto-Mediterranean mid bathyal	Sand	A6.3: Deep-sea sand	<	
Atlanto-Mediterranea	Mud	A6.4: Deep-sea muddy sand	<	

Biozone (for reference)	Substrate type (for reference)	Habitat type in EUNIS v2007-11 classification (for reference)	Qua.	Habitat type in MSFD benthic broad habitats (2017) classification
n mid bathyal				
Atlanto-Arctic upper bathyal	Seabed	A6: Deep-sea bed	<	Upper bathyal sediment or Upper bathyal rock and biogenic reef
Atlantic upper bathyal	Seabed	A6: Deep-sea bed	<	
Arctic mid bathyal	Seabed	A6: Deep-sea bed	<	
Atlantic mid bathyal	Seabed	A6: Deep-sea bed	<	
Atlanto-Mediterranean mid bathyal	Seabed	A6: Deep-sea bed	<	
Arctic lower bathyal	Rock or other hard substrata	A6.11: Deep-sea rock	<	Lower bathyal rock and biogenic reef
Atlantic lower bathyal	Rock or other hard substrata	A6.11: Deep-sea rock	<	
Arctic lower bathyal	Coarse sediment	A6: Deep-sea bed	<	Lower bathyal sediment
Arctic lower bathyal	Mixed sediment	A6.2: Deep-sea mixed substrata	<	
Arctic lower bathyal	Mud	A6.5: Deep-sea mud	<	
Arctic lower bathyal	Sand	A6.3: Deep-sea sand	<	
Arctic lower bathyal	Mud	A6.4: Deep-sea muddy sand	<	
Atlantic lower bathyal	Coarse sediment	A6: Deep-sea bed	<	
Atlantic lower bathyal	Mixed sediment	A6.2: Deep-sea mixed substrata	<	
Atlantic lower bathyal	Mud	A6.5: Deep-sea mud	<	

Biozone (for reference)	Substrate type (for reference)	Habitat type in EUNIS v2007-11 classification (for reference)	Qua.	Habitat type in MSFD benthic broad habitats (2017) classification
Atlantic lower bathyal	Mud	A6.4 or A6.5: Deep-sea muddy sand or Deep-sea mud	<	
Atlantic lower bathyal	Sand	A6.3: Deep-sea sand	<	
Atlantic lower bathyal	Mud	A6.4: Deep-sea muddy sand	<	
Arctic lower bathyal	Seabed	A6: Deep-sea bed	<	Lower bathyal sediment or Lower bathyal rock and biogenic reef
Atlantic lower bathyal	Seabed	A6: Deep-sea bed	<	
Arctic upper abyssal	Rock or other hard substrata	A6.11: Deep-sea rock	<	Abyssal
Arctic upper abyssal	Mixed sediment	A6.2: Deep-sea mixed substrata	<	
Arctic upper abyssal	Mud	A6.5: Deep-sea mud	<	
Arctic upper abyssal	Mud	A6.4: Deep-sea muddy sand	<	
Arctic upper abyssal	Seabed	A6: Deep-sea bed	<	
Atlantic upper abyssal	Rock or other hard substrata	A6.11: Deep-sea rock	<	
Atlantic upper abyssal	Coarse sediment	A6: Deep-sea bed	<	
Atlantic upper abyssal	Mixed sediment	A6.2: Deep-sea mixed substrata	<	
Atlantic upper abyssal	Mud	A6.5: Deep-sea mud	<	
Atlantic upper abyssal	Mud	A6.4 or A6.5: Deep-sea muddy sand or Deep-sea mud	<	
Atlantic upper abyssal	Sand	A6.3: Deep-sea sand	<	

Biozone (for reference)	Substrate type (for reference)	Habitat type in EUNIS v2007-11 classification (for reference)	Qua.	Habitat type in MSFD benthic broad habitats (2017) classification
Atlantic upper abyssal	Mud	A6.4: Deep-sea muddy sand	<	
Atlantic upper abyssal	Seabed	A6: Deep-sea bed	<	
Atlantic mid abyssal	Rock or other hard substrata	A6.11: Deep-sea rock	<	
Atlantic mid abyssal	Coarse sediment	A6: Deep-sea bed	<	
Atlantic mid abyssal	Mixed sediment	A6.2: Deep-sea mixed substrata	<	
Atlantic mid abyssal	Mud	A6.5: Deep-sea mud	<	
Atlantic mid abyssal	Mud	A6.4 or A6.5: Deep-sea muddy sand or Deep-sea mud	<	
Atlantic mid abyssal	Sand	A6.3: Deep-sea sand	<	
Atlantic mid abyssal	Mud	A6.4: Deep-sea muddy sand	<	
Atlantic lower abyssal	Rock or other hard substrata	A6.11: Deep-sea rock	<	
Atlantic lower abyssal	Coarse sediment	A6: Deep-sea bed	<	
Atlantic lower abyssal	Mixed sediment	A6.2: Deep-sea mixed substrata	<	
Atlantic lower abyssal	Mud	A6.5: Deep-sea mud	<	
Atlantic lower abyssal	Mud	A6.4 or A6.5: Deep-sea muddy sand or Deep-sea mud	<	
Atlantic lower abyssal	Sand	A6.3: Deep-sea sand	<	
Atlantic lower abyssal	Mud	A6.4: Deep-sea muddy sand	<	
Atlantic lower	Seabed	A6: Deep-sea bed	<	

Biozone (for reference)	Substrate type (for reference)	Habitat type in EUNIS v2007-11 classification (for reference)	Qua.	Habitat type in MSFD benthic broad habitats (2017) classification
abyssal Atlantic mid abyssal	Seabed	A6: Deep-sea bed	<	

Mediterranean

Biozone (for reference)	*Substrate Folk 5*	*EUSeaMap 2016 full-detail modeled habitat type*	*Qua.*	*MSFD benthic broad habitat type (2017)*
Infralittoral	Coarse sediment	**A5.13: Infralittoral coarse sediment**	>	Infralittoral coarse sediment
Infralittoral	Mixed sediment	**A5.13: Infralittoral coarse sediment**	>	Infralittoral mixed sediment
Infralittoral	Mud	A5.33: Infralittoral sandy mud	<	Infralittoral mud
Infralittoral	Mud	A5.34: Infralittoral fine mud	<	
Infralittoral	Rock or other hard substrata	A3: Infralittoral rock and other hard substrata	<	Infralittoral rock and biogenic reef
Infralittoral	Posidonia oceanica meadows	A5.535: [Posidonia] beds	<	
Infralittoral	Dead mattes of Posidonia oceanica	A5.5353: Facies of dead "mattes" of [Posidonia oceanica] without much epiflora	<	
Infralittoral	Sand	A5.23: Infralittoral fine sands	<	Infralittoral sand
Infralittoral	Cymodocea nodosa meadows	A5.531: [Cymodocea] beds	<	
Circalittoral	Coarse sediment	A5.14: Circalittoral coarse sediment	>	Circalittoral coarse sediment
Circalittoral	Coarse sediment	A5.46: Mediterranean biocoenosis of coastal detritic bottoms	>	
Circalittoral	Mixed sediment	A5.14: Circalittoral coarse sediment	>	Circalittoral mixed sediment
Circalittoral	Mixed sediment	A5.46: Mediterranean biocoenosis of coastal detritic bottoms	>	
Circalittoral	Mud	A5.35: Circalittoral sandy mud	<	Circalittoral mud or

Circalittoral	Mud	A5.36: Circalittoral fine mud	<	Offshore circalittoral mud
Circalittoral	Mud	A5.38: Mediterranean biocoenosis of muddy detritic bottoms	<	
Circalittoral	Mud	A5.39: Mediterranean biocoenosis of coastal terrigenous muds	<	
Circalittoral	Mud	A5.47: Mediterranean communities of shelf-edge detritic bottoms	>	
Circalittoral	Rock or other hard substrata	A4.26 or A4.32: Mediterranean coralligenous communities moderately exposed to or sheltered from hydrodynamic action	<	Circalittoral rock and biogenic reef
Circalittoral	Rock or other hard substrata	A4: Circalittoral rock and other hard substrata	<	
Circalittoral	Sand	A5.25: Circalittoral fine sand	<	Circalittoral sand
Circalittoral	Sand	A5.26: Circalittoral muddy sand	<	
Circalittoral	Sand	A5.46: Mediterranean biocoenosis of coastal detritic bottoms	>	
Circalittoral	Coarse sediment	A5.47: Mediterranean communities of shelf-edge detritic bottoms	>	Offshore circalittoral coarse sediment
Circalittoral	Mixed sediment	A5.47: Mediterranean communities of shelf-edge detritic bottoms	>	Offshore circalittoral mixed sediment
Circalittoral	Rock or other hard substrata	A4.27: Faunal communities on deep moderate energy circalittoral rock	=	Offshore circalittoral rock and biogenic reef
Circalittoral	Sand	A5.47: Mediterranean communities of shelf-edge detritic bottoms	>	Offshore circalittoral sand
Mediterranean bathyal	Rock or other hard substrata	A6.1: Deep-sea rock and artificial hard substrata	=	Lower bathyal rock and biogenic reef and Upper bathyal rock and biogenic reef
Mediterranean bathyal	Mixed sediment	A6.2: Deep-sea mixed substrata	<	Lower bathyal sediment or Upper bathyal sediment
Mediterranean bathyal	Sand	A6.3: Deep-sea sand	<	
Mediterranean bathyal	Sand	A6.4: Deep-sea muddy sand	<	

Mediterranean bathyal	Mud	A6.51: Mediterranean communities of bathyal muds	<	
Mediterranean bathyal	Mud	A6.511: Facies of sandy muds with Thenea muricata	<	
Mediterranean abyssal	Mixed sediment	A6.2: Deep-sea mixed substrata	<	Abyssal
Mediterranean abyssal	Sand	A6.3: Deep-sea sand	<	
Mediterranean abyssal	Sand	A6.4: Deep-sea muddy sand	<	
Mediterranean abyssal	Mud	A6.52: Communities of abyssal muds	<	

Black Sea

Biozone	Substrate type	Habitat type in EUSeaMap 2016 full-detail classification (for reference)	Qua.	Habitat type in MSFD benthic broad habitats (2017) classification
Infralittoral	Coarse sediment	Infralittoral coarse and mixed Sediment	>	Infralittoral coarse sediment
Infralittoral	Mixed sediment	Infralittoral coarse and mixed Sediment	>	Infralittoral mixed sediment
Infralittoral	Mud	Infralittoral mud or sandy mud	=	Infralittoral mud
Infralittoral	Rock or other hard substrata	Infralittoral rock	=	Infralittoral rock and biogenic reef
Infralittoral	Sand	Infralittoral muddy sand	<	Infralittoral sand
	Sand	Infralittoral sand	<	
	Sand	Infralittoral sand and muddy sand	<	
Soft Bottom shallow circalittoral	Coarse sediment	Circalittoral coarse and mixed Sediment	>	Circalittoral coarse sediment
	Coarse sediment	Shallow circalittoral shelly organogenic sand	>	
Soft Bottom shallow	Mixed sediment	Circalittoral coarse and mixed Sediment	>	Circalittoral mixed sediment

circalittoral	Mixed sediment	Shallow circalittoral mud and organogenic sandy mud/muddy sand	>	
Soft Bottom shallow circalittoral	Mud	Circalittoral terrigenous muds	<	Circalittoral mud
	Mud	Shallow circalittoral mud and organogenic sandy mud/muddy sand	>	
Rocky circalittoral	Rock or other hard substrata	Circalittoral rock	=	Circalittoral rock and biogenic reef
Soft bottom shallow circalittoral	Sand	Shallow circalittoral mud and organogenic sandy mud/muddy sand	>	Circalittoral sand
	Sand	Shallow circalittoral shelly organogenic sand	>	
Soft bottom deep circalittoral	Coarse sediment	Deep circalittoral anoxic coarse sediments	<	Offshore circalittoral coarse sediment
	Coarse sediment	Deep circalittoral mixed sediments	>	
Soft bottom deep circalittoral	Mixed sediment	Deep circalittoral anoxic mixed sediments	<	Offshore circalittoral mixed sediment
	Mixed sediment	Deep circalittoral mixed sediments	>	
	Mixed sediment	Deep circalittoral suboxic mixed sediments	<	
Soft bottom deep circalittoral	Mud	Deep circalittoral anoxic muds	<	Offshore circalittoral mud
	Mud	Deep circalittoral anoxic sandy mud	<	
	Mud	Deep circalittoral mixed sediments	>	
	Mud	Deep circalittoral mud	<	
	Mud	Deep circalittoral suboxic calcareous muds	<	
	Mud	Deep circalittoral suboxic sandy mud	<	
Soft bottom deep	Sand	Deep circalittoral anoxic muddy sand	<	Offshore circalittoral

circalittoral				sand
	Sand	Deep circalittoral anoxic sand	<	
	Sand	Deep circalittoral mixed sediments	>	
	Sand	Deep circalittoral sand	<	
	Sand	Deep circalittoral suboxic muddy sand	<	
	Sand	Deep circalittoral suboxic sand	<	
Black Sea bathyal	Coarse sediment	Bathyal coarse sediment	<	Upper bathyal sediment or Lower bathyal sediment
	Mixed sediment	Bathyal mixed sediment	<	
	Mud	Bathyal anoxic muds	<	
	Mud	Bathyal sandy mud	<	
	Sand	Bathyal muddy sand	<	
	Sand	Bathyal sand	<	
Black Sea abyssal	Mixed sediment	Abyssal seabed	<	Abyssal
	Mud	Abyssal seabed	<	
	Mud	Abyssal seabed	<	
	Sand	Abyssal seabed	<	
	Seabed	Abyssal seabed	<	

Appendix 4 Crosswalks between MSFD broad habitat types, Habitats Directive Annex I marine habitat types and MAES European marine ecosystem typology

MAES marine ecosystem and habitat types (2013)	**MSFD broad habitat types** (Commission Decision (EU) 2017/848)	**Habitats Directive Annex I marine habitat types**
BENTHIC HABITATS		
Marine inlets & transitional waters Littoral rock and biogenic reef	Littoral rock and biogenic reef	1130 Estuaries 1150 Coastal lagoons 1160 Large shallow inlets and bays 1170 Reefs 1650 Boreal Baltic narrow inlets 8330 Submerged or partially submerged sea caves
Coastal Littoral rock and biogenic reef		
Marine inlets & transitional waters Littoral sediment	Littoral sediment	1130 Estuaries 1140 Mudflats & sandflats not covered at low tide 1150 Coastal lagoons 1160 Large shallow inlets and bays 1650 Boreal Baltic narrow inlets
Coastal Littoral sediment		
Marine inlets & transitional waters Shallow sublittoral rock and biogenic reef	Infralittoral rock and biogenic reef	1120 *Posidonia* beds (included to indicate that this is considered to be a biogenic forming habitat by EUSeaMap, which then links it to this MSFD habitat type through its biogenic aspect, see Mediterranean Sea table in Appendix 3) 1130 Estuaries 1150 Coastal lagoons 1160 Large shallow inlets and bays 1170 Reefs 1650 Boreal Baltic narrow inlets
Coastal Shallow sublittoral rock and biogenic reef		

		8330 Submerged or partially submerged sea caves
Marine inlets & transitional waters Shallow sublittoral sediment **Coastal** Shallow sublittoral sediment	Infralittoral coarse sediment	1110 Sandbanks slightly covered all the time 1120 *Posidonia* beds 1130 Estuaries 1150 Coastal lagoons 1160 Large shallow inlets and bays 1650 Boreal Baltic narrow inlets
Marine inlets & transitional waters Shallow sublittoral sediment **Coastal** Shallow sublittoral sediment	Infralittoral mixed sediment	1110 Sandbanks slightly covered all the time 1120 *Posidonia* beds 1130 Estuaries 1150 Coastal lagoons 1160 Large shallow inlets and bays 1650 Boreal Baltic narrow inlets
Marine inlets & transitional waters Shallow sublittoral sediment **Coastal** Shallow sublittoral sediment	Infralittoral sand	1110 Sandbanks slightly covered all the time 1120 *Posidonia* beds 1130 Estuaries 1150 Coastal lagoons 1160 Large shallow inlets and bays 1650 Boreal Baltic narrow inlets
Marine inlets & transitional waters Shallow sublittoral sediment **Coastal** Shallow sublittoral sediment	Infralittoral mud	1120 *Posidonia* beds 1130 Estuaries 1150 Coastal lagoons 1160 Large shallow inlets and bays 1650 Boreal Baltic narrow inlets
Marine inlets & transitional waters Shallow sublittoral rock and biogenic reef **Coastal** Shallow sublittoral rock and biogenic reef	Circalittoral rock and biogenic reef	1160 Large shallow inlets and bays 1170 Reefs 1650 Boreal Baltic narrow inlets 8330 Submerged or partially submerged sea caves

Marine inlets & transitional waters Shallow sublittoral sediment	Circalittoral coarse sediment	1160 Large shallow inlets and bays 1650 Boreal Baltic narrow inlets
Coastal Shallow sublittoral sediment		
Marine inlets & transitional waters Shallow sublittoral sediment	Circalittoral mixed sediment	1160 Large shallow inlets and bays 1650 Boreal Baltic narrow inlets
Coastal Shallow sublittoral sediment		
Marine inlets & transitional waters Shallow sublittoral sediment	Circalittoral sand	1160 Large shallow inlets and bays 1650 Boreal Baltic narrow inlets
Coastal Shallow sublittoral sediment		
Marine inlets & transitional waters Shallow sublittoral sediment	Circalittoral mud	1160 Large shallow inlets and bays 1650 Boreal Baltic narrow inlets
Coastal Shallow sublittoral sediment		
Shelf Shelf sublittoral rock and biogenic reef	Offshore circalittoral rock and biogenic reef	1170 Reefs 8330 Submerged or partially submerged sea caves
Shelf Shelf sublittoral sediment	Offshore circalittoral coarse sediment	N/A
Shelf Shelf sublittoral sediment	Offshore circalittoral mixed sediment	N/A
Shelf Shelf sublittoral sediment	Offshore circalittoral sand	N/A
Shelf Shelf sublittoral sediment	Offshore circalittoral mud	N/A
Open ocean Upper bathyal rock and biogenic reef	Upper bathyal rock and biogenic reef	1170 Reefs (8330 Submerged or partially submerged sea caves ?)

Open ocean Upper bathyal sediment	Upper bathyal sediment	N/A
Open ocean Lower bathyal rock and biogenic reef	Lower bathyal rock and biogenic reef	1170 Reefs (8330 Submerged or partially submerged sea caves ?)
Open ocean Lower bathyal sediment	Lower bathyal sediment	N/A
Open ocean Abyssal rock and biogenic reef Abyssal sediment	Abyssal	1170 Reefs (8330 Submerged or partially submerged sea caves ?)
PELAGIC HABITATS		
Marine inlets & transitional waters Low/reduced salinity water (of lagoons) Variable salinity water (of coastal wetlands, estuaries and other transitional waters) Marine salinity water (of other inlets)	Variable salinity water	N/A
Coastal Coastal waters (*)	Coastal water (*)	
Shelf Shelf waters (*)	Shelf water (*)	
Open ocean Ocean waters (*)	Oceanic/beyond shelf water (*)	

(*) The MAES typology uses the terms “waters” but the MSFD broad habitat types use the term “water”.